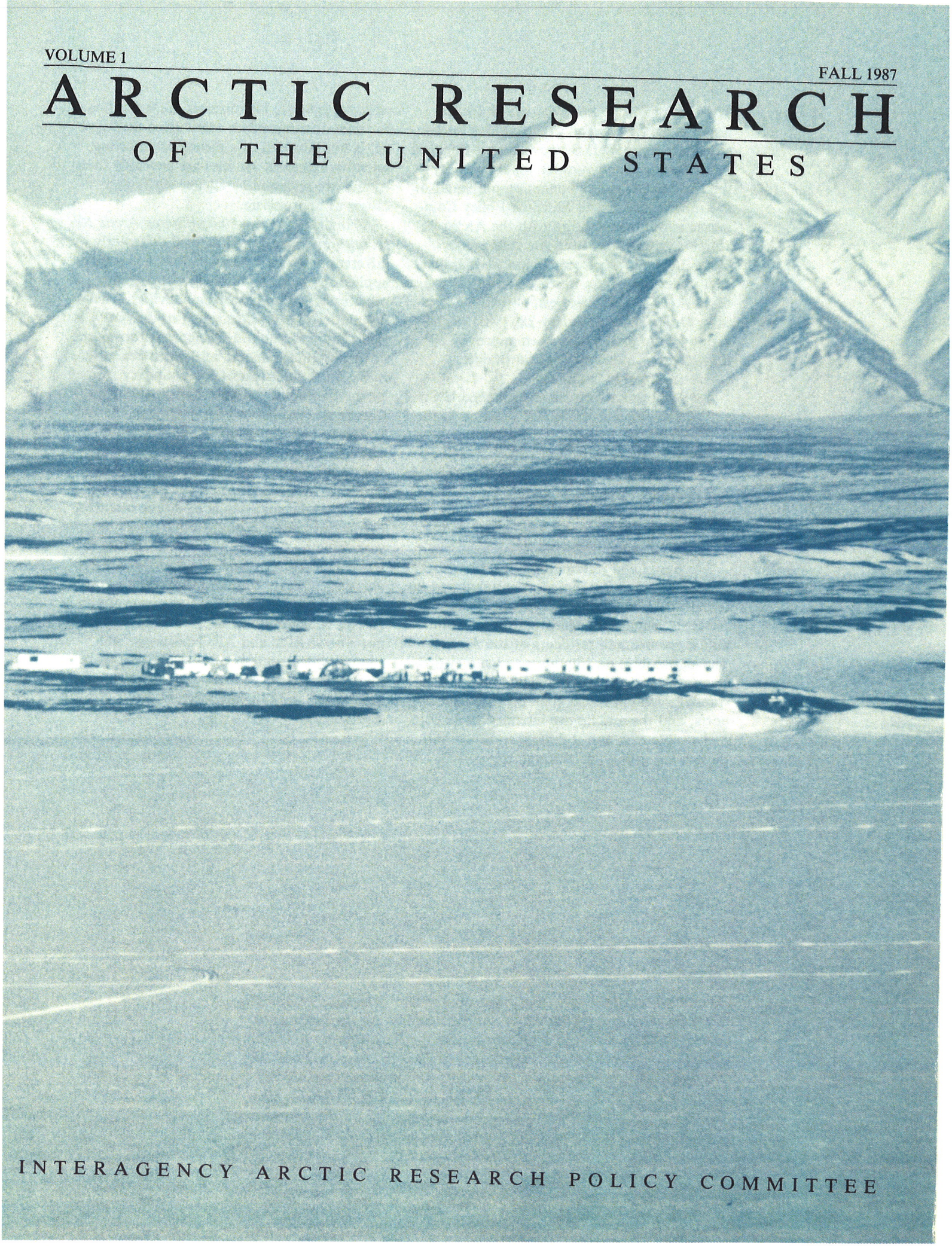
VOLUME 1

FALL 1987

# 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 by the National Science Foundation on behalf of the Interagency Arctic Research Policy Committee and in cooperation with 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
- 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 non-technical 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 *United States 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." However, areas outside of the boundary are discussed in the journal when considered relevant to the broader scope of Arctic research.

It is our intent to publish two issues per year initially; one will be devoted to summaries of U.S. Government programs of the previous fiscal year, and the other to non-government reports. This inaugural issue contains several background articles on the ARPA; reports of IARPC and ARC meetings; and summary descriptions of agencies' FY 86 research programs, with funding tabulations itemized as in the *United States Arctic Research Plan.*

Jerry Brown, Head
Arctic Staff, NSF

## *Cover*

*Looking south into the Brooks Range, northern Alaska. The buildings form the Toolik Lake Research Station operated by the Institute of Arctic Biology, University of Alaska, Fairbanks, primarily for summer projects sponsored by the Department of Energy (see p. 67) and the National Science Foundation (see p. 33). This area includes the recently designated Long-Term Ecological Research (LTER) site. The Trans Alaska Pipeline and the Dalton Highway are on the east side of Toolik Lake. (Photograph courtesy of the Institute of Arctic Biology.)*

VOLUME 1 FALL 1987

# ARCTIC RESEARCH
## OF THE UNITED STATES

## Interagency Arctic Research Policy Committee

National Science Foundation
*Erich Bloch, Chairman*
Department of Commerce
*Joseph O. Fletcher*
Department of Defense
*Ronald L. Kerber*
Department of Energy
*James F. Decker*
Department of Health and Human Services
*George E. Hardy, Jr.*
Department of Interior
*William R. Horn*
Department of State
*John D. Negroponte*
Department of Transportation
*George W. McDonald*
Environmental Protection Agency
*Vaun Newill*
National Aeronautics and Space Administration
*Lennard A. Fisk*
Smithsonian Institution
*Robert Hoffmann, Observer*
Office of Management and Budget
*Norine Noonan, Observer*
Office of Science and Technology Policy
*Beverly Berger*

IARPC Staff
Division of Polar Programs, Room 620
National Science Foundation
Washington, D.C. 20550
(202) 357-7817

# *U.S. Arctic Research Policy*

*Adopted February 3, 1986, by the Interagency Arctic Research Policy Committee*

*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 which 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 which benefits from and contributes to mutually beneficial 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 in 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.

To achieve these goals and objectives, research and its support will focus on:

*National Security*

- Environmental phenomena and processes relating to defense;
- Human health and biology in the Arctic;
- High latitude communications; and
- Arctic marine technology

*Regional Development with Minimal Environmental or Adverse Social Impact*

- Arctic marine technology relating to transportation systems and offshore operations;
- Collection and long-term monitoring of baseline data on relevant parameters for cumulative environmental impacts;
- Environmental, health, behavioral, and societal aspects of development;
- Sea state, ice reporting and weather forecasting.

*Scientific Research on Arctic Phenomena and Processes and Aspects of Science Best Studied in the Arctic*

- Systematic collection of basic data related to physical, biological, materials, social, cultural, health and behavioral phenomena and the establishment of an Arctic data and information system;
- Effects of Arctic conditions on global climate and weather;
- Effects of pollution on global climate and weather patterns, and their mitigation; and
- Preserving and conserving wildlife and essential habitats.

# The Interagency Arctic Research Policy Committee

ERICH BLOCH
Chairman, IARPC

## Introduction

The purposes of the Arctic Research and Policy Act of 1984 were to establish national policy, priorities and goals, and to provide a program plan for basic and applied scientific research with respect to the Arctic. In the three years since passage of the Act, considerable progress and success have been realized in attaining these objectives. A national Arctic research policy was formulated and approved (see opposite page). A comprehensive Arctic research plan was prepared, submitted to the President, and in turn transmitted to the Congress on July 31, 1987. Steps for implementing the Plan and the priority research it identifies are underway. These accomplishments are the results of the extraordinary cooperation among member agencies of the Interagency Arctic Research Policy Committee and the Arctic Research Commission, both authorized under the Act and established by President Reagan in his Executive Order 12501 dated January 28, 1985. The participation in the planning and review process by the State of Alaska, residents of the Arctic, the private sector, and public interest groups substantially enhanced the technical and functional values of the Plan. The planning process created new awareness of and opportunities for Arctic research, as well as for the application of existing and new knowledge to economic, societal, security, and environmental challenges facing the U.S. in the Arctic. This first issue of *Arctic Research of the United States* presents a snapshot of recent involvements of the U.S. agencies in the Arctic, and highlights activities of the Arctic Research Commission and the Interagency Committee.

In my role as Director of the National Science Foundation, I am required by the Act to ensure that the requirements of Section 108 pertaining to the Interagency Committee are fulfilled. Furthermore, the Act and Executive Order require that NSF be responsible for implementing Arctic research policy. In this context, I am pleased to report on the ARPA activities since its enactment and on how the Committee and its member agencies are fulfilling their responsibilities. I encourage you to read the Act and the Executive Order found in the final pages of this issue, and to obtain a copy of the *United States Arctic Research Plan* for more details on what is discussed below.

*Erich Bloch, the Director of the National Science Foundation, is Chairman of the Interagency Arctic Research Policy Committee. He also serves as an ex officio member of the Arctic Research Commission. He is the NSF representative on numerous committees and councils, including the Committee on Earth Sciences of the Federal Coordinating Council on Science, Engineering and Technology, the Ocean Principals Group, the National Research Council's Government–University–Industry–Research Roundtable, the Federal Council on the Arts and Humanities and the President's National Commission on Space (ex officio advisory).*

## Interagency Committee Responsibilities

Among the Interagency Committee's assigned responsibilities are the following:

- Survey Arctic research conducted by Federal, State, and local agencies, universities, and other public and private institutions.
- Work with the Arctic Research Commission to develop and establish an integrated national Arctic research policy.
- Develop a five-year plan to implement the national policy.
- Consult with the Commission on development of the plan, and existing and future research programs.
- Provide the necessary coordination, data, and assistance for the preparation of a single integrated, coherent multiagency budget request for Arctic research.
- Facilitate cooperation among Federal, State and local governments in Arctic research, and recommend the undertaking of neglected areas of research.
- Coordinate and promote cooperative Arctic research programs with other nations.
- Promote Federal interagency coordination of all Arctic research activities, including logistical planning and coordination and the sharing of data and information associated with Arctic research.

In order to accomplish these tasks, a group of staff representatives reporting to the Interagency Committee began work in late 1984. Based on guidance from the Interagency Committee, the staff conducted a series of planning sessions, workshops and reviews. The following is a summary of major events and activities of the Committee, the Commission, and the staff that led to the development of the Arctic research policy and the *United States Arctic Research Plan.*

| | |
|---|---|
| December 1984 | Initial Meeting of IARPC Staff Representatives |
| January 1985 | Presidential Executive Order Establishing Interagency Committee and Commission |
| March 1985 | Arctic Research Commission Sworn In |
| April 1985 | First Arctic Research Commission and IARPC Meetings |
| July 1985 | IARPC Progress Report to President and Congress |
| September 1985 | IARPC Report: *Federal Arctic Research: Detailed Listing of Existing U.S. Programs* |
| November 1985 | IARPC Workshop: Weather and Ice Dynamics, Hanover, New Hampshire |
| January 1986 | Arctic Research Commission Report: *U.S. on the Arctic Rim*<br>First Arctic Budget to Congress |
| February 1986 | Second IARPC Meeting; Report to President and Congress; Adoption by IARPC of Arctic Research Policy |
| March 1986 | IARPC Workshops:<br>Land and Cultural Resources, Anchorage, Alaska<br>Marine Ecosystems, Boulder, Colorado |
| May 1986 | IARPC Workshop: Energy and Minerals Resources, Anchorage, Alaska<br>Arctic Research Commission Report: *National Needs and Arctic Research: A Framework for Action*<br>IARPC Staff Workshop: Plan Review and Recommendations |
| October 1986 | IARPC Workshop: U.S. Arctic Resident Review, Barrow, Alaska |
| November 1986 | IARPC Consultative Workshop: Anchorage, Alaska |
| January 1987 | IARPC Workshop: Social Science, Washington, D.C.<br>Arctic Research Commission Report: *The United States, an Arctic Nation* |
| March 1987 | Third IARPC Meeting: Review and Approval of Arctic Research Plan |
| July 1987 | Final Plan Transmitted to the President and Congress |

## *U.S. Arctic Research Policy*

The Arctic Research and Policy Act directed the Interagency Committee to "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." The U.S. Arctic research policy approved by the Interagency Committee at its February 3, 1986, meeting (p. 2) is based on the Committee's early understanding that any broad regional research policy must be general in nature as well as consistent with overall U.S. policy in the Arctic.

The Committee relied on two statements of policy: The President's National Security Decision Directive 90 (April 14, 1983) and the Arctic Research and Policy Act, particularly Section 102 on Findings and Purposes. NSDD 90 identifies four basic elements of U.S. Arctic national policy: 1) protecting essential security interests in the Arctic region; 2) supporting sound and rational development in the Arctic region, while minimizing adverse effects on the environment; 3) promoting scientific research contributing to knowledge of the Arctic environment or of aspects of science which are most advantageously studied in the Arctic; and 4) promoting mutually beneficial international cooperation to achieve the above objective. Development of the policy statement was undertaken in consultation with the Arctic Research Commission. The U.S. Arctic research policy includes both an identification of U.S. interests and a statement of goals and objectives to carry out these interests. It states that 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 which are most advantageously studied in the Arctic.

Further, 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 of 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.

## *Development of the Plan*

The Act instructs the Interagency Committee to prepare a comprehensive five-year program plan for the overall Federal effort in Arctic research. Included in the plan shall be: 1) an assessment of national needs and problems, 2) a statement of goals and objectives, 3) a detailed listing of existing Federal programs, 4) recommendations for necessary program change, and 5) a description of action to be taken to coordinate the budget process.

Without going into detail on the contents of the Plan, it suffices to say that it supports the Arctic research policy and corresponds to the Commission's framework for Arctic research and its recommendations as described in the following article by Chairman James Zumberge. The Plan consists of three major technical sections. The Atmosphere–Oceans section emphasizes several interagency initiatives on sea ice and biological productivity. The Land section focuses on natural resources, engineering challenges and research to improve understanding of how land environments respond to natural variations and human-induced changes. The section on People relates to their health, economic and social environments, and history.

The following steps were taken in preparation of the Plan.

The required assessment of national needs and problems was based on the National Research Council and its Polar Research Board report entitled "National Issues and Research Priorities in the Arctic." Priorities within disciplines were established based on literally hundreds of previous recommendations and reports. This report, published in July 1985, satisfied the requirement for the initial assessment of national needs and problems.

A statement of goals and objectives was developed and included in the Arctic research policy as discussed earlier. These provided guidance for the recommendations developed in the Plan.

A detailed listing of Federal Arctic programs was published in September 1985. Prior to the Act, no single source of published information existed on the scope and magnitude of Federal agency programs in or related to the Arctic. Agencies defined activities according to their own mission definitions of research. Thus, the programs include basic and applied research as well as monitoring. Initially, a total of 70 programs and projects totaling $79 million were identified and listed for FY 85. Future revisions and additions will be reported annually in this journal and summarized in the biennial update of the Plan as required by the Act.

Recommendations for necessary programs were developed based on review of the Polar Research Board report on national issues and research priorities, the agencies' programs, existing and planned programs, and the Commission's reports. Nine guiding recommendations were developed, covering:

Ice dynamics, weather and climate
Marine ecosystems
Energy and mineral resources
Land environments
Coastal processes and engineering
Health
Social science
Data, information and logistics
International cooperation

The recommendations either placed additional emphasis on existing programs or filled gaps in them. They cut across the requirements of several agencies, were predominantly multi- and interdisciplinary, and conformed with the Commission's conclusion that:

> "The basic premise for an Arctic Research Plan should be development of a comprehensive, interdisciplinary, coordinated approach to the acquisition of the scientific and engineering knowledge required to respond to national needs in the Arctic, including national security and defense, resource development, protection of the environment, and the well-being of the population."

An annual, coordinated compilation of the Federal agencies' budgets for Arctic research has been prepared since FY 85. As indicated, the report *Federal Arctic Research* provided an integrated budget which identified $79 million in Federal support for FY 85. Subsequent revisions raised the initial FY 85 estimate to $87 million, in large part due to previously unidentified upper atmospheric research in several agencies. The agency annual budget summaries were reviewed and approved by the Interagency Committee at the February 3, 1986, and March 23, 1987, meetings. Further, the Office of Management and Budget includes a separate section on Arctic research among the special analyses which are prepared annually as part of the President's Budget Request.

The Act did not provide additional funding for Arctic research. Agencies are expected to request and justify funds for these activities as part of their normal budgetary processes. During the planning process it became obvious that the major impediment to enhancing the funding of new Arctic research was com-

petition with non-Arctic research within individual agencies and not between Arctic research programs themselves. However, as the Plan evolved it became apparent that well-conceived and mission-related initiatives did receive more favorable responses if they were tied to the emerging Arctic Research Plan. It is anticipated that as the Plan becomes available in its approved form, agencies will provide levels of funding consistent with it and existing programs.

It is enlightening to compare today's expenditures with those of a decade ago. During the 1970s, the former Interagency Arctic Research Coordinating Committee (IARCC) compiled annual budget expenditures of the Federal agencies. This Committee was dissolved in 1978 and its last compilation was based on Fiscal Year 1977 (see *Arctic Bulletin*, No. 15, 1978). The FY 77 expenditures are shown in the budget table for comparison and show considerable shifts in agency programs over the past decade. The actual dollar value of the $62 million research expenditure in FY 77 is very likely equal to or in excess of current U.S. Arctic research expenditures of about $90 million.

| | FY 77 | FY 85 | FY 86 | FY 87 | Est. FY 88 |
|---|---|---|---|---|---|
| | (Thousands of dollars) | | | | |
| Department of Defense | 5,920 | 22,624 | 26,636 | 25,837 | 27,916 |
| Department of Interior | 34,950 | 26,450 | 23,877 | 22,853 | 21,796 |
| National Science Foundation | 7,310 | 19,429 | 18,144 | 19.162 | 21,597 |
| National Aeronautics and Space Administration | 230 | 7,229 | 7,999 | 13,520 | 16,586 |
| Department of Commerce | 6,930 | 5,548 | 5,187 | 4,555 | 2,730 |
| Department of Energy | 830 | 2,815 | 4,736 | 3,686 | 3,286 |
| Department of Health and Human Services | 1,280 | 1,493 | 1,756 | 1,587 | 1,128 |
| Smithsonian Institution | — | 507 | 519 | 519 | 719 |
| Department of Transportation | 390 | 565 | 410 | 150 | 250 |
| Environmental Protection Agency | 1,180 | 400 | 400 | 300 | 0 |
| Department of State | — | 16 | 16 | 16 | 16 |
| Department of Agriculture | 2,680 | — | 850 | 850 | 850 |
| Total | 61,700 | 87,076 | 90,530 | 93,035 | 96,874 |

## *Future Plans*

The preparation and publication of the Arctic research policy and the Plan are only the beginning of an implementation process. We are aggressively developing approaches for implementing the Plan and for monitoring progress. Interagency plans fail for a number of reasons, including lack of continuous active and enthusiastic oversight, lack of a coherent agency-by-agency accomplishment plan which details what each agency is responsible for, insufficient policy-level sponsorship to allow successful competition with other programs, and failure to adequately deal with variability in how agencies fund programs. The Interagency Committee believes that a strategy establishing the staff representatives as an oversight group assisted by specialty groups to further integrate and coordinate agencies' programs will ensure fulfillment of the expectations of the Act. These groups and staff will review progress and provide written reports to our Interagency Committee.

At press time a limited number of multiagency programs were being considered for coordination and implementation, building on existing programs within agencies and proposed new thrusts. These included:

- Arctic Ocean Dynamics and Productivity
- Arctic Climate
- Atmospheric Coupling
- Land Interactions and Trends
- Social and Health Adaptation of Arctic People
- Resource Development and Technologies

Several of these multiagency activities will contribute to understanding of the role of the Arctic in global change. Cross-cutting issues for the successful conduct of Arctic research will be considered, including ready access to data and information, availability of research platforms and logistics, and development and sharing of international research opportunities.

A dominant theme that has emerged from the interagency planning process is the need for long-term baseline data. While the collection of such data is not generally considered to be research, it forms a needed base for future research efforts and is essential to understanding global change. Stable funding and logistics support are required if these long-term data bases are to be acquired and maintained. A workshop on Arctic data requirements necessary to address long-term change will take place in spring 1988.

The training and involvement of Native people in research has received heightened interest as a result of the Act. Native residents want to be involved in the design and implementation of research in the U.S. Arctic, particularly that concerning subsistence use of wildlife, and they want to play a management role in decisions concerning the marine- and

land-based ecosystems. One principal IARPC goal in implementing the Plan will be to provide for this involvement whenever and wherever possible. In addition, Native groups throughout the U.S. Arctic have appealed for the establishment of regional Arctic resource centers for the purpose of facilitating research and providing educational opportunities for Arctic residents. Such centers would improve the flow of information to and from the scientific community.

Finally, program effectiveness can be improved by increased cooperation among all interested parties. In the future, organizations with greatly differing missions can, with little additional effort, devise ways to work together toward a common goal. Federal agencies need to actively explore ways to cooperate with each other, and involve indigenous people, State and local government, universities, industry, and other countries in further refining and accomplishing the Arctic research agenda. We look forward to the further development of international Arctic science cooperation with nations sharing common interests in the Arctic. Future issues of *Arctic Research of the United States* will report on progress towards accomplishing many of the programs and plans presented in this inaugural issue.

## *Publications*

Copies of the following publications are available from Polar Coordination and Information Section, Division of Polar Programs, National Science Foundation, Washington, D.C. 20550.

*National Issues and Research Priorities in the Arctic.* Polar Research Board, National Research Council, Washington, D.C. July 1985.

*Federal Arctic Research: Detailed Listing of Existing U.S. Programs, Initial Compilation.* Interagency Arctic Research Policy Committee, Washington, D.C. September 1985.

*Arctic Five-Year Research Plan Consultative Workshop.* Final Report, Toborg Associates, Inc., Washington, D.C. April 1987.

*United States Arctic Research Plan.* Interagency Arctic Research Policy Committee, NSF 87-55, Washington, D.C. July 1987.

# *The U.S. Arctic Research Commission*

JAMES H. ZUMBERGE
Chairman, U.S. ARC (1985–87)

JUAN G. ROEDERER
Chairman, U.S. ARC (1987–)

## *Background*

The Arctic Research and Policy Act of 1984 (Public Law 98-373, July 31, 1984) defines United States interests in the Arctic and emphasizes the need for research to ensure that the goals of U.S. Arctic policy are met. It establishes a framework for developing priorities in basic and applied research in the Arctic and a coherent national Arctic research effort.

Recognition of the need for Arctic research in the U.S. national interest is not new. Research in Arctic Alaska has been conducted since shortly after the United States acquired it from Russia in 1867, and it increased steadily during the first half of this century. Such research was supported largely by the Federal government. In 1986, Federal expenditures for Arctic research amounted to some $83 million, with additional substantial amounts contributed by industry and state and regional organizations.

Was there a need, then, for special legislation to foster Arctic research and to create two new organizations with specific responsibilities for developing Arctic research policy and planning a research program to implement it? To answer that question we need only consider that all Federal research dollars appropriated by the Congress are channeled through mission-oriented agencies. These agencies support the research that will help them to fulfull their particular responsibilities; in fact, there is continuing pressure on them to ensure that their research expenditures are directly relevant to their mandated missions. Lacking was a means of ensuring continuing review of the overall Arctic research effort in relation to national goals and emerging needs. Improved coordination of logistic support for Arctic research and more effective management of the data and information resulting from such research are additional critical needs meriting sustained attention.

The Arctic Research and Policy Act, therefore, gives new status and incentive to what has often been seen as a fragmented, uneven, sometimes ignored research effort. It promises to produce greater interdisciplinary, interorganizational cooperation in research; improved cost-effectiveness and research productivity; and more rapid communication and application of research results. The needs are urgent, the budgetary constraints severe. The two new organizations created under the Act (the Interagency Arctic Research Policy Committee and the U.S. Arctic Research Commission) have their work cut out for them.

The Arctic Research Commission consists of three members selected from academic or research institutions, one from industry, and one from the indigenous residents of the U.S. Arctic, with the Director of the NSF serving ex officio. In providing representation of these various constituencies on the Commission, the intent was to ensure that it would give attention to both national needs and those of State and local governments, to both scientific questions and practical problems, and to both short-term objectives and the longer-term needs required by the Nation.

Among the Commission's assigned responsibilities are the following:

- Develop and recommend an integrated national Arctic research policy.
- Cooperate with the Interagency Arctic Research Policy Committee in establishing a national Arctic research program plan to implement the policy, and advise and assist the Interagency Committee as needed.
- Foster cooperation among Federal, State and local governments in regard to Arctic research, and work with the Governor of Alaska and State organizations in formulating Arctic policy.
- Review Federal agency research programs in the Arctic to improve coordination, and review the annual budget request for Arctic research in relation to the goals of the five-year research plan.
- Recommend ways to improve logistical planning and support for Arctic research.
- Suggest methods for improving efficient sharing and dissemination of data and information on the Arctic.

It should be noted that the Commission has no power, other than that of persuasion, and that it does not provide funds for research. It

*Dr. James H. Zumberge is President of the University of Southern California. In addition to serving as the first Chairman of the Commission, he concurrently presided over the Scientific Committee for Antarctic Research. He is a former Chairman of the U.S. National Research Council's Polar Research Board. Due to competing university obligations, Chairman Zumberge resigned in October 1987. In December the President named Vice-Chairman Juan Roederer, former Director of the University of Alaska's Geophysical Institute, to replace him as Chairman of the Commission.*

does, however, as stipulated in the Act, report to the President and to the Congress by January 31 of each year on its activities during the previous fiscal year, as well as at other times when particular issues arise. For example, when projected FY 1987 budget cuts would have eliminated data collection in the Bering Sea that was essential to management of fisheries in that area, the Commission wrote to the President and members of Congress. The letter called attention to the high priority the Commission had accorded marine ecosystem research and the opportunities it provided for Federal/State/industry/university cooperation in research vital to U.S. economic interests. These funds were subsequently restored.

## *The Commission Begins Its Work*

*The original members of the Commission were James H. Zumberge (Chairman), President, University of Southern California, Los Angeles; Juan G. Roederer (Vice-Chairman), University of Alaska, Fairbanks; Oliver Leavitt, Vice President, Arctic Slope Regional Corporation, Barrow; Elmer E. Rasmuson, Anchorage; A. Lincoln Washburn, University of Washington, Seattle; and Erich Bloch, ex officio, National Science Foundation. Staff: W. Timothy Hushen (Executive Director), Lyle Perrigo (Senior Staff Officer), and Lisa Ramirez (Administrative Assistant). In the fall of 1987 Dr. Zumberge resigned as Chairman and was succeeded by Vice-Chairman Roederer.*

Members of the Arctic Research Commission were appointed on February 28, 1985, and the Commission began its work shortly thereafter. From March through September 1985, the Commisssion met three times. One session included public meetings in Fairbanks, Barrow, Prudhoe Bay, and Anchorage, Alaska, and site visits to two development sites in Alaska. Testimony received at these meetings, interaction with the Interagency Committee, participation in scientific conferences and symposia on Arctic research, and communication with concerned organizations and individuals all helped to shape the Commission's statement on Arctic research policy. In addition, the Commission's recommendations on research needs and priorities (*National Needs and Arctic Research: A Framework for Action*, May 1986) provided valuable guidance in the development of the U.S. Arctic Research Plan.

Consistent with the Arctic policy statement issued by the White House in 1983, the Commission's policy statement emphasized that "It is in the national interest of the United States to support scientific and engineering research in all pertinent fields to implement its national policy of protecting essential security interests in the Arctic, promoting rational development . . . while minimizing adverse environmental effects, and contributing to the knowledge of the Arctic environment or of aspects of science that are most advantageously studied in the Arctic." The policy further specifies that in its support of Arctic research, the United States should ensure: Coordination of Federal research efforts with those of State and local governments and the private sector; development of an Arctic research plan that is responsive to national and regional needs and interests and that takes into account the unique features and challenges of the Arctic; and, in recognition that the Arctic is a broad geographic area and that its problems and scientific needs are shared by many nations, increased international cooperation in Arctic research. Suggested research objectives include use of the Arctic as a natural laboratory to enhance scientific understanding and provide the basic knowledge required to deal with problems of national defense, global climate and weather forecasting, exploitation of renewable and nonrenewable resources, environmental protection and pollution control, effective transportation and communication systems, natural hazards, health, and protection of indigenous cultures and lifestyles.

Throughout its deliberations on Arctic research policy, the Commission had also considered research needs and ways to arrive at setting priorities. The approach it adopted was to view the Arctic as a large-scale natural system made up of strongly interacting components. Understanding the processes and interrelationships within the system would provide the key to solution of problems such as those related to resource development, environmental protection, and health, as well as to broader problems of climate, air pollution, and marine and terrestrial ecosystems. The Commission concluded that "The basic premise for an Arctic Research Plan should be development of a comprehensive, interdisciplinary approach to the acquisition of the scientific and engineering knowledge required to respond to national needs in the Arctic . . . ." It stressed the need for complementary basic and applied research to advance fundamental knowledge and at the same time to allow us to better understand and deal with fundamental problems. In setting priorities, it found that a useful criterion is the ability to predict changes induced by nature, such as climate or the extent and seasonal variability of sea ice. Another major consideration was to make use of the natural laboratory that the Arctic provides for research on phenomena and processes that have impacts far beyond the region. For example, research on climate, health, natural hazards (such as earthquakes and volcanism), frozen ground, and human, animal and plant adaptations to extreme cold and long periods of darkness has widespread implications and applications.

Based on these considerations the Commission recommended the following programs of research in order of priority:

- Research to understand the Arctic Ocean (including the Bering and marginal seas, sea ice, and seabed), and how the ocean and the Arctic atmosphere operate as coupled components of the Arctic system.

The recommended research is relevant to defense issues, development of renewable and nonrenewable resources, prediction of marine ecosystem reactions to natural and man-induced change, forecasting of Arctic weather and impacts of Arctic phenomena on global weather patterns, prediction of climatic change, and prediction of sea ice conditions and other maritime hazards.

- Research to understand the coupled land and atmosphere components of the Arctic system.

In a complementary way, such research, focused on the terrestrial environment, also aims at goals similar to those enumerated above.

- Research to understand the high-latitude upper atmosphere and its extension into the magnetosphere.

Emphasis here is on advancing prediction of disturbances in space and mitigating their effects on communication and defense systems.

The Commission further recognized an urgent and ongoing need for research directed specifically to the health of Arctic inhabitants and their adaptation to Arctic conditions, as well as to the effects of resource development and industrial growth. From the regional standpoint, such research is of the highest priority, but its implications transcend regional boundaries and it merits high priority in national and international efforts. Therefore, the Commission recommended as the highest pripriority for the health–culture–socioeconomic component of the Arctic system:

- Research to identify and resolve the major health, behavioral, and cultural problems that derive from the distinctive character of the Arctic environment and from increasing resource development, industrialization, and urbanization.

## *The Commission's Second Year*

During the period from October 1985 through September 1986, a principal objective of the Commission was to increase its interaction with the scientific and engineering communities and with representatives of governmental, industrial, and academic organizations in Alaska. To achieve this objective, it

- Opened an office at the University of Alaska's Arctic Environmental Information and Data Center in Anchorage.
- Began publishing a newsletter to provide current information on its activities and on matters relevant to Arctic research and policy.
- Established a Group of Advisors, consisting of 24 scientists and engineers, individual members of which participated in public sessions organized by the Commission, reviewed draft documents, and provided information on research needs.
- Held four meetings, including three public sessions in Seattle, Kodiak and Anchorage, to obtain a wide range of views on Arctic research policy and needs.
- Visited industrial sites in Alaska to learn about problems and special research needs or oppportunities.
- Met with the Governor and State Legislature of Alaska and with State legislative and executive groups concerned with Arctic research.
- Published two reports on its findings and recommendations, in addition to which three Commission members published articles on Commission activities in scientific journals.
- Participated in national and international meetings concerned with Arctic research.

## *Arctic Research Plan*

In regard to its mandated responsibilities, besides the development of the policy and priority statements previously described, the Commission continued its close cooperation and interaction with the Interagency Committee. To provide guidelines for the development of the Five-Year Arctic Research Plan, the Commission prepared the report *National Needs and Arctic Research: A Framework for Action.* In addition, the Commission prepared an analysis of the preliminary draft of the five-year plan and subsequently attended the workshop held by the Interagency Committee in November 1986 to assist in the refinement and further development of the plan. The Commission reviewed the interim final draft plan at its meeting on March 5–6, 1987, and subsequently endorsed it and complimented the Interagency Committee on its work. From their inception, the Commission and Interagency Committee have maintained the complementary relationship that the provisions of the Act were designed to encourage.

## *Federal/State Cooperation*

In addition to meeting with the Governor and Legislature of the State of Alaska in January 1986, the Commission encouraged the adoption of an Alaska research policy, which was subsequently approved and signed into law in May 1986. The Governor and the Commission Chairman proposed to the relevant Federal and State agencies the creation of joint Federal/State task forces in fisheries ecosystem research and health. These groups were established and, in response to their charge, reviewed research needs and recommended programs of research for Federal/State cooperation.

The emphasis in the fisheries ecosystem report was on studies of the relationship of fluctuations in fish and shellfish populations in the Bering and Chukchi Seas to the interannual variation of maximum ice extent and seasonal ice retreat.

The recommended priorities for Federal/State cooperation in health research included trends in the types and incidence of cancer in Arctic Native populations, the possible relationship of polyunsaturated fatty acids in the cold water fish and marine mammals that constitute a substantial part of the Native Alaskan diet to the low incidence of coronary heart disease among these populations, and studies of the incidence and causes of injuries, which are the leading cause of death for all age groups in Alaska and are also a major health problem in the contiguous 48 states.

The Commission, at its March 1987 meeting, endorsed these recommended Federal/State research programs in fisheries ecosystem and health research and informed the President and members of Congress regarding the need to provide the resources to implement the recommended research.

A third focus of Federal, State, and Commission concern is information handling. As a joint Federal/State Committee on Natural Resource Information Management was already working on problems in this field, the Commission and the Governor of Alaska encouraged its efforts and will continue to work with the successor Council on Northern Resources Information Management toward more effective procedures for the collection and transfer of research information and data. The Commission also met with the president of the Arctic Oil and Gas Association to discuss ways to expedite public awareness of, and access to, nonproprietary reports and data. The Association subsequently made arrangements to transfer a number of reports and data sets to the public domain.

## *Logistics*

The Commission's mandate calls for recommendations to improve logistic support for Arctic research. Because the Commission's highest research priority was understanding the Arctic Ocean and the way the ocean and atmosphere operate as a coupled system, the initial logistic focus has been on support and facilities for ocean research. Of particular concern is the need for an ice-capable research vessel for the Arctic.

In a letter to the President and members of Congress, and in testimony to the House Subcommittee on the U.S. Coast Guard and Navigation of the Committee on Merchant Marine and Fisheries, House of Representatives, the Commission pointed out that the United States does not have a research vessel that can operate in ice-covered seas in the Arctic, yet one is urgently needed. Further, even if the Executive Branch and Congress act immediately to authorize construction of such a vessel it would take three to four years before a new ship could be commissioned.

Therefore, the Commission urged that the U.S. lease, with or without an option to buy, an ice-capable research vessel to alleviate the short-term need for such a vessel in the Arctic. Several foreign icebreakers are currently laid-up because of the downturn in the oil industry, and one of these vessels might be modified and put under charter to meet the immediate need. Over the longer term, however, the national interest calls for further improving the ice capability of at least one of the planned U.S. Navy additions to the national research fleet, or some other approach to acquiring a dedicated ice-worthy research vessel, planned and equipped for a variety of scientific missions.

The Commission Chairman also met with the Director of the National Science Foundation on the same subject, and with the Commandant, U.S. Coast Guard, to discuss ways to maximize the use of icebreakers in the best interests of the United States and its scientific community.

In addition to urging the acquisition of an ice-capable research vessel dedicated to Arctic work, the Commission held a workshop in November 1986 to review logistic capabilities in the Arctic, including satellite systems, terrestrial systems, buoys, and other instrumen-

tation, as well as problems of coordination and management. Follow-up surveys continue. The Commission visited Arctic research bases in the U.S. and Canadian Arctic during July 1987 and expects to issue its recommendations later this year.

## *Arctic National Wildlife Refuge*

At its March 1987 meeting, the Arctic Research Commission received information from the Department of the Interior and from the Wilderness Society on possible impacts of oil and gas exploration in the Arctic National Wildlife Refuge (ANWR), with particular emphasis on the calving grounds of the Porcupine caribou herd. The Commission has no authority to adjudicate such issues, but it believes strongly that the decision-makers need the best scientific information available. As part of its July meeting, the Commission visited ANWR and held a public meeting in Kaktovik, the major village of the refuge.

## *International Cooperation*

Statements of Arctic policy, descriptions of Arctic research needs, and discussions of research opportunities focus repeatedly on the need for international cooperation. The Arctic is a broad geographic region, and the scientific questions and practical problems that it presents cannot be fully explored and understood by piecemeal efforts within individual countries. It has been suggested that a cooperative research organization comparable to the Scientific Committee on Antarctic Research (SCAR) would be a useful forum for furthering international cooperation in the Arctic. However, there is no treaty in the North comparable to the Antarctic Treaty that makes a cooperative approach to Antarctic research possible. The boundaries of several nations fall within the Arctic, but other countries not on the Arctic Rim, such as the United Kingdom, Switzerland, West Germany, Poland, France and Japan, also engage in Arctic research.

To explore interest in organizing an international forum for discussion of Arctic research issues of mutual concern, the Commission held a small *ad hoc* meeting in July 1986 in San Diego, California, in which representatives of a number of SCAR nations that also had Arctic interests participated. There was consensus on the need to improve cooperation, particularly in research on environmental problems.

A follow-up session was held in February 1987 in Oslo, with scientists from Canada, Denmark/Greenland, Finland, Iceland, Norway, the Soviet Union, Sweden and the United States taking part. The group discussed existing arrangements for international cooperation in Arctic research and their limitations. Participants agreed that individual countries should develop better internal structure and coordination of their Arctic research activities as a basis for international efforts. The group recognized and emphasized that most scientific problems in the Arctic are circumpolar and demand a cooperative approach. Individual nations cannot work in isolation and keep in the mainstream of scientific progress.

It was agreed that a small working group would prepare a paper summarizing the arguments for and against the creation of a new international Arctic science organization and ways that it might be structured and implemented. It was also emphasized that the intent was not to replace or compete with existing organizations but to complement and facilitate their efforts. The paper will be circulated for discussion within each country, after which the representatives plan to meet again to decide how to proceed.

## *National Awareness*

Another thrust in the Commission's current work is to foster awareness that the United States is indeed an Arctic nation, and that it has economic, military, medical, environmental, political, and other interests directly related to the Arctic. One of the most persuasive discussions of the "Age of the Arctic" has been put forward by Oran Young (see *Foreign Policy*, Winter 1985–86, pp. 160–179, and *Oceanus*, 29(1), Spring 1986, pp. 9–17). The Commission arranged for a lecture by Dr. Young at a public meeting in Anchorage in April 1986. He emphasized that issues related to the Arctic are demanding increasing attention, requiring not only knowledge of natural systems but of cultural, social, economic, legal, political, and military developments in the Arctic environment. U.S. interests demand that this country recognize and take its place among the Arctic nations. The Arctic Research and Policy Act offers an opportunity for an effective response to this challenge, which in various ways involves some of the most urgent problems facing the United States now and in the 21st century.

To foster widespread recognition of this position is a main emphasis in the Commission's current plans.

For further information on the Commission and its activities, see:

*National Needs and Arctic Research: A Framework for Action.* Report of the U.S. Arctic Research Commission to the President and the Congress of the United States of America. U.S. Arctic Research Commission, Los Angeles, May 30, 1986.

*The United States: An Arctic Nation.* Report of the U.S. Arctic Research Commission to the President and the Congress of the United States of America for the Period 1 October 1985–30 September 1986. U.S. Arctic Research Commission, Los Angeles, January 31, 1987.

*U.S. on the Arctic Rim.* Report of the U.S. Arctic Research Commission to the President and the Congress of the United States of America for the Period 1 March–30 September 1985. U.S. Arctic Research Commission, Los Angeles, January 31, 1986.

*On the Arctic Rim.* Newsletter of the U.S. Arctic Research Commission. U.S. Arctic Research Commission, Anchorage, April and August 1986, and May 1987.

*Research Priorities in the Arctic: U.S. Arctic Research Commission Gets Down to Business*, by J.G. Roederer: EOS, Transactions, American Geophysical Union, vol. 67, no. 24, June 1986.

*Arctic Research in the National Interest*, by A.L. Washburn and G. Weller: Science, vol. 233, 8 August 1986.

*National Needs in Arctic Research*, by A.L. Washburn: Journal of Cold Regions Engineering, vol. 1, no. 1, p. 2–9, March 1987.

*The Arctic Ocean—Introduction*, J.H. Zumberge: Oceanus, vol. 21, no. 1, p. 2–8, Spring 1986.

# *Arctic Research*

## *The View from Congress*

U.S. SENATOR FRANK MURKOWSKI

The United States is an Arctic nation that has only very recently begun to play the part. Thousands of Americans live and work in the Arctic, and we have substantial natural resources and important strategic interests there. However, we have only recently begun to think of ourselves as an Arctic nation. This new journal, *Arctic Research of the United States,* is evidence of this new and welcome awareness.

When I was first elected to the U.S. Senate in 1980, Alaskans asked me to foster the creation of a comprehensive National Arctic Research Policy, an effort begun almost 20 years earlier by Alaska's first Senators. Indeed, as early as 1960, Alaskans in Washington were arguing that national goals in the Arctic required the United States to direct a greater share of national scientific resources toward research in the far north.

While an increase in Arctic research did occur during the 1970s, largely due to the construction of the Trans-Alaskan Pipeline, government Arctic research was almost exclusively performed on an ad-hoc, program-oriented basis. The nation's Arctic Research Program, if you could call it that, was a fragmented collection of projects and programs that lacked clear direction, coordination, or an overall guiding policy.

By 1980, our stake in the Arctic had clearly risen. By that time, America was addicted to Arctic oil, deriving some 20% of our domestic production from a single Arctic field at Prudhoe Bay, Alaska. At the same time, new developments in military technology, most notably nuclear-powered submarines and long-range bombers equipped with cruise missiles, transformed the Arctic from a seemingly benign and remote polar region to one of the most strategic places on earth. Indeed, the Arctic was beginning to be recognized as the true common border between the superpowers.

As a result of these developments, a new push for a policy-guided Arctic research effort began. As a result of my efforts, in addition to those of Senators Ted Stevens and Henry "Scoop" Jackson, and Representatives Don Young, Doug Walgren, Don Fuqua and others, Congress passed the Arctic Research and Policy Act (ARPA) of 1984.

In passing ARPA, Congress intended that the nation as a whole become more informed about the Arctic and the fact that the United States is an Arctic nation. Our lack of knowledge about the Arctic had been a clear source of frustration to Congress during the 1970s, when the discovery of oil at Prudhoe Bay and a global energy crisis moved Congress to enact a number of new statutes affecting the future of the Arctic. With hindsight, it's easy to see that the Congressional debates which preceded passage of the Alaska Native Claims Settlement Act of 1971, the Trans-Alaska Pipeline Act of 1973, the Alaska Natural Gas Transportation Act of 1976, and the Alaska Lands Act of 1980 were sometimes characterized by ill-informed, sensational, and misleading information.

For instance, the Senate was only able to narrowly pass the Trans-Alaska Pipeline Act with the tie-breaking vote of the Vice President. Many Senators who opposed the pipeline believed the assertions of extreme environmentalists who argued that any development would seriously jeopardize the future of the central Arctic caribou herd and other wildlife. While we now know that responsible development can occur in the Arctic, ignorance of the truth in 1973 almost exacted a significant price—the pipeline might never have been built.

As an aside, it's interesting to note that a similar debate is taking place today on the exploration of the Arctic National Wildlife Refuge. Fortunately, experience at Prudhoe Bay and continuing research have taught us a great deal about the effects of development on caribou and other Arctic wildlife. Because we now know more, the debate on ANWR will hopefully be waged with scientifically supportable conclusions rather than alarmist supposition and emotionalism.

With the publication of the first issue of this new journal, it's appropriate for me to

*Senator Frank Murkowski (R-Alaska) is a member of the Senate Energy and Natural Resources Committee, the Foreign Relations Committee, the Select Committee on Intelligence, the Indian Affairs Committee, and the Committee on Veterans' Affairs, where he serves as Ranking Minority Member.*

reflect on what ARPA has accomplished thus far, and Congressional expectations for ARPA in the future.

As a consequence of ARPA:

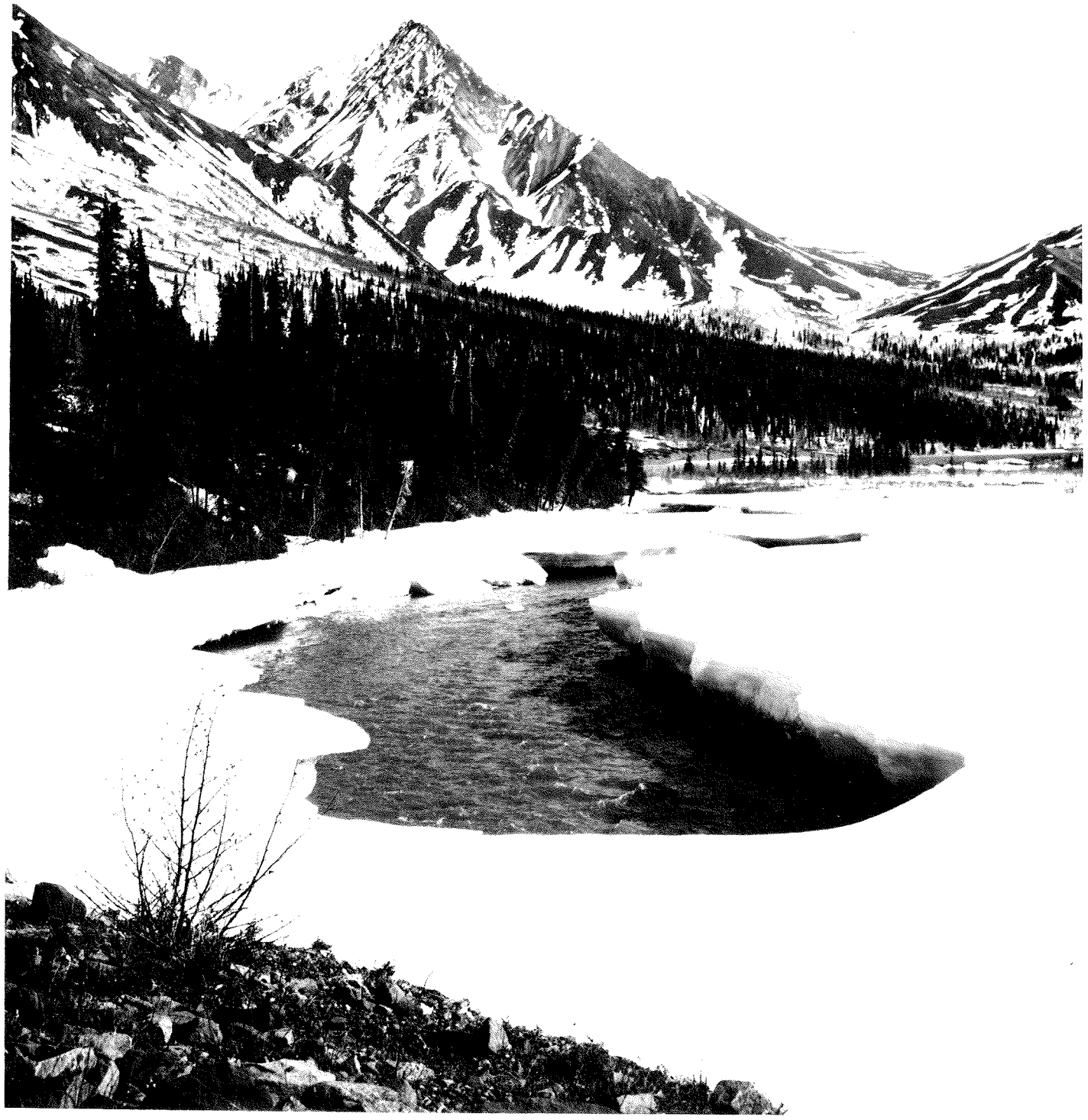
- The United States now has an Arctic research policy.
- The United States now has an Arctic Research Commission which meets regularly to advise the President and Congress on Arctic research policy.
- The United States has a Federal interagency committee to coordinate Federal Arctic research efforts.
- We have an Arctic Research Plan which was sent to the President and Congress in July 1987.
- We have coordinated agency budgets.
- We are looking closely at the need for new research platforms, icebreakers, and other mechanisms for studying the Arctic.

The fact is, we've come a long way in the short time since the passage of the Arctic Research and Policy Act. And that's fortunate, because there is much we must know about the Arctic if we expect to move into what some have called the "Age of the Arctic" with confidence. For instance:

- We must find the new technologies we need to develop Arctic resources wisely while protecting the Arctic ecosystems.
- We must fully understand how Arctic systems operate if we expect to address problems such as Arctic haze and the "greenhouse effect" and other processes for which the Arctic provides an important window on global change.
- We must improve our knowledge of glaciers, sea ice, permafrost, and snow in order to perfect new Arctic air, land and maritime transportation technologies.
- We must fully understand disruptive auroral displays and high latitude atmospheric disturbances if we expect to enjoy dependable telecommunications capabilities in the Arctic.
- Finally, the Arctic, in contrast to the Antarctic, is home to an indigenous people who have lived and hunted in the region since time immemorial. We must fully understand the Arctic and the short- and long-term impacts of what we do there if we expect to protect the unique lifestyle of the Inuit (Eskimo) people.

Beginning sometime in the 100th Congress, I expect one or more Congressional Committees to convene oversight hearings to assess ARPA's effectiveness in achieving its stated goals. The work of the Commission, the effectiveness of the Interagency Committee structure, the distribution of current research appropriations, and questions involving research logistics and icebreakers are all special areas of interest that might be explored at these hearings.

Regardless of the outcome of those hearings, one thing is certain: the Arctic, once considered a remote and forgotten area of our planet, is emerging as one of the most important regions of the world. Congress has recognized this fact. Building on the foundation of ARPA, the United States is poised to take its rightful place as a leader among the Arctic nations of the world.



# *Department of Interior*

*The Department conducts research, mapping and monitoring programs throughout Alaska and its offshore regions and manages lands established under the Alaska National Interest Lands Conservation Act. These activities are performed by six services or bureaus, each with administrative and technical offices located in Alaska. In FY 86, a total of $24 million was identified in support of these activities.*

## *Minerals Management Service*

MMS FY 86 FUNDING (thousands)

| | |
|---|---|
| Offshore Minerals | 288 |
| Environmental Studies | 10,340 |

The Minerals Management Service regulates the leasing, exploration and development of oil and gas in the Federal waters of the U.S. Outer Continental Shelf/Exclusive Economic Zone (OCS/EEZ). The MMS is required by law to assure that operations are safe and pollution-free and that the "best available and safest technologies" are used in the development of oil and gas. Also, the MMS must determine the environmental cost and possible multiple-use conflict in support of leasing and subsequent development and production activities in the OCS/EEZ. Arctic research and environmental studies are conducted under the Technology Assessment and Research Program (TA&R) and the Alaska Environmental Studies Program respectively. These studies are conducted in concert with universities, private companies, and other Federal agencies. An annual summary of Alaska OCS activities is available from MMS OCS Information Program, 1951 Kidwell Drive, Suite 601, Vienna, Virginia 22180.

### *Technology Assessment and Research Program*

The TA&R Program projects fall into three categories: 1) well control or the prevention of oil well blowouts, 2) the verification of offshore structures and pipelines, and 3) technologies to prevent air and ocean pollution. Programmatic emphasis is upon current and prospective operations in the deep waters of continental slopes and in the ice-infested waters of the Arctic. Ice in its various forms is the basic hindrance to Arctic offshore oil and gas operations, whether it be seabed permafrost, spray icing of platforms, or pack ice forces upon structures. Much research has been done in those areas; however, there is a pressing need to continue technological investigations for the foreseeable future because of the very heterogeneous nature of the ice and the continuing changes and technological advances in offshore operational practices. Whereas in the Beaufort Sea, for example, the focus of technological development is upon shallow water drilling operations, future drilling and production is likely to migrate to deeper waters in the moving ice zone, where the associated problems of storage and transportation of hydrocarbons will be considerable. These operations will need to make use

*Artificial gravel island in Beaufort Sea.*

of new kinds of structures, among which are likely to be subsea production systems and underwater hydrocarbon storage platforms.

For further information see *Technology Assessment and Research Program for Offshore Minerals Operations*, 1986 Report, OCS Study MMS86-0083. Compiled and edited by John B. Gregory and Charles E. Smith, USDI/MSS, 647 National Center, Reston, Va. 22091.

## *Alaska Environmental Studies Program*

Study activities have focused on baseline information on distribution, abundance, and migratory patterns of marine species, potential disturbances to the marine environment, and oceanographic and meteorological conditions. Major categories of study have included:

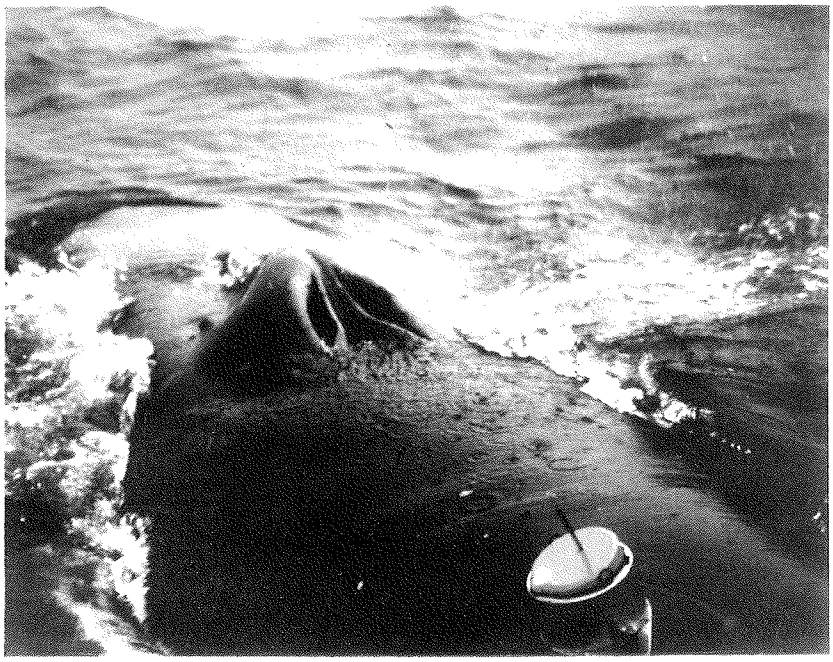
### *Contaminant Sources and Effects*

These studies are designed to determine the predevelopment distribution and concentration in the natural environment of potential contaminants commonly associated with oil and gas development. The nature and magnitude of contaminant inputs and environmental disturbances that may accompany exploration and development, such as spilled oil, are also studied.

### *Endangered Species*

Studies have concentrated upon observations of bowhead whale migration routes, potential feeding areas and behavior. A unique role of bowhead study components has been to support seasonal drilling and geophysical survey monitoring program needs. Other recent studies on endangered species include emphasis on surveys of distribution and abundance of endangered whales, feeding ecology of gray whales, and experimental research on gray and humpback whale behavior in response to oil and gas sound sources.

*Satellite-linked whale tag.*

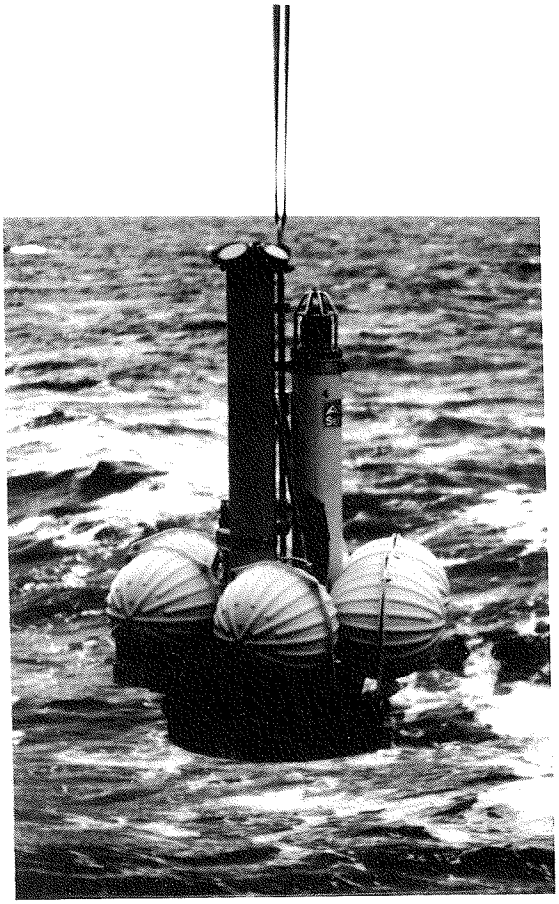


### *Living Resources*

There are large numbers of cetaceans and pinnipeds in the Alaska offshore which are not endangered species. These include ringed seals, bearded seals, beluga whales, walrus and others. The studies program has investigated life history, food habits, abundance and distribution of several important species, as well as aspects of their interaction with oil and gas activities. Recent emphasis has focused on the study of effects of on-ice seismic exploration on ringed seal behavior and distribution. Other studies have investigated sensitivity of beluga whales to noise and disturbance. The results of these studies have been used in devising and evaluating potential mitigating measures. In addition to important studies on marine mammals, other studies have addressed commercial and subsistence fisheries and marine birds. Fisheries studies were targeted at important Bering Sea commercial fisheries species such as salmon, red king, Tanner, blue king, and Korean hair crabs. Work has been conducted on simulation modeling of fisheries with the intent to quantify potential damage to commercial fisheries if accidental oil spills were to occur. Nearshore fisheries studies have been conducted in the Bering, Beaufort and Chukchi Seas. Major studies of seabirds have been completed, including population studies in the Bering Sea and reproductive ecology and trophics of marine birds of the Gulf of Alaska. Seabird studies have also been conducted in areas of the Beaufort and Chukchi Seas and shorebird research in the southern Chukchi.

### *Oil Spill Fate and Effects*

Recent studies have investigated the effects of hydrocarbons on king crabs, Tanner crabs, and salmonids. The MMS and NOAA participated in the Baffin Island oil spill test program in the Canadian Arctic and investigated the weathering of spilled oil in open water and in sea ice.



*Acoustic doppler profiling current measurement.*

## *Pollutant Transport*

This research has continued to simulate hypothetical oil spill transport in open and ice-covered waters by means of a circulation model. These simulations are key to sale-specific environmental impact statement preparation. Related physical oceanographic studies have investigated currents, tides, sea ice motion, and meteorological forcing. The results of these studies are used in computing probabilities of oil spill contact for different coastal areas. A model and user's manual is complete for oil weathering in open water, and is being expanded to ice-filled waters. Another model has quantified losses of commercially important fisheries to oil spills. Underway is an effort to model movements and distribution of oil in surf zone environments.

## *Environmental Geology*

This studies program has investigated bottom gouging by ice ridges, ice ridge and lead formations, ice motion, and, to a lesser degree, subsea permafrost behavior. Other studies focus on possible constraints imposed by meteorological conditions, such as structural and spray icing, sea ice movement, storm surge, and extreme winds and waves. In FY 86, long-term studies of geologic processes and hazards of the Beaufort and Chukchi Shelf and coastal regions were completed. The information from these studies is used in defining potential areas of exploration difficulty.

## *Ecosystems*

Recently, several study efforts performed field analyses of key ecosystems. These have included the Alaska Peninsula Ecosystem Study in the southeastern Bering Sea, the Yukon River Delta Ecosystem Study in the east-central Bering Sea, the Camden Bay Ecosystem Study in the eastern Beaufort Sea, and the Peard Bay Ecosystem Study in the northern Chukchi Sea. These ecosystem studies are multidisciplinary and consider the biological and physical processes of the ecosystems rather than descriptions of them. These process studies have generally provided much more comprehensive information on ecosystem functions than purely descriptive studies.

## *Environmental Monitoring*

Since 1981, the MMS has performed monitoring studies of bowhead whales. In 1986, the MMS continued efforts to develop additional, targeted monitoring programs. Through an interagency agreement with NOAA/OCSEAP, the studies staff participated in the planning and conducting of the Beaufort Sea Monitoring Workshop. Results of the workshop have been used by the MMS studies staff in direct contracting of a Beaufort Sea Monitoring Program. The goal of the program is to test hypotheses regarding long-term change in sediments and lower trophic levels. A workshop to consider monitoring needs in the Bering Sea was held in winter 1986. These and other targeted study efforts are expected to provide the basic framework by which the Alaska Region will meet biological monitoring needs under the OCS Land Act Amendments.

## *Social and Economic*

This program began in 1976 with the recognition by the Department of the Interior that societies of rural Alaska were especially vulnerable to the influences of industrial development. Recently, the program has become more focused in its analysis of the effect of offshore development on various social systems.

# U.S. Geological Survey

FY 86 FUNDING (thousands)

| | |
|---|---|
| Natural Hazards | 285 |
| Glaciology | 250 |
| Sea ice | 240 |
| Marine Geology | 400 |
| Energy and Minerals | 2800 |
| Mapping | 2300 |
| Magnetosphere | 25 |

The U.S. Geological Survey conducts research in the Arctic under several multidisciplinary topics: ice and climate, glaciology, natural hazards, deep continental studies, energy and minerals, mapping, and magnetosphere. The following briefly describes the current base programs, goals, recent accomplishments, and future directions.

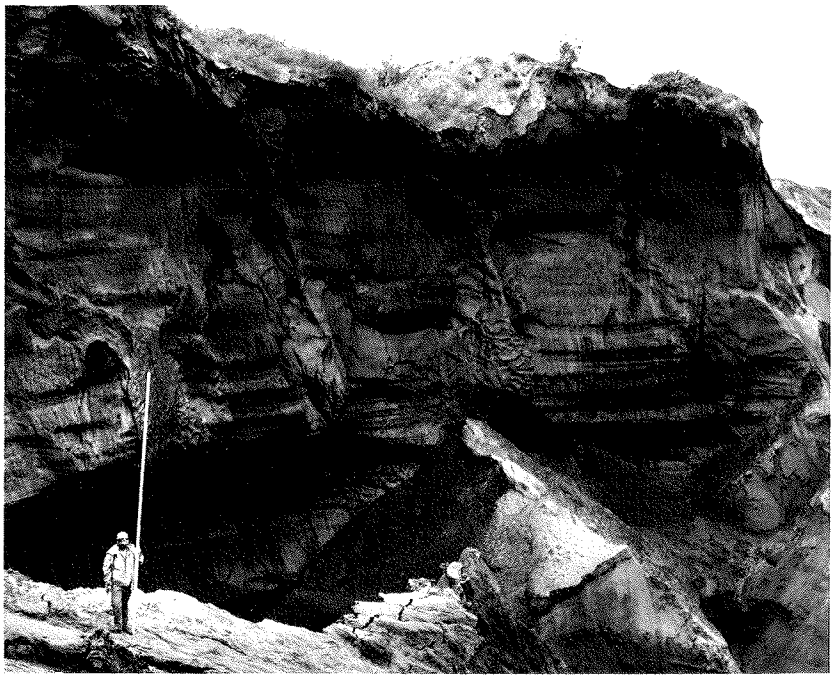
## Ice and Climate

The goals of ice and climate research are: 1) to investigate the role of sea ice, ice sheets, snow, glaciers and polar oceans in the variation of mesoscale, regional and global climate; 2) to develop aircraft and satellite techniques with passive and active microwave to observe all of the phenomena listed above on an all-weather, day-or-night basis at time scales ranging from daily to interannual; 3) to develop numerical models for sea ice dynamics and thermodynamics, ice-sheet flow, and glacier flow; and 4) to investigate the interaction of the upper ocean and sea ice, especially in the marginal ice zone.

Long-standing joint programs with NASA and the French Space Agency (CNES) continued. These involved a three-level observational system using satellite, aircraft and surface sensors to acquire simultaneous observations of sea ice, ice sheets, snow and oceans. USGS took part in both the design of microwave sensors for satellite missions and in the subsequent analysis and use of the satellite data. USGS researchers participated in the planning and performance of aircraft remote sensing missions in conjunction with the satellite missions and in surface-truth experiments on drifting ice stations, ships and ice sheets. They also participated in the marginal ice zone experiments in the Fram Strait/East Greenland Sea. A joint USGS/NASA study of the Upper Colorado River Basin snowpack using Nimbus-7 SMMR observations to measure snow water equivalence is now entering its fifth snow season. USGS developed numerical models for sea ice dynamics and thermodynamics in cooperation with other agencies, notably the Goddard Space Flight Center of NASA. Numerical models of glacier flow and ice sheet flow were developed and tested with remote sensing data from surface-based radar sounders and aircraft and satellite radars.

Detailed studies were made of late-Tertiary and Quaternary marine, lacustrine, eolian and glacial sediments and permafrost of the North Slope and interior basins of Arctic Alaska as key to Arctic climate change and high-latitude sedimentary processes.

*Glacier in Alaska Range.*



*Ice wedges, Titaluk River, Arctic Coastal Plain.*

## *Glaciology*

The goals of glaciology research are to understand the complete cycle of glacier behavior, advise on specific hazards, assess glaciers as a resource, develop and use methods of prediction of glacier behavior, and assess the importance of Alaskan glaciers to interpretation of climate.

The program maintains instrumentation at several glaciers in different climate areas to obtain continuous measurements of high-altitude climate, snow and ice balance, and glacier flow. Current research includes analyses of these baseline data; studies to develop new techniques in glaciology; and studies of surging glaciers, ice-dammed lakes and calving glaciers, both to obtain new knowledge of these hazards and to learn more about glaciological principles and processes. A computer model relating climate data from long-term weather stations to mountain climate, glacier snow and ice storage, and glacier runoff was developed for the Columbia Glacier, Alaska, predicting its retreat.

## *Natural Hazards*

The overall goal of USGS research on Arctic natural hazards (earthquakes, volcanoes, landslides) is to mitigate losses by providing earth science data and evaluations essential for land use planning, including the leasing of offshore areas, engineering design, and emergency preparedness decisions.

A comprehensive study is planned of earthquake hazards in the Anchorage area. Studies have been directed toward resolving geologic elements and seismogenic processes in southern coastal Alaska, with the goal of estimating long-term earthquake potential, particularly in the Yakataga, Shumagin and Unalaska seismic gaps. Regional and global seismographic stations are being operated. The 1986 eruptions of Augustine Volcano, an island strato-volcano in lower Cook Inlet about 175 miles southwest of Anchorage, have been monitored and studied. Engineering geologic maps have been completed for eight 1:250,000-scale quadrangles in the National Petroleum Reserve in Alaska (NPRA), and the coastal plain portion of the Arctic National Wildlife Refuge (ANWR) has also been mapped. Other recent work includes studies of the distribution, character and thermal regime of permafrost.

## *Deep Continental Studies*

This research effort promotes multidisciplinary studies of the continental lithosphere and focuses on the deep crustal environments and processes that control or influence near-surface geology. The goal is to obtain information about the composition, structure and dynamics of the earth's crust and upper mantle in order to understand the occurrence of energy and mineral resources and processes associated with major geologic hazards such as earthquakes and volcanic eruptions. In the Arctic, activities in the Deep Continental Studies Program are conducted as part of the Trans-Alaska Lithosphere Investigations. TALI is a multidisciplinary program to investigate the structure, composition and evolution of the Alaskan crust along a north–south corridor, following the route of the trans-Alaska pipeline and extending offshore across the Pacific and Arctic continental margins.

Several major geologic problems will be addressed by the TALI studies proposed for the next several years. On the Pacific continental margin, the ongoing processes of subduction and accretion—key processes in the evolution of Alaska and western North America—will be examined. On the Arctic continental margin, concentration will be on the deep configuration and history of rifting of the Beaufort margin and the relation of rifting to events in the Brooks Range and Canada Basin. In the interior, TALI studies will examine the configuration and history of the Denali fault sys-

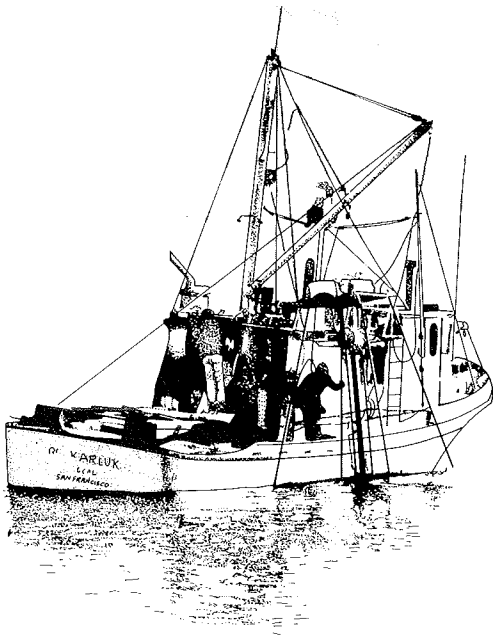
tem, a late Mesozoic collision suture reactivated as a major Cenozoic strike-slip fault; the thicknesses, structures, roots and histories of the many terranes recognized between the Alaskan Range and the Brooks Range; the configuration and history of the Kaltag–Tintina fault system, which borders and disrupts a collage of crustal slices on the north margin of the Yukon–Tanana Upland; and the nature of the crust beneath the Yukon–Koyukuk Basin and the basin's structural history.

## *Energy and Minerals*

The goals of energy and mineral research in the Arctic are to attain a systematic understanding and description of the geologic settings where energy and mineral resources occur or are apt to occur, both onshore and offshore; and to provide quantitative energy and mineral resource assessments for land use planning or estimating the Arctic's contribution to the Nation's total resource base. The research base includes such programs as the Alaska Mineral Resources Assessment Program (AMRAP), Marine Geology/EEZ (Exclusive Economic Zone), and Evolution of Sedimentary Basins.

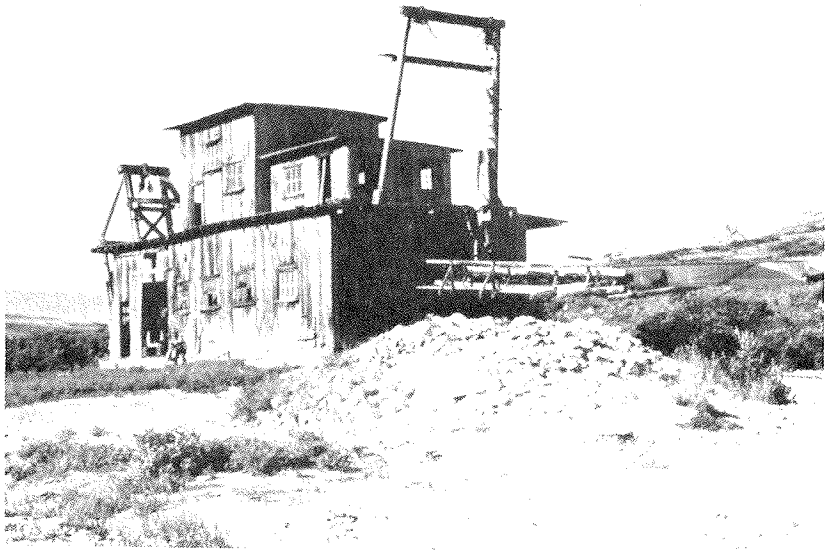
The USGS, with the Bureau of Land Management, has completed a major study of the geological, geophysical, geochemical, and oil and gas resources of the Arctic National Wildlife Refuge (ANWR) as required by the Alaska National Interest Lands Conservation Act (ANILCA). Analyses suggest that the ANWR may contain super-giant accumulations of oil and gas that could rival the Prudhoe Bay field. A substantial data set that includes raw seismic data (digital tapes) and a detailed report on the petroleum geology of ANWR (USGS Bulletin 1778) is scheduled to be released in 1987.

Chromite-bearing mafic and ultramafic rocks were recently investigated in central Alaska, and field work was completed for a mineral survey of the Steese–White Mountains to provide input to Bureau of Land Management land use plans. Environmental geologic studies were made of coastal erosion, sediment budget, and ice gouging in the Alaskan and Canadian Beaufort Sea, and the offshore stratigraphy of the Chukchi Sea. A research cruise in the Bering Sea systematically imaged the seafloor using Geologic Long Range Inclined Asdic (GLORIA) sonar surveys. The quantity and quality of coal were assessed in the central and eastern portion of the Alaskan




*The USGS research vessel* Karluk *performs geophysical research in Arctic coastal regions.*

*Seafloor morphology, Beaufort Sea.*



*Abandoned gold dredge, Harris Creek, Seward Peninsula.*

North Slope depositional environments. Coal is known to exist in the offshore Alaskan Arctic; preliminary studies indicate potentially large quantities. Investigations have been made of the regional geochemistry, diagenesis, stratigraphy, sedimentology, tectonic framework, and mineral potential of Alaska North Slope basins and the geologic processes operating therein. A preliminary assessment of the undiscovered oil and gas in the Arctic onshore and offshore has been made in collaboration with the Minerals Management Service as part of an updated national assessment.

## *Magnetosphere*

Geomagnetic measurements are made to infer the physical properties of the earth's interior and atmosphere to aid in navigation of air, sea and space vehicles and satellites, and to identify short- and long-term variations of the magnetic field for thousands of maps and charts. Accurate, up-to-date magnetic information is necessary to orient some 4000 airport instrument approach systems, to establish and verify land surveys, to operate sophisticated weapons systems, to determine the effects of solar and terrestrial magnetic substorms on communications and other electronic systems, and to estimate the amounts of energy transferred within the coupled system of the magnetosphere and the ionosphere.

The USGS operates three magnetic observatories in Alaska, one of which is located at Barrow on the Arctic coast. This station is of particular importance as it is the only source of data close to the geomagnetic pole where charged particles following magnetic field lines enter and leave the earth. These data are critical to our understanding of the effect of sunspots on communications and of the relationships between the earth's internal magnetic field and the atmospheric magnetic field.

## *Arctic Mapping Activities*

The goals of the National Mapping Program with respect to Arctic Alaska include preparing and maintaining a variety of high-quality multipurpose base maps and digital cartographic data bases to meet specific national priorities, including the requirements of Federal and State agencies, the Congress, and others. The primary mapping series is 1:63,360-scale (1 inch = 1 mile) topographic maps. The remaining unmapped areas in this series for Arctic Alaska will be available by 1990. Complete 1:250,000-scale topographic map coverage is available for all Arctic Alaska. In addition, 12 multi-color 7.5-minute orthophotomaps at 1:24,000 scale are available for the Prudhoe Bay area.

Other cartographic data and products available include black-and-white orthophotoquads at 1:63,360 scale for selected areas; a series of 25 black-and-white Landsat RBV image maps at 1:250,000 scale for Alaska north of 68° latitude; advance copy of multicolor Landsat MSS image maps at 1:250,000 scale for ANWR; side-looking airborne radar (SLAR) data; SLAR image maps at 1:250,000 scale for selected areas; land cover maps and digital data; digital elevation data at 1:250,000 scale and selected areas at 1:63,360 scale; digital planimetric data at 1:2 million scale; Alaska Boundary Series of 1:250,000-scale maps for the ANILCA units; Alaska High-Altitude Photography program products, including 1:120,000-scale black-and-white and 1:60,000-scale color infrared coverage for most of Arctic Alaska; and small-scale State Base maps and million-scale topographic quadrangle maps.

The first phases of data collection for the Federal Land Information System were completed in 1985. Information essential to the development of policy governing mineral exploration and resource development on Federal lands and data on surface and subsurface ownership, restrictions, and withdrawals related to mineral development were obtained from BLM's Alaska Automated Land Records System and combined with data from the USGS's

various mineral resource data and assessment programs, the Bureau of Mines' Mineral Industry Locational System, and the USGS's base cartographic and water resources data programs.

Additional information on Arctic Alaska mapping activities may be obtained from the National Cartographic Information Center, U.S. Geological Survey, 4230 University Drive, Anchorage, Alaska 99508-4664.

Results of other U.S. Geological Survey activities are reported annually in several publications. See, for example, *Geologic Studies in Alaska by the U.S. Geological Survey During 1986*, U.S. Geological Survey Circular 998 (Branch of Alaskan Geology, 4200 University Drive, Anchorage, Alaska 99508-4667), and *Annual Report of the U.S. Geological Survey* (USGS, Reston, Virginia 22092).

---

# *Fish and Wildlife Service*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Marine Mammals | 1300 |
| Terrestrial Mammals | 600 |
| Migratory Birds | 900 |
| Fisheries | 241 |
| Cooperative Research | 250 |

The Fish and Wildlife Service established the Alaska Fish and Wildlife Research Center in June 1986. Although most of the research is performed on National Wildlife Refuges across Alaska, much of it is national and international in scope. The Center addresses a wide variety of Arctic and Subarctic research problems involving anadromous fisheries; land and marine mammals; seabirds, shorebirds and waterfowl; and the development of new methodology, including geographic information systems, the use of satellites to track polar bears and caribou, and the use of mitochondrial and nuclear DNA analyses to separate fish and wildlife populations. Much of the research is focused on minimizing the impact of resource development on fish and wildlife. Another major aspect is the construction of population models for species subject to hunting—both for sport and for subsistence—across international boundaries.

The FWS Arctic research is conducted under three broad topics: migratory birds, mammals and fisheries. The following briefly describes the base programs, goals and recent accomplishments.

## *Migratory Birds*

In 1986, research by the Migratory Bird Section encompassed studies of seabirds, shorebirds and waterfowl. Long-term studies have been found to be essential in the Arctic because of the tremendous variation inherent in the environmental conditions of this region.

### *Seabirds*

Recent studies of seabirds in Alaska have focused on potential conflicts between the maintenance of a stable seabird population and the rapidly expanding development of a bottom fishery. Related to this effort is an attempt, through analysis of 11 years of data, to determine whether certain seabird populations are indeed stable or are declining. Reproductive success for some species has been so consistently poor that it is unlikely that normal environmental conditions in the Arctic are responsible. Another major effort is aimed at identifying those characteristics of the open ocean that may be critical for the survival of Alaska seabirds. Summary charts derived from infrared satellite images archived at the Arctic Environmental Information and Data Center in Anchorage are being used to identify oceanographic features that favor successful foraging by seabirds. Satellite images are also being used to delineate the winter positions of the Bering Sea ice edge where ivory gulls and murres may feed on epontic (under-ice) fish and zooplankton.

### *Shorebirds*

Most research on shorebirds involved analysis and publication of data collected previously on an array of species, concentrating mainly on aspects of habitat use, migration and breeding ecology of species likely to be most affected by nearshore coastal development in Alaska. Some field work was begun during 1986 to determine the population status and distribution of the bristle-thighed curlew, a rare and little-known species that first became of concern to Center biologists during earlier studies of shorebirds on the Yukon–Kuskokwim Delta.

*White-fronted geese (note radio collar on adult goose at back).*

## *Waterfowl*

Studies of waterfowl have been the major effort in the Migratory Bird Section during the past several years in terms of both funding and staffing. Recent declines in populations of emperor geese, white-fronted geese, cackling Canada geese, and black brant nesting on the Yukon Delta National Wildlife Refuge prompted several studies of their nesting ecology. Research on the nesting ground has defined several basic needs for proper management of the species: methodology for obtaining unbiased estimates of nesting density and reproductive success over a 1200-square-mile nesting area; characterization of habitat use during different phases of nesting and brood-rearing; and determination of the factors influencing mortality of adults, eggs and young.

During 1986, a major research effort was also directed at determining how the reproductive success of the geese was being affected by Arctic foxes, which have been very abundant and have preyed heavily on goose eggs during recent years. At two brant colonies all foxes were removed before geese began nesting and were excluded from the colony until hatching was completed. As a result, hatching success increased dramatically. In-depth studies of the ecology of Arctic foxes are examining the factors influencing their abundance, their alternate prey, and their hunting patterns so that Center biologists can understand the interactions between the populations of foxes and geese.

Two other major studies were conducted on geese staging on the Alaska Peninsula during migration. One examined cackling Canada geese, the species of greatest concern, and their use of two very small areas in which the entire population appears to concentrate during fall before a long over-water migration to wintering areas. The second, a cooperative study, assessed the way aircraft disturbance associated with Outer Continental Shelf exploration and development affects geese staging in spring and fall at Izembek Lagoon. Virtually the entire world's population of Pacific black brant stages on this lagoon in fall.

# *Mammals*

In 1986, the Mammal Section conducted studies on five different species—polar bears, Kodiak bears, sea otters, walrus and caribou. Studies on two of these species, sea otters and walrus, were begun in 1986 because potential conflicts or changes in the status of both populations compelled managers to obtain better information on their numbers, distribution and movements. Recent technological advances have enabled Center scientists to use new, more efficient techniques in most of these studies. In addition, biologists have embarked on a separate cooperative study investigating the potential uses of several new methodologies.

## *Polar Bears*

The Fish and Wildlife Service is mandated by the 1976 International Agreement for the Conservation of Polar Bears to conduct research and to take appropriate action to protect the ecosystems of which polar bears are a part. To comply this past year, the Center's research staff has monitored, by satellite radio tracking, the movements of 33 instrumented female polar bears along the coasts of Alaska, the Soviet Union and Canada. The objectives were to delineate the bounds of the two populations hypothesized to occur along Alaska's coast, to determine the extent we share Alaska's western population with the Soviet Union, to assess the size, composition and status of the respective populations, and to describe the effects of human activities, e.g. oil and gas development and Native subsistence hunting, on polar bear movements and maternity denning. Movement data indicate that the Chukchi/Bering Sea population is segregated from the Beaufort Sea population and is shared with the Soviet Union. Past

*Polar bear with radio collar, Chukchi Sea.*

research has indicated the Beaufort Sea population's eastern boundary to be in the vicinity of Cape Bathurst, Northwest Territories, Canada. These findings have serious ramifications as the 1976 Agreement also dictates that internationally shared populations are to be managed by consultation. Alaska and Canada have begun this process through a joint Memorandum of Understanding between the user groups of Alaska and Canada.

## *Kodiak Bears*

During 1986, a Research Center biologist stationed at Kodiak National Wildlife Refuge was engaged in defining habitat use and evaluating aerial inventory techniques for brown bears. Long-term monitoring of adult females has provided evidence that the productivity of Kodiak brown bears is lower than had previously been assumed.

Data from this study have been incorporated into the Kodiak Refuge Comprehensive Conservation Plan, which is used to establish priorities for land trades, and were also used to help prepare the State Bear Management Plan for Kodiak and adjacent islands.

## *Sea Otters*

As the result of real and perceived conflicts over shellfish between humans and sea otters, the Center started new studies at Kodiak Island, Prince William Sound, and southeast Alaska in 1986 to examine the impacts of sea otters on shellfish populations. The goals are to develop reliable censusing procedures for sea otters, quantify sea otter food habits and activity budgets, measure the abundance and size of prey populations along a gradient of sea otter predation intensity, and with the aid of implanted radio transmitters document daily and seasonal movement.

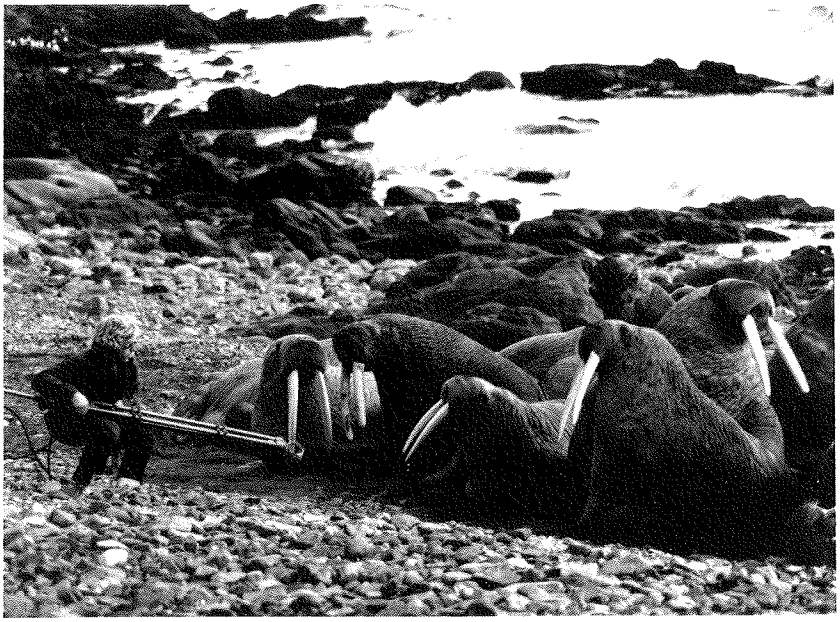
## *Walrus*

Walrus research was reactivated in 1986 to enhance the accuracy and precision of the methods used to indicate population trends and thus reduce the lag in management response. The Center established a Cooperative Education Agreement and Research Work Order with the Cooperative Wildlife Research Unit at the University of Maine to: 1) develop expertise on walrus within the FWS, 2) develop techniques for capturing walrus, 3) develop techniques for tracking walrus using satellites, and 4) quantify potential biases now present in the joint United States–Soviet Union walrus surveys.

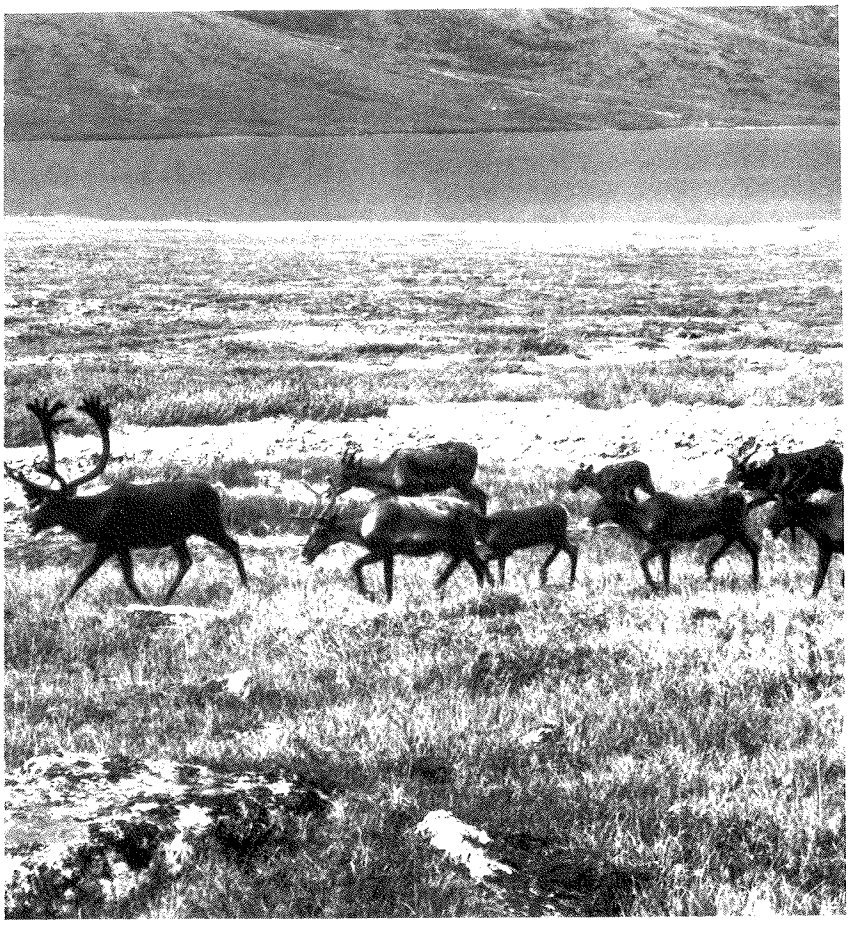
## *Caribou*

The Fish and Wildlife Service, the Canadian Wildlife Service, and the Alaska Department of Fish and Game have long-term research commitments to investigate the impacts of oil development on Arctic caribou and their habitat. Cooperative research efforts are underway to: 1) assess the short-term and long-term impacts of oil exploration and development on caribou productivity, survival and habitat; and 2) recommend effective actions to mitigate negative effects if they occur.

A prototype system to radio-track caribou with polar-orbiting satellites was developed in 1984. This system is now operating and providing accurate data several times each day on the locations of 20 caribou in the Central Arctic Herd (CAH) and the Porcupine Caribou Herd (PCH). Computerized image processing and geographic information systems are being used to correlate topographic features, vegetation types, predator distribution, and man-made features with caribou distribution and movement. Information is being collected



*Attaching collar to Pacific walrus.*



*Caribou herd in northern Alaska.*

from caribou in the PCH and two segments of the CAH, one near the Kuparuk oil field and one near Marsh Creek where no development has occurred. The use of habitats and the patterns of movement of these three groups of caribou will be compared to determine the influence of oil development on the CAH and to see if data from the CAH can be extrapolated to the PCH. Eventually, computer simulation models will be developed to predict the impacts of development. Proposed scenarios of oil exploration and development will be incorporated into the computerized system to predict and minimize both the level of habitat loss and impacts on the population.

## *Fisheries*

In 1986, the Fisheries Section conducted three studies in the Arctic region. The first involved genetic stock separation of chum and chinook salmon of the Yukon River Drainage in order to provide information for the ongoing Canada/U.S. treaty negotiations concerning Yukon River salmon allocation problems. All major spawning stocks of chum and chinook salmon in both Canadian and U.S. waters of the Yukon River are being genetically identified by enzyme electrophoresis. Samples from the fishery at the mouth of the Yukon River were taken weekly, genetically characterized by enzyme electrophoresis, and then proportionately assigned to the various spawning areas using a statistical program known as Genetic Stock Identification (GSI). The first results are due in the spring of 1988 for the next round of negotiations between Canada and the U.S.

Two other studies in cooperation with Region 7 and funded by Minerals Management Service also involve genetic stock separation. One is to genetically characterize spawning stocks of Arctic char on the North Slope of Alaska and Canada, and to determine if important stocks are present in areas of the Beaufort Sea being considered for oil and gas development. The second study is to genetically characterize major spawning populations of all five species of Pacific salmon in Bristol Bay, and to determine if any of the important stocks rear in offshore areas south of Bristol Bay, which is being considered for oil and gas leasing.

Additional details are available in the Alaska Fish and Wildlife Research Center Annual Report (USFWS, 1011 East Tudor Road, Anchorage, Alaska 99509).

# *Bureau of Land Management*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Fire Control | 350 |
| Minerals and Mining | 150 |
| Pipeline | 175 |
| NPRA | 100 |
| ANWR | 305 |
| Northwest Habitat | 150 |
| Teshekpuk Habitat | 105 |

The Bureau of Land Management's Arctic research program consists primarily of inventory, monitoring and applied research activities focused on the energy and minerals and renewable resources missions of the Bureau. Under the requirements of the Federal Land Management and Policy Act, the BLM is also responsible for developing plans for managing the Public Lands and the land's resources. These plans take various forms, the most common of which are resource management plans (RMP) and habitat management plans (HMP). Development of these plans is essential if the Bureau is to successfully accomplish its management responsibilities. The Bureau's work is performed entirely on land and in freshwater environments; it has no marine or offshore mission or responsibilities.

The Bureau's Arctic mineral investigations are concentrated on five areas at present. One major area is the Arctic National Wildlife Refuge (ANWR) where the work is associated with the Congressionally mandated exploration and evaluation of the ANWR's coastal plain. The BLM cooperates with the Fish and Wildlife Service (FWS) and the Geological Survey in this study. Its effort is directed toward estimating the amount of economically recoverable oil and gas, providing information on the infrastructure and transportation facilities necessary to develop these resources, evaluating how the area's oil and gas are related to the Nation's need, and helping to assess the likely impacts of oil and gas development on wildlife and wildlife habitat. Farther west, in the National Petroleum Reserve (NPRA), the BLM is presently conducting another minerals resource evaluation in the Utukok Special Area in the vicinity of the Utukok River. Here the objective is to determine the extent and accessibility of coal resources. Earlier observations have indicated that the NPRA may contain some of the largest coal fields on the North American continent.

*Trans Alaska Pipeline and adjacent Dalton Highway in the Alaska Utility Corridor.*

The BLM's NPRA Lease Monitoring Program has both inventory and monitoring elements. One objective is to evaluate potential oil and gas lease tracts and provide an estimate of the quantities of recoverable hydrocarbons likely to be present. Such information is needed to set minimum acceptable bids for sale of these leases. The BLM also monitors activities on the leases once construction and drilling begin, and it monitors geophysical activities to assure protection of other resource values. Under this program the Bureau also investigates the potential for surface and subsurface land exchanges to better facilitate the development of the area's mineral resources while at the same time enhancing protection of NPRA's wildlife, cultural, and other unique values.

Two minerals programs have primarily monitoring objectives. Working under the "Agreement and Grant of Right-of-Way for the Trans Alaska Pipeline," an agreement between the U.S. Government and the oil and gas industry, the BLM monitors day-to-day operations to make certain that signatories to the agreement are in compliance with the approved stipulations. Issuance of temporary use permits is an important function of the monitoring effort, since the right-of-way granted for the pipeline is only 54 feet wide, and some maintenance operations must be conducted on adjacent government lands.

Under authority of the 1872 Mining Act, the BLM conducts surface monitoring of mining activities associated with the development of locatable mineral resources. At the present time, this effort is primarily focused on placer mining of gold resources. As part of this program, the Bureau reviews mining plans and monitors mining operations to assure compliance with the approved plans.

In the area of renewable resources, the Bureau is initiating a major research effort on waterfowl in the Teshekpuk Lake area in the northeastern NPRA. This area is home to a wide variety of waterfowl and shorebirds,

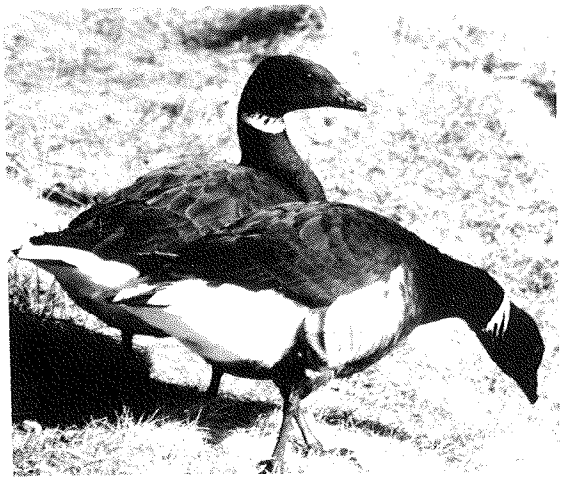
*Gold-bearing sand being washed under pressure.*

provides critical habitat for black brant geese during certain periods of their annual cycle, and is potentially important as a transportation corridor for North Slope oil and gas development activities. The research is focused on black brant geese and is especially concerned with the energetic requirements of this sensitive species and how development activities might interfere with these requirements.

In the central Arctic management area (CAMA), which overlaps a portion of the utility corridor, the BLM is conducting an interdisciplinary study as required by Section 1001 of the Alaska National Interest Lands Conservation Act (ANILCA). This is a study of wilderness and wildlife values as well as an evaluation of oil and gas resource potential and transportation requirements in the central Arctic area. The study will provide a significant part of the data and information required by the Bureau to prepare a resource management plan for the public lands involved and to complete preparation of the report to Congress required by December 1988.

A number of investigations are underway in the BLM's Arctic District as a regular part of its ongoing management activities. A major focus of the effort is on the continued monitoring of falcon populations to assure protection and continued recovery of the Arctic peregrine falcon along the utility corridor and the Colville River. Other ongoing activities in the Arctic District include the monitoring of caribou and grizzly bear populations. In FY 88 and 89 a major effort is planned to prepare a habitat management plan for the Colville River, with a primary objective being to evaluate the birds of prey and their habitats and assess the possibility of creating a special birds-of-prey area along this river. In 1990 and 1991 the Bureau plans to prepare an HMP for the Utukok Special Area. Inventories are planned for FY 88 and 89 of fishery resources along the utility corridor and overwintering fish populations in the Teshekpuk Lake area.

In the Bureau's Kobuk District a number of inventory and monitoring efforts are underway or planned for the near future. Monitoring efforts focus on reindeer range and on caribou, fish, moose and peregrine falcon populations. A cooperative effort with the Alaska Department of Fish and Game, the Fish and Wildlife Service and the National Park Service will focus on the movements of the western Arctic caribou herd and its interactions with reindeer in the reindeer range areas. In cooperation with the FWS, peregrine falcon populations are being monitored. The Bureau is also working on an RMP and a Range Animal Management Plan for the area. During FY 87 a major effort was underway to prepare allotment management plans for existing reindeer allotments. In the next several years inventories will be made of cultural and historical values in the mountains near Nome. Historical values in the area are primarily related to the gold rush days. A recreational fish inventory is planned for the Seward Peninsula and the Galena Basin. A wildlife inventory is planned for the Squirrel River area in FY 88, and grizzly bear and wolf inventories are planned for FY 88 and 89. A reindeer range geographic information system will also be developed. A continuing snow monitoring effort is also underway in the Kobuk District. Snow depths are being measured twice a year at four locations.



*Black brant geese near Teshekpuk Lake.*

# *National Park Service*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Noatak National Preserve | 205 |
| Gates of the Arctic National Park and Preserve | 174 |
| Bering Land Bridge National Preserve | 241 |
| Yukon-Charley Rivers National Preserve | 49 |
| Denali National Park and Preserve | 258 |

The National Park Service conducts research in all of the areas it manages in Arctic Alaska: Gates of the Arctic National Park and Preserve (8,440,000 acres), Noatak National Preserve (6,560,000 acres), Bering Land Bridge National Preserve (2,770,000 acres), Cape Krusenstern National Monument (660,000 acres), and Kobuk Valley National Park (1,750,000 acres).

As units of the National Park System, these areas are managed to conserve the scenery and natural and cultural resources they contain for the use of present and future generations of people. Additionally, portions of Gates of the Arctic, Noatak and Kobuk are included in the National Wilderness Preservation System for the purpose of preserving their wilderness character. The principal uses of these units of the National Park System are for recreation and inspiration. In addition, they furnish a limited harvest of plant and animal resources for customary and traditional subsistence uses by rural residents, and, in the Preserves, for sport hunting.

In managing these areas to conserve scenery and resources while providing for non-consumptive and consumptive uses, the National Park Service conducts applied research on specific topics identified in park resource management plans. This research may include physical, biological, socioeconomic and cultural sciences, depending on the nature of the management information need that has been identified. The research may be conducted by Park Service scientists, by contractors, by cooperators, or by independent scientists.

*Brown bear immobilized to receive a new radio collar.*

During FY 86, the National Park Service sponsored a variety of natural and cultural research projects in these Arctic area parks. In the Noatak National Preserve and environs, it participated in two cooperative projects with the Alaska Department of Fish and Game regarding the distribution and activities of brown bears. These studies should continue for at least two additional years. Preliminary results indicated that the brown bear population in a 719-square-mile study area was 44 bears, 30 of which were adults.

In the Gates of the Arctic National Park and Preserve, the Service started a three-year study of the use and effects of all-terrain vehicles; began a three-year wolf ecology study in cooperation with the Alaska Department of Fish and Game; and took the first steps in conducting a lake fish study with the U.S. Fish and Wildlife Service.

Research at the Bering Land Bridge National Preserve involved continuation of a willow ecology study and the beginning of a three-year reindeer/wildlife (caribou and muskox to date) relationship study in cooperation with both the Alaska Department of Fish and Game and the University of Alaska.

Research outside, but related to, these Arctic areas included river ecology, air quality and fisheries surveys, and a cooperative caribou study with the Alaska Department of Fish and Game in Yukon–Charley Rivers National Preserve; the third year of a caribou study and the first year of a three-year predation study at Denali National Park and Preserve; continuation of development of a geographic information system that would service all of the units of the National Park System in Alaska; continuation of fire ecology and effects studies; continuation of regular surveys and monitoring of wildlife populations; and completion of a study of interactions between wild and hatchery-produced salmon in northwest North America, with special reference to the Noatak River. Cultural resource studies included initiation of archeological and historical investigations in Bering Land Bridge National Preserve and continuation of similar studies in Gates of the Arctic National Park and Preserve.

During the past several years at Denali, caribou calves captured within 1 to 5 days of birth and instrumented with mortality-sensing radio collars have provided information on the extent, timing, and causes of neonatal

*Lakeshore research camp in tussock tundra of the Noatak National Preserve.*

mortality. Forty percent of the instrumented calves died prior to 1 June. Those deaths were attributed to grizzly bears (47%), wolves (29%), unknown predators (13%), golden eagles (7%), wolverine (1%) and drowning (1%).

The study of fire ecology and effects continued in 1986 through assessment of the historical role of fire in forested parks by cross-dating tree-ring samples, by determining the burned areas from the vegetation mosaics apparent in aerial photographs and satellite imagery, by comparing plant composition on similar habitats within and adjacent to burned areas, and by collecting ground coverage and fuel inventory data. These data will be used to derive land cover analyses from satellite thematic mapper data to form a basic layer in the GIS data base being developed for each park. The study also gathered fire behavior and weather information from ongoing natural fires in the parks. These data, along with the fuel inventory information, will be used to refine models for predicting fire behavior in Alaskan fuel types. Information from this study will be used in developing comprehensive fire management plans for each park.

Investigators' annual progress reports and National Park Service Research/Resources Management Reports on topics mentioned here are available from the Regional Chief Scientist, National Park Service, 2525 Gambell St., Anchorage, Alaska 99503-2892.

# *Bureau of Mines*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Minerals | 1550 |

The Bureau of Mines conducts mineral studies to provide information on mineral endowments and the potential for economic mineral resource development. These activities include evaluation of the mineral reserve potential of mineralized areas, estimation of the inferred reserve base at specific deposits, and bulk sampling of ores, especially for critical and strategic minerals. These programs are conducted and managed through the Mineral Data Analysis Directorate in the Bureau of Mines. The information is used by Federal policymakers, the land planning agencies, and the Congress, who make land use and policy decisions that affect the availability, economics and long-term supply of domestically produced minerals. In addition, the Bureau coordinates preparation of the Annual Report of the Secretary of the Interior to the Congress under the Mining and Minerals Policy Act of 1970 (Public Law 91-631) which analyzes the overall U.S. mineral industry and the key problems that affect the industry, the nation's vulnerability to mineral supply disruptions, and major issues related to minerals resource evaluation and minerals development on public lands.

The Bureau's Arctic program is composed primarily of three activities: mining district studies in Alaska, site-specific investigations on Federal lands to identify strategic and critical minerals, and review of draft environmental impact statements for proposed Federal construction projects to determine if mineral issues have been adequately addressed. Site-specific investigations are used to follow up favorable results from the mining district work. At the direction of the Senate Appropriations Committee, the Bureau of Mines developed a long-term minerals plan for Alaska. The plan provides for a systematic investigation of mining districts to include identification and estimation of mineral reserves, characteristics of economic mineralization, mineral extraction methods, metallurgical treatment methods, and evaluation of the production potential, including relationships to known mineral supplies. Bulk samples are collected

*Drilling through a moving glacier, Mount Henry Clay, Alaska.*

for chemical analysis and metallurgical testing. The objective is to determine the mineral endowment of Alaska and the potential for economic development by private enterprise with an emphasis on critical and strategic minerals. A typical mining district study requires four years of effort.

The Bureau is developing a statistical assessment method for estimating the economic potential of mineral resources. In joint work with the Alaska Division of Geological and Geophysical Surveys, this method has been applied in the assessment of the mineral endowment of the Kantishna area of the Denali National Park and Preserve, the northern portion of the Alaska Haul Road, and an assessment of the northwest region of Alaska. Similar efforts are directed to the estimation of the economic mineral potential of the Kuskokwim area, the Juneau Mining District, and the Valdez Creek Mining District.

The Bureau of Mines is assisting the Bureau of Land Management in a major land use decision by conducting an economic impact analysis of the Steese–White Mountain area.

To assist the placer mining industry of Alaska to comply with Alaska environmental regulations, the Bureau of Mines' Tuscaloosa Research Center conducted a series of demonstration projects in Alaska during 1986 and 1987. These were designed to test the applicability of technologies available to the industry to improve discharge water quality and to dewater slurries from mineral processing operations. Using the polymer polyethylene oxide (PEO), placer discharge waters are treated to reduce turbidity to conform to State of Alaska allowables. The flocculated material is deposited in a disposal pit, an operation that facilitates improved reduction techniques.

The Bureau is establishing a technology transfer office in Alaska which will facilitate technology transfer to assist Alaska miners and Federal land managing agencies in Alaska in the solution of major minerals-related problems.

# National Science Foundation

*NSF research is concerned with the entire Arctic region, including Alaska, Canada, Greenland, Svalbard, the Arctic Ocean and adjacent seas, and the upper atmosphere and near space. Research falls principally within six major scientific disciplines: atmospheric sciences, ocean sciences, biological sciences, earth sciences, glaciology, and engineering. The total budget for FY 86 was $18 million.*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Atmosphere | 5759 |
| Oceanography | 3860 |
| Biology | 2823 |
| Glaciology | 2478 |
| Earth Sciences | 1935 |
| Engineering | 663 |
| Coordination/ Commission | 626 |

For several decades the National Science Foundation has had a visible commitment to Arctic research. Since 1970 it has sponsored a formal Arctic Research Program assigned to the Division of Polar Programs. A number of other Divisions and programs throughout NSF, primarily in the Directorate for Geosciences and the Division of Biotic Systems and Resources, support research in and on the Arctic as part of their overall funding. This dual funding mode within the Foundation offers multiple sources of support to researchers interested in the Arctic. Research grants are provided on the basis of unsolicited proposals and are peer-reviewed.

In FY 85 and 86 NSF awarded funds for Arctic research to 83 institutions in 32 states and the District of Columbia. There were 167 individual research projects in 1985 and 173 in 1986. NSF's support of Arctic research, including facilities support and other field operations, over the past several years is shown below (in thousands of dollars):

| | FY 80 | FY 81 | FY 82 | FY 83 | FY 84 | FY 85 | FY 86 |
|---|---|---|---|---|---|---|---|
| Arctic Program (DPP) | 5,665 | 5,774 | 5,887 | 6,209 | 7,344 | 7,947 | 8,002 |
| Other NSF programs | 7,425 | 9,627 | 8,650 | 6,732 | 9,191 | 11,482 | 10,143 |
| Total | 13,090 | 15,401 | 14,537 | 12,941 | 16,535 | 19,429 | 18,145 |

## Atmospheric Sciences

NSF supports Arctic atmospheric research in meteorology, climate dynamics, tropospheric chemistry, aeronomy, magnetospheric physics, and solar-terrestrial physics. Within these disciplinary areas, research involves studies of Arctic stratus clouds, Arctic haze, the long-range transport of aerosols and trace gases over the Arctic Basin, precipitation and dry deposition on the Greenland ice sheet, magnetosphere–ionosphere interactions, very low frequency waves, the aurora, and the precipitation of energetic particles from the magnetosphere by VLF waves and magnetic pulsations.

The chemistry of auroral processes, including the production of nitric oxide and its transport to lower altitudes, is a concern of aeronomy research. Auroral research by optical techniques is concentrated at Fairbanks, Alaska, for the night-time aurora and at Spitzbergen for the day-time aurora. The dynamics of the mesosphere and thermosphere are investigated using spectroscopy of airglow emissions and interferometric observations of upper atmosphere neutral and ion wind velocities.

Meteorology research is carried out in Greenland, both in coastal regions and on the ice sheet, over the Arctic Basin by aircraft and ships, and at ground stations around the perimeter of the basin. Efforts are directed at examining trace deposition of pollutants that originate at mid-latitudes and studying the radiative heat balance as it is affected by clouds. Analysis of data acquired from the 1983 and 1986 Arctic Gas and Aerosol Sampling Project (AGASP) over Alaska, Canada and Greenland continues.

A main thrust of the upper atmospheric physics research is a multi-investigator study of ULF wave–particle interactions. There is a concentration of ionospheric, magnetospheric and ULF instrumentation located in the Roberval–Lake Mistissini, Quebec, area, which is magnetically conjugate to the ULF wave injection facility at Siple Station, Antarctica. In addition, ionospheric and auroral instrumentation is maintained at Frobisher Bay, N.W.T., and Sondrestromfjord, Greenland, regions that are conjugate to similar equipment in Antarctica.


*Incoherent Scatter Radar Facility at Sondrestrom, Greenland.*

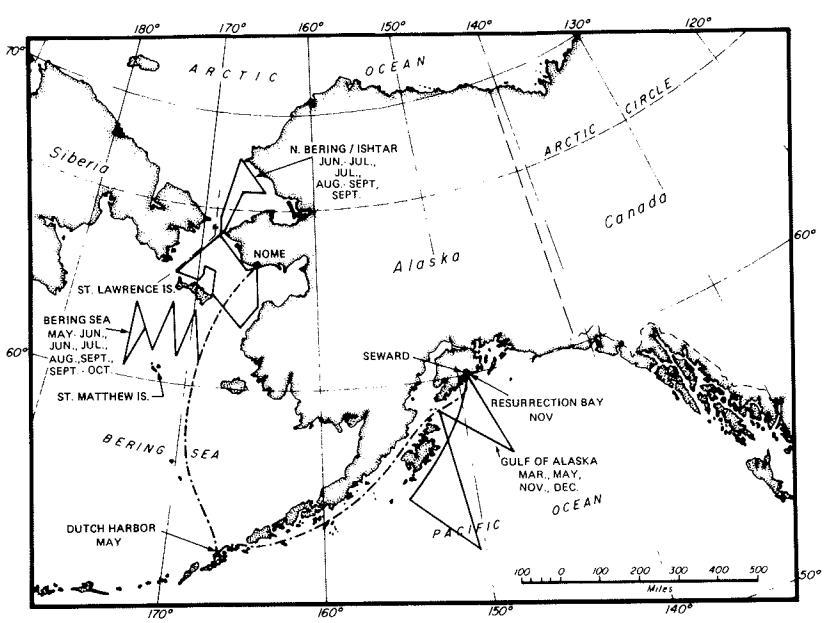
A special upper atmospheric facilities program provides support for four large atmospheric observatories, including the incoherent scatter radar facility located in Sondrestromfjord. This facility is dedicated to providing a better understanding of high-latitude magnetospheric–ionospheric–atmospheric coupling phenomena and atmospheric dynamics. It is the northernmost station in a chain of upper atmospheric observatories reaching from Greenland to the magnetic equator. These facilities are operated simultaneously to allow scientists to investigate global-scale upper atmosphere phenomena. Current research is carried out by staff and users of this facility and includes investigations into global modifications of the ionosphere and thermosphere triggered by energy deposition into the polar ionosphere, joint NSF–NASA–USAF radar/sounding rocket experiments of high-latitude ionospheric irregularities, and joint radar/airglow experiments of the high-latitude thermosphere.

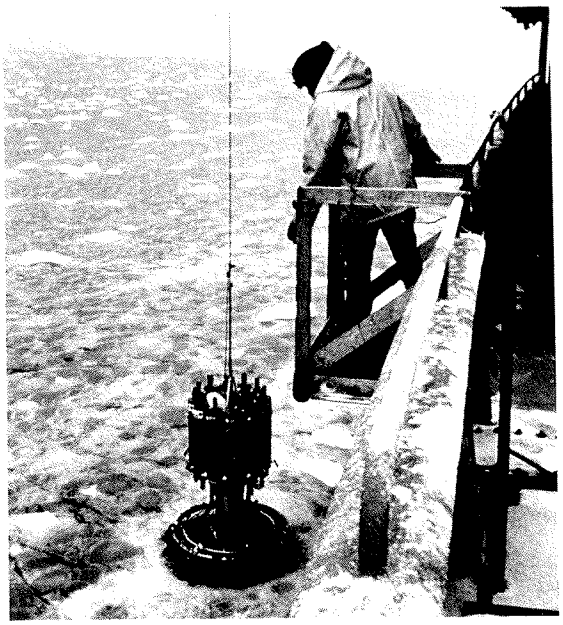
## *Ocean Sciences*

Arctic ocean research includes physical and biological oceanography, modeling, paleoenvironmental studies, and marine geology and geophysics. The emphasis in physical oceanography is on the ocean dynamics at the pack ice edge and the effect of polynyas. A secondary emphasis is on the use of tracers to define movements of water masses within the Arctic Basin. The program supports the use of traditional techniques, such as moored current meter arrays, as well as measurement of Freons in the ocean, which reveals how long it has been since the water mass was last exposed at the ocean surface. Measurements of dissolved noble gases—helium, neon and argon—are expected to provide information on the freezing and melting cycles of sea ice.

Environmental modeling research is providing numerical models of Arctic environmental processes, including the kinematics and thermodynamics of the ocean, sea ice and atmosphere. The emphasis is now on studies of the effects of the distribution and quality of environmental data on the accuracy of numerical models. It is expected that the effort will be extended to oceanic circulation, pack ice dynamics, regional climate, and related processes.

Marine paleoenvironmental studies seek to reconstruct Arctic climates through geological time using observations of the sedimentary structure of the ocean bottom planktonic assemblages and paleomagnetic field directions within the sediment. This research is developing analytical techniques for improving the resolution and precision with which individual events may be identified. It also involves developing a reliable stratigraphy and time scale for Arctic events from the existing sediment



*Oceanographic measurements from RV* Alpha Helix *in ice-covered Bering Sea; vessel track at left.*

cores, and initiating new coring programs in strategic locations. At this time a reliable stratigraphy is being developed through a synthesis of available lithological, biological, radiometric, isotopic and paleomagnetic techniques.

Marine geology and geophysics research is determining the nature of geological processes active in the Arctic, and the evolution of the tectonic units of the Arctic Ocean and its marginal seas. The immediate goals are to investigate Arctic processes such as the dynamics of sediment flow from a glacially fed fjord to the continental shelf and to understand the structural and stratigraphic development of continental margins as an indicator of tectonic processes associated with plate boundary movement. During this year a study of the ventilation of the Arctic Ocean was also initiated.

While new hydrographic data are sparse, the results of recent extensive work in adjoining shelf seas, and studies on chemical tracers, point to the importance of shelf processes, including brine rejection, in deep water renewal.

The Bering Strait and its adjoining waters, the Bering and Chukchi Seas, form a region of major importance to the ocean sciences. The only flow between the Pacific and Arctic Oceans takes place in this region, and this flow affects the properties of both the Arctic Ocean and its outflow of water into the Atlantic. The multi-investigator project ISHTAR (Inner Shelf Transfer and Recycling) in the Bering and Chukchi Seas is investigating the seasonal and interannual variation in the northward transport of water and its influence on biological processes in the system. Results to date show that, contrary to predictions, outflow of nutrients from the Yukon River does not sustain a spring phytoplankton bloom in the inner shelf region. Attention is now focused on the physical and biological properties of the Bering shelf water, the Alaska coastal water, and the Anadyr River water. These three water masses show distinct productivity regimes with different patterns of organic matter deposition and subsequent nutrient regeneration. Research will lead to a better understanding of mechanisms responsible for the high productivity of the Bering Sea. The Division of Ocean Sciences provides ship operations support for the University of Alaska's R/V *Alpha Helix* (approximately $1.5 million in FY 86).

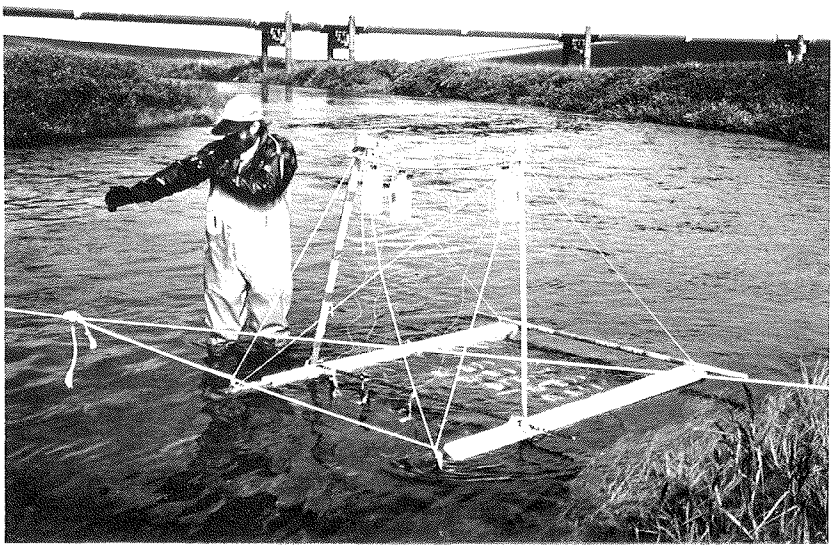
## *Biological Sciences*

Biological research includes terrestrial, freshwater and marine biology. Objectives for Arctic land-based systems research include increasing knowledge of the structure and function of ecosystems—freshwater and terrestrial—and increasing knowledge of the distribution, abundance and population dynamics of organisms; improving understanding of the adaptations of organisms to their environ-

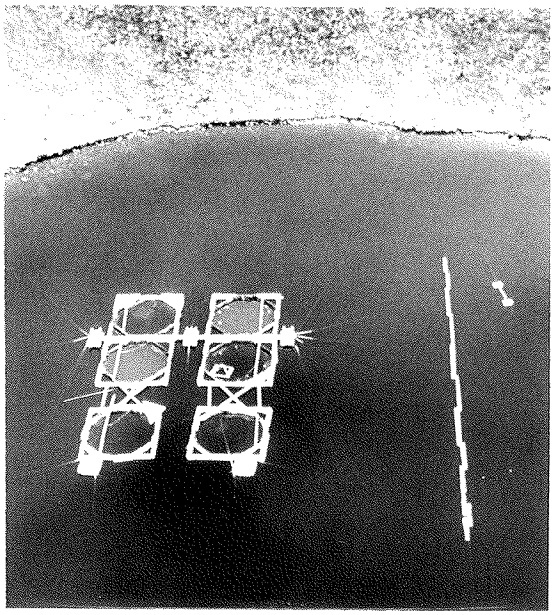
ment; and developing knowledge useful in the management of ecosystems.

Major ongoing research projects consist of multidisciplinary freshwater and terrestrial ecosystem studies focused on the effect of nutrients on Arctic lake and riverine systems in the vicinity of Toolik Lake and northward along the pipeline road. Change in the ecology of rivers and lakes in Arctic Alaska caused by experimental manipulation of nutrients and fish populations has been the topic of this long-term project. Results to date show alterations in the ecosystem of a pristine river caused by the addition of a limiting nutrient. Before the addition of phosphorus, most of the river's energy was generated through microbial metabolism. After phosphorus enrichment, the biota shifted to photosynthetic organisms and the biomass of photosynthetic algae on rocks increased by a factor of ten. The increase in size of aquatic insects suggested food limitation at higher trophic levels. These studies are testing hypotheses of how populations in lakes and rivers are regulated. The research will improve prediction of how the resources of Arctic lakes and rivers will react to disturbance of nutrient cycles by nitrogen and phosphorus addition from road effluents, dust and drainage changes, and potential overfishing of trout and grayling.

The biological research programs support individual projects on a variety of topics, including the effects of oil facilities on the breeding of tundra birds, succession studies in tundra plant communities and nutrient dynamics of tussock tundra, and collaborative research on the systematics of holarctic mammals.



*Nutrient experiment on Kuparuk River.*

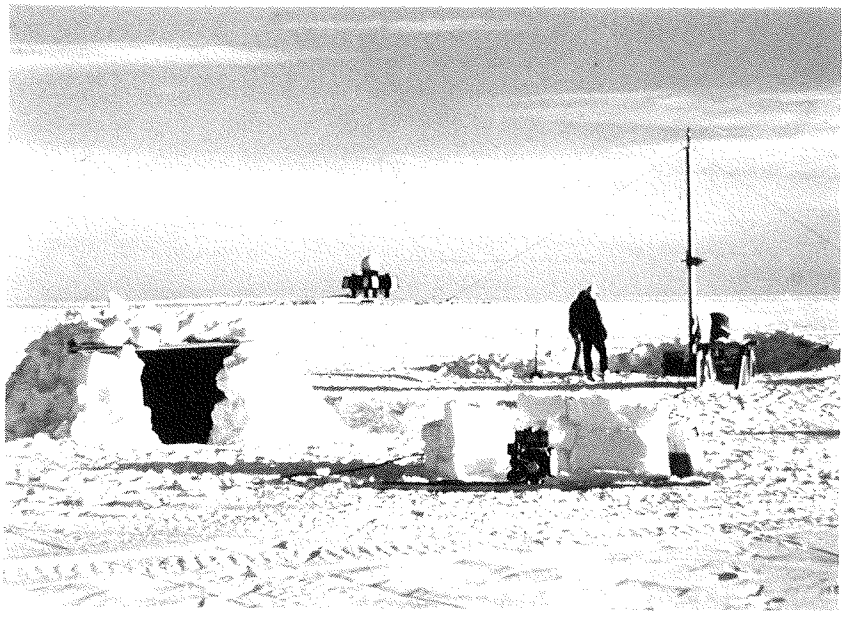


*Experimental enclosures in Toolik Lake area.*

Other projects on a wide variety of marine biology topics are also supported: feeding of gray whales and walrus, chitin digestion by baleen whales, the ecological significance of the post-spawning death of Pacific salmon, and the impact of sea otters on coastal food chains.

## *Glaciology*

Glaciology research is performed largely in Greenland and Alaska. The objectives of the glaciology program include: 1) recovery and analysis of ice cores, particularly to study long-term climatic change; 2) study of ice dynamics, particularly the physics of fast glacier flow, in relation to the potential problem of rising sea level due to future climatic warming; 3) numerical modeling of glaciers, ice streams and the Greenland ice sheet; 4) observation and interpretation of glacial evidence in relation to the waxing and waning of Northern Hemisphere ice sheets during the Quaternary, and study of sediment flux in relation to tidewater glaciers; 5) development of an improved remote sensing capability to measure ice thickness, surface elevations, internal layering, and the characteristics of the ice/bed interface; and 6) development of improved methods such as hot water drilling to gain access to glacier and ice stream beds for direct measurement of subglacial water pressures, bed structure, and the characteristics of subglacial hydraulic systems.



*Shallow ice core drilling at Dye 3, Greenland.*

Ice cores obtained from Northern Hemisphere glaciers are of particular interest to climatologists as they contain a record of the environment where the majority of the world's population has lived. This record goes back beyond 100,000 years and could provide data for predicting future climatic trends. Scientists from numerous disciplines are applying chemical and physical techniques to extract data on volcanic activity, changes in atmospheric composition, and climatic indicators. These studies, conducted at U.S. and foreign institutions, demonstrate the importance of ice sheets as repositories of data on global climate and processes, and chemistry of past global atmospheres.

The second Greenland Ice Sheet Program (GISP II) is presently being considered as a joint effort of Denmark, Switzerland and the United States. GISP I, involving the same countries, successfully drilled and studied a 2037-m ice core (recording climatic history of approximately the last 90,000 years) from Dewline Site 3 (Dye 3) in south-central Greenland. The GISP II project plans to recover and study a 3000-m ice core (possibly a record of the past 200,000 years) from central Greenland. The previously drilled Dye 3 hole is being monitored regularly to provide additional data on the dynamics of the ice sheet. Airborne radar ice surveys and a complementary surface traverse are underway to provide glaciological data for the selection of the deep drilling site in central Greenland.

A recent intensive study in the St. Elias Mountains of Alaska yielded new insight into the mechanics of surging glaciers. A fundamental transformation of the subglacial hydraulic system leading to formation of a linked system of water-filled cavities, with water pressures close to ice overburden pressures, was found to be the cause of the surge. In West Greenland, a multiyear study of a large ice stream that discharges icebergs into a coastal fjord has yielded extensive data on deformation and velocity, the annual cycle of iceberg calving, and the response of the ice stream to tide changes within the fjord. Studies such as these may lead to understanding of why this ice stream differs substantially from the great ice streams of Antarctica.

## *Earth Sciences*

Geologic, geophysical and Quaternary research is supported throughout much of the Arctic region. Through the entire geologic section, from Precambrian to Recent, projects seek to develop an understanding of the tectonic evolution and geologic history of the Arctic Basin as a whole, and to answer regional and local geologic questions. The evolution of Cretaceous and early Tertiary mega-

*Extruding lake bottom core, Etivlik Lake, Alaska.*

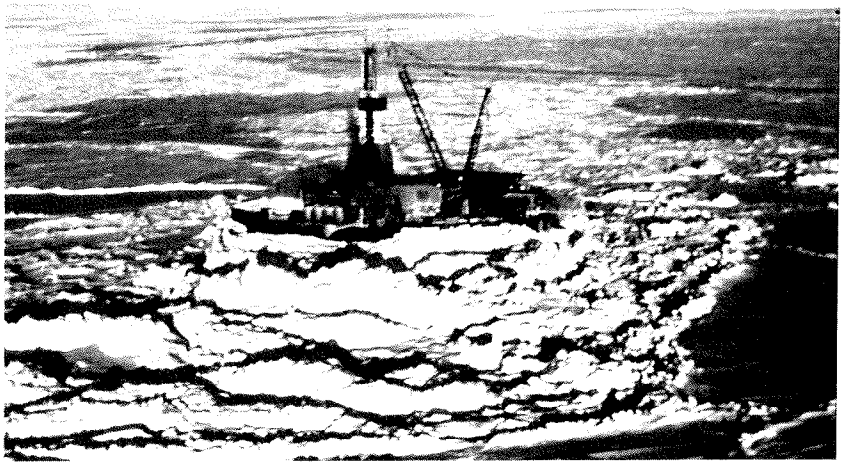
invertebrates of the Arctic Basin is being examined as a stimulus to evolution in other areas of the globe. Geophysical probing of the earth's mantle and crust provides a basis for our understanding of large-scale tectonic motion, while micro-earthquakes may provide clues for predicting future earth movements and volcanic activity. Geophysical surveys, including magnetic, gravity, seismic refraction and reflection, provide a clearer understanding of how the Arctic region fits within the global tectonic scheme. Investigations focus on the definition of plate boundaries and intraplate deformation. Arctic regions demonstrate wider swings in climate through geologic time than temperate and tropical regions. Studies of the paleoclimate are therefore not only significant to understanding of the geologic history of the Arctic, but yield important data on global climatic history. Evidence of the paleoclimate of the last 12,000 years is particularly well preserved in the lake sediments and paleosoils. Studies of shallow water sediments and terrestrial deposits are important for establishing a detailed chronology of paleoclimatic and paleoecologic events.

## *Engineering*

Support in the engineering and material sciences disciplines related to the Arctic and other cold regions includes studies of the mechanical properties of ice, the hydraulic conductivity of frozen soils, metamorphism of dry snowpacks, three-dimensional analysis of ice, permafrost, and support of international conferences such as the Fourth International Conference on Cold Regions Hydrology. A new initiative in Cold Regions Science and Engineering in the University/Industry Cooperative Research Centers is underway. This activity focuses on ice mechanics and modeling. The Engineering Directorate is the principal supporter of these activities.

Permafrost research is primarily related to Alaska, where extensive areas are underlain by perennially frozen ground. In addition, considerable areas of the Beaufort Sea continental shelf are underlain by subsea permafrost. Research on permafrost is designed to determine the distribution and origin of frozen sediments, ground ice and its properties, and recent climate changes as recorded in ground temperatures. The extent and significance of subsea permafrost were investigated as a result of exploration for oil and gas on the continental shelf. The seafloor has significant engineering importance in the production of oil and gas. Basic research on terrestrial permafrost has yielded significant data on paleoclimate and on engineering geology in areas with potential energy and mineral resources.

*Artificial island in pack ice, Beaufort Sea.*



## *Coordination*

NSF also supports a program of polar information and advisory services, provides support for the Interagency Arctic Research Policy Committee, includes funds for the Arctic Research Commission in its annual budget, partially supports the National Academy of Sciences Polar Research Board, and supports workshops and studies to further develop and implement Arctic research planning and policy. The annual listings of NSF-supported projects are available from the Polar Coordination and Information Section, Division of Polar Programs, National Science Foundation, Washington, D.C. 20550.

# Department of Defense

*Arctic research is conducted by all three services and includes virtually all environmental sciences, engineering, and health disciplines. A total of $26.6 million was devoted to basic research and related testing in FY 86.*

## U.S. Navy

DOD FY 86 FUNDING (thousands)

| | |
|---|---|
| Upper Atmosphere | 4523 |
| Atmosphere | 2799 |
| Oceanography | 7191 |
| Snow & Ice Hydrology | 2257 |
| Permafrost & Frozen Ground | 797 |
| Geology | 509 |
| Engineering | 5596 |
| Medical & Health | 2964 |

Within the Arctic and other high-latitude regions, the Navy is engaged in research activities ranging from basic environmental investigations to applied work on specific problems related to operational systems. These activities are pursued within a number of organizations. The Office of Naval Research (ONR) in Arlington, Virginia, supports basic, multidisciplinary efforts through contracts, primarily with academic institutions. The Naval Ocean Research and Development Activity (NORDA) and the Institute for Naval Oceanography (INO) at Bay St. Louis, Mississippi, the Naval Environmental Prediction Research Facility (NEPRF) in Monterey, California, and the Naval Research Laboratory (NRL) in Washington, D.C., perform both basic and applied research, with emphasis on acoustics, numerical modeling, and remote sensing. The Office of Naval Technology (ONT) in Arlington, Virginia, together with a number of specific laboratories [Naval Underwater Systems Center (NUSC) in New London, Connecticut, Naval Ocean Systems Center (NOSC) in San Diego, Naval Surface Weapons Center (NSWC) in Silver Springs, Maryland, Naval Civil Engineering Laboratory (NCEL) in Port Hueneme, California], are involved principally in applied research and development associated with operational systems. This article is limited to basic Arctic research (fiscal subelement 6.1), which totaled about $10 million. The activities of the various Naval organizations are synthesized here without distinction in order to better focus on phenomena and regions of interest and methods of approach.

The overall goal of Naval research in the Arctic sciences is to provide an accurate knowledge of the environment for Naval operations at high latitudes. In pursuit of this goal the Navy performs comprehensive theoretical and experimental basic research on a range of Arctic processes. Applications associated with this environmental knowledge base include estimates of sea ice properties and motion; of ambient noise; of acoustic propagation loss, volume reverberation and ice scattering/absorption; of local ocean turbulence intensity; of ocean currents and sound speed fields associated with fronts and eddies; of wind, wave, icing and fog conditions; of gravity and magnetic anomalies; and of sediment distribution and stability.

Research objectives are: 1) to determine the temporal and spatial structure of mass, momentum and energy fields within the Arctic system; 2) to understand the order and mechanism of interaction among principal structural components; and 3) to determine the net flux of principal system constituents. Mass includes both inorganic and organic constituents: water (solid and liquid phase), dissolved ionic species, biomass (lower trophic levels), suspended material, sediments, and crust. Momentum and energy include a broad spectrum of motion: acoustic vibrations, turbulence, gravity/inertial/planetary waves, eddies, mean circulation, and tectonic adjustment.

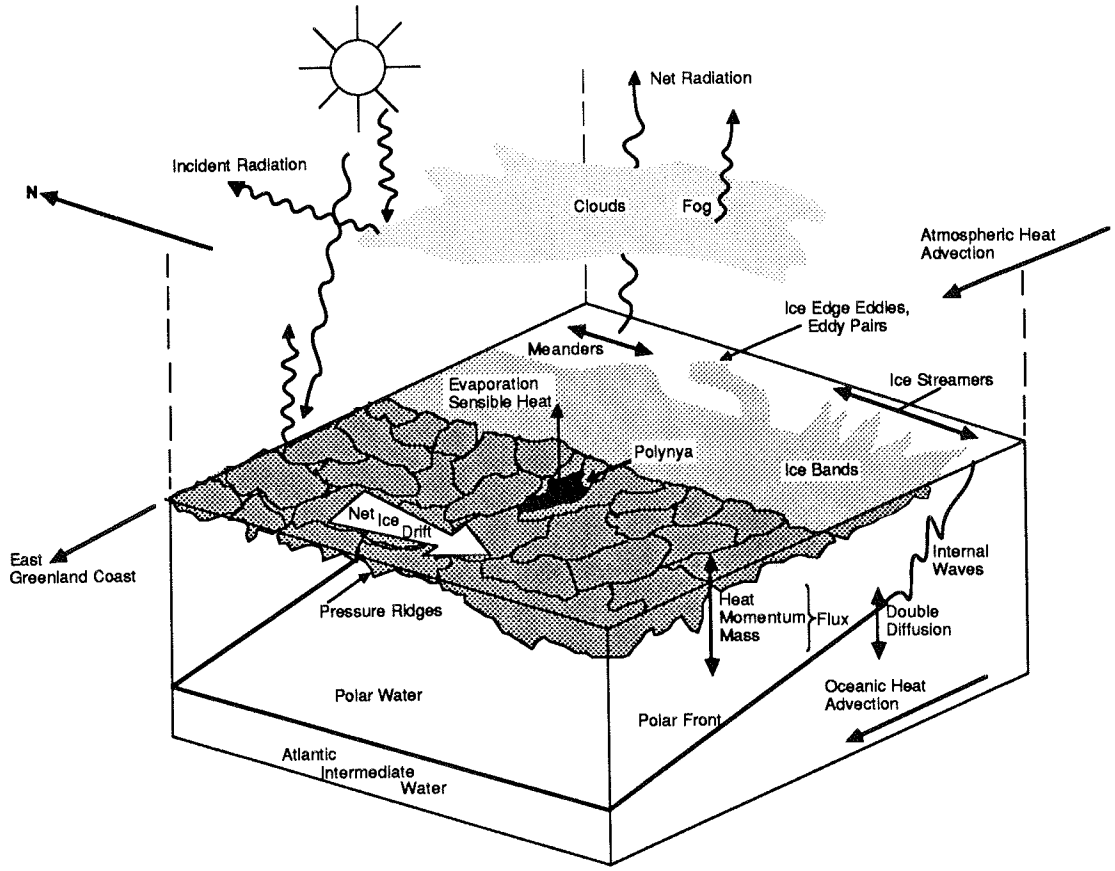
These objectives form the basis of investigations into specific phenomena and regions of interest. These phenomena and regions are studied from a multidisciplinary perspective to provide a full understanding of their statistics and dynamics. Contributing disciplines in order of relative emphasis include physical oceanography, acoustics, ice dynamics, biological oceanography, meteorology, geological oceanography, chemical oceanography, and geophysics. Within each discipline, insight is pursued through sampling and modeling supported by a viable infrastructure. Sampling includes remote, interfacial and in-situ sensing, with the strategy of determining optimal distributions in time and space. Modeling includes analytical, numerical and physical, with the strategy of formulating essential governing dynamics and estimating event proba-

*Ice camp; aerial view shows open lead.*

bilities and resultant statistics. Among disciplines, some infrastructure elements (e.g. computers, platforms, data management systems) are common, and shared use of such resources is encouraged. In general, a balance between sampling and modeling efforts is maintained.

Specific phenomena of current interest include mesoscale eddies, fine structure/turbulence, ambient noise generation, acoustic propagation/attenuation, air–ice–ocean stress, electromagnetic energy–ice interaction, biomass productivity, lead development, deep convection, particle flux, ice–sediment interaction, and high-latitude frontal zones. Specific regions of focus include the marginal ice zones, Fram Strait, Greenland/Norwegian Seas, Bering/Chukchi Seas, Barents Sea, and the central Arctic. Investigations for which enhanced funding has been formally identified within ONR are termed Accelerated Research Initiatives (ARI's). ARI's are defined to be of five-year duration with fixed funding profile, and are established on the basis of scientific merit, technical feasibility/timeliness, and Naval relevance. Recent ARI's within the ONR Arctic Sciences Program include the Marginal Ice Zone Experiment (MIZEX), Remote Sensing, Arctic Acoustics, Real-Time Environmental Arctic Monitoring (R-TEAM), and Arctic Oceanography. In addition there is the program element supported by direct Congressional appropriation termed the University Research Initiative (URI). The Arctic URI is focused on Ice Mesoscale Modeling. The objectives and methods of approach for the principal ARI's and the URI, outlined below, are illustrative of Naval Arctic basic research in general. Accomplishments associated with core investigations and mature Initiatives are documented principally through publication in the reviewed scientific literature.

The overall objective of the MIZEX ARI was to improve understanding of the mesoscale physical and biological processes by which ocean, ice and atmosphere interact in the region of the ice edge. Specific oceanic processes are eddy generation related to inherent flow instabilities and boundary forcing mechanisms, wind-driven upwelling, fine structure generated by water mass mixing, and intermediate/deep water formation. Specific ice processes are flexural disintegration by surface gravity wave action, melting rate, production rate, and interaction with electromagnetic energy. Specific atmospheric processes are boundary layer deepening and vorticity development associated with mechanical and thermodynamic forcing. The main field effort within the ARI was integrated within a larger, coordinated international program marshaling the resources of 11 nations and the expertise of over 200 scientists and technicians. A variety of sampling techniques were utilized from seven ships, eight fixed-wing aircraft and four helicopters. Summer field experiments began in June–July 1983 on a limited scale. The full-scale experiment was conducted in May–June 1984, with a subsequent reduced-level investigation in March–April 1987 to extend coverage over a seasonal range. The Fram Strait region, between Svalbard and Greenland, was selected as the MIZEX site due to its central role in Arctic Ocean Basin exchange. Results of the MIZEX effort have been reported in a series of MIZEX Bulletins published by the



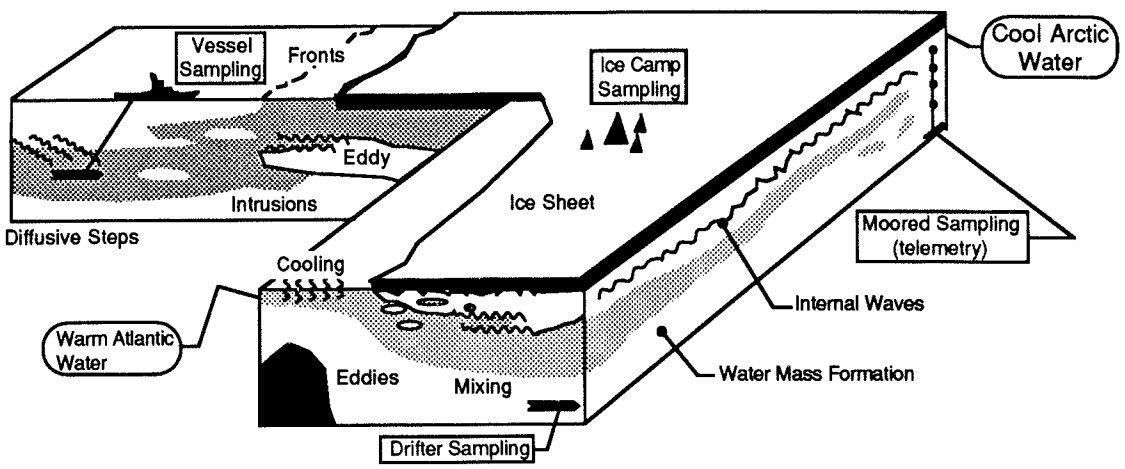

*Phenomena and processes of interest in the MIZEX ARI.*

Army Cold Regions Research and Engineering Laboratory as well as in the open literature.

The objectives of the Arctic Acoustics ARI are to relate ambient noise sources with environmental forcing mechanisms, to understand the relationships between the morphology and physical properties of ice and the scattering/absorption losses of reflected acoustic energy, to determine the effect of small-scale oceanic density variability on the coherence of sound signals, and to determine the effect of the large-scale oceanic density field on sound propagation paths. The ambient noise spectrum (1–10,000 Hz) is related to processes that effect ice fracture and ice floe interaction. To determine this relationship, events are localized with wide aperture arrays while atmospheric and oceanic velocity/pressure/density fields and ice moduli/heat flux are simultaneously measured. Theory for noise generation resulting from these processes is derived to predict noise spectral amplitudes from a knowledge of the forcing fields.

A sampling program designed to address the small-scale coherence objectives formed part of the Arctic Internal Wave Experiment (AIWEX) conducted in spring 1985 north of Prudhoe Bay. Ambient noise sensing techniques, low-frequency ice reflection measurement, and initial performance of an Arctic Remote Autonomous Measurement Platform (ARAMP) for concurrent acoustic/environmental data acquisition were investigated in an ARAMP Pilot Experiment in spring 1987, also north of Prudhoe Bay. Refinements of these methods will be integrated into a multicomponent field experiment in spring 1989 near the Fram Strait marginal ice zone. In consort with the 1989 experiment, a large-scale tomography investigation will be undertaken as part of the Greenland Sea Project.

The objectives of the R-TEAM ARI are to determine the low-frequency (10 to 90 days) variability in transport of mass and momentum between the Greenland Sea and both the Arctic Ocean and the Barents/Kara Sea, to understand the dynamics of this transport as related to the major constituent current systems and their interaction, and to evolve efficient sampling strategies for input to predictive numerical circulation models. To determine low-frequency variability requires time series data of sufficient range and resolution, here 360 days and 2 days, respectively. To provide efficient sampling for predictive model input requires instruments with near-real-time reporting capability, regardless of surface ice conditions. The combination of these two requirements has resulted in the development of a subsurface mooring system




that can telemeter data from a series of networked sensors through an antenna programmed to ascend from a standby depth to the surface at desired intervals coincident with satellite overpasses. Initial field tests for the prototype design took place in spring/summer 1987, and an operational system is planned for deployment in fall 1988. Subsequent mooring arrays will be located to address the complementary field experiments occurring within the region during 1989. Telemetered subsurface data combined with satellite imagery will enable the dynamical testing and numerical model refinement objectives to be addressed concurrent with the array deployment.

The overall objective of the Arctic Oceanography ARI is to understand the role of mesoscale and small-scale processes (1 hour to 30 days, 1 m to 10 km) in the transport of mass and momentum between the Arctic Ocean and the Greenland Sea. Physical oceanographic objectives focus on understanding the generation and dissipation of mesoscale eddies, internal waves, and small-scale mixing and their mechanisms of energy exchange, both downscale in governing the distribution of fine structure and upscale in determining the net large-scale transport. Biological oceanographic objectives relate to understanding the relative role of physical structure/dynamics and organism physiology and behavior in enhanced primary productivity, indicated by biomass concentration, light and sound fields. Meteorological objectives are to understand the atmospheric boundary layer dynamics across the marginal ice zone, including air-ice-ocean feedback mechanisms, and to determine the structure of the coupled momentum flux field. To address these objectives, a comprehensive field effort will be conducted as part of the Coordinated Eastern Arctic Experiment (CEAREX) in the Fram Strait region from fall 1988 through spring 1989. CEAREX will include an ice-fast ship drifting from north of the Yermak Plateau through the Fram Strait in winter 1988–89, as well as an eddy dynamics experiment in the marginal ice zone in spring 1989 utilizing additional vessels for open water and aircraft for remote sensing observations.

The overall objectives of the Ice Mesoscale Modeling URI are to understand and model (numerically) the dynamics and the mechanics of the Arctic ice-ocean system. Specific goals are to properly formulate ice rheology physics by combining large-scale with micromechanical forces, to forecast the mechanical and acoustic properties of sea ice by combining microscale physics with hydrodynamic model predictions, and to statistically analyze existing remote sensing data to determine the relative importance of forcing functions (wind stress, heat flux, ice keel drag). New generation vector processing computers are a central tool in achieving the overall objectives. Fracture mechanics is providing insight into forces required for ridge formation and polynya development. Micromechanics establishes a physical basis for understanding crack development and ambient noise. Understanding the mechanical properties of sea ice allows the properties of individual floes to be specified. Floe-floe interaction can then be treated

statistically to determine ensemble behavior. Remote sensing analyses include synoptic-scale and interannual variability in ice extent and concentration, the effects of snow melt, the distribution of drafts, leads and polynyas, the variability and organization of cloud cover, and the spatial and temporal structure and amplitude of the surface wind field.

The Navy's basic research programs in the Arctic, particularly field experiments, benefit substantially from U.S. interservice, U.S. interagency, and international participation. Cooperative efforts in providing funding, resources and coordination have made possible significant advances in understanding an environment that is both challenging and remote. Such cooperation is essential for future progress in maintaining the knowledge base that transitions to many Navy, as well as civilian, applications.

## *Publications*

Readers may obtain further information on some of the research described in this article from the following publications:

*Thermohaline circulation in the Arctic Mediterranean Seas*, by K. Aagaard, J.H. Swift and E.C. Carmack: Journal of Geophysical Research, vol. 90, p. 4833–4846, 1986.

*MIZEX East 83/84: The summer marginal ice zone program in the Fram Strait/Greenland Sea*, by MIZEX Group: EOS, Transactions American Geophysical Union, vol. 67, no. 23, p. 513–517, 1986.

*Marginal ice zone special issue*, edited by R.D. Muench, S. Martin and J.E. Overland: Journal of Geophysical Research, vol. 92, no. C7, p. 6715–7225, 1987.

# *U.S. Army*

Six U.S. Army organizations are involved in Arctic research: the Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire; the Cold Regions Test Center, Ft. Greely, Alaska; the Natick Research, Development and Engineering Center, Natick, Massachusetts; the Research Institute of Environmental Medicine, Natick, Massachusetts; the Army Research Office, Research Triangle Park, North Carolina; and the Medical Research and Development Command, Ft. Detrick, Maryland. Their research, summarized below, ranges from basic studies of cold regions processes and materials to support of Army operations in the Arctic environment.

## *Cold Regions Research and Engineering Laboratory*

The mission of CRREL, a Corps of Engineers laboratory in Hanover, New Hampshire, is to study the characteristics of cold regions and to apply this knowledge to the solution of cold regions problems of the Army and other Federal or State agencies. CRREL conducts by far the largest share of the Army's Arctic-related research. In FY 86, Arctic-related research was performed in two major areas: 1) snow and ice, and 2) Arctic engineering. This research, with a total expenditure of $9.3 million, has resulted in important advances in our understanding of cold regions phenomena.

Results of the research are published in refereed open literature and in in-house reports. These publications, along with several thousand others dealing with cold regions science and technology published throughout the world, are annually indexed in the *Bibliography on Cold Regions Science and Technology*, which is prepared by the Library of Congress for CRREL. Computerized searching of the cold regions data base is available commercially from the ORBIT Search Service (8000 Westpark Drive, McLean, Virginia 22102).

### *Snow/Ice Research*

One of the most important FY 86 accomplishments was the completion of a cold regions environmental data base on the effects of winter weather on electro-optical propagation systems. Detailed environmental data obtained on electro-optical system performance in wet snow and fogs have now been incorporated with other cold regions data in the Atmospheric Aerosol and Optics Data Library


*Collecting frazil samples on the Tanana River.*

at the Army's Atmospheric Sciences Laboratory.

In addition, CRREL tested and monitored the development of a number of meteorological measurement systems. A light-scattering rain gauge was modified to measure snowfall and snowfall density and to distinguish between precipitation types (snow, rain, drizzle) and snow crystal types. This instrument, smaller and more accurate than conventional precipitation gauges, provides a wider dynamic range and measures parameters other than precipitation that affect electro-optical system performance.

Under the Small Business Innovative Research program, a radiosonde ice detector was developed that detects icing conditions in the upper atmosphere. The device has demonstrated its reliability and promises to be very effective for predicting icing on helicopters and other aircraft. This vibrating wire detector was also shown to be an accurate anemometer that can perform in icing conditions that disrupt the operation of all other types of anemometers.

Research in cold regions hydrology in FY 86 primarily concerned runoff prediction and determining the winter regime of northern rivers. Significant progress was made in developing a methodology for determining the magnitude of streamflow—whether from direct precipitation or from snowmelt runoff. Work was also done on the evaluation of sensors for measuring snowmelt and water flow beneath the snow pack.

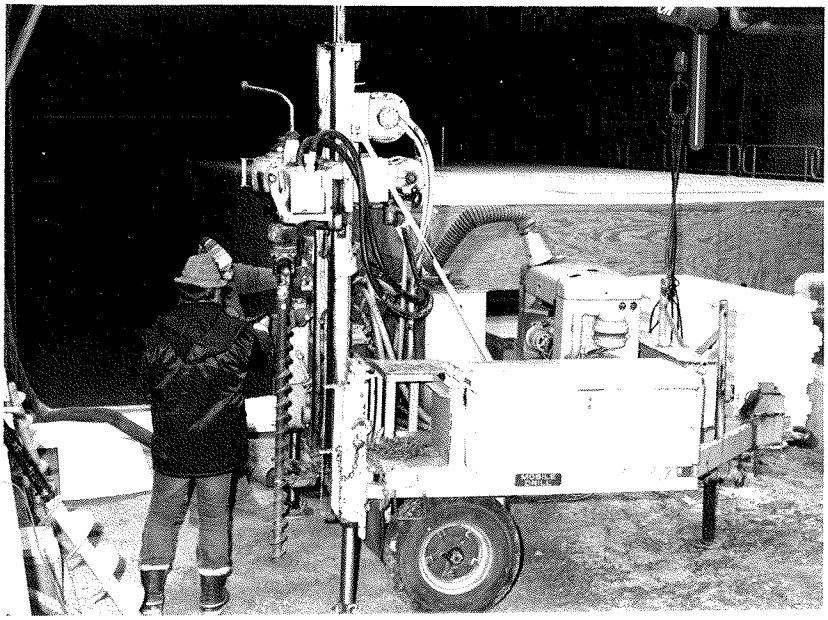
Another major hydrologic research effort was a study of the winter regime of the Tanana River near Fairbanks, Alaska. The characteristics of the frazil ice beneath the ice surface were studied by drilling through the ice cover and obtaining frazil samples. Findings indicated a number of stationary areas of frazil in the river that restricted water movement and thus increased flow and bed erosion in the open channels.

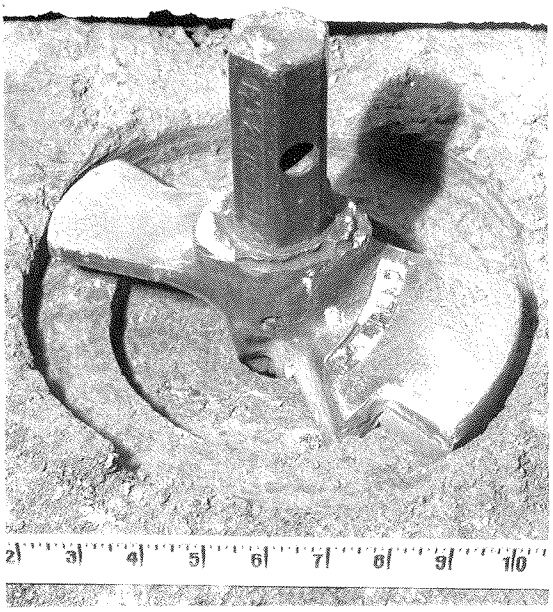
A statistical study was completed of the height and occurrence of ice pressure ridges in the Arctic Ocean. This information, obtained from radar imagery, is of major importance to construction and petroleum development.

Other sea ice studies included the building and analysis of an artificial ice ridge that is similar to ridges formed in the Beaufort Sea and other locations in the Arctic Ocean. The data from this research will be useful in predictive models of ice consolidation and ridging in Arctic waters.

In addition, research continued on determining the properties (strength, stress and strain) of saline and freshwater ice. New end-cap designs for ice samples were tested to improve tension tests on ice, and a patent was issued to one of the laboratory's research engineers for an improved triaxial compression test apparatus.

Geological investigations concentrated primarily on evaluation of remote sensing imagery for environmental monitoring and for land use classification. Enhancement techniques for Landsat imagery were evaluated





*Mobile drill and bit for frozen soils.*

and experimental use of other imagery systems was explored at an Alaskan site. In addition, research has addressed the specific problems of shoreline and embankment erosion in cold regions and permafrost terrain, in particular along the Tanana River in Alaska.

## *Arctic Engineering*

CRREL's Arctic engineering research program deals with the behavior of construction materials at subfreezing temperatures and with environmental engineering in the Arctic and other cold regions environments. Research was conducted on improved claddings for buildings in cold regions and on improving design, repair and maintenance of roofing systems. A miniature valve to relieve roof blisters was tested and found to work well at field locations.

A method for freeze-dewatering sludge from wastewater treatment plants was developed and a prototype sludge dewatering facility was constructed. Other environmental engineering research focused on solving operational problems at northern wastewater treatment systems, nitrogen removal from these systems, and development of on-site systems for water supply and waste treatment. Research continued on optimizing the use of heat pumps to recover energy from wastewater.

Research on placement of concrete at low temperatures concentrated on new procedures and mix designs to eliminate the need for special protection during subfreezing weather. The performance of roller-compacted concrete at low temperatures was also evaluated.

Following several years of research, a shallow snow mobility model was completed to predict the performance of wheeled and tracked vehicles in a shallow snow cover. Shock attenuation experiments in snow covers were conducted, as well as experiments to determine heat transfer rates in snow. An improved auger bit was developed for use in fine-grained frozen soils, with penetration rates greater than 5 feet/minute.

CRREL continued to develop improved procedures for construction and maintenance in areas of deep seasonal frost. Field studies and research in the newly completed Frost Effects Research Facility resulted in development of improved criteria for prediction of the response of pavement and base courses in frozen, thawing and thawed states. Methods for predicting the extent and effects of freeze–thaw cycles and frost heave were also investigated, based on analysis of heat and mass transfer in instrumented soil test sections. Foundation tests were conducted in areas of seasonal frost, with emphasis on isolated footings, unheated crawl spaces and perimeter insulation.

## *Cold Regions Test Center*

CRTC, one of three natural environment test sites under the control of the U.S. Army Test and Evaluation Command, is located at Ft. Greely, Alaska, about 100 miles southeast of Fairbanks. It performs technical testing for the Army Materiel Command developers, some joint technical-operational testing, and testing for other Defense agencies and armed services, government agencies such as NASA, and industry. The center covers over 600,000 acres of subarctic land. It has developed firing ranges (up to 50 km) and its various support facilities and instrumentation allow the testing of a variety of military equipment.

CRTC's FY 86 budget for Arctic-related activities was $1.7 million. Testing included evaluation of various types of individual clothing and equipment, tents, shelters, mine systems, mortar and artillery ammunition, chemical protective equipment, optical cables, helicopter equipment, and vehicles. Additionally, long-term surveillance of a wide variety of ammunition and missiles is ongoing.

## *Natick Research, Development and Engineering Center*

The Natick Research, Development and Engineering Center, in Natick, Massachusetts, had an FY 86 Arctic-related budget of $860,000. It is in the Troop Support Command and conducts research on cold regions clothing, equipment and rations.

### *Cold Regions Clothing and Equipment*

An extended cold weather clothing system is being developed for the ground soldier that will provide environmental protection at temperatures from +40°F to -60°F. In addition, a cold-weather aircrew clothing system will be designed to provide environmental protection during preflight, in-flight, ejection and survival situations. It will also provide flash fire protection and will be lighter and less bulky than existing items. The system will provide cold weather protection sufficient for the performance of duties at -60°F for five minutes, -30°F for 10 minutes, and +40°F for the duration of a typical aircraft mission.

An effort is being made to reduce the weight and bulk of the Army's white vapor barrier boot without sacrificing cold weather protection. New or state-of-the-art materials will be incorporated into the design. Natick will perform advanced development of a multi-purpose overboot for use in extreme cold weather. It will be 20% lighter and 15% less bulky than the current cold weather combat footwear.

In addition, Natick is developing environmentally and POL-protective handwear for use in extremely cold environments by personnel involved in fuel handling. A related effort has been the development of electrically heated prototype gloves to be used by aircrewmen at -40° or below.

*Skis have been adapted for the UH-60 Blackhawk helicopter for use in snow and on tundra.*

*All-temperature living system designed to insulate using closed-cell foam.*

Equipment being developed for the soldier in cold regions includes a 100% synthetic extreme cold weather sleeping system that is lighter and less bulky than the current system and provides four hours of rest/sleep in ambient temperatures to -60°F. In another effort an insulated canteen is being developed for use within the climatic range of -40 °F to +110 °F. Troops will be able to thaw it by direct heat application. Natick is also developing a lightweight, durable system of 12 state-of-the-art components (skis, boots, etc.) which will allow military forces to efficiently traverse ice- and snow-covered terrain.

### *Cold Regions Rations*

In extreme environments, voluntary dehydration and anorexia are problems which may contribute to decreased productivity. A current project will identify existing beverage mixes or suggest new ones that will encourage water consumption, and will suggest menu modifications to optimize food and water intake. In another project, a nonfreezing ration is being designed to be used in cold weather environments that require high caloric density for both weight and volume (4500 calories per day). There is also an urgent requirement to improve the performance of the Army Combat Field Feeding System in cold weather environments.

## *Research Institute of Environmental Medicine*

In FY 86, the Research Institute of Environmental Medicine in Natick, Massachusetts, spent $1.14 million on Arctic-related research that included:

- Development and characterization of models of cold injury that specifically identify areas of clinical management of frostbite and hypothermia.
- Cell culture modeling of cellular disabilities associated with environmental extremes; this involves the utilization of specific cell types (in particular, endothelial cells) and their response to different environmental extremes, including cold, which is directly relevant to the hospital management of hypothermia and frostbite victims.
- Structural and functional alterations induced by exposure to environmental extremes—the cellular and subcellular changes associated with environmental stress.
- Prophylaxis susceptibility in predisposing factors of cold injury, the factors that render one more susceptible to cold-related injuries.
- Treatment of cold injury—specific treatment modalities for trenchfoot, frostbite and hypothermia, and specific clinical questions concerning the rational management of these injuries.
- Psychological interventions as prophylaxis or treatment for climatic disease, involving utilization of psychological training techniques to enhance performance (e.g. increasing blood flow in the hands and feet during cold exposure).

## *Medical Research and Development Command*

Arctic-related research being conducted under the auspices of the Medical Research and Development Command, Ft. Detrick, Maryland, includes the work by the Research Institute of Environmental Medicine and contractual research projects performed by several universities. The university research is essentially investigating basic cold physiology and cold stress adaptation. The FY 86 budget for Arctic-related research totaled $960,000 (excluding funding for the Research Institute of Environmental Medicine).

*Instrumentation (Knollenberg probes) for determining snow crystal size, shape and concentration.*

## *Army Research Office*

ARO in Research Triangle Park, North Carolina, sponsors Arctic-related research that is grouped into three areas: snow, ice, and the atmosphere. All of this research is being conducted under contract with various universities and is focused on understanding the materials or processes. The total FY 86 budget for Arctic-related research funded by ARO was $840,000.

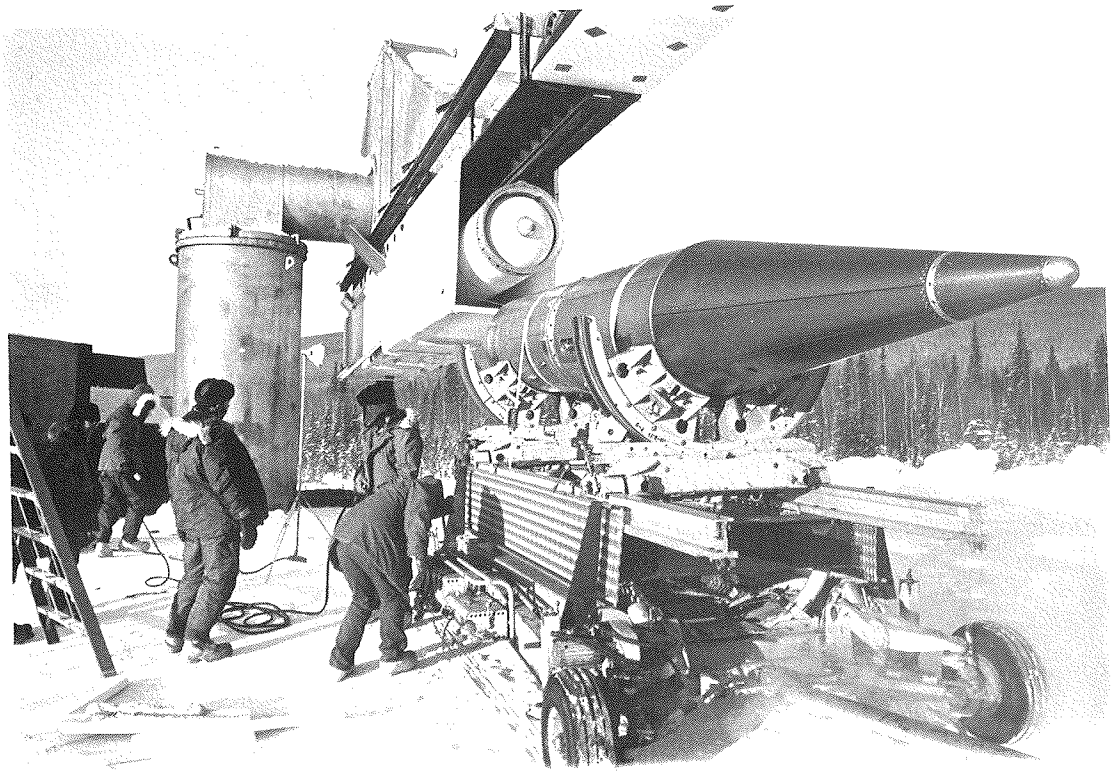
Snow research is directed toward a better understanding of high rate deformation and development of constitutive relations for the material. Ice research is concentrated in two areas: the fundamental mechanics of failure in freshwater ice, and river icing, with particular emphasis on the nucleation mechanisms and development of frazil and anchor ice. The atmospheric sciences program is concerned with propagation at near millimeter wavelengths (NMMW) under adverse weather, including snowfall. A second major thrust is development of a scientific data base and physically based models for NMMW backscatter (clutter) from snow. These projects support the mission research of CRREL and the other Army cold regions R&D activities.

# *U.S. Air Force*

The Air Force Office of Scientific Research (AFOSR) at Bolling AFB, Washington, D.C., is the single manager for basic research in the United States Air Force. AFOSR supports this research through direct contracts or grants to universities, industry sources and nonprofit organizations. In addition, it collaborates with other DOD and government research agencies to sponsor basic research at various institutions. AFOSR also funds and oversees contract and in-house basic research at Air Force laboratories, which also perform and support additional applied research activities.

Most USAF research related to the Arctic environment is in the area of atmospheric sciences. AFOSR and the Air Force Geophysics Laboratory (AFGL) at Hanscom AFB, Massachusetts, are responsible for this environmental research, which can generally be divided into lower atmosphere and upper atmosphere categories. The lower atmosphere portion focuses on the conventional meteorological processes in the troposphere and stratosphere. The upper atmosphere program primarily emphasizes the high-latitude ionized portion of the atmosphere above 50 km altitude. Most of the Arctic-related research sponsored by AFOSR and AFGL falls into this second category. Total FY 86 funding was $4.5 million for the upper atmosphere and $2.8 million for the lower atmosphere.

Most of the gravity wave research projects used some data from the very high frequency (VHF) radar at Poker Flat, Alaska. This research is concerned with propagation, momentum flux, turbulence, and transport associated with gravity waves at both high and lower latitudes. At higher latitudes and altitudes, gravity waves become particularly important because their turbulence is believed to contribute substantially to the vertical trans-



*Preparation for rocket launch at Poker Flat.*

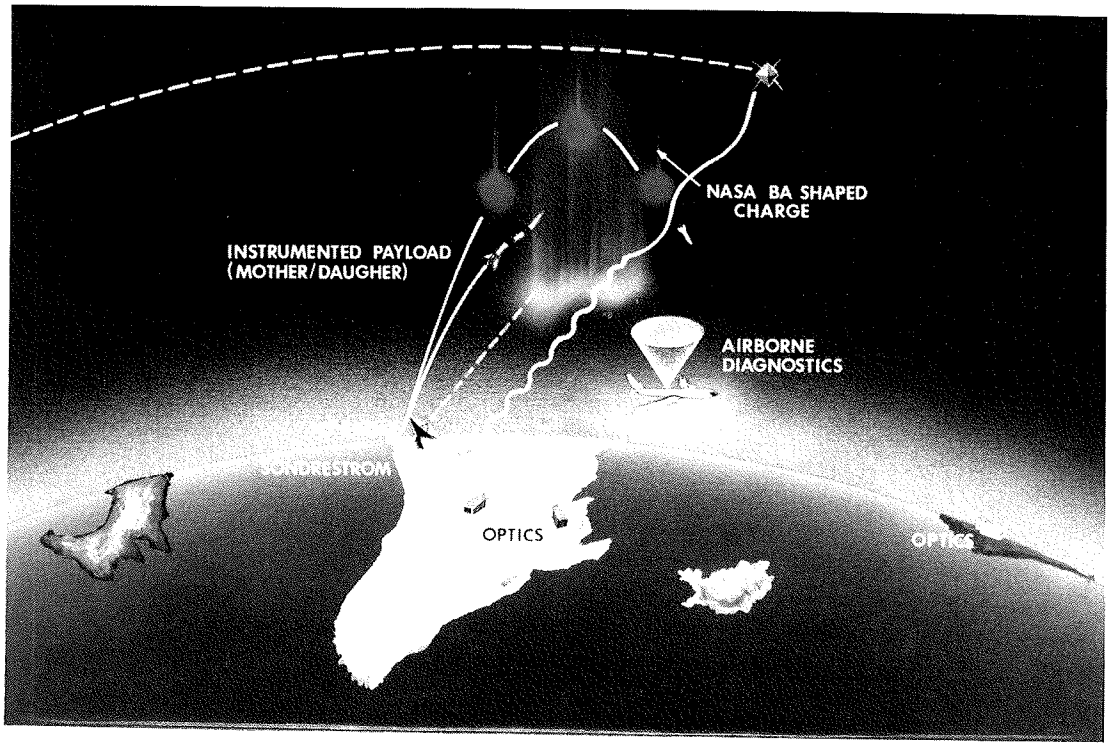
port of heat and molecular constituents in the mesosphere and lower thermosphere (50 to 100 km altitude). USAF-sponsored lidar remote sensing development has aided observational campaigns aimed at measuring the high-latitude atmosphere. Lidar measurements of aerosols and winds co-sponsored by AFOSR and AFGL are planned. Numerical efforts include research on boundary layer and radiation parameterizations for global numerical weather prediction models. These models may benefit most from enhanced parameterizations in polar regions where these physical effects appear to play such an important role.

Nearly all of AFOSR and AFGL upper atmosphere programs focus on the high-latitude, high-altitude polar environment. The parts of the atmosphere of interest include the neutral mesosphere (50 to 80 km altitude) and thermosphere (80 to 500 km), along with the ionosphere (ionized region of the atmosphere above 60 km). The reason for this strong emphasis is the environmental impact of these regions on Air Force communications, radar, and space systems.

There were ten AFOSR-sponsored programs plus a large AFGL effort dealing with these parts of the polar atmosphere. Investigators are using a variety of observational data to develop a greater understanding of the structure and processes of the upper atmosphere. High-frequency and incoherent-scatter radars, optical and infrared devices, and a number of satellite-borne sensors are providing high-quality data for the auroral oval and polar cap regions. Extensive analysis of these data is improving basic understanding of processes in these regions. These processes include electromechanical, chemical, dynamic and thermodynamic, electrical fields, currents, joule heating, emissions, ionization patches, arcs and other irregularities. This knowledge in turn is leading to new and improved analytic and predictive models used for determining or specifying the infrared spectrum and/or electron density. Some models have already transitioned from the research to the operational community.

An example of this transition from research to operations was the Ionospheric Conductivity and Electron Density (ICED) model, which began providing operational electron density profile data at the Air Force Global Weather Central in 1986. Work on this model by researchers at the National Geophysical Data Center (NGDC) in Boulder was jointly sponsored by AFOSR and AFGL. The model will continue to undergo improvements, including expansion to encompass more of the polar cap region.

Much of the high-altitude polar research sponsored by AFOSR and AFGL emphasizes coupling between the neutral atmosphere and ionosphere, between the magnetosphere and ionosphere, or between the lower and upper




*Polar Acceleration Regions and Convection Studies (Polar ARCS).*

atmosphere. Observations and models yield evidence of strong interrelationships between these regions. Many of these interactions will need to be incorporated into future analytic and predictive models.

Arctic-related meteorological research at AFOSR and AFGL is somewhat limited. In FY 86, there was only one project at AFOSR totally devoted to this area of research, with several other contracts, grants, and in-house efforts at either AFOSR or AFGL which were partially related or which had some specific applicability to the Arctic environment.

The primary AFOSR grant in this area was being carried out at Columbia University, and focused on the interaction between clouds and snow- or ice-covered surfaces. It is supportive of cloud modeling work being performed in the United Kingdom under AFGL sponsorship. The principal objective of this project is to investigate relationships and feedbacks, primarily in regions and at times when snow cover is forming or dissipating. A secondary objective is to propose improvements for retrieval algorithms used for operational snow and cloud models. The researchers are also looking at the snow cover's impact on or association with other climatic variables, potential anthropogenic climate changes, and ground stability.

During FY 86, the first year of research on this project, geographical and year-to-year variability was examined. Based on limited data sets, it appears that clouds play a significant role in the onset of the melt season over sea ice, but may be less important over Arctic lands. Other related snow-melt factors contributing to the variability included conditions of the snowpack, the surface albedo, the seasonal and latitudinal distribution of solar radiation reaching the top of the atmosphere, and the frequency and tracks of synoptic weather systems.

Other lower atmosphere research efforts are indirectly related to Arctic research and focus on atmospheric gravity waves, remote sensing techniques, and numerical modeling.

# Department of Commerce

## National Oceanic and Atmospheric Administration

*NOAA performs research and services in pursuit of its environmental monitoring and prediction responsibilities in the high-latitude regions of the planet. Individual research programs focus on special features of the Arctic environment and how they contribute to an understanding of the global system. NOAA also conducts research in support of services it performs, such as weather forecasting and fisheries management. Expenditures totaled $5.2 million in FY 86.*

### Meteorology, Climate and Air Quality

FY 86 FUNDING (thousands)

| | |
|---|---|
| Arctic Haze | 477 |
| Trace Constituents | 170 |
| Climate Modeling | 200 |
| Environmental Prediction | 340 |
| Fisheries Assessment | 2000 |
| Bowhead Whales | 1000 |
| Fur Seals | 500 |
| Sea Grant | 200 |
| Strategic Assessment | 300 |

#### Geophysical Monitoring at Remote Polar Sites

At the Geophysical Monitoring for Climatic Change (GMCC) observatories of NOAA's Boulder, Colorado, Air Resources Laboratory (ARL), measurements are made for study of the impact that atmospheric trace constituents have on climate. At four baseline observatories, located in remote and undisturbed locations far from significant anthropogenic pollution sources, continuous and discrete measurements are made of the levels, trends, and variability of atmospheric trace constituents. Of the four stations, one is in the Arctic—Barrow Observatory in Alaska. Regularly monitored quantities include carbon dioxide, total column ozone, vertical profiles of ozone, surface ozone, stratospheric water vapor, chlorofluorocarbons, nitrous oxide, stratospheric aerosols, methane volumetric aerosol scattering coefficient, condensation nuclei concentration, solar radiation, meteorological variables, and precipitation chemistry. Observations are interpreted to determine source and sink regions, global burdens, spatial gradients, and temporal trends.

#### Cooperative Arctic Buoy Program

The Cooperative Arctic Buoy Program is managed by NOAA's Office of Climatic and Atmospheric Research (OCAR), Rockville, Md., with contributions from the Canadian Atmospheric Environment Service, the Norwegian Government, the Department of the Interior, and the Office of Naval Research. The Program seeks to: 1) measure and archive the pressure field and ice velocity and their year-to-year variations, 2) investigate the relationships between atmospheric variables and ice behavior, 3) determine ice export from the Arctic Basin, and 4) improve real-time high-latitude pressure maps and forecasts of wea-

*Buoy deployment in Bering Sea ice.*

ther and ice conditions. In FY 86 the U.S. Navy began supporting an operational buoy program in conjunction with and expanding on the Cooperative Arctic Buoy Program. The data from these buoys are transmitted via the ARGOS satellite system.

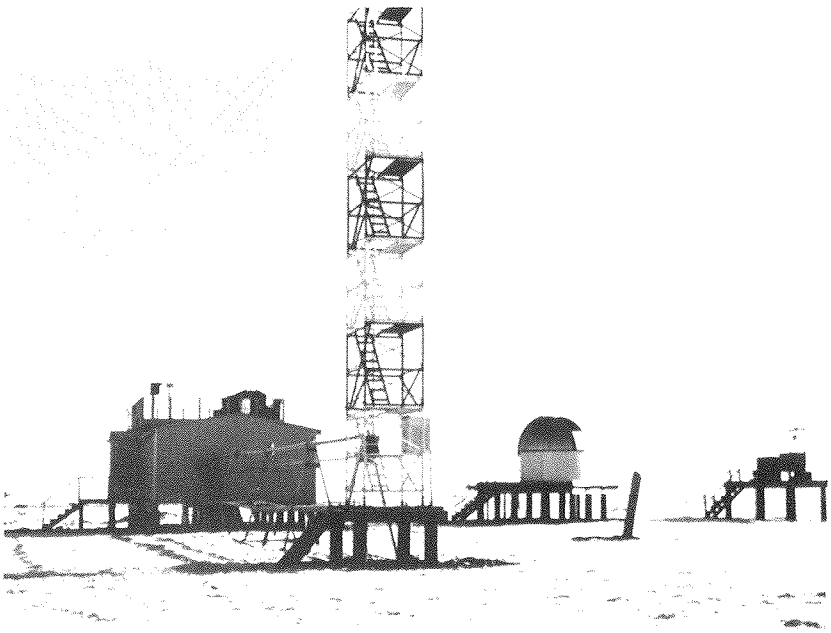
### *Cryosphere–Ocean–Atmosphere Modeling*

At NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, N.J., researchers have developed coupled cryosphere–ocean–atmosphere models to test the influence of ice sheets on the sensitivity of climate to anticipated changes in radiatively active gases such as $CO_2$. Such models are used to study a wide variety of geophysical problems, including polar ocean circulation and mixing.

### *Arctic Boundary Layer*

NOAA researchers are applying observational results and modeling techniques to improve our understanding of the Arctic atmospheric boundary layer. Arctic sea ice is heterogeneous over scales less than 10–20 km. The gust probe system on the NOAA research aircraft has been used to relate the regional wind stress field to the regional wind field over first-year sea ice. NOAA scientists have developed a second-order-closure turbulence model for the Arctic atmospheric boundary layer. The model, which emphasizes the importance of strong low-level inversions, calculates the regional wind stress from large-scale meteorological conditions and regional roughness.

*Geophysical Monitoring for Climatic Change station at Barrow, Alaska.*



### *Arctic Cyclone Expedition*

NOAA's Wave Propagation Laboratory (WPL), in Boulder, Colo., in cooperation with other NOAA components, NASA, the U.S. Navy, and institutions in Great Britain, Iceland and Norway, carried out an Arctic Cyclone Expedition (ACE) during January and February 1984. The experiments were conducted along the Arctic pack ice edge between Greenland and Norway, and were centered on the use of NOAA and NASA P-3 research aircraft. By flying over 100 hours in a dozen flight patterns, ACE sought to achieve three major objectives: 1) to measure $CO_2$ fluxes between the atmosphere and ocean in the vicinity of the ice edge, 2) to develop and evaluate the performance of numerous remote systems for sensing ice and ocean parameters, and 3) to study several Arctic weather systems that pose a major threat to fishing vessels and offshore oil operators. Analysis of data from ACE and from NOAA satellites continued in FY 85 and 86 and provided the first detailed description of Arctic mesoscale frontal structure and polar lows. In FY 87 another expedition will further investigate Arctic meteorology.

### *Arctic Gas and Aerosol Sampling Project*

AGASP is a multifaceted cooperative research program designed to determine the distribution, transport, chemistry, aerosol physics, and radiative effects of the polar air pollution phenomenon known as Arctic haze. Conceived, organized and directed by NOAA, the project involved participants from the United States, Canada, Norway, Sweden, the Federal Republic of Germany, and Denmark during two intensive field study periods, March–April 1983 and 1986. The core field research program consisted of airborne measurements tied to similar baseline station measurements at Barrow, Alaska, Alert, N.W.T., and Ny Alesund, Spitzbergen. The results of the 1983 program were published in special issues of *Geophysical Research Letters* (May 1984) and *Atmospheric Environment* (December 1985).

In the second field activity period (AGASP-II), the heavily instrumented NOAA WP-3D flew missions tied to the Barrow GMCC station, then flew to Thule, Greenland, where joint flights were conducted over the Canadian Alert station in conjunction with the University of Washington C-131 (carrying a downward-looking aerosol lidar) and the Atmospheric Environment Services (Canada)

Twin Otter aerosol physics aircraft. In the Alaska portion of the program, the WP-3D found and characterized a 50-mile-wide transport zone of pollution more dense than those observed on AGASP-I. Over Alert, all three aircraft measured up to six distinct layers of haze, which were also observed by Alert's upward-looking lidar. On other flights, the NOAA WP-3D penetrated the stratosphere over Alaska where heavy loadings of fresh volcanic debris were collected. These materials bear the same mineral signature as the debris from Mt. St. Augustine, which erupted during the first week of the AGASP-II field program.

### *Air Pollution Diffusion Over the Alaskan North Slope*

The Meteorology Division of NOAA's Air Resources Laboratory is involved in a study of air pollutant dispersal over the North Slope of Alaska. Diffusion there is determined by the very flat snow-covered surface, the presence of strong winds, the occurrence of surface temperature inversions, and the use of relatively low stacks amid isolated building complexes. In the near field, the effects of plume downwash in the lee of buildings probably dominate plume transport and diffusion. In the far field, the unique Arctic setting eventually determines plume behavior. This three-year study began in the spring of 1986 and is funded by the U.S. Environmental Protection Agency. While its general goal is to obtain a better understanding of plume transport and diffusion under Arctic conditions, the near source impact of North Slope $NO_x$ emissions has become the central concern.

## *Sea Ice and Icing*

### *The Arctic Polynya Experiment*

Researchers from NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington, conducted the Arctic Polynya Experiment (APEX) in the vicinity of St. Lawrence Island in the northern Bering Sea during the winter of 1984–85. The purpose was to investigate physical processes in the atmosphere, sea ice, and ocean, and to observe the interaction of a wind-driven polynya with regional dynamics and thermodynamics. The data are being analyzed to determine the effects on sea ice motion of baroclinic currents caused by brine rejection during the freezing of ice in the polynya, barotropic currents due to set-up on the shelf (particularly differences between the Anadyr Strait and Sphanberg Strait), internal ice stress due to the presence of St. Lawrence Island, wind stress, and Coriolis force.

### *Sea Ice Drift*

Scientists at PMEL have also been studying sea ice drift near the Bering Strait. The Bering and Chukchi shelves within 300 m of the Strait are typically shallower than 50 m. Little is known about the behavior of ice on such shallow shelves with such complicated geometry. In the previous decade, studies of ice motion in the eastern Bering Sea indicated that ice floes typically are created along the west coast of Alaska, in Norton Sound, and along the south side of St. Lawrence Island, and drift southwestward, driven by northeasterly winds, until they melt at the ice edge. Ice drift measurements taken since 1982 do not confirm this simple conveyor picture of ice motion. Instead, it appears that the Bering Sea north of St. Lawrence Island, including Norton Sound, exports ice toward the north, in the mean in some years and episodically in all years. Although the northeastern Bering Sea does not supply ice to the Bering Sea ice edge, it may be a significant source of ice for the Chukchi Sea.

### *Ice Forecasting Modeling*

A model for forecasting the extent of sea ice in the Bering Sea has been developed by PMEL scientists. It uses the NOAA National Meteorological Center (Camp Springs, Md.) spectral atmospheric model forecasts of sea level pressure and air temperature and NMC sea-surface temperature analyses to predict the balance between thermodynamic and advective processes in maintaining the position of the ice edge. Work is continuing to improve the model of water advection. The model has been run by the Navy/NOAA Joint Ice Center in Suitland, Md., and the output is used as guidance by the Alaska Ocean Service Center for operational Bering Sea ice forecasts.

### *Vessel Icing*

PMEL scientists have developed a new algorithm to relate rate of growth of freezing spray on medium-sized vessels to air and sea temperature and wind speed. Results are based on better data than those used in previous studies, rigorous statistical procedures, and the physics of icing. The algorithm predicts four times greater icing rates than previous

*Vessel icing.*

methods. The new procedures have been put into operational use by the National Weather Service and the North Atlantic naval fleet.

## *Fisheries*

### *Bering Sea Resource Assessment*

NOAA's National Marine Fisheries Service (NMFS) in Seattle, Washington, assesses stock condition for crabs and groundfish in the Gulf of Alaska and the Bering Sea. These assessments are independent of the biases inherent in fisheries statistics, and cover conditions of the multispecies community as a whole. The data serve multispecies and multidiscipline purposes (fish/fish, fish/mammal, fish/bird, fish/environment). Combined with information from the fishery itself (catch, effort, size, age, location, etc.), they result in analyses of stock condition and recommendations for management of both the fishery and its environment. The information includes stock unit identification, estimates of potential yield, contemporary condition of stocks, short-term (1–3 year) prediction of change, interaction of the separate species and groups, and response to environmental change. Populations are sampled at sea aboard NOAA ships, chartered fishing vessels, and cooperating foreign research vessels. Major surveys occur triennially in the eastern Bering Sea, the Gulf of Alaska, and the Aleutian Islands. Annual surveys are made for critical species such as king and Tanner crab. Special purpose surveys are made to reconnoiter new areas and to study processes that affect predictions.

Methodology includes bottom trawl surveys for crabs and demersal fish; hydroacoustic and midwater trawl surveys for semipelagic fish; and special-purpose sampling for eggs, larval and juvenile fish, and shellfish. Trawl and acoustic samples are expanded to provide minimum biomass estimates and analyzed to define community structure; biological samples are taken to define processes of change. Recruitment indices and processes that result in variations in abundance are studied to improve prediction. To increase accuracy and precision of assessment, NMFS conducts biological research to define recruitment processes, develops computer models to simulate the interactions and dynamics of population change, and supports contract research to improve methods and survey design.

### *Arctic Marine Mammals*

NMFS is conducting bowhead whale research that is mainly aimed at assessing the species and the impact of native take on the whale population. At the present, NMFS is cooperating with the North Slope Borough and the Alaskan Eskimo Whaling Commission in bowhead whale population enumeration and biological studies. The program's main emphasis is on collecting comparative data on recruitment rates as well as more accurately determining life history parameters, primarily by means of aerial photogrammetry and photo-identification, and by aging whales. NMFS also conducts northern fur seal research designed to determine population trends and causes for decline.

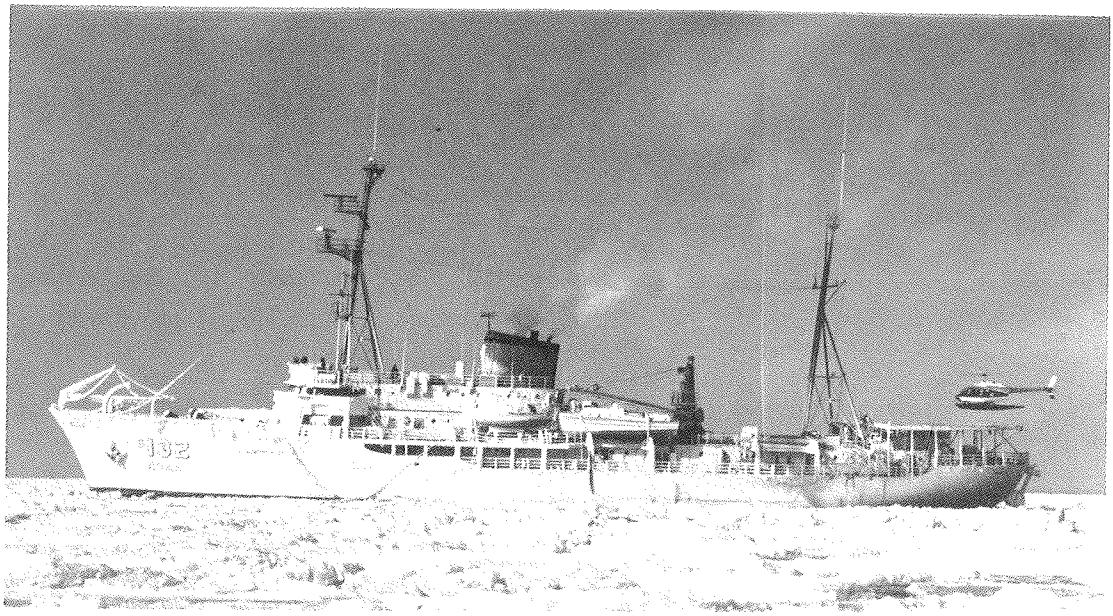
### *Bering Sea Fisheries*

The NOAA-managed Sea Grant Program sponsors various fisheries-related research projects within the University of Alaska system. These projects address topics such as interannual variability in the Bering Sea, the potential for genetic improvement of salmon, Alaska pollock feeding functions, and Alaska seafood microbiological profiling.

## *Ocean Assessment*

### *Bering, Chukchi and Beaufort Seas Data Atlas*

NOAA's Ocean Assessment Division (OAD) in Rockville, Md., has prepared a Bering, Chukchi and Beaufort Seas Data Atlas. Its purpose is to synthesize the best available information on important Exclusive Economic Zone (EEZ) characteristics for decision-



*Surveyor in Chukchi Sea*

makers. Five categories of information for the EEZ and adjacent coastal areas are included: physical environments, biotic environments, living marine resources, economic activities, and jurisdictions. A prepublication edition of the atlas to be made available in FY 87 will include 113 thematic maps and associated texts.

### *Outer Continental Shelf Environmental Assessment Program*

OAD's Alaska Office in Anchorage conducts and manages the Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP), which provides the Department of the Interior with information about the OCS environment to allow sound management decisions to be made regarding mineral development. This includes, but is not limited to, hazards, mechanisms of pollutant transport and dispersion, contaminant distribution, and effects of pollutants on regional biota and ecosystems. Most of this work is funded by the DOI Minerals Management Service (see p. 17).

## *Related Programs*

### *Fisheries–Oceanography Coordinated Investigations*

Another important program which began in the Gulf of Alaska but will extend to the Arctic is the Fisheries–Oceanography Coordinated Investigations (FOCI), which began as a separately funded program in FY 86. It is a joint effort by NOAA scientists at PMEL and the Northwest and Alaska Fisheries Center (NWAFC) to address the question of recruitment variability of commercially valuable fish and shellfish stocks of the Gulf of Alaska and Bering Sea. The long-term goal is to establish environmental indices which can be monitored and interpreted to provide useful forecasts of recruitment.

The major FOCI program for FY 86 through FY 90 is a study of the physical-biological environment of the pollock fishery in the western Gulf of Alaska called the Fisheries–Oceanography Experiment (FOX). FOX was established as the first regional study by NWAFC and PMEL because of the importance of the resource, because of the fact that the majority of pollock spawn in a small geographic area, and because recruitment variability has been monitored through five annual surveys of the spawning stock. The hypothesis of FOX is that survival of zero-age pollock is enhanced by remaining in the coastal region as opposed to being transported to the offshore Alaska Stream current.

Preliminary results from FOX show that there is large year-to-year variability in larval abundance and that these changes are accompanied by changes in the physical environment. Interannual variations in the abiotic environment will not account for all fluctuations in year-class strength. Other factors, such as competition for food and predation, particularly during early life stages, must also be considered. Furthermore, it is unlikely that a single factor in the physical environment would account for all of the fluctuations due to the abiotic environment, or that any factor has the same impact every year.

### *Solar-Terrestrial Services and Research*

A subject which has an important Arctic component but which is really global in nature is solar-terrestrial services and research. NOAA's Space Environment Laboratory (SEL) in Boulder, Colorado, provides round-the-clock, real-time forecasts and warnings of solar and space disturbances and conducts research to support and improve these services. Operated in cooperation with the U.S. Air Force Air Weather Service, SEL is the center of the Nation's solar-terrestrial services, including solar and geomagnetic monitoring and forecasts, which meet a variety of civilian, military, commercial, and Federal agency requirements.

SEL's Magnetospheric Physics Project devotes special attention to polar cap studies in its research on the dynamical processes by which material and energy are transported from the solar wind into the magnetosphere, stored, and eventually dissipated in the Earth's ionosphere. SEL has developed a preliminary computer procedure to identify the polar cap entry region for solar cosmic rays. The size of the region has been shown to be a function of particle energy, geomagnetic disturbance conditions, and local time.

Other SEL studies include research using the NOAA TIROS satellite total energy data to investigate the symmetry, or conjugacy, of the Northern and Southern Hemispheres with respect to energy input and studies of the high-latitude auroral regions in the ionosphere.

## *Operational Weather, Hydrological and Ice Services*

### *Navy/NOAA Joint Ice Center*

The Navy/NOAA Joint Ice Center (JIC) provides basic ice data, analyses, predictions and other advisory information as guidance to National Weather Service Forecast Offices with sea/lake ice forecast responsibilities. The JIC also makes information available to the research community, to private industry consultants, and to other civil interests.

Global sea ice information derived from Advanced Very High Resolution Radiometer (AVHRR) data have become the basis of many of the JIC products. In the Arctic region, the large-area JIC products are used as guidance by the Anchorage Ocean Service Center for issuance of detailed ice analyses and forecasts for the Beaufort, Chukchi and Bering Seas to support safe maritime and coastal activities.

NOAA's Program for Regional Observing and Forecasting Services (PROFS) has as its main mission the improvement of short-range weather prediction by identifying and developing advanced electronic data assimilation, integration, analysis and display techniques. An ancillary project began in 1986 to apply these tools to the ice analysis and forecasting problem and to design an interactive workstation for use in the Joint Ice Center.

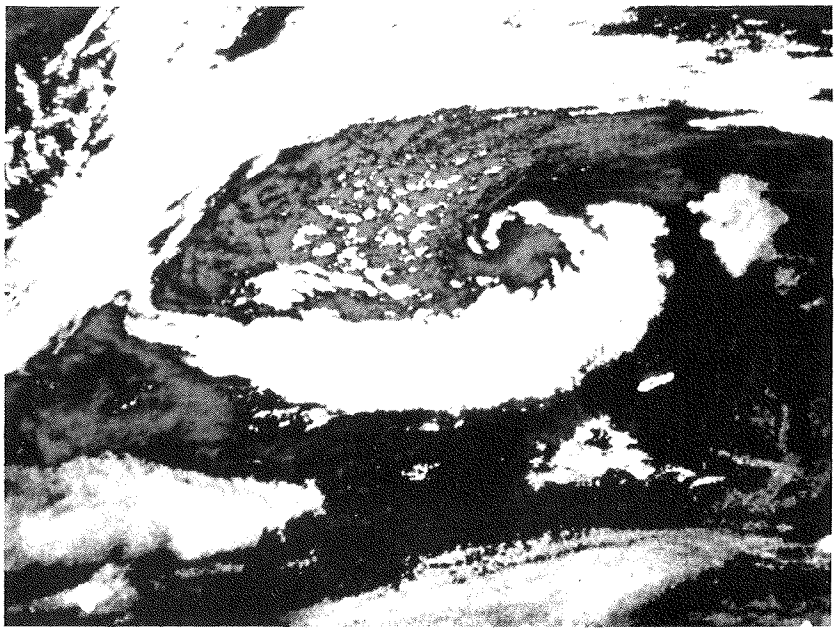
### *Weather Services*

NOAA's National Weather Service provides the general public with weather information, warnings, and forecasts covering the Nation. The Weather Service Forecast Office in Fairbanks is responsible for providing these services to the northern part of Alaska. More detailed zonal and local forecasts, as well as winter weather and coastal flood warnings, are also issued.

As part of its domestic aviation weather services program, the NWS prepares the Alaska Aviation Weather TV broadcast, which is produced in Anchorage by WAKM-TV and is carried over the Public Broadcasting System station to approximately 75 communities. The five-evening-per-week 30-minute program is oriented to aviation and meteorological education for pilots.

Hydrological forecasts and services of the NWS include river and flood forecasts, snow-

*Servicing meteorological station in Bering Sea.*



*Satellite view of polar low in the North Atlantic.*

melt and water supply forecasts, and an airborne gamma radiation snow survey to infer snow water content for hydrological forecasts. At coastal stations around the country, including Alaskan stations, NWS issues marine weather forecasts for coastal and offshore areas, as well as high-seas marine warnings and forecasts.

## *Tsunami Information*

To provide timely and effective tsunami information and warnings to Pacific communities, the NWS operates the Tsunami Warning System program. Seismograph and tide stations participate in the program. The Alaska Tsunami Warning Center in Palmer, Alaska, is operated for the protection of Alaska.

## *Satellite, Data and Information Services*

NOAA's National Environmental Satellite, Data and Information Service (NESDIS) manages the U.S. civil operational earth-observing satellite systems. NESDIS also has the basic responsibility to collect, archive, process and disseminate environmental data; to develop analytical and descriptive products to meet user needs; and to provide specialized data analyses and interpretations. As part of this overall responsibility, NESDIS collects and maintains a variety of Arctic and Antarctic environmental data sets. Another center that is of particular relevance to the Arctic is the National Geophysical Data Center in Boulder, which includes World Data Center A for Glaciology (Snow and Ice).

A valuable source of high-latitude data is the Advanced Very High Resolution Radiometer on NOAA's polar-orbiting TIROS satellites. Magnetic tape and hard copy prints of the AVHRR data are archived by the NESDIS National Climate Data Center. The Joint Ice Center is the largest user of Arctic AVHRR data. NESDIS also uses the AVHRR data to produce the weekly Northern Hemisphere Snow and Ice Charts.

A 1986 report by the Marine Board of the National Research Council entitled *NOAA Information Services for U.S. Arctic Marine Operations: An Assessment of Needs and Technology* is available from the National Academy Press, 2101 Constitution Avenue, Washington, D.C. 20418.

# National Aeronautics and Space Administration

*NASA supports diverse research programs in the Arctic that emphasize the application of air- and spaceborne technologies to studies in earth and space science. These programs, which include the study of oceans and ice sheets, space plasma physics, and land processes, were funded for a total of $8.0 million in FY 86.*

## Polar Oceans and Ice Sheets

FY 86 FUNDING (thousands)

| | |
|---|---|
| Ocean Sciences | 2727 |
| Sounding Rocket | 858 |
| Dynamics Explorer | 2900 |
| Space Plasma | 614 |
| Solar Terrestrial | 77 |
| Atmospheric Sciences | 200 |
| Land Processes | 623 |

The objectives of this program are to use spaceborne sensors to determine the characteristics of the polar ice cover and to understand how polar ice is influenced by and in turn influences the atmosphere and ocean. Specific long-range scientific goals include determining the energy flux between the ocean and atmosphere at high latitudes, identifying the processes that control the formation of intermediate and deep ocean water, measuring the mass balance of the great ice sheets, and understanding the processes which control the growth, motion and decay of sea ice.

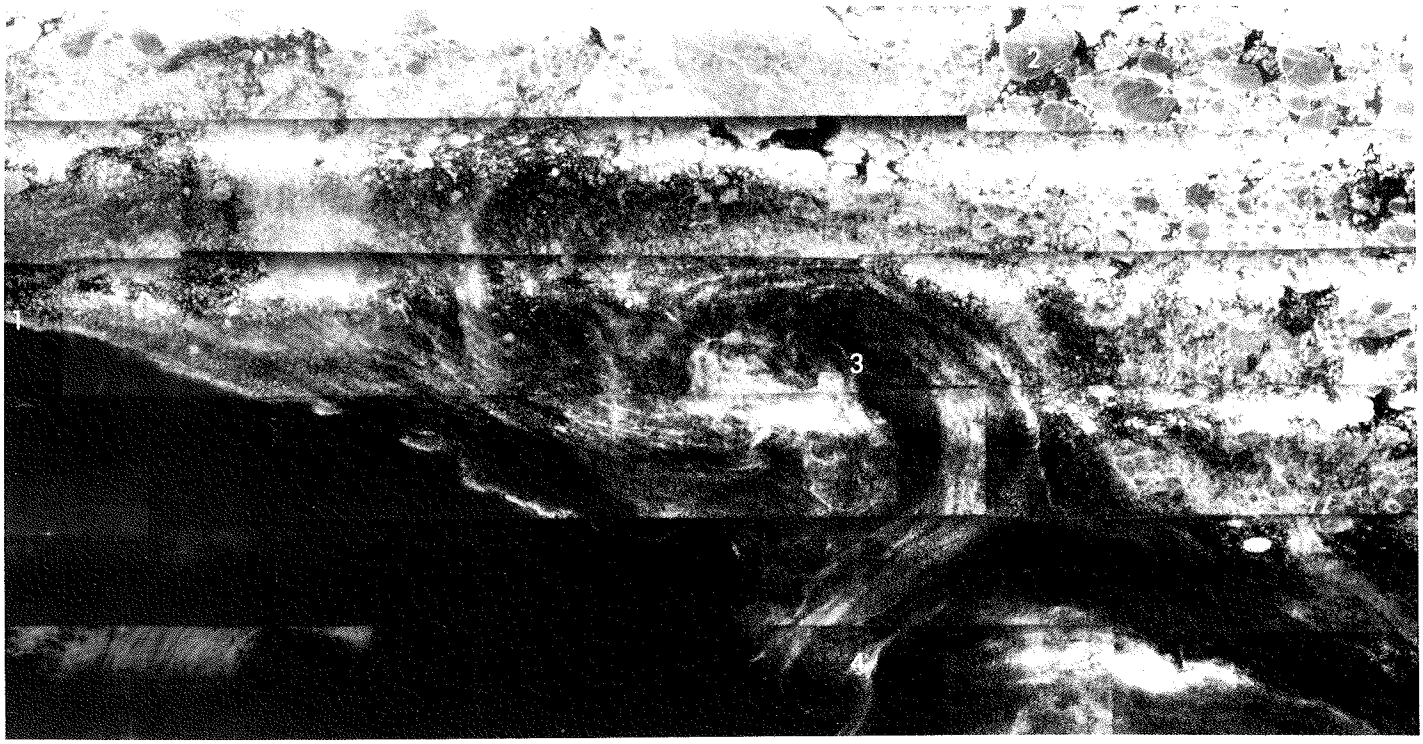
Our immediate goal is to improve our capability to measure from space the extent, type, movement and surface characteristics of polar ice cover. This involves understanding the relationships between ice morphology and electromagnetic wave propagation in order to develop algorithms to extract geophysical parameters from the satellite data. In each case, NASA has been working closely with ONR to collect and analyze surface ship and aircraft data pertaining to the scattering and emission properties of sea ice. Significant progress in this area has occurred recently, including development of a better description of how snow cover and wetness affect the microwave signature of sea ice. This work in turn will likely impact on research initiated to characterize the spring melt of the Arctic ice pack through the analysis of SMMR data.

Algorithms to exploit detailed knowledge of microwave signatures continue to mature with the successful tests and comparisons of ice concentration algorithms for both active and passive microwave data. This work is leading to a better understanding of where the two techniques can be used to produce complementary ice concentration estimates. For example, SAR may provide better estimates in areas of low ice concentration but issues remain involving the separation of ice, smooth water and wind-roughened water microwave signatures.

In May 1987 the NASA P-3 was flown over the Arctic Ocean and the Greenland Sea as one component of a multi-sensor program (including an aircraft-mounted X-band SAR commissioned by the Admiralty Research Establishment and under-ice acoustic profiles collected by a British submarine) to study the characteristics of Arctic multiyear sea ice. Onboard the NASA aircraft were passive microwave radiometers, infrared sensors and photographic equipment; most exciting was the operation of an airborne optical lidar integrated with a global positioning system for measuring surface elevation, potentially a key indicator of ice type and thickness. Preliminary results suggest that elevation of the sea ice can be measured accurately to a few centimeters.

Important work was completed by researchers from the University of Washington who analyzed the contribution of polynyas in the Sea of Okhotsk to the flow of intermediate-depth ocean water into the North Pacific. Based on ice concentration estimates derived from SMMR data and on heat flux estimated from WMO weather station data they have estimated the flux of cold, dense water produced in the polynyas and along the coast to be on the order of 0.5 sverdrup. Other research also focusing on the Sea of Okhotsk and the Bering Sea shows that fluctuation in the extent of sea ice in these areas is strongly coupled to the position of high and low pressure systems over the Aleutian Islands and Siberian coast. It is hoped that further use of satellite data to study large-scale geophysical processes will be stimulated by the recently published Arctic sea ice atlas compiled by C.L. Parkinson and others from ESMR data collected between 1973 and 1976 (see p. 66).

The Special Sensor Microwave Imager




*The marginal ice zone: 1) ice edge, 2) multiyear floes, 3) spiral eddy, 4) floes driven by current.*

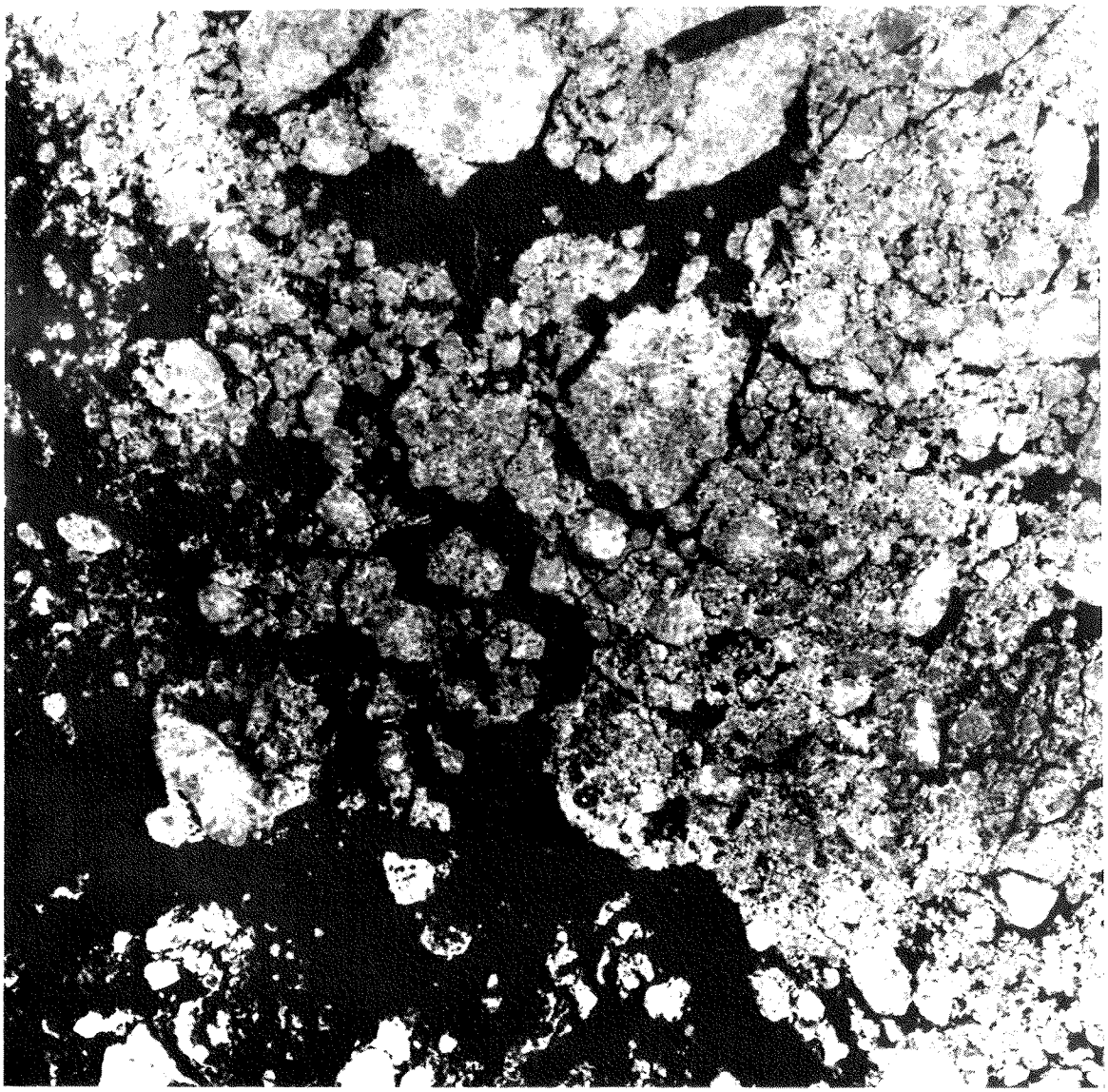
(SSM/I) was successfully launched in June 1987 as part of the Defense Meteorological Satellite Program. In an effort to make available to the polar community gridded brightness temperature data and derived products from SSM/I, NASA's Jet Propulsion Laboratory and the National Snow and Ice Data Center in Boulder, Colorado, are implementing at the NSIDC a node of the NASA Ocean Data System dedicated to archiving SSM/I data (Weaver and others, 1987). Software for loading SSM/I data and producing maps of sea ice concentration and extent is currently in place at NSIDC as part of the plan for establishing the NSIDC as the operational node for SSM/I retrospective data. In addition, a calibration and validation team has been established and tasked with: determining the degree to which the sea ice and snow parameters derived from SSM/I data meet the observational requirements of the science community; providing NASA's Sea Ice Algorithm working group with enough information for them to make recommendations for possible algorithm changes; monitoring the performance of the sensor and providing for routine checks of product quality. To facilitate the comparison of data collected by previously flown passive microwave imaging instruments, both ESMR and SMMR data are being integrated into the node and will be provided to investigators on the SSM/I grid.

Research into the utilization of radar altimeters to measure the surface topography of ice sheets is continuing, and good progress has been made in compiling elevation maps of the Greenland ice sheet using GEOSAT data. Unfortunately, comparison with similar maps prepared from Seasat altimeter data has been complicated by unanticipated orbit uncertainties. Resolution of this issue as well as a critical evaluation of the contribution of altimeters to ice sheet glaciology will be focused on by a NASA Science Working Group in 1987.

The work described above represents the efforts of many individuals; summaries of their activities can be found in the Annual Report of NASA's Oceanic Processes Branch (Code EEC, NASA Headquarters, Washington, D.C. 20546).

## *Alaska SAR Facility*

Much progress was made on the Alaska SAR Facility Project in FY 86 and FY 87 (see below). Preliminary designs for the receiving ground system and the SAR processor system were approved. A functional design of the archive and operations system has also been proposed and the details of the design will be the object of a review to be held in early FY 88. A major research highlight was the development by JPL scientists of software to mosaic individual SAR images onto a single map projection. The technique was successfully tested on Seasat data collected over central Alaska and is being transferred to the ASF in preparation for ERS-1 data.



*Arctic ice pack.*

The University of Alaska is becoming a focus for more activity as the ASF program matures. Bids have been let by the UA-Fairbanks for modifications to the Elvey Building where the ASF will be located, and current plans call for installation of the antenna system by the summer of 1988. In July 1987 the UA-F convened the first meeting of the Prelaunch Science Working Team composed of representatives selected by the Oceans and Land Processes Branches of NASA Headquarters. The group is tasked with providing and updating science requirements for the facility, developing a prelaunch science plan, and making recommendations for a geophysical processing capability to be ready at the time of ERS-1 launch. With regard to the last point, a subpanel of the PSWT has formed to look at extracting ice motion vectors from SAR data. Several promising approaches have been proposed, including methods that rely on initialization by an operator or are fully automated. Potential algorithm schemes include hierarchical correlation, feature tracking, or hybrid methods relying on aspects of both of the other techniques. Work on these algorithms is expected to continue through this winter in an effort to refine their accuracy in regions of strong shear or rotation.

Negotiations are proceeding to conclude an agreement between the Japanese Government and NASA for the acquisition of real-time SAR and optical data from J-ERS-1 at the ASF as well as access to the J-ERS-1 global data set. Pending the outcome of these negotiations, NASA plans to expand the processing capability of the ASF to include optical data, largely in support of anticipated Land Processes research.

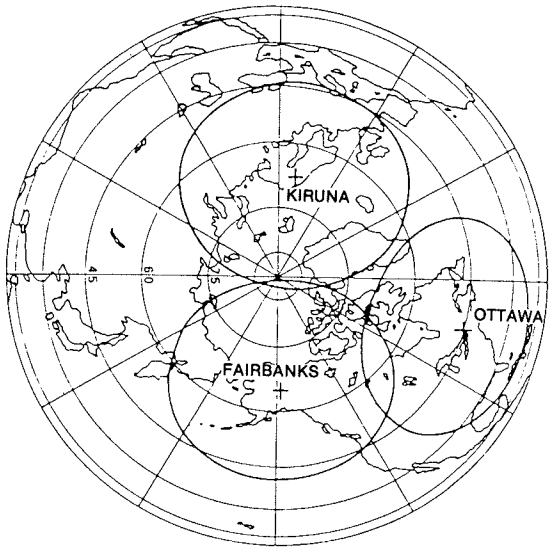
Three SAR-equipped satellites are planned for launch in the early 1990s. These are the European Space Agency's First Remote Sensing Satellite (E-ERS-1), Japan's Earth Resource Satellite (J-ERS-1), and Canada's

Radarsat. There is no provision for recording SAR data aboard E-ERS-1. Thus as data are received by that satellite, they must be transmitted in real time to ground receiving stations within view of the satellite. The J-ERS-1 spacecraft does have an onboard recording capability and offers the prospect of a global data set.

In anticipation of the needs of the U.S. research community, NASA—in concert with NOAA, ONR and NSF—has considered various general locations for a research facility whose functions would be to receive SAR data, to process these data into images, to derive geophysical products from these images, to manage an archive for appropriate products, and to serve as a focal point for a program utilizing SAR for both basic and applications research. From the collective agency perspective, research in the Arctic appears to offer greatest potential benefit through the utilization of SAR technology.

Several factors were considered in selecting a site for the facility. The consensus of the agencies was that the facility should be placed in the hands of an organization primarily interested in the application of SAR technology to solving basic and applied research problems in the Arctic. Combining this requirement with the need to maximize reach over the Arctic Ocean, the West Ridge of the University of Alaska-Fairbanks campus was considered an optimal site.

Funds to begin design and implementation of the facility were authorized in the FY 86 budget and continue through FY 89. The highlight of the facility will be a new SAR processor currently under development at NASA's Jet Propulsion Laboratory. The processor will be capable of handling data from all three satellites and processing the raw data into images in about one tenth real time. Agreements are in place between NASA and ESA for acquisition of ERS-1 data at the ASF; international agreements to acquire J-ERS-1 and Radarsat data at ASF are pending. An advanced data archive system is also under development and is being designed to facilitate access to the ASF by users from around the country. The SAR-related components of the ASF are planned to be functional in time for the launch of E-ERS-1 in April 1990.




*Approximate station masks for the E-ERS 1 satellite at Kiruna, Sweden; Fairbanks, Alaska; and Ottawa. Note the almost complete coverage of the Arctic Ocean.*

## *Space Plasma Physics*

Space plasma physics research at NASA is administered by the Space Physics Division of the Office of Space Science and Applications at NASA Headquarters in Washington, D.C. The general goal of the space plasma research program is to understand the fundamental properties of space plasmas and the complex interactive processes that control the environments of the earth, the planets and the sun where plasmas play a significant role, including the processes associated with plasma flow throughout the interplanetary medium. Emphasis is placed on solar-terrestrial physics to gain a better understanding of the plasma processes involved in the sun–earth interaction chain whereby solar variations lead to short-term and long-term changes in the environment of the earth. A major emphasis is on the terrestrial geospace system through simultaneous measurements at several locations so that quantitative models of the cause and effect processes can be constructed and tested. There is circumstantial evidence that energy input to the atmosphere in the form of energetic particles and electromagnetic fields may couple to the lower atmosphere. Evidence suggests that thunderstorm electric fields couple from the lower atmosphere into the ionosphere. Neither the downward coupling nor the upward coupling processes are well understood but these processes may be important to the overall earth system and will be studied in more detail during the NASA Global Change program. Knowledge gained from space plasma research is also applied to the interpretation of plasma processes in laboratory plasmas and in remote astrophysical systems and to the protection of technological systems. On the ground, effects such as current surges in pipe-

*Aurora over Poker Flat Research Range, Alaska.*

lines and powerlines during auroral events occur, and in space other effects take place, such as charging of telecommunication satellites in geostationary orbit due to energetic particle bombardment during geomagnetic substorms.

## *Sounding Rockets and Balloons*

Balloons with volumes exceeding millions of cubic feet carry instruments weighing several hundred pounds to near the top of the atmosphere where only a few tenths of a percent of atmospheric constituents remain. Rockets carry experiments above the atmosphere, to heights of several hundred kilometers. The experiments carried by rockets are both active and passive. Active experimental packages include electron guns designed to emit narrow beams as well as wave emission and chemical release experiments.

The scientific objectives of balloon- and rocket-borne experiments are to study the electrodynamic auroral processes, and often the experiments are coordinated with orbiting spacecraft. Experiments are also frequently designed in collaboration with international groups. For example, in one campaign the participants from Denmark and the United States studied how the ionosphere and the lower thermosphere are coupled (see below). On the average about 20 rockets and 1–5 balloons are launched annually from sites in Alaska, Canada, Greenland, northern Scandinavia, Antarctica and equatorial regions. The sounding rocket and balloon experiments specific to Arctic research are supported at an annual level of about $1 million and the participants include more than 40 different research groups from universities, non-profit institutions, and aerospace industries.

The Greenland I and II international campaigns that occurred in 1985 and 1987 included scientists from the Danish Meteorological Institute, the Air Force Geophysical Laboratory, the National Science Foundation, and NASA. Chemical tracers were used to evaluate the extraterrestrial forcing function of the upper atmosphere, and the ionosphere and magnetosphere were studied through measurements of joule heating and measurements of momentum transfer down to the mesosphere.

## *Satellite Programs*

The National Academy of Sciences has completed a study entitled *An Implementation Plan for Priorities in Solar-System Space Physics* (National Academy Press, 1985) which proposes a systematic plan of solar and space plasma physics research until 1995. It gives the International Solar-Terrestrial Physics program the highest priority and supports efforts to define U.S. contributions through the use of satellites, instruments, data handling and modeling. Planning for the program is being done with the Japanese Institute of Space and Astronautical Science (ISAS) and the European Space Agency (ESA). ISAS is developing the Geotail Spacecraft designed to explore the geomagnetic tail of the Earth. ESA continues to develop the Solar and Heliospheric Observatory (SOHO), a solar pointed spacecraft to measure basic physical processes of the Sun, and Cluster, a set of four spacecraft to study basic plasma phenomena using multipoint measurements to resolve space and time variations near magnetospheric boundaries. NASA plans to launch Geotail and one ESA mission.

*Assembling rocket at Poker Flat.*

A Cooperative Solar Terrestrial Research (COSTR) effort has already begun by which NASA will provide the necessary support for U.S. investigators on the Geotail, SOHO and Cluster missions. The next essential step to make NASA a full partner in ISTP is contained in the proposed science new start for FY 88. The Global Geospace Science Program (GGS) includes two new U.S. spacecraft to be added to the ESA and ISAS spacecraft. These new spacecraft are designed to cover the polar regions with both in situ and remote auroral imaging measurements with the Polar spacecraft and the Wind spacecraft for baseline measurements of solar wind input to the magnetospheric system. Responses of the inner magnetosphere to the various inputs sampled by SOHO, Wind, Geotail and Polar are to be measured by the Combined Release and Radiation Effects Satellite (CRRES), a joint DOD/NASA program. CRRES is described further below.

## *Operating Explorers*

Perhaps the most cost-effective spacecraft ever launched by NASA and the workhorse of Explorers is the IMP-8 satellite, now about 13 years old. It continues to function well as the only existing monitor for solar wind conditions input to the Earth's magnetosphere and it also provides a crucial baseline for missions to the other planets.

The International Sun-Earth Explorers (ISEE), launched in 1977, continue to be operational, and over 100 scientific papers per year are published based on their very rich and growing data set. These papers cover the full range of space plasma phenomena, from collisionless shocks and boundary layers to wave-particle interactions and currents along auroral field lines, which involves the coupling of the ionosphere and magnetosphere.

The International Cometary Explorer (ICE), formerly ISEE-3, intercepted Comet Giacobini-Zinner in September 1985. This was the first ever comet encounter and the orbital maneuvers involved were the most complicated ever performed by a spacecraft. ICE passed precisely through the comet's tail and provided critical data on its tail field, plasma environment and dust content. The analysis work now being done on the ICE data is a critical complement to the Halley encounters in March 1986 because none of the Halley armada passed through the cometary tail. In particular, it was learned that the ion tail model of dual lobes of opposite polarity separated by a neutral sheet was correct while dust levels were several orders of magnitude less than the predicted rate. ICE also detected waves and energetic particles millions of kilometers upstream from Halley.

The Dynamics Explorer (DE) spacecraft continues to provide unique data on ionosphere-magnetosphere interactions and auroral morphology, as well as on global airglow and ozone measurements. A special campaign of ground-based rocket, balloon, and satellite observations was carried out during April–June 1986 in which DE was a key player. Global auroral imaging of the southern pole was performed by DE, while similar imaging of the northern pole was done by the Swedish Viking polar orbiter, which was launched in January 1986. This campaign, called PROMIS (Polar Region and Outer Magnetosphere In-

ternational Study), demonstrated the utility of carefully coordinated measurements in the geospace environment, the core theme of the ISTP program.

During 1986, the Active Magnetospheric Particle Tracer Explorer (AMPTE) began its extended mission phase involving passive measurements of the inner magnetosphere. Continued analysis of observations made during the active phase has provided important tests of cometary models (which affected some plans for the Halley encounters), and plasma-field interactions in the outer magnetosphere. Ion composition measurements from AMPTE are proving to be especially important because they have demonstrated the important role of the ionosphere as a source of ions for the magnetosphere.

### *Future Spacecraft Programs*

Investigations have been selected and defined for the first tethered satellite mission, a joint program with Italy. The first shuttle-based mission will investigate the electrodynamical interaction between the 20-km tether wire and the ambient plasma. Tethered devices provide a unique tool for plasma physics experiments, and are especially applicable to space technology plasma problems such as spacecraft charging, return currents, sheath effects and induced fields, which are critical for all space vehicles, small or large.

The NASA science objective of the Combined Release and Radiation Effects Satellite (CRRES) involves the release of chemicals from 48 canisters located on the satellite. Forty of these releases will occur at low altitude and eight will occur at several earth radii distances. These active experiments are to be monitored from ground-based, airborne and satellite instruments to determine the origin, energization and flow of plasma in the magnetosphere. NASA and DOD share interest in the measurement of space radiation effects on microcircuits, which is the prime CRRES objective.

Payload development continues on the Space Plasma Lab/Spacelab mission. Instruments from Spacelab-1, Spacelab-2 and ATLAS-1 will be combined to carry out further investigations in beam-plasma and wave-particle interactions. Instrumentation developed for this mission will eventually become part of the Space Station Solar-Terrestrial Observatory.

## *Land Processes*

### *Analysis of Arctic–Subarctic Biomes*

Permafrost, or perennially frozen ground, is the dominant, controlling environmental factor in Arctic and Subarctic regions, which cover approximately 25 percent of the land surface of the world. By maintaining low soil temperatures, permafrost restricts plant growth, increases surface water runoff, inhibits groundwater recharge, and limits nutrient cycling. Research to study the real distribution, thickness, and temperature regime of permafrost utilizing Thematic Mapper satellite data has been conducted.

Satellite-derived environmental data layers, such as tree canopy cover, species composition, surface temperature, and potential incoming solar radiation, have been incorporated within a regression model to predict the areal distribution and physical characteristics of permafrost. This combination of remotely sensed data, together with geophysical borehole investigations and field observations, has provided the basis for development of new and improved nondestructive techniques for deriving physical parameters of permafrost from existing conventional and satellite-derived data.

A geographic data base incorporating Thematic Mapper (TM) satellite data was used to develop and evaluate logistic discriminant functions for predicting the distribution of permafrost in a boreal forest watershed. The data base included both satellite-derived information and ancillary map data. Five permafrost classifications were developed from a stratified random sample of the data base and evaluated by comparison with a photo-interpreted permafrost map using contingency table analysis and soil temperatures recorded at sites within the watershed. A classification using a TM thermal band and a TM-derived vegetation map as independent variables yielded the highest mapping accuracy for all permafrost categories.

### *Regional Methane Flux in Northern Latitude Ecosystems*

Recent findings of both atmospheric modeling studies and field observations provide evidence that northern wetlands may be a major source of global tropospheric methane. Current estimates of regional methane flux from high-latitude tundra and taiga ecosystems, however, are severely limited by a lack of data representing the spatial complexity and

*Permafrost terrain in valley bottoms, Poker-Caribou Creeks research watershed.*

seasonal variability of these wetlands. To this end, a stratified aggregation yielding magnitude and precision estimates of regional methane flux is being conducted. Satellite remote sensing plays a key role in the approach, providing community to regional and seasonal landscape stratifications which can be readily and meaningfully related to methane flux.

Ground observations and simulation studies in coordination with land surface stratifications based upon remote sensing are being utilized to develop a regional estimate of methane flux for the Alaskan Arctic tundra and taiga. Initial ground observations are being used to determine the magnitude and variability of methane flux along select environmental gradients known to affect the biogeochemical processes related to methanogenesis. Net methane flux is then estimated within spatial ecological strata derived from Landsat Multispectral Scanner Subsystem and NOAA Advanced Very High Resolution Radiometer data. Various estimation approaches of regional flux based upon AVHRR and AVHRR/MSS strata are being assessed through sensitivity analyses on the precision of these estimates. Ground flux measurements coupled with multitemporal AVHRR data are providing the basis for an assessment of the seasonal variability of methane flux for Alaskan Arctic tundra ecosystems.

## *Geologic Research in Arctic Regions*

NASA-sponsored geologic research in the high northern latitudes covers a diversity of topics, including integrated field, laboratory, and satellite and aircraft remote sensing studies of the Brooks Range tectonic history (Cornell University), igneous and metamorphic petrology of Greenland (Dartmouth College), geomorphology of polar landforms (Jet Propulsion Laboratory), and sedimentologic studies of the Yukon River/Bering Sea confluence (University of Alaska–Fairbanks). NASA's Alaska Synthetic Aperture Radar (SAR) Facility (ASF) at the University of Alaska–Fairbanks will provide the opportunity to obtain radar data from the European Earth Resources Satellite-1 (ERS-1) beginning in 1990, and the geology program is currently considering proposals which would use data from the ASF in studies of tectonics, permafrost, coastal processes and geomorphology in the Arctic region. Negotiations with Japan and Canada may also lead to the use of the ASF to receive data from the Japanese Earth Resources Satellite-1 (J-ERS-1) and Canada's Radarsat, adding optical, thermal, and different wavelength and polarization radar satellite data to the cadre of potential tools of study. The selection of the thermal and optical wavelengths to be flown on J-ERS-1 was made

with application to geologic research in mind. The availability of these data should be particularly useful to NASA geological studies. While the NASA Geology Program does not have a specific high latitude studies subprogram it is recognized that Arctic geology can have significant, even fundamental application to the objectives of the Geology Program, and it is anticipated that the wealth of data expected from the Alaska SAR Facility will inspire a larger number of proposals to do work in the Arctic than have been received in previous years.

## Publications

Readers may obtain further information on some of the research described in this article from the following publications:

*The Alaska Synthetic Aperture Radar (SAR) Facility Project*, by F. Carsey, K. Jezek, J. Miller, W. Weeks and G. Weller: EOS, vol. 68, no. 25, p. 593–596, 1987.

*MIZEX special issue*, edited by R.D. Muench, S. Martin and J.E. Overland: Journal of Geophysical Research, vol. 92, no. C7, p. 6715–7225.

*Arctic sea ice, 1973–1976: Satellite passive microwave observations*, by C.L. Parkinson, J.C. Comiso, H.J. Zwally, D. Cavalieri, P. Gloersen and W.J. Campbell: National Aeronautics and Space Administration, NASA SP-489, 296 p., 1987.

*Passive microwave data for snow and ice research: Planned products from the DMSP SSM/I system*, by R. Weaver, C. Morris and R.G. Barry: EOS, vol. 68, no. 39, p. 769, 776, 777, 1987.

# *Department of Energy*

***DOE Arctic research efforts included studies of the effects of landscape disturbance and carbon dioxide enrichment of the atmosphere, seismotectonics, magnetic field annihilation in the magnetosphere, energy data base management, and unconventional gas recovery methods. Funding totaled $4.7 million in FY 86.***

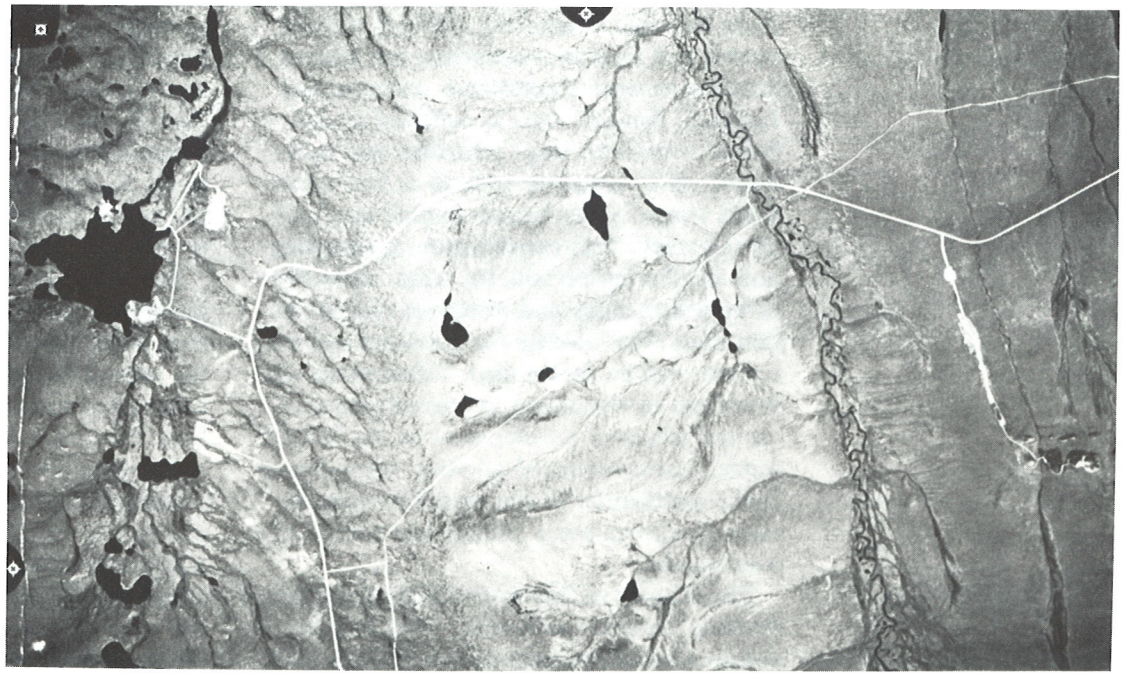
## *Tundra Ecosystem Response to Disturbance (R4D)*

| FY 86 FUNDING (thousands) | |
|---|---|
| Ecosystem Response | 1400 |
| Carbon Dioxide | 300 |
| Arctic Offshore Research | 1550 |
| Gas Hydrates | 1000 |
| Aurora Effects | 126 |
| Aleutian Seismicity | 360 |

The North Slope of Alaska is dominated by tundra vegetation, essentially all of which is underlain by permafrost. Tussock tundra covers about 80% of the 220,000 km² of Arctic Alaska, with about 40% of this area underlain by known coal reserves. Portions of the Arctic National Wildlife Refuge dominated by tussock tundra are estimated to contain 4.8 billion barrels of oil and 11.5 trillion cubic feet of gas.

The Ecological Research Division, Office of Health and Environmental Research, sponsors university research to investigate tussock tundra in order to evaluate and quantify the Response, Resistance and Resilience to, and Recovery from, Disturbances in Arctic Ecosystems (R4D program). Specific objectives are to determine effects and develop models based on ecosystem disturbances commonly created by energy development so that appropriate, cost-effective measures can be utilized to minimize deleterious disturbances; and to extend the results to other Arctic and alpine areas which are important because of likely impact from energy development. Anticipated benefits of this research include both increased knowledge of Arctic ecology and development of tools such as models for improved environmental engineering capabilities in order to minimize future disturbances, to develop mitigation techniques, and to provide environmentally sound planning of utility corridors and road routes.

Working out of the Toolik Lake research camp operated by the Institute for Arctic Biology, University of Alaska, Fairbanks, 15 investigators (from the University of Alaska, Clarkson College, University of Colorado,



*Aerial photograph of the Toolik Lake research area with pipeline and highway. Toolik Camp (see front cover) is in upper left.*

*Gauging of summer runoff from experimental watershed.*

Ohio State University, San Diego State University, University of Wisconsin, and Woods Hole Marine Biological Laboratory) are cooperating in an intensive study of tussock tundra. This integrated, ecosystem-level research program is being carried out at the R4D intensive study site in the Imnavait Creek watershed, a tributary of the Sagavanirktok River near Toolik Lake. The site is accessed via Materials Site 117 (MS-117) on the Dalton Highway, about 150 miles south of Prudhoe Bay. Components of the R4D program include intensive observations of environmental variables such as microclimate, precipitation, hydrology, and radiant energy flux.

Experimental methods, including manipulation of water and nutrient inputs along a hill slope drainage comprising fellfield, tussock tundra and riparian vegetation, are used to examine terrestrial ecosystem structure and function. Runoff water is collected at calibrated weirs with stage recorders and automated water sampling systems at first-order water tracks in the intensive study site, and on the creek. This combination of sampling and monitoring permits the water chemistry to be tied to stage and discharge records so that mass flux budgets for nutrients and major ions can be determined. Information also is utilized in evaluating the performance of various stages of development of the SLOPE model, particularly the additive, three-dimensional application of the model to estimate mass flux from water tracks, and from larger watersheds.

The ecology of Imnavait Creek is studied to develop materials and energy flux budgets, estimate autochthonous biomass and production, determine invertebrate food webs, and evaluate differences in food resources among habitats within the stream. Knowledge gained will be used to examine the effects of perturbations either to the watershed terrestrial and riparian systems, or to the stream itself.

Naturally occurring abundances of radiocarbon and the $^{13}C/^{12}C$ isotopic ratio in organisms and their food sources are used to allocate the relative importance of various origins of food in old peat, new food sources derived from terrestrial plants, and autochthonous sources in the aquatic ecosystem.

Spatial relationships between landform geometry and ecologically important factors such as snow distribution, wind direction, solar insolation, soil type and plant biomass are being established and quantified. The use of aircraft- and satellite-derived digital terrain data as input to radiation balance models for quantifying and evaluating the effects of local topography on incident radiation is being evaluated. Remote sensing techniques, combined with GIS data, and mapping are methods used to apply information and models developed for the intensive study site to other sites.

Modeling plant response to altered nutrient availability, and implementation of appropriate management practices during cleanup operations after an anthropogenic disturbance, require understanding of the processes that drive the plant-nutrient interactions. Decomposition rates are determined for organic substrates with kinetic analyses of enzymes associated with microbial decomposition. Fungal hyphae are an important component of the decomposer community that brings about the recycling of nutrients. The presence and activities of fungal catabolic enzymes present in the soil complex and loss of organic litter components are determined for experimental plots. The concentration of nitrogen per unit of organic matter in the decomposing system is followed over time.

Previous work suggests that the quality of available food is an important factor influencing rodent populations, and that change in the vegetation of disturbed habitats will probably affect small mammals through change in their food supply. Patterns of distribution and density of rodent populations along drainage areas are determined and related to changes in vegetation associated with natural and human disturbance. Models of dry heat transfer through fur predict energy available for activity, growth and reproduction in different environments.

*Sampling for invertebrates and microbiota in a small beaded stream on the R4D test site.*

Coordination among the R4D program, the North Slope Borough, the Alyeska Pipeline Service Company, and other Federal and State agencies is viewed by DOE as critical to the continuance of the program in Alaska. In 1986, program coordination activities were shared between the University of Alaska, Fairbanks, and San Diego State University. These activities included arranging permits, liaison with industry, supporting travel, field site logistics for investigators, maintaining communications, and support of planning and coordination meetings. Further information on the R4D program can be obtained from the *Newsletter of the Department of Energy R4D Program,* and from several R4D program reports. These are available from the R4D Program Manager, Ecological Research Division ER-75, Office of Health and Environmental Research, Department of Energy, Washington, D.C. 20545.

## *Response of Tundra Ecosystems to Elevated Atmospheric $CO_2$*

The Carbon Dioxide Research Division, Office of Basic Energy Sciences, is supporting research on the effects of increased $CO_2$ and climate change on Arctic ecosystems. Because of their large reserves of organic carbon and their potential sensitivity to global warming, ecosystems north of 60°N may be important to the global carbon balance due to atmospheric carbon dioxide increase. Given the potential significance of these ecosystems, it is critical to estimate their current carbon balance as precisely as possible, to improve estimates of future carbon balance of world climate changes, and to assess the uncertainty associated with these changes.

Based on information currently available, it is unclear whether northern ecosystems will provide a negative or positive feedback in the global carbon cycle with the predicted increase in atmospheric carbon dioxide. The current distribution of organic carbon and temperature of different vegetation types, and analyses of paleoclimates and stratigraphies, indicate that with increasing temperature, the organic content of the Arctic should increase while that of the Subarctic should remain about the same. Process studies indicate that with increasing temperatures, respiration will increase more than photosynthesis, while decomposition and mineralization may be temperature-insensitive. The net effect should be increasing carbon in these ecosystems.

In order to understand the potential effects of increased atmospheric carbon dioxide on the carbon balance of Arctic and taiga ecosystems it is first necessary to understand the basic processes of carbon accumulation and loss in northern systems, the rates at which these processes are occurring, and factors controlling the rates.

Research on the biological processes that regulate the flux of fixed carbon into and out of the terrestrial ecosystem of Arctic tundra is being conducted by the Systems Ecology Research Group at San Diego State University. An experimental approach has been used to provide carbon dioxide enrichment to tussock tundra plots temporarily covered with temperature-controlled, clear Plexiglas chambers at Toolik Lake, Alaska. Carbon dioxide concen-

*Experimental $CO_2$ enrichment chambers.*

trations of 1.5 and 2 times ambient levels were maintained in these small 1-$m^3$ chambers. In addition, simulation modeling approaches were used to examine and predict carbon storage changes in community structure and dynamics, and potential modifications of the distributional area of the tundra type over a longer term than that of the experimental chamber study. The intensive measurements of the field study will be used to validate the model and to extrapolate changes suggested by the experimental data. More information on this program may be obtained from the Carbon Dioxide Research Division, Department of Energy, Washington, D.C. 20545.

## *Arctic and Offshore Research (AOR) Subprogram*

The primary mission of DOE in Fossil Energy (FE) is to conduct the coal, petroleum, and gas research and development program in order to expand the knowledge base industry can use to bring efficient, economically competitive, and environmentally acceptable new fossil energy resources and technology options into the marketplace. The research and development programs are designed to enhance the use of domestic fossil fuels by encouraging diverse scientific and technological advances at all stages of the research, development and commercialization cycle. The Arctic area of the United States is one of the Nation's most promising future sources of fossil fuel.

The DOE/FE is active in those Arctic research activities that advance the technology base for recovering Arctic fossil fuels. A program to reduce the technological and economical uncertainties of recovering these resources has been developed and implemented through the Arctic Offshore Research Information System and the geoscientific research of fossil energy development in the Arctic environment. The objectives are to: 1) establish and maintain a readily accessible, high quality, fossil-energy-oriented information system to capture and present information on the Arctic that is needed for fossil energy development; and 2) provide data collection, data analysis, and research that complement those of other participating research groups for the purpose of quantifying the critical environmental forces (ice accretion, ice island movements and impacts on stationary structures, ice intrusion, seafloor stability, and sub-ice oil and gas development feasibility).

The Arctic Offshore Research Information System (AORIS) is a fossil-energy-related technology data base that will collect and assess information on Arctic/offshore characteristics. The AORIS consists of two parts, the bibliographic/management information system (containing references and informational abstracts on fossil-energy-related Arctic research) and the scientific/engineering technology information system (containing quantitative data and description of analytical models on sea ice and seafloor/soils characteristics as related to Arctic fossil resource recovery). The contractor estimates that the bibliographic/management information system will contain 4000 to 8000 citations. The first phase of AORIS will be accessible through DOE/RECON in the third quarter of FY 87, and the second in late FY 87 or mid-FY 88.

In another project, five data-gathering buoys were deployed on the largest ice islands in the cluster off Axel Heiberg Island in the Arctic Ocean to determine ice island generation and drift path prediction. The final report on determining multiyear pack ice and ridge ice thickness with airborne remote sensing techniques was completed. The work on controlling factors in the location of the ice-ridging shear zone has been completed.

*Diver resting on agitated slush ice during studies of ice rafting in the Beaufort Sea.*

## *Unconventional Gas Recovery Program—Gas Hydrates*

The gas hydrates program is designed to evaluate their potential as a future supply of gas. The immediate problem to be addressed

is to validate the extent of the resource, estimate the potential resource, and develop the economic exploration and production technology to the proof-of-concept level. Activities will focus on the development of a comprehensive technical program that seeks ways to identify, quantify and produce the gas associated with hydrate formations.

DOE/FE has completed work concerning analyses of hydrates and their identification and formation characteristics. Resources have been identified in expected locations in several areas, including the Alaska North Slope.

Project plans call for computer simulation of a field-scale, multiple well extraction process for hydrates. This activity will include the use and/or enhancement of conventional simulation models and the application of the results of hydrate physical characterization work. With the knowledge gained thus far, the first field tests were conducted on the North Slope. The tests will measure gas hydrate characteristics in place using geophysical and geochemical techniques. Industry-drilled wells are being used. The North Slope was chosen because of the industry drilling data that are available to be integrated with and help validate the data obtained. The Canadian government is interested in gas hydrates, both as a potential safety hazard in drilling operations and as a potential energy resource. A memorandum of understanding (MOU) between the U.S. Secretary of Energy and Canada concerning energy research and development has been signed. One area of potential collaboration included in the MOU is gas hydrate research. A cooperative work effort with the University of Alaska was initiated in late FY 86. This latter work will expand the evaluation of the gas hydrate potential on the North Slope.

Proceedings of the annual review meetings on gas hydrates, Arctic/Offshore Research, and deep source gas contractors are published and available (see C.A. Komar, 1986, U.S. Department of Energy, Morgantown Energy Technology Center, Morgantown, West Virginia 26507-0880).

## *Magnetic Field Annihilation in the Magnetosphere*

Plasmas in thermonuclear fusion research devices and in space around the Earth have much in common. The Earth's magnetosphere provides a unique opportunity to study some of the basic characteristics of plasmas. At the Geophysical Institute of the University of Alaska, Fairbanks, studies are conducted on the basic processes associated with magnetic reconnection, ion heating across a collisionless shock, and the generation of electromagnetic waves through electron cyclotron maser mechanisms that are taking place in the solar corona and in the magnetosphere. Energy-related geophysical problems of the Arctic region are also studied. In particular, electric currents in power transmission lines and in oil/gas pipelines, induced by auroral activity, are investigated. Such currents have been shown to cause electrical surges that interfere with operation of protective relay devices.

## *Seismotectonics of the Eastern Aleutian Arc*

The geophysical processes of subduction and arc-magnetism are investigated using seismological methods by investigators at Lamont-Doherty Geophysical Observatory, Columbia University. The purpose of the study is to obtain a fundamental understanding of convergence at a plate margin and to assess seismic risk to future energy projects in an active arc-trench back arc system. Seismotectonic information for most of the Eastern Aleutians is interpreted. In the Shumagin Islands, a 300-km-long arc segment is studied by operating a digital seismic network with 14 remote stations linked by telemetry. This segment is a seismic gap with a high probability for a great earthquake ($M > 8$) in the next two decades. Research topics include the geometry of the descending Pacific slab, velocities in the upper mantle and crust of the overriding North American plate, seismic source and strong motion properties, inversion of travel time residuals for velocity perturbations in the arc's magmatic root zone, seismic and eruptive activity of Pavolof Volcano, and the integration of these results with geodetic deformation data to investigate plate coupling.

Applications of these studies concern the geothermal energy potential of the Aleutian Arc and seismic, volcanic and tsunami hazards to offshore oil lease-sale areas directly adjacent to the Shumagin seismic gap. Technical objectives are the sensing of wide-dynamic-range seismic ground motions of small and large earthquakes for engineering applications. The seismotectonic results for the Shumagin network area are integrated with results from teleseismic and other geophysical observations from the Aleutian Arc outside the Shumagin seismic gap.

# *Department of Health and Human Services*

*Arctic health research supported by the Department of Health and Human Services is conducted primarily by the Centers for Disease Control and the National Institutes of Health through grants and contracts and totaled $1.8 million in FY 86. Collaborative studies are performed with other health care providers including the Indian Health Service, the Alaska Department of Health and Social Services, and the University of Alaska.*

| FY 86 FUNDING (thousands) | |
|---|---|
| Disease Control | 828 |
| Vaccine Evaluation | 790 |
| Cancer in Alaska Natives | 138 |

A Federal Arctic health research presence has existed in Alaska for almost 40 years, initially as the Arctic Health Research Center. The Centers for Disease Control maintains an Arctic Investigations Laboratory in Anchorage, staffed with epidemiological, laboratory, statistical, and support personnel. This facility includes two fully equipped laboratories for microbiologic and immunologic testing, a serum bank, mainframe and microcomputers, and offices. The Arctic Investigations Laboratory conducts epidemiologic and laboratory research concerning problems unique to and/or at increased rates among Alaskan Natives and other circumpolar populations. Current emphasis is on infectious diseases, including acute as well as long-term complications of infection. In addition, work is being conducted on other diseases in which epidemiologic assistance has been requested by IHS or Native health corporations. Areas of major emphasis include hepatitis B, *Haemophilus influenzae*, and *Streptococcus pneumoniae.*

Alaska Natives were among the first people in the United States to receive the plasma-derived hepatitis B vaccine. Persons of all ages and both sexes were vaccinated and are being followed to determine the need for a booster dose. This information is needed by local as well as national health authorities. Hepatitis B carriers have been identified and are being screened with alpha-fetoprotein blood tests to identify early curable liver cancers.

The National Institute of Allergy and Infectious Diseases (NIH) has an ongoing contract-supported study conducted by the University of California–Los Angeles among Alaskan Natives. This double-blind, placebo-controlled, randomized efficacy trial was begun in Alaska in December 1984 to test a new *Haemophilus influenzae* type b (Hib) protein-polysaccharide conjugate vaccine in a high-risk population of Native infants. The vaccine or placebo control is currently administered as part of a primary immunization series at 2, 4 and 6 months of age simultaneously with diphtheria, tetanus and pertussis (DTP). The study is designed to assess the protective efficacy of the vaccine in reducing the incidence of invasive Hib disease. The current activities in Alaska include educating the population and promoting the trial, recruitment, case ascertainment, immunization and collection of clinical data and serum specimens. It is anticipated that the re-

*Arctic Investigations Laboratory staff member works in village clinic to separate serum from bloods drawn for Alaska Native hepatitis B project.*

*Mother looks on as project nurse from Arctic Investigations Laboratory administers shots to baby enrolled in* Haemophilus influenzae *vaccine efficacy trial.*

cruitment of 2000 infants will be completed by the fall of 1987. No significant differences have been observed in the reported rates of local and systemic reactions between the vaccine and placebo groups. In addition, no adverse effects have been associated with vaccine administration. Efficacy and other data from the trial should be available by August 1988 and will include three years of recruitment and one year of follow-up studies. It is hoped that an effective vaccine for the prevention of Hib infections in infants will be available by 1990 as part of the routine well-baby care vaccination schedule.

Alaskan Natives are known to be at greatly increased risk for nasopharyngeal cancer (NPC), a viral-associated tumor. The National Cancer Institute (NIH) supported two research projects related to Epstein-Barr virus (EBV) and cancer. Alaskan Native cases were enrolled in the study of American NPC designed to examine the application of EBV-specific serologic markers in the diagnosis, prognosis and follow-up of NPC.

Serological testing indicated that there is a high degree of sensitivity and specificity for IgA anti-viral capsid antigen (VCA) and IgG anti-early antigen (EA) responses in NPC patients, and that this serological testing is reliable for the diagnosis of the less-differentiated forms of NPC (WHO 2 and WHO 3 histopathology). Antibody-dependent cell cytotoxicity (ADCC) titers determined at diagnosis also appear to be of prognostic value, in that patients with high ADCC titers had a better prognosis for survival. On the basis of clinical, pathological and serological criteria, a new scoring system with potentially greater prognostic accuracy than current systems has been developed that should enable the identification of high-risk patients at the time of diagnosis.

Projects are also being conducted on botulism, echinococcus multilocularis, and chronic persistent viruses. Other areas under study because of their potential association with infectious agents and/or their emergence as significant health concerns include cancer, arthritis, anemia, diabetes, rheumatic fever and rheumatic heart disease. An emphasis is placed on applied epidemiology and development of programs of prevention and control applicable to remote and isolated populations. Studies involving Alaskan Natives are not only of great importance to the Native people themselves, but have broad implications nationally and internationally.

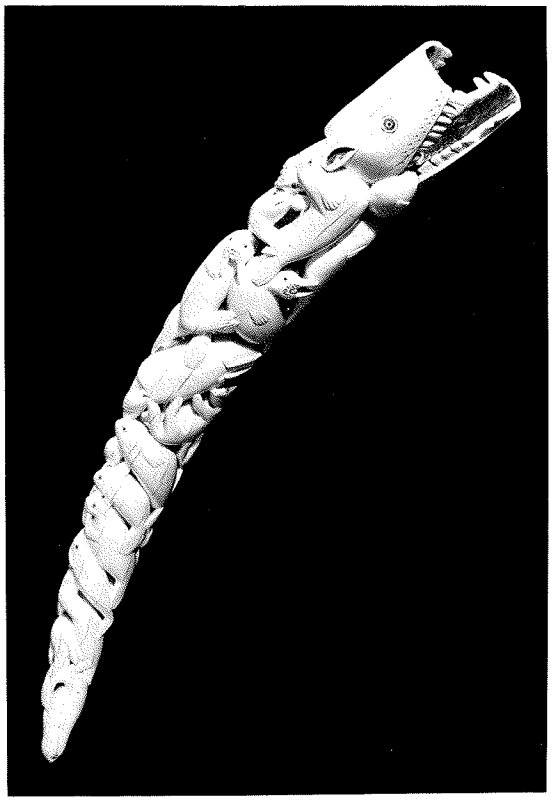
# *Smithsonian Institution*

*The Smithsonian's activities span the entire area of the North American Arctic, from Labrador and Greenland to the Pacific coast, and include the circumpolar regions of Arctic Eurasia as well. A total of $500,000 was devoted to these Arctic activities in FY 86.*

| FY 86 FUNDING (thousands) | |
|---|---|
| Anthropology | 463 |
| Biology | 56 |

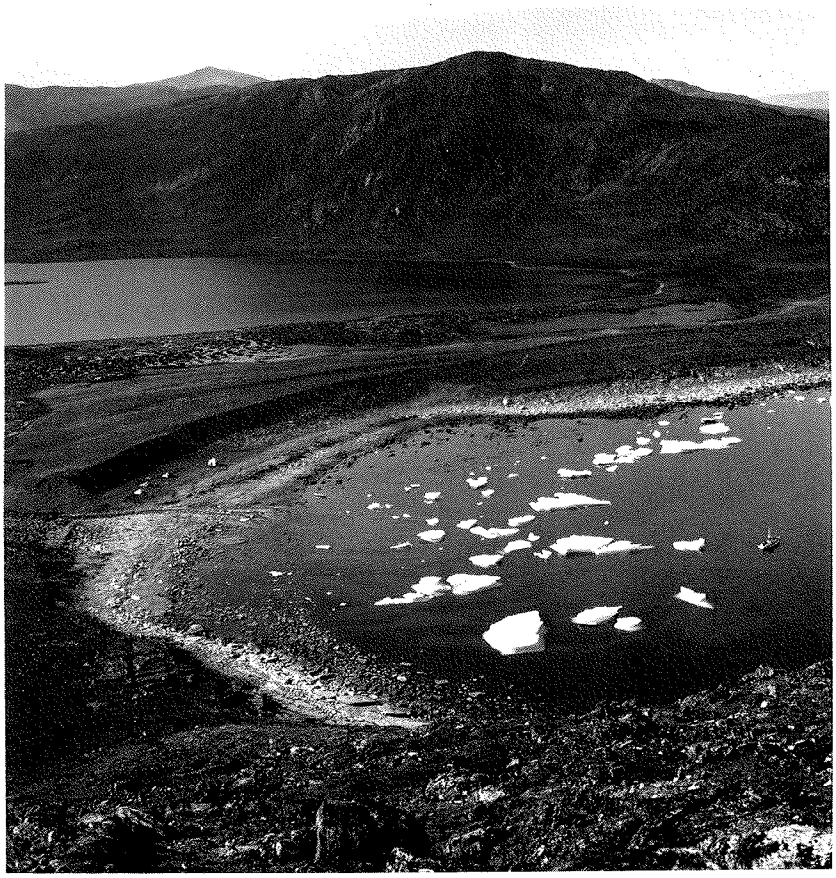
The Smithsonian Institution has a history of Arctic research that began with the search expeditions for Sir John Franklin in Canada in the 1850s and with the Western Union Telegraph surveys in Alaska in the 1860s. Out of these projects grew major natural history and anthropological programs that resulted in the Smithsonian becoming a leading organization in collection, research, publication and exhibition of Arctic subjects. Much of this work has been done in collaboration with other U.S. government agencies and with universities and foreign institutions.

The Smithsonian functions as a research and educational institution and as a repository for national collections in the fields of natural history, anthropology, art and history. A significant portion—probably 5 or 10 percent—of these collections is Arctic or Subarctic in nature, with the largest body of materials (primarily anthropology and zoology specimens) held by the Museum of Natural History's Departments of Anthropology, Vertebrate Zoology and Paleobiology. Public education on Arctic subjects has been conducted through the Smithsonian's regular and special exhibition programs and through popular books, telecommunications, lecture courses, and conferences. Because the Institution's Arctic collections, especially its Alaskan holdings, are large, systematic and well-documented, they are frequently consulted by researchers from universities and government agencies. Assistance to outside research is facilitated by fellowships, visiting scholar programs, collections, loans, and curatorial response to scientific inquiries.



## *Environmental and Cultural Dynamics of the Forest-Tundra Boundary*

Long-term research on the prehistory and paleoecology of the forest-boundary zone in central and northern Labrador seeks to understand factors influencing culture change across this environmental boundary for the past 10,000 years. During the historic period in Labrador, as in many other areas of the North American Arctic, Eskimo culture distributions have been confined largely to the tundra regions, whereas Indian cultures have been found largely in forested or transitional ecozones. Presumably, occupations by prehistoric Indians and Eskimos followed the ethnographic pattern, since this pattern is widespread throughout North America. Tests of this hypothesis involve correlating, over thousands of years, the geographic range of prehistoric Indian and Eskimo groups with the geography and timing of forest-tundra boundary and other environmental shifts. This research has involved archeological and paleoenvironmental work over a 1200-kilometer



*Nulliak Cove, a Maritime Archaic archeological site in northern Labrador.*

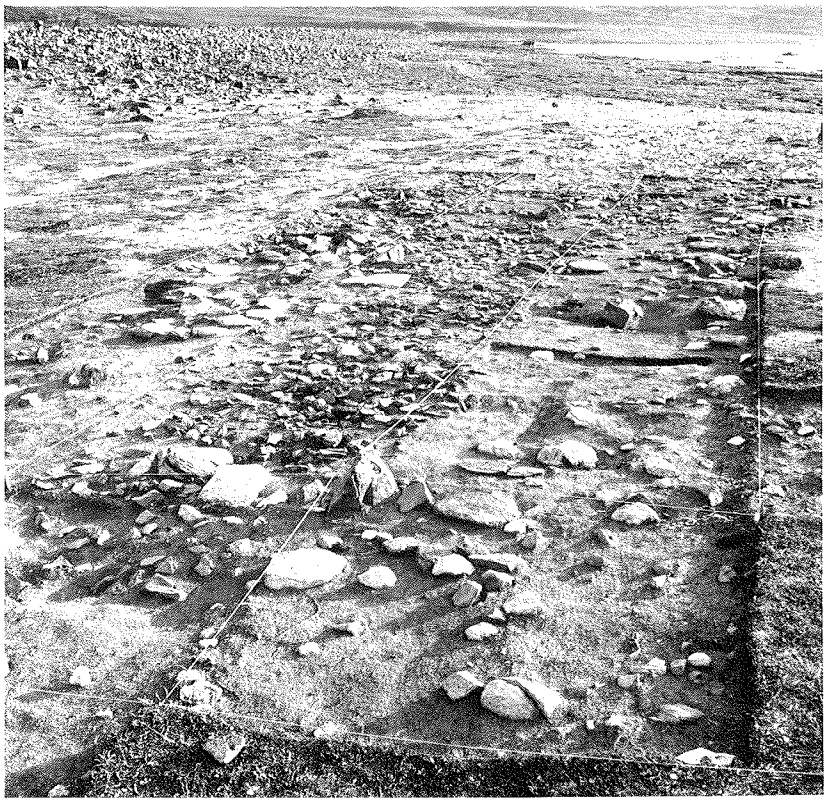
length of coast from the Strait of Belle Isle to Hudson Strait. Investigation of more than 1000 archeological sites has produced large inventories of artifacts, radiocarbon dates, and environmental samples. These have provided the basis for reconstructing an 8000-year sequence of Indian cultures and a 4000-year sequence of Eskimo cultures.

Early results indicated strong correlation between Indian northward expansions and paleotemperature rise; and Eskimo southward expansions during periods of climatic cooling were closely tuned to proxy/temperature variations in Greenland ice cores and other climatic indicators. However, except for the initial revegetation of the coast, paleotemperature seemed to have little effect on the forest-tundra boundary, which has remained relatively static in north-central Labrador for the past 4500 years. During this time major reversals and expansions and retractions of Indian and Eskimo boundaries have occurred. Preliminary results suggest that transitory phenomena—rapid, short-term weather and climatic patterns and changes in the marine systems (especially ice-related changes)—and historical and social factors such as aggression, disease and accommodation tactics all must be considered. Above all, the research demonstrates complexity and dynamism in the Labrador prehistoric cultural record and the importance of maritime adaptations as stabilizing elements in northern cultural development. Whereas many Arctic and Subarctic regions have long been viewed as culturally backward cul-de-sacs, it now appears that they require different adaptations that lead to ethnic and cultural divergence through time; that they may support complex, artistically creative cultures; and that they can produce valuable comparative insights for the understanding of hunting and gathering stage cultures for other times and regions of the globe.

## *Archeology of the Frobisher Expeditions of 1576–78*

During the course of Martin Frobisher's search for the Northwest Passage he established the first post-Norse European colony in Arctic North America. The archeological remains left behind by Frobisher's "gold" mining and exploring expeditions constitute one of the most important undocumented historic sites in North America. However, because of its Arctic location and the fact that the site was abandoned when Frobisher's ore turned out to be worthless, the site lapsed into obscurity until rediscovered by Charles Francis Hall in 1861. Nevertheless, in the 125 years since its rediscovery, no serious archeological research has been conducted, while erosion and pilfering continue to reduce the historic and scientific value of this important site.

In 1981 the Smithsonian surveyed Kodlunarn Island and recovered important archeological materials, most of which conform closely to expectations for a Frobisher occupation. Continuing laboratory study of the Frobisher materials, and of related historical documentation in England, have led to plans for a joint United States–Canadian program aimed at historic sites archeology of the Frobisher voyages and a complementary study of the effects of early European contact on Baffin Island Inuit society. It is thought that Frobisher's men and their abundant supply of material goods, greatly desired by the technologically and socially innovative Inuit, may have altered the traditional pattern of Eskimo culture development of this region hundreds of years before European interest in Arctic regions revived. These studies offer useful parallels to Inuit cultural development in Labrador and Greenland, as well as in the western



*Excavation of structure at Nulliak Cove.*

Arctic where European-Inuit relations resulted in remarkably similar patterns of culture change.

## *Archeological Surveys on Kodiak Island, Alaska*

Archeological excavations on Kodiak Island for Smithsonian began in 1931 at the large Our Point site in Uyak Bay. Hrdlicka's *Anthropology of Kodiak Island* (1944) was the first major synthesis of the archeology and physical anthropology of the region. Subsequently, the Archeological Survey of Canada conducted excavations on Kodiak and defined the general culture history of the island. More recently, a new project has been organized by Bryn Mawr College in cooperation with the Smithsonian. The Kodiak Archeological Project has developed in close cooperation with the Kodiak Area Native Association (KANA), and incorporates, in addition to archeological and paleoenvironmental research, local employment and educational programs for Kodiak Natives and local residents (Pullar and Jordan 1986).

Archeological resources on Kodiak Island are among the richest in Alaska, and their investigation is particularly urgent in that many of these sites are being destroyed by a combination of coastal erosion and tectonic subsidence. Many of these villages contain several hundred housepits. Sites at Karluk River, one of the most productive salmon fishing rivers in the world, stretch a distance of 20 miles upriver to Karluk Lake, with numerous sites around the lake itself. Radiocarbon dates reveal an occupational sequence beginning with early Ocean Bay I (ca. 5000 B.P.), and proceeding through the Kachemak (3500–800 B.P.) and Koniag (800–200 B.P.) traditions, the latter being the direct ancestors of the historic Koniag Eskimo at the time of Russian contact in 1784 (Jordan and Knecht, n.d., Knecht and Jordan 1985).

The Kodiak Archeology Project, while not in the Arctic region of Alaska, is important as one of the largest research programs currently underway in Alaska. The island's rich natural resources have made it one of the most densely populated regions of Alaska and a probable center of South Alaskan prehistoric cultural development. Strategically located between the Tlingit, Aleut and Eskimo ethnic regions, Kodiak has great potential for producing new understandings of cultural development at the confluence of a variety of different cultural traditions. In the face of severe damage by marine erosion, the pace of archeological work has quickened, and major projects have now begun in cooperation with KANA, which hopes to build a regional museum to interpret these finds and foster a better local awareness of Kodiak's unique past. The Smithsonian expects to continue to assist the Bryn Mawr and KANA efforts through use of its Hrdlicka collections and Native American Museum Training programs. The Kodiak project is an excellent model of collaboration between anthropologists and Native peoples in scientific research and public education that can have important rewards for all concerned.

## *St. Lawrence Island Site Assessment Survey*

The archeological resources of St. Lawrence Island are among the most important in North America bearing on the question of Eskimo culture origins. Situated at an Arctic crossroads between Siberia and Alaska, St. Lawrence Island Eskimos have thrived in large villages supported by one of the richest Arctic ecosystems in the world. The remains of their houses, food, tools, and burials (including tattooed bodies) are frequently found in pristine condition, preserved by permafrost. In

*Stone house foundation at Late Punuk Eskimo site at Meregta, St. Lawrence Island.*

the 1930s and 40s archeological work in the deeply frozen midden sites was pioneered by Smithsonian archeologist Henry Collins, who used these finds to reconstruct a 2000-year record of Alaskan Eskimo cultural development that revealed astonishingly high levels of artistic achievement by ancient Okvik and Old Bering Sea cultures. Numerous archeologists followed in Collins' pioneering footsteps to further develop the prehistory of St. Lawrence and nearby Punuk Island.

In 1984, the Smithsonian undertook a survey of St. Lawrence Island sites to assess their state of archeological preservation in the face of growing damage at the hands of Native excavators seeking artifacts for sale on the international art market. An inventory of major sites was conducted in cooperation with the St. Lawrence Island Native Corporation and documentation was gathered on site size and state of preservation (Crowell 1984, 1987).

Following this survey the Smithsonian attempted to reach agreements with the St. Lawrence Island people to find ways to reduce the mining of sites and to promote the cultural and educational values of the island's archeological resources. Cooperative excavation proposals included provisions for Native retention of recovered ivory stock for sale to the contemporary carving market, with preservation of prehistoric artifacts and other archeological data in local musuems or other suitable repositories. To date, however, these efforts have not met with support from the financially hard-pressed residents, who resist outside interference in what they consider a local prerogative, the sale of their ancestors' artifacts to meet the people's modern needs. Concerted effort is needed to find a solution to this cultural tragedy before the island's unique history has been irrevocably lost. Future St. Lawrence Islanders may find themselves having to turn to Soviet archeologists working at better-protected Siberian sites for a view of their past.

## *Special Exhibitions*

In 1983 an ethnographic exhibition, "Inua: Spirit World of the Bering Sea Eskimo," based on the collections made by Edward W. Nelson in western Alaska in 1877–1881, opened in Washington (Fitzhugh and Kaplan 1983). The show was accompanied by an interpretive catalogue of the Nelson collection and republication of Nelson's monograph, *The Eskimos About Bering Strait*. The show traveled to six other cities in North America, including Juneau, Fairbanks and Anchorage. A small "mini-Inua" version of the exhibit was circulated to Alaskan villages and Native museums by the Alaska State Museum. Subsequently, this exhibit toured in Arctic Canada courtesy of the Prince of Wales Northern Heritage Center. In 1987 it toured Greenland. A new version of "Inua" is being prepared for circulation in Europe under the auspices of the U.S. Information Agency Arts America Program.

A second major exhibition currently being developed concerns the history and anthropology of the North Pacific. This show, "Crossroads of Continents: Cultures of Alaska and Siberia," is being prepared in collaboration with the Institute of Ethnography of the Soviet Academy of Sciences, under the auspices of the International Research and Exchanges Board of the American Council of Learned Societies. "Crossroads" will open at the Smithsonian's Museum of Natural History in September 1988 and will subsequently tour Seattle, New York, Anchorage, Los Angeles, Indianapolis and Ottawa, and will travel to the U.S.S.R. for venues in Moscow, Leningrad and other cities with the assistance of the U.S.S.R. Ministry of Culture. Catalogues, scholarly symposia, films and other programs accompany this historic joint U.S.–Soviet enterprise.

## *Biological Programs*

Since the middle of the last century, Smithsonian scientists have been studying the fauna

*Rack support post of whalebone at Meregta.*

and flora of Arctic regions, particularly in Alaska. Many survey expeditions were conducted, especially in the latter part of the last century and the early years of the present one. These resulted in large documentary collections of Arctic plant and animal specimens that today rank among the most important in North America. Substantial resources are devoted annually to the care of these collections, which continue to serve scholars at large as a basis for systematic and evolutionary studies of the Arctic biota. Limited survey and other biological research has been conducted in recent years, but a new effort is being made to resume active Smithsonian work in the Arctic.

Since the early 1960s several botanists have been actively engaged in Arctic taxonomic studies, producing taxonomic revisions of Arctic lichens, and studying the evolutionary radiation of the harebell complex (*Campanula rotundifolia* complex, family Campanulaceae) in Arctic/Subarctic Alaska and Canada and in Eurasia as well. The latter included surveys of the flora in the Brooks Range, Alaska. Work on this project will be renewed in the near future. Study of the systematics and evolution of Arctic rodents has been ongoing for many years in the Alaskan Arctic/Subarctic, the Yukon Territory, and parts of the Soviet Union.

In addition, the Smithsonian Oceanographic Sorting Center has provided curatorial support for the National Science Foundation to sort and distribute collections of marine organisms obtained by American scientists on Arctic research cruises. It is expected that this work will continue on behalf of the scientific community at large.

## *New Initiative*

The Smithsonian has developed plans for creating a center for Arctic anthropological and biological research to further research exemplified by that of Henry Bascom Collins, who died on October 21, 1987. This program seeks to redevelop research initiatives that have lapsed during recent years through the attrition of resources and personnel devoted to Arctic studies, particularly in Alaska. In addition to adding professional and technical staff, the program calls for funding exhibition development, collections acquisition, Native American museum and research training, scholarly fellowships and symposia, publications and other activities. It is anticipated that the Museum will be able to establish its proposed Center for Arctic Studies in Anthropology and Biology in FY 88, on the basis of new Federal and private money now expected.

## *Publications*

*Archeological survey and site condition assessment of St. Lawrence Island, Alaska*, by A.L. Crowell: Office of History and Archaeology, Anchorage, 1984.

*An archeological survey of Uyak Bay, Kodiak Island, Alaska*, by A.L. Crowell: Office of History and Archaeology, Anchorage, 1986.

*The economics of site destruction on St. Lawrence Island*, by A.L. Crowell: The Northern Raven, vol. VI, no. 3, p. 1-3. The Center for Northern Studies, Wolcott, Vermont.

*Inua: Spirit World of the Bering Sea Eskimo*, by W.W. Fitzhugh and S.A. Kaplan: Washington: Smithsonian Institution Press, 1983.

*Cultures in Contact: The European Impact on Native Cultural Institutions in Eastern North America, A.D. 1000-1800*, by W.W. Fitzhugh (Ed.): Anthropological Society of Washington Series (Arctic chapters). Washington: Smithsonian Institution Press, 1985.

*Archeological research on western Kodiak Island: The development of Koniag culture*, by R.H. Jordan and R.A. Knecht: In Aurora. Anchorage: Alaska Anthropological Association, n.d.

*Nunakakhnak: A historic period Koniag village in Karluk, Kodiak Island, Alaska*, by R.A. Knecht and R. Jordan: Arctic Anthropology, vol. 22, no. 2, p. 17-35, 1985.

*The Kodiak archaeological project, 1983-86: Perspectives from the Native association and the principal investigator*, by G. Pullar and R. Jordan: The 5th Inuit Studies Conference, Montreal, 1986.

# Department of Transportation

*The Department of Transportation conducts polar marine transportation research. Coast Guard icebreakers support governmental and nongovernmental research, both in the eastern and western Arctic, and perform sea ice and iceberg reconnaissance. A total of $400,000 in direct research funding was expended in FY 86.*

## U.S. Coast Guard

### Icebreaker Operations

DOT FY 86 FUNDING (thousands)

| | |
|---|---|
| Arctic Pollution | 200 |
| Marine Transport | 210 |

During FY 86 the U.S. polar icebreaker fleet was employed in all routine polar operating areas: the Antarctic, the western Arctic, and the eastern Arctic. There were two deployments to the western Arctic. U.S. Coast Guard cutter *Polar Sea*'s Arctic West Summer operations in the Beaufort/Chukchi areas under Maritime Administration sponsorship were concluded during October. They entailed ice ridge profiling and ice-impact global load data collection. A spring Arctic West Winter deployment to the Bering Sea was conducted by USCGC *Polar Sea* under U.S. Navy sponsorship. This project involved ship mechanics interaction with ice in the marginal ice zone (MIZ) and anti- and de-icing methodology. A series of wave buoy deployments and CTD casts were also conducted.

The annual icebreaker support for Greenland resupply was provided by USCGC *Northwind*. Data in support of the U.S. Navy Biological Environmental Arctic Project were obtained by ship's personnel using equipment installed prior to the ship's departure.

*U.S. Coast Guard Polar Class icebreaker viewed through a first-year pressure ridge in the Arctic.*

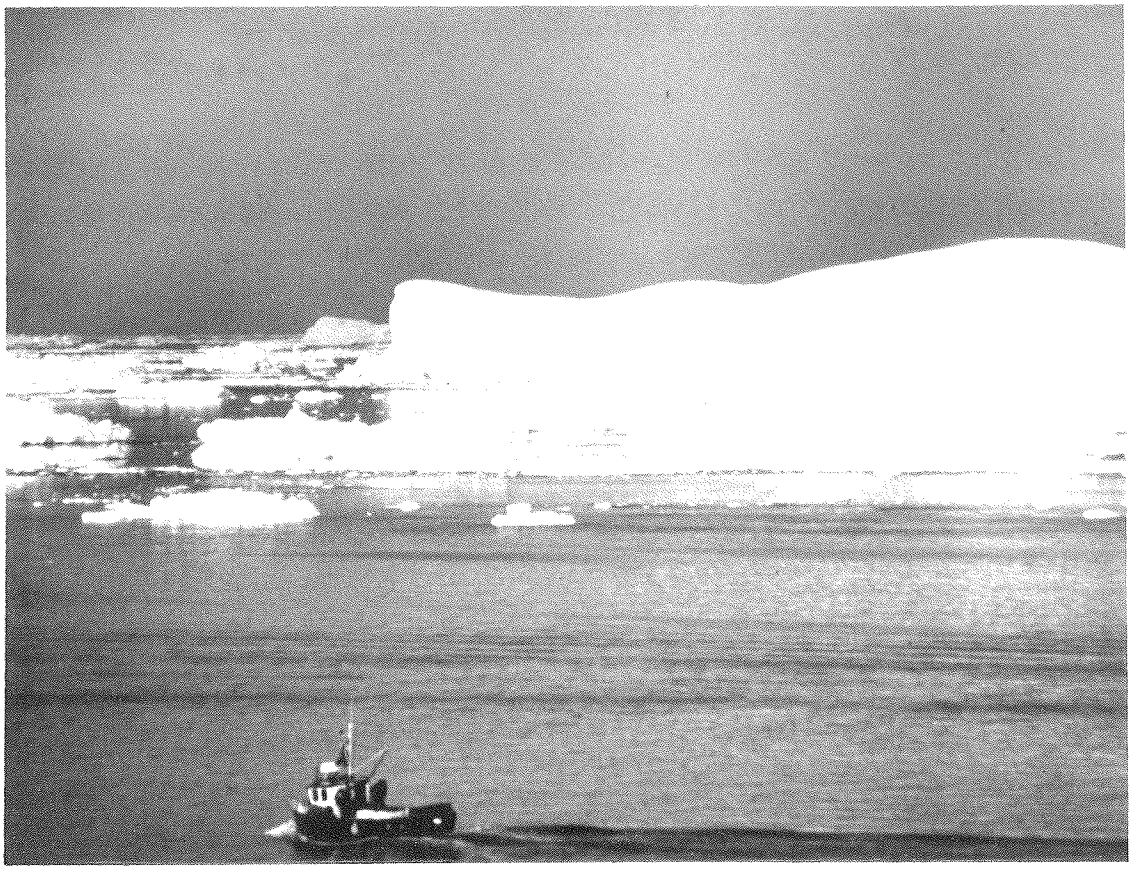
Funding of icebreaker time is a major factor in deployment planning. There are three basic daily cost categories to the user: transit costs, operating costs, and surcharges (for ship maintenance and helicopters). All dedicated-time users during a given deployment share transit costs. "Piggy-backing" projects during a given time frame allows the sharing of operating costs and surcharges as well. The mutual benefits of such arrangements have been demonstrated. For general information the estimated 1988 costs of icebreaker time are provided below.

| | *Avg daily fuel consumption (gal.)* | | *Daily surcharge (1988)* | |
|---|---|---|---|---|
| *Class* | *Transit to project area* | *Operating in project area* | *Maint.* | *Helicopters* |
| Polar | 13,400 | 11,500 | $4670 | $1525 |
| Wind | 6,000 | 5,000 | $3530 | $1525 |

It should be noted that heavy icebreaking increases the operating fuel consumption. (FY 88 government fuel price is $0.65/gal.)

### Sea Ice Reconnaissance

The U.S. Coast Guard supports studies to improve icebreaker navigation in sea ice through the acquisition of remotely sensed data for route planning and ice plotting. At present U.S. polar icebreakers rely primarily on visual reconnaissance from onboard helicopters. Due to helicopter flight restrictions, information is limited spatially and temporally, and is more qualitative than quantitative. These studies assess the value of remote sensing systems in saving icebreaker time and fuel, reducing wear and tear on the vessels, and lessening the chance for besetment in ice.



*Fishing boat and icebergs at Jakobshavns, West Greenland.*

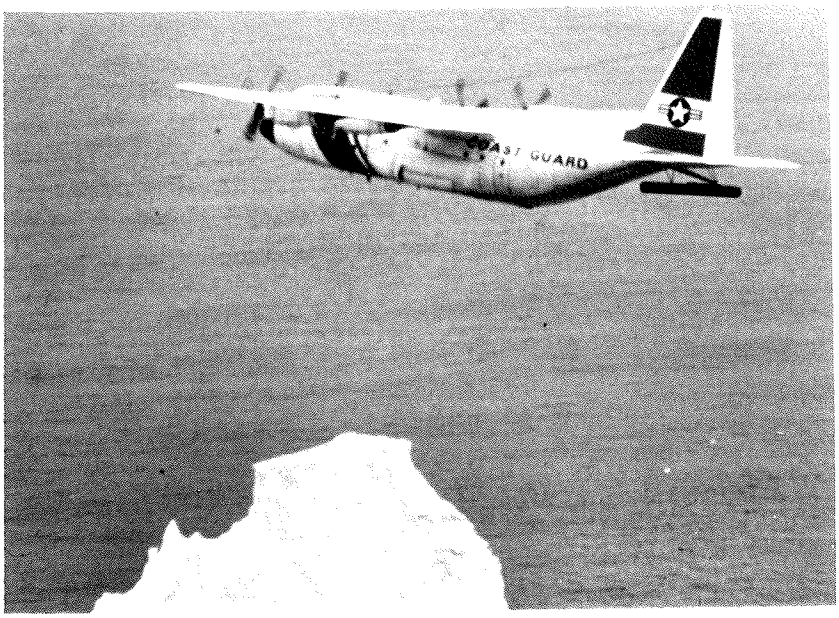
A 1984 pilot project involved a single overflight of the USCGC *Polar Sea* in late November when it was beset in a shear-zone pressure ridge near Point Barrow. This project utilized the Intera Ltd. STAR-1 system to create synthetic aperture radar (SAR) images of the sea ice in the vicinity of the icebreaker. The film was processed on board the aircraft and air-dropped at the end of the flight. The icebreaker used the imagery to navigate through the ice after freeing itself from the pressure ridge.

In an effort to define the operational parameters of a processing system for a planned spaceborne remote sensor with application to sea ice reconnaissance, an ERS-1 (European Remote-sensing Satellite) preflight experiment is planned in conjunction with the Arctic Summer West 88 deployment of a Polar Class cutter to the Chukchi and Beaufort Seas in the fall of 1988. The icebreaker will provide ground truth support to a multiagency, multinational experiment team for microwave remote sensing aircraft overflights. Investigators will study the electromagnetic signatures of sea ice and snow during the freezeup period (late September to early October) to shed some light on the ice classification ambiguities that are normally found at this time of the year. ERS-1 preflight experiments are needed to enhance the operational utility of the data that will be available at the Alaskan Synthetic Aperture Radar Facility in 1990/91.

## *Iceberg Reconnaissance*

The U.S. Coast Guard's International Ice Patrol (IIP) participated in BergSearch '84 to assess the ability of airborne imaging radars to detect icebergs in open water. BergSearch '84 took place from 2–7 April 1984 in the Grand Banks region off Newfoundland. Five U.S. and Canadian aircraft plus one research vessel participated in an effort to quantify the ability of a number of different aircraft imaging radars to detect icebergs of all sizes in sea states from low to moderate. Data were collected on the probability of detection for each of the radars for a common target area, as well as for repeated passes over the same target by each radar. Efforts were made to find a reliable method for discriminating between icebergs and vessels. Additional work in the 1985–86 ice patrol season with the AN/APS-135 Side-Looking Airborne Radar increased the data base on probability of detection.

More studies on the detection of icebergs in sea ice took place in March 1987 in conjunction with the Canada–U.S. LIMEX-87 project in the Labrador Sea.



*U.S. Coast Guard SLAR-equipped HC-130 participates in iceberg detection experiments.*

## *Arctic Pollution Response*

Under the Clean Water Act of 1977 and the National Oil and Chemical Substances Contingency Plan, the Coast Guard, as Federal On-Scene Coordinator (OSC), is responsible for effectively directing pollution response operations for any oil spill which occurs in the coastal waters of the United States, and for initiating Federal response operations when the spiller fails to take effective action. The discovery of oil and gas along the Alaskan coast has led to exploration and development onshore, and if the price of crude oil rises offshore drilling on the continental shelf is certain to increase rapidly within the next several years.

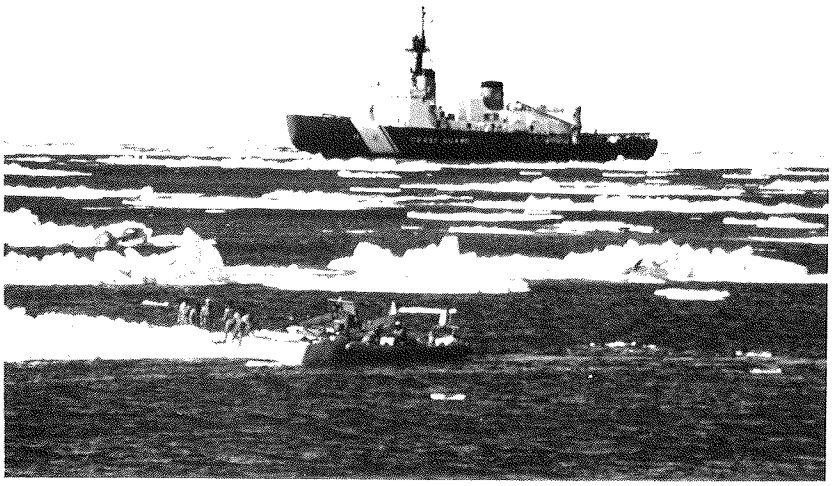
The objective of the Arctic Pollution Response project is to develop methods to detect and monitor oil spills in Arctic and Subarctic Alaska and investigate countermeasures and cleanup technology for ice-infested regions to ensure Coast Guard expertise as Federal On-Scene Coordinator. The current effort focuses on the Coast Guard's role as spill response monitor, as industry is developing a significant response capability in this region and will probably handle the actual cleanups. Efforts are being made to provide a standby Coast Guard capability to handle those spills where the oil industry does not have a direct responsibility, as in an offshore tanker spill.

The technical approach for this project is to divide the tasks into groups according to the response functions being addressed, i.e. spill behavior and trajectory forecasting, detection and surveillance, and countermeasures and cleanup.

The first group of project tasks is directed toward understanding and predicting the behavior and movement of oil spills in an Arctic environment, particularly in the offshore regions of the Beaufort Sea. This work is being carried out primarily at the Coast Guard Research and Development Center at Groton, Connecticut. Several basic research efforts have been completed on oil weathering in the Arctic, oil spreading and movement in broken ice, oil pooling under ice, oil spill movement under open water conditions in the coastal regions of the Beaufort Sea, oil spill movement in the offshore regions of the Beaufort Sea, and dynamics of ice breakup in Prudhoe Bay. An environmental atlas for the North Slope region has been compiled that covers the general oceanography and meteorology of the region. These studies have been used to develop: 1) a short-term model for predicting oil spill physical behavior (spreading, vertical migration, weathering, etc.) and oil spill movement in Prudhoe Bay and coastal areas of the Beaufort Sea, 2) a bulk transport model to predict long-term movement of an oil spill entrapped in an ice pack in the offshore regions of the Beaufort, and 3) an operational field guide on oil spill behavior and movement to assist Coast Guard personnel in determining optimal cleanup strategies for spills in ice-infested waters. Future efforts will focus on completing environmental atlases for Norton Sound, Bristol Bay, Bering Sea and Chukchi Sea.

The second group of project tasks focuses on developing techniques to detect oil spills in an Arctic environment, define the extent of contamination, and monitor subsequent movement. Specific research topics include techniques for detecting oil under ice, electronic and visual techniques for tagging and tracking oil spills in ice, and airborne surveillance systems for monitoring the extent and movement of spills in ice. Efforts to date have focused on detecting oil under ice using electromagnetic and acoustic methods, and investigating the use of satellite-tracked buoys to tag and monitor the movement of oil spills in ice.

The third group of project tasks comprises cooperative efforts with other organizations to test and develop Arctic oil spill countermeasures and cleanup equipment. The emphasis is not on developing new equipment for Coast Guard use, but rather on defining and being familiar with state-of-the-art technology in order to better meet spill response monitoring and contingency plan review responsibili-



*U.S. Coast Guard icebreaker support of marginal ice zone studies in the Arctic.*

ties as Federal On-Scene Coordinator. Specific efforts include: 1) developing a Countermeasures and Cleanup Field Guide that recommends specific methods, systems and equipment for the containment and cleanup of oil in the situations described in the Spill Behavior Field Guide, and 2) cooperative testing with other interested parties such as Canadian AMOP (Arctic Marine Oilspill Program) and ACS (Alaskan Clean Seas).

# *Maritime Administration*

## *Arctic Marine Transportation Program*

The Maritime Administration by law and tradition is the Government agency most concerned with the adequacy of the U.S. merchant marine, the supporting shipyards, and other infrastructure necessary to meet national needs. As such it assumed a lead role in coordinating a program to facilitate the development of new marine transportation systems for the Arctic.

As development expands in the Arctic regions, the need for operational data on which to base criteria for the design of marine transportation systems has become increasingly important. For commercial Arctic marine transportation to become a viable alternative in the future, the problems experienced by the Polar Class icebreakers must be addressed and solved. To address these problems the Arctic Marine Transportation Program was initiated in 1979. The U.S. Coast Guard has been a major cosponsor, providing direct funding as well as the use of the Polar Class icebreakers as research platforms. Other sponsors of this program include the U.S. Navy, the interagency Ship Structure Committee, the American Bureau of Shipping, the State of Alaska, participating members of the Alaska Oil and Gas Association, and the Canadian Ministry of Transport.

Field trips for data collection were made during both summer and winter seasons and included the first marine winter transit to Point Barrow in 1981 followed by a second winter transit to Wainwright in 1983. The last scheduled field trip in this program was completed in the 1986 summer season. Analysis of these data and production of summary documents are being completed during FY 87.

The Arctic Marine Transportation Program has pursued three overall goals:

- To develop a technical, environmental and safety data base and guidelines which will enable the government to make rational decisions concerning future Arctic activities, especially those involving marine transportation systems.
- To develop design criteria and design tools for ice transiting vessels ranging in size from supply boats, icebreakers, and icebreaking escort vessels to large icebreaking tankers. Such criteria will also be valuable for design of offshore structures in Alaskan ice-covered waters.
- To facilitate the commercial development of large icebreaking ships that can successfully operate in Alaskan ice-covered waters on a year-round basis in a safe, effective and efficient manner.

Three major program activities have contributed toward achieving these goals.

### *Environmental Data Collection*

Data were collected (on routes over which commercial ships might operate) on the characteristics of Arctic sea ice, including physical dimensions, frequency of occurrence, strength, and rate of movement. Measurements were made of the thickness of level ice, as well as the size, shape, orientation and frequency of pressure ridges. Ice coring was performed at test locations to determine the flexural ice strength by obtaining a vertical salinity and temperature profile of the ice and subsequently using an empirical relationship to calculate the strength. Ice drift was also measured.

The data collected are necessary for the design of cargo ships of sufficient structural

*Ice coring in the southern Beaufort Sea.*

strength and power for safe, reliable and economic operation. Much of the data obtained over the past 5 years, plus all additional available data, have been published in an *Alaskan Marine Ice Atlas* (1983, Arctic Environmental Information and Data Center, University of Alaska, 707 A Street, Anchorage, Alaska 99501).

## *Design Criteria*

A number of projects have been undertaken to improve design criteria or to provide design guidelines for future marine systems. Work is underway to develop criteria for hull structures which relate ice impact loads to ice conditions and ship parameters such as displacement, speed, hull shape and hull location. Predictive tools are being developed for estimating powering requirements as a function of ice conditions and hull shape, size and speed.

## *Operational Guidelines*

A number of research activities have focused on the safe and efficient operation of ships in ice-covered Arctic waters. They include research on the maneuverability requirements of ships as a function of ship size, hull shape, speed, rudder characteristics and ice conditions. Other research has addressed the establishment of guidelines for safety and survival needs for Arctic operations. Standard equipment for survival of personnel now being used on commercial vessels is inadequate for use in Arctic climates.

As a result of this program both industry and government now believe year-round marine transportation to the Arctic has been proven feasible. Winter transits through the Bering Strait, previously considered unfeasible by some experts, have been accomplished regularly. Low-friction hull coatings have been proven effective in reducing icebreaking resistance and are now recommended for all future ice-transiting ships. New analytic models have been developed to predict performance of commercial ice-transiting ships in level ice and pressure ridges. Large quantities of environmental data, unavailable before, have been collected and published. New methodology for predicting local ice impact loads on ship structure has been developed from full-scale measured data.

In summary, this program, now nearing completion, has filled a data gap which had previously discouraged the development of commercial Arctic marine transportation systems. Industry can proceed confidently to develop such systems as are necessary and desirable for satisfaction of commercial and national interests. Government will continue its involvement through the regulatory and permitting processes.

# *Environmental Protection Agency*

***EPA Cold Climate Research covers the spectrum of environmental problems, including treatment control technology, human health, air pollution effects, water pollution effects, and solid waste disposal, and was funded at $400,000 in FY 86.***

## *Cold Climate Research*

FY 86 FUNDING
(thousands)
Cold Climate Research 400

The EPA's Cold Climate Research Program is an extramural program of the Office of Research and Development (ORD) that is managed out of ORD's Environmental Research Laboratory at Corvallis, Oregon. The emphasis is on environmental research that relates to cold climates. The research concerns primarily environmental problems in the State of Alaska, but other cold regions of the U.S. can benefit.

The Corvallis Laboratory works directly with the EPA Region X Alaska Operations Office in Anchorage to coordinate the conduct of ongoing research projects and to develop priorities for future studies. The Operations Office does not engage in research, its primary function being to coordinate EPA's regulatory responsibility with the State of Alaska. However, it provides the primary link to the State of Alaska interests and works with them and ORD in the development of research priorities. Because of the broad spectrum of environmental research, the Corvallis Laboratory calls upon other ORD laboratories to provide project officers for research that falls outside the expertise available at Corvallis.

During 1986, there were five active research projects.

*Prudhoe Bay oil field.*

### *Impact of Oil Development on Coastal Tundra Wetlands*

The goal of this project is to produce a guidance document for assessing the impact on wetland environments of oil and gas development along Alaska's North Slope. Such guidance will assist Federal, State, local, and industrial groups by providing a common base of information for the preparation of environmental impact assessments. In addition, field work is being planned to evaluate the use of a geographic information system to characterize waterbird habitat, density and distribution in a North Slope wetland environment. This technique could have wide application to "advanced identification" of areas vulnerable to dredge and fill activities. Identification of such areas is required by the Clean Water Act (40CFR, Sect. 230.80).

### *Ecosystem Impacts of Placer Mining*

Placer mining for gold has increased sharply in recent years. This project is designed to assess the significance of particle size and certain heavy metals, especially arsenic, associated with placer mining discharges and their impact on aquatic life. It will also evaluate fish avoidance reactions to turbid waters caused by such mining.

### *Urban Air Pollution*

Wood stoves find heavy use in Alaska. This project is designed to assess the potential health impacts of wood smoke in Alaskan urban areas. It has been coordinated with EPA's Integrated Air Cancer Project (IACP). The study area is the Mendenhall Valley, near Juneau. Air data were collected during 1986 for

*Stratified smoke plume produced by burn-off at test well, Prudhoe Bay.*

the specific objectives of 1) comparing this area with other IACP urban areas in the lower 48, 2) determining effects of low temperatures on the distribution of mutagens/carcinogens between particulate and gaseous phases, and 3) determining population exposure to wood smoke and comparative cancer risk.

## *Models of Industrial Pollutants*

Development of oil and gas along Alaska's North Slope has led to the installation of many gas-fired generators which have given rise to predictions of $NO_x$ levels in excess of EPA's air quality standards. Existing mathematical models are considered inadequate for confirming or refuting these predictions. This project is developing models that can accurately predict pollutant levels under the atmospheric conditions found along the North Slope. A consortium of oil companies have been evaluating the downwash problem through wind tunnel studies. EPA is focusing its attention on the development and improvement of predictive models for dispersion. An assessment of suitable field data has shown there is inadequate information available to test these models. Field studies are being planned to gather North Slope data suitable for model development and improvement.

## *Biodegradation of PCBs*

Polychlorobiphenyls have found their way to soils in some areas of Alaska, particularly around military sites. Disposal of PCB-contaminated materials and soils is costly because suitable disposal sites are not available in Alaska and highly contaminated materials must be shipped to the lower 48 for disposal. This project is in the planning stage and is being designed to assess the feasibility of degrading PCBs to safe levels through the use of microorganisms. Current plans call for assessment of the state of the art of PCB biodegradation, definition of most promising technologies, feasibility of application in cold climate conditions, and recommendations for testing the most promising methodologies.

# *Department of State*

***The Department has responsibilities for international policy issues related to the Arctic, chairs the Interagency Arctic Policy Group, organizes joint meetings with Canada and Denmark and administers the Man and The Biosphere Program. Direct support for MAB was $16,000 in FY 86.***

| FY 86 FUNDING (thousands) | |
|---|---|
| Northern Science Network | 16 |

The Interagency Arctic Policy Group (IAPG), which the Department of State chairs, has overall responsibility for making recommendations on and overseeing and coordinating international activities relating to the Arctic. The IAPG also coordinates intergovernmental Arctic-related meetings. The Department of State's Office of Marine Sciences and Polar Affairs within the Bureau of Oceans and International Environmental and Scientific Affairs is responsible for coordinating international activities concerning the Arctic on a day-to-day basis. The Office deals with matters concerning U.S. foreign policy issues in the Arctic.

U.S. and Canadian Arctic hydrocarbon and resource developments are currently reviewed in annual talks on hydrocarbon developments in the Beaufort Sea. These talks are organized and co-chaired by representatives of the Department of State and of the Canadian Ministry of External Affairs. The talks provide an excellent venue for exploring related issues and environmental concerns. The annual meetings have gradually increased in scope to cover almost any item of technical, scientific or environmental interest to either Canada or the United States in this area of the Arctic. They provide a useful forum in which to explore problems and share information in an informal fashion.

*Ice cores being loaded during close-down of glaciology camp in central Greenland.*

The Department of State also collects and collates proposals each year from U.S. scientists for research in Greenland. The annual compilation of proposals is forwarded by the Department to the Danish Commission for Scientific Research in Greenland, which organizes a meeting each April between U.S. representatives, led by the Department of State, and Danish authorities and scientists. The proposals, funded by the National Science Foundation and several other agencies, including DOD, are formally presented at this annual meeting. This cooperative arrangement has as its basis the U.S.–Danish Defense of Greenland Agreement signed in 1951.

The Department of State also administers the Man and the Biosphere Program (MAB). The United States has continued to participate in this program, though it has withdrawn from UNESCO, under whose aegis the international MAB program is organized. MAB is an interdisciplinary, problem-focused research approach to management concerns which arise from the interactions between human activities and natural systems. MAB seeks to provide a bridge between fundamental science and technological development.

The U.S. MAB program provides a structure and modest funding for communication and research in many areas. Within the U.S. MAB program the Arctic Directorate has concentrated on supporting research on northern resource use and ecosystem relationships. The U.S. National Committee for MAB approved funding from multiagency contributions for the following projects: the establishment of long-term multidisciplinary environmental monitoring in the Noatak National Preserve in northwestern Alaska, study of the relationship of indigenous peoples to the environment in the national parks and reserves in Scandin-

*Noatak Preserve treeline-tundra transition.*

avia, the development of a comprehensive Alaskan vegetation classification system for use by resource managers, and the exchange of information with China on musk-ox biology and management. The International MAB Biosphere Reserve Program currently includes four sites in Alaska: the Denali National Park, the Noatak National Preserve, the Aleutian Islands National Wildlife Refuge and the Glacier Bay/Admiralty Island Biosphere Reserve.

The Arctic Directorate is cooperating with other northern countries and with UNESCO-MAB in a Northern Science Network to facilitate improved communication and understanding among scientists, public and private policy makers, resource managers, and residents of the North. The Northern Science Network initially adopted three "themes" for implementation: 1) Studies on ecology and land use of subarctic birch forest. Birch forests are used for reindeer herding and sheep grazing, sport and subsistence hunting, fishing and tourism. 2) Development of, and monitoring and research in, Biosphere Reserves and other protected areas. Biosphere Reserves are a major concern of national MAB committees in Canada, Norway, the United States, and the U.S.S.R. The theme includes research and monitoring in other types of reserves such as parks, ecological reserves and watershed research areas, to study industrially and experimentally induced disturbance effects. 3) Land use and grazing animals: socio-economic, biological and environmental effects. Land use conflicts occur in a large area of the circumpolar north, notably between grazing animals (principally reindeer) and wild ungulates, hunters, tourists, and industrial operations such as logging, energy development, and mining.

The primary objectives of the Northern Science Network are to strengthen scientific activities by exchange of information, education, and facilitating interdisciplinary synthesis. The Network's activities involve the international scientific community, local residents, managers and decision-makers in public and private sectors. The U.S. MAB assisted the Northern Science Network in convening an International Conference on Arctic Science Policy and Development in August 1985 at the University of Alaska. The *Proceedings* of the conference are available from the MAB Office, Department of State.

# *Department of Agriculture*

*Although the Department of Agriculture is not a member of the Interagency Committee, representatives of its several Alaska-based services were invited to participate in the research planning process and review. An estimated $850,000 is devoted to USDA support of Arctic research on forests, rangelands, soils and snow in Alaska.*

## *U.S. Forest Service*

FY 86 FUNDING (thousands)

| | |
|---|---|
| Forest Service | 650 |
| Soil Conservation | 200 |

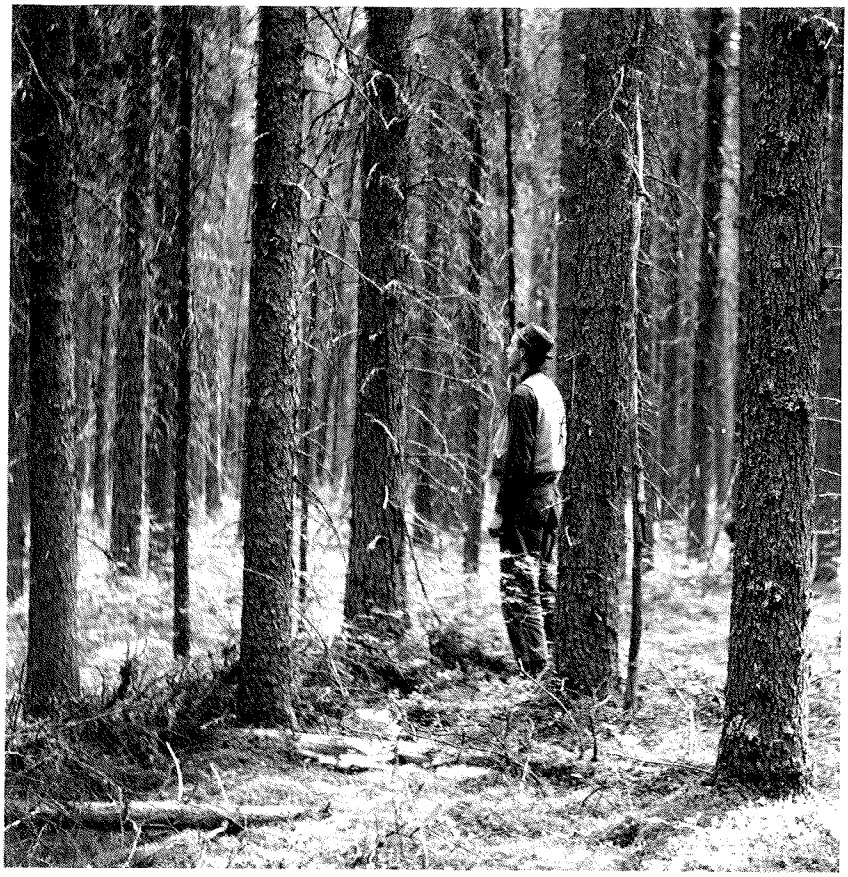
The taiga zone of Alaska covers 250 million acres stretching from the south slopes of the Brooks Range to the north slopes of the Chugach Range, and from the Canadian border on the east to the Bering Sea on the west. This area contains 106 million acres of spruce–birch–aspen forest, of which at least 22 million acres is commercial forest land (annual growth of at least 20 cubic feet/acre/year). About one-third of this central and northern Alaska forest—the taiga—is located within the ARPA-defined Arctic, north of the Porcupine–Yukon–Kuskokwim Rivers (PYK) line. The remainder of the forest is often found on sites having a combination of elevation, slope and aspect which gives an "equivalent latitude" equal to or greater than the strictly "Arctic" latitude limits. Most of the taiga zone is an area of discontinuous permafrost. South slopes and river margins tend to be free of permafrost; north-facing slopes are generally underlain by permafrost close to the surface.

*Air temperature station in interior Alaska.*

The taiga forest of Alaska consists of a mosaic of vegetation types. Distribution of these types is controlled largely by soil temperature and fire history. The warmer, more productive sites are occupied by white spruce, aspen, paper birch and balsam poplar. The less-productive forests are largely black spruce and sometimes tamarack. Drainage differences, the presence or absence of permafrost, exposure, and other geomorphic features create the bogs, alpine tundra, numerous lakes, marshes, woodlands, and forests that form the vegetation mosaic. In fact, the taiga is so heterogeneous that it is difficult to characterize and manage.

Historically, forests have provided large amounts of wood to interior Alaskan residents. Millions of cords were used to run the large steam-powered sternwheelers in early mining and settlement days. From the 1930s and 40s through the late 60s, forest harvesting occurred at a much reduced level, with the major portion used for the production of house logs and rough construction lumber that was used locally. During the late 1960s and 70s forest harvesting increased significantly. The increased utilization of interior Alaska's forest resources has led to heightened awareness of the importance of sound forest management practices. Yet because of a generally low level of forest management experience and research information there remains a great deal to do to upgrade and improve forest management practices in these northern forests.

Uses other than wood extraction have long been extremely important in the taiga of interior Alaska. The region is justly famous for its big game and small game mammals, waterfowl and other birds, anadromous and freshwater fish, and important furbearer species. All provide food, income and recreation for



*Forest productivity research site.*

Alaska's residents and visitors. Recent wide fluctuations in moose population levels have pointed to the need for resource managers to gain a better understanding of wildlife/habitat relationships in the taiga. In addition, the need to protect the water resources is becoming increasingly apparent, especially as placer gold mining and other stream water use increases.

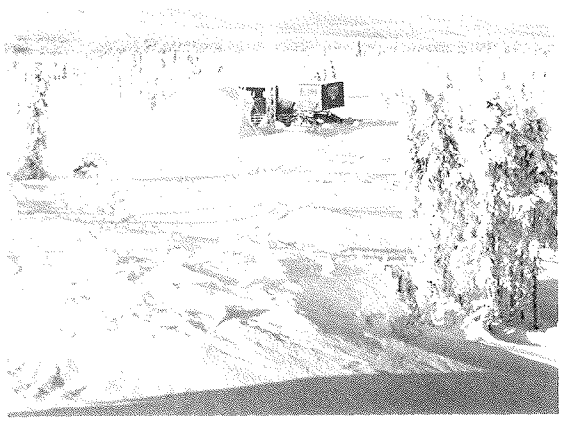
Natural disturbances to taiga ecosystems make a considerable impact on how the biological communities function. For centuries, lightning-ignited forest and tundra fires burned extensive areas during the summer months. Effective fire suppression has been practiced in Alaska for roughly 20 years, reducing the average area burned each year from about 990,000 acres to a current 400,000 acres or less. Recently, however, the natural role of fire in the maintenance of many of interior Alaska's ecosystems has begun to become more widely accepted. As a result, beginning in 1979 a series of fire management plans have been developed which alter the fire suppression policy on millions of acres in interior Alaska. Research on fire ecology is needed to understand the new policy implications.

Trees and shrubs in both commercial forest stands and wildlife habitats are subject to severe attack by insects. Bark beetles in white spruce and defoliators on hardwoods and spruce are the major forest insect pests. Although the immediate impacts of these insects are apparent, the long-term relationship of these forest pests to the taiga ecosystem is not well understood by the land manager.

Management of the forest resource cannot take place without accurate assessment of the current resource situation and periodic updates to see what changes are occurring. With the increasing impact of man on what was previously pristine land, this assessment is becoming increasingly important. Research on the forest and related resource inventories will be useful to forest land managers.

Relatively little research has been accomplished in the high-latitude forests of Alaska. There is a pressing need for acquisition of long-term baseline data describing current high-latitude forest conditions, both to better assess the potential for renewable resource development and exploitation and to provide a basis for evaluating possible long-term climatic change, anthropogenic pollution, including Arctic haze and acidic precipitation, and the consequences of such stress on biological productivity and ecological system functioning. Major research needs remain concerning forest ecology, vegetation classification and characterization, basic inventory of the extent and nature of the forests and forest-related resources, watershed science, and fire ecology.

*Caribou Peak in winter.*



The Forest Service has research projects in Fairbanks and Anchorage that address some of the problems mentioned above. They have an annual budget of about two million dollars, of which about one-third goes to problems in or directly related to the Arctic. Research emphasis is on the following main problem areas:

- Classification of the vegetation of the taiga and correlation with soil and other site information.
- Influence and role of fire in forest management practices.
- Regeneration techniques, genetic potential, and harvesting impacts for interior Alaskan white spruce.
- Defining impacts and interrelationships between white spruce trees, site characteristics, spruce beetles, and major defoliators.
- Effects of timber harvest and placer mining on stream sedimentation and water quality.
- Estimation of timber and related resource inventory for interior forests.

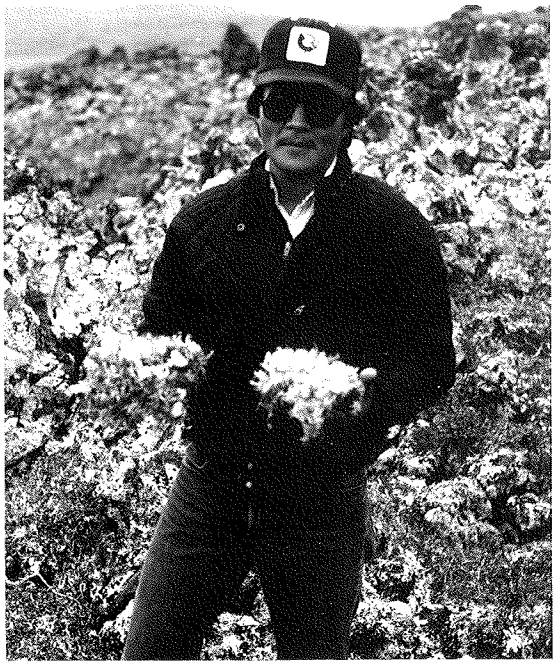
## *Soil Conservation Service*

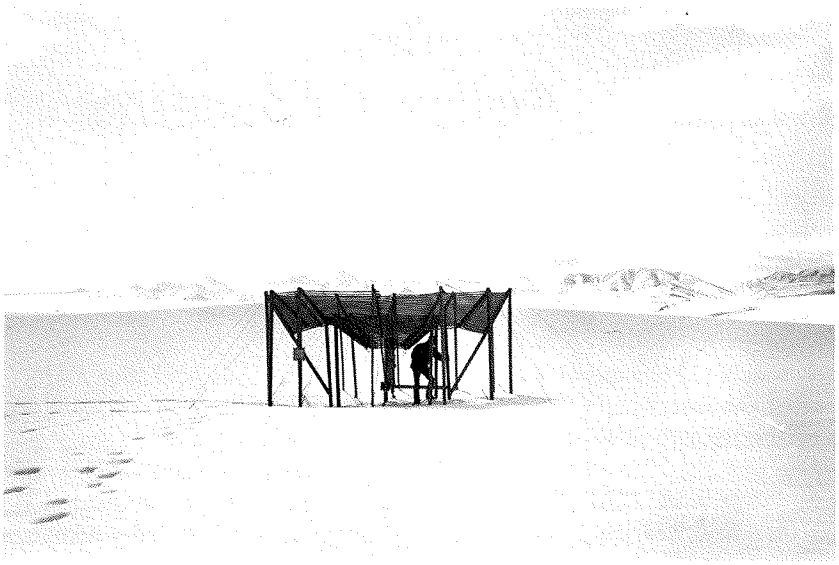
The Soil Conservation Service, working through Alaska's Soil and Water Conservation Districts, has continued monitoring climate, snow accumulation and rangeland conditions and trends in the Arctic and Subarctic sections of Alaska. These activities provide guidance for the development of the State's natural resources. The annual expenditure is estimated at $200,000.

Climate data from throughout Alaska, with emphasis on the Yukon Valley and other areas identified as having agricultural potential, are being analyzed to determine local growing seasons, growing degree-days, solar energy and other variables related to agricultural operations. Frost frequency and frequency of winter temperature extremes are also being documented. Collection of these data is helping to meet the research needs for agricultural crop management and crop variety selection and breeding.

To meet the need for proven plant materials to solve erosion and other resource problems the Plant Materials Center in Palmer, Alaska, managed by the Alaska Division of Agriculture and coordinated with the SCS Plant Materials Program, operates a program to assemble, test, release and maintain foundation stock for improved conservation and agricultural plants adapted to Arctic and Subarctic environments. During 1986, six conservation plants were released for commercial production: 'Rhode' feltleaf willow (*Salix alaxensis*), 'Wilson' bebb willow (*Salix bebbiana*), 'Oliver' grayleaf willow (*Salix brachycarpa*), 'Roland' pacific willow (*Salix lasiandra*), 'Long' mountain willow (*Salix barclayi*) and 'Egan' American sloughgrass (*Beckmannia syzigachne*). The five native Alaska willows were released as windbreaks for the Palmer and Delta regions. The American sloughgrass was released for wetland restoration and erosion control. 'Gruening' alpine bluegrass (*Poa ampula*) is scheduled for release in the near future for revegetation, reclamation and erosion control.

*Reindeer in summer corral, Seward Peninsula; lichens from protected area, Nunivak Island.*





*Wind-shielded snow gauge, Toolik River, northern Alaska.*

In the process of developing technology for sound management practices for western and northwestern Alaska reindeer ranges, the Soil Conservation Service has completed and published the range report for the Seward Peninsula. Also, a Range Survey of Nunivak Island, Alaska, was completed and made available in a three-volume report to land managers. The Nunivak survey includes an inventory of range sites on the island with data on site distribution, herbage production, and condition and trend data. In 1986 an additional study site was established on reindeer range for the purpose of monitoring lichen recovery on burned areas. A thorough understanding of lichen ecology is essential for maintaining high quality winter grazing lands for reindeer as well as caribou and musk-ox populations.

Soil surveys provide vital resource information for research activities as well as development and planning purposes. Forestry management progams, recreation planning and other development activities such as oil and gas facilities, transportation corridor selection and agricultural development are highly dependent upon soil survey information. During 1986, the Soil Conservation Service completed final correlation and manuscripts for soil surveys in the Yentna, Copper River and Upper Tanana areas. Field data collection and mapping were also completed for the Kantishna Soil Survey area near the confluence of the Tanana and Yukon Rivers, and field mapping was completed on 42,880 acres of the North Star Soil Survey.

A basic data requirement for a wide variety of research activities in Arctic and Subarctic environments is snow accumulation. Snowpack covers nearly every acre of Arctic Alaska for 5-9 months of the year. It impacts just about every outdoor activity, and the resources and people of the Arctic region. The Snow Survey Program coordinated and managed by the Soil Conservation Service is a cooperative program, in which all State and Federal land and resource management agencies and soil and water conservation districts contribute toward the basic data collection effort. Alaska's unique environment leads to a multitude of activities that require snowpack data: snowmelt runoff in permafrost areas; glacier melt contribution to hydroelectric reservoirs; glacier movements and glacier-dammed lake burstout; flood dynamics; wildlife ecology; winter survival; environmental responses of anadromous fisheries during the freshwater portion of their life cycles; frost penetration in urban and agricultural areas; winter soil moisture loss; and vegetative responses to winter vehicle travel in the Arctic. The last supports research on development of winter access methods over sensitive Arctic vegetation types, the results of which are important to both the oil industry and land managers.

The Soil Conservation Service contributes to the research effort by striving to improve methods and technology of collecting snow and related climatological data. SCS has developed improved methods for field installation of sensors and automated data collection systems in the Arctic environments. The Snow Survey Program in 1986 consisted of a network of 205 data collection sites. Of these, 18 are equipped with snow pillows; 24 provide continuous temperature data; 9 provide soil temperature; 5 provide solar radiation information; 11 provide wind data; and 19 are radio-telemetered. There are 38 precipitation storage gauges, 30 of which provide continuous record and 16 of which are equipped with Wyoming windshields.

Current program priorities in Arctic Alaska are:

- The development of proper grazing management on reindeer ranges in support of reindeer herding as a traditional subsistence activity.
- Classification and mapping of Arctic soils to allow for wise land use management decisions.
- Collection and management of snow data in support of research efforts and planning activities for other Federal, State and local units of government.

Snow Survey Reports are available from Soil Conservation Service, 201 East 9th Avenue, Suite 300, Anchorage, Alaska 99501.

*Reports of Meetings*

# *Interagency Arctic Research Policy Committee*

## *First Meeting: April 29, 1985*

Committee Members or Agency Representatives Present: *Erich Bloch, Chairman; Philip Chen, Department of Health and Human Services; Howard Dugoff, Department of Transportation; Joseph Fletcher, Department of Commerce; Edward Harrison, Department of Defense; Kenneth Hood, Environmental Protection Agency; William Horn, Department of the Interior; James Malone, Department of State; Barbara Moore, Office of Science and Technology Policy; Norine Noonan, Office of Management and Budget; Norman Terrell, National Aeronautics and Space Administration; Alvin Trivelpiece, Department of Energy.*

Chairman Erich Bloch welcomed the attendees to this first meeting of the Interagency Committee. He discussed the legislation which authorized the Committee, and President Reagan's Executive Order of January 28, 1985, which established it. He then reviewed the purpose of the Committee and the action taken by NSF to convene a staff representatives group. The Committee is to develop and establish a national Arctic research policy and a five-year plan to implement that policy.

Senator Murkowski, the principal sponsor of the Arctic Research and Policy Act, discussed the need for the Committee to objectively examine Arctic science policy in light of the important decisions that will need to be made on how development of resources will affect the Arctic. He discussed the intent of the Arctic Research and Policy Act to develop a comprehensive national science policy for the Arctic, to obtain scientific knowledge in order to make decisions, and to enable the decision-making process to support the wise development of resources. He indicated that scientific knowledge could help resolve the conflicts between developers and the environmental community.

Dr. A. Lincoln Washburn, member of the Arctic Research Commission, presented a comprehensive discussion of the Arctic, the kinds of science that are important for an understanding of it, and the relation of science in the Arctic to the national interest (see *Science*, 233, August 8, 1986, for details of presentation).

James L. Malone, Assistant Secretary for Oceans and International Environmental and Scientific Affairs, Department of State, presented the proposed Arctic research policy. He reviewed the role of the Department of State in setting overall Arctic policy, through the Interagency Arctic Policy Group (IAPG) established by National Security Decision Memorandum 144, and the relationship between overall Arctic policy and Arctic research policy. He then presented the proposed Arctic Research Policy statement. The statement is organized according to four major subject areas: national security, rational development with minimum adverse environmental or social impact, scientific research on phenomena and processes best studied in the Arctic, and promotion of mutually beneficial international cooperation in Arctic research. Mr. Malone stated that he believed the proposed Arctic Research Policy statement to be comprehensive, and asked the Chairman if the Committee could adopt it. After some discussion, the Committee agreed to accept the policy statement in principle.

Joseph Fletcher, Assistant Administrator for Research, National Oceanic and Atmospheric Administration, representing the Department of Commerce, reviewed the requirements of the Arctic Research and Policy Act: to survey existing Arctic research, to develop an integrated national Arctic research policy, to develop a five-year plan to implement the policy, and to develop a single coherent multiagency budget for Arctic research. He reviewed the accomplishments of the staff representatives group, the policy development process, the process of determining research priorities, the role of the National Academy of Sciences, and proposed activities to be conducted by the Interagency Committee. He stated that the staff representatives need policy guidance before they put together the five-year plan, particularly as related to budgetary constraints. He outlined several scenarios that might be considered: no new programs (i.e. a current-level-of-effort budget), new programs balanced by the reduction or elimination of established programs, and development of two or three major new initiatives.

Mr. Bloch called for comments on the work plan for completing the five-year plan as developed by the staff representatives. After some discussion, the Committee agreed that the staff representatives should develop the five-year plan.

William Horn, Assistant Secretary for Fish, Wildlife and Parks of the Department of the

*Complete transcripts of the meetings and lists of attendees are available from Polar Coordination and Information, Division of Polar Programs, NSF.*

Interior, reviewed the Federal budget picture, and in particular research and development spending in the Arctic. Arctic research was estimated to have received about $81 million in FY 85 and a projected $84 million in FY 86. Mr. Horn raised the question: "Does that eighty-million-plus expenditure fit the type of policies and priorities that this Committee and the Arctic Research Commission want to establish?" Mr. Horn reviewed the budget-reporting format developed by the staff representatives group. The budget format identifies expenditures according to major areas such as national security and rational development.

Dr. Juan Roederer, Vice-Chairman of the Arctic Research Commission, presented a statement to the Committee from Dr. James Zumberge, the Chairman of the Arctic Research Commission. He stated that the Arctic Research Commission looks forward to cooperating with the Interagency Committee in the development of the five-year plan.

Mr. Bloch read the rules for public participation in meetings of the Committee, as they were published in the *Federal Register*. He then called on the following persons for their statements:

Mark Winslow, representing the Governor of Alaska

Judith Brady, Executive Director, Commonwealth North

Dr. Walter Spring, Alaska Oil and Gas Association

David Benton, representing the Alaska environmental community

## *Second Meeting: February 3, 1986*

*Committee Members or Agency Representatives Present: Erich Bloch, Chairman; Philip Chen, Department of Health and Human Services; James Devine, Department of the Interior; William Fitzhugh, Smithsonian Institution; Joseph Fletcher, Department of Commerce; Edward Harrison, Department of Defense; Kenneth Hood, Environmental Protection Agency; Helen McCammon, Department of Energy; Caroline Mederos, Department of Transportation; John Negroponte, Department of State; Norine Noonan, Office of Management and Budget.*

Since the agencies' FY 87 budget requests had not yet been transmitted to Congress, the Committee, chaired by Erich Bloch, met in executive session to discuss them. James Devine of the U.S. Geological Survey, representing the Department of the Interior, presented the budget requests. He reported that agency programs had been impacted by the Gramm-Rudman-Hollings legislation, which mandated a 4.3% reduction in total spending authority.

At the beginning of the open session John Negroponte, Assistant Secretary of the Department of State's Bureau of Oceans and International Environmental and Scientific Affairs, presented the proposed U.S. Arctic Research Policy statement. He noted that the statement was prepared within the guidelines of overall U.S. Arctic policy, and that both the Interagency Arctic Policy Group and the Arctic Research Commission had provided useful comments on the previously approved-in-principle statement. The policy statement (presented in full on page 2 of this journal) was then unanimously adopted by the Committee.

Joseph Fletcher of the National Oceanic and Atmospheric Administration described a proposed process to be followed by the Committee for completion of the first five-year Arctic research plan as required by Section 109 of the Arctic Research and Policy Act. He noted that the only element of the process yet to be completed was the section dealing with recommendations for necessary program changes. He described the staff representatives' proposal for a number of working groups to address substantive portions of the plan. These groups would indicate why the selected area of activity is important, analyze research needed to deal with the area, identify research not now underway, and develop a multiagency research plan based on the recommended program changes. Full participation in the review process would be afforded to the non-governmental sectors specifically identified in the Act. Several agency representatives described how they would complete their sections of the plan. The Committee then approved the proposed planning process.

Chairman Bloch then described to the Committee the content of the formal biennial report to Congress. The Committee members approved the report for transmittal to Congress.

Dr. Juan Roederer, Vice Chairman of the Arctic Research Commission, presented a report on the Commission's activities. He discussed the Commission's publication *National Needs in Arctic Research: A Framework for Action.*

Martha Fox of the Governor of Alaska's Washington office described the State of Alaska's Arctic Research Policy and its Science and Engineering Advisory Committee. She stated that the Governor of Alaska has pledged the State's full cooperation with the Interagency Arctic Research Policy Committee.

Caleb Pungowiyi, Nome, Alaska, representative of the Inuit Circumpolar Conference, presented a statement on behalf of the Native residents of the Arctic.

Joseph Price, Chief, Science and Technology Division, Library of Congress, presented a statement on behalf of the Library on the dissemination of literature concerning Arctic research.

## *Third Meeting: March 23, 1987*

Committee Members or Agency Representatives Present: *Erich Bloch, Chairman; James F. Decker, Department of Energy; Joseph Fletcher, Department of Commerce; George Hardy, Department of Health and Human Services; Edward Harrison, Department of Defense; Robert Hoffmann, Smithsonian Institution; Kenneth Hood, Environmental Protection Agency; Richard Johnson, Office of Science and Technology Policy; Wayne Marchant, Department of the Interior; Richard Miller, Department of Transportation; Edward Wolfe, Department of State.*

Chairman Erich Bloch convened the meeting. Dr. Jerry Brown of the National Science Foundation presented a summary of the United States Arctic Research Plan. He noted that the Plan may be best characterized as a national agenda for both short- and long-term Arctic research, is consistent with the Arctic Research Commission's recommendations, and represents a consensus built around Federal agency needs and extensive consultation with the Commission, the State of Alaska, Arctic residents, the private sector, public interest groups, and reports of the National Research Council. The Plan conforms with the Arctic Research Policy statement (see p. 2). Formal comments in support of the Plan were made by Joseph Fletcher, Department of Commerce; Edward Wolfe, Deputy Assistant Secretary, Department of State; Wayne Marchant, Deputy Assistant Secretary for Water and Science, Department of the Interior; and Dr. Juan Roederer, Vice Chairman of the Arctic Research Commission. Chairman Bloch asked for the Committee's agreement that the Plan be prepared for transmittal to the President and the Congress by July 31, 1987, subject to minor editing. There being no objection, Mr. Bloch directed the staff representatives to complete the Plan.

Wayne Marchant presented the interagency budget information. He noted that there was an overall increase in the budget for Arctic research projected from FY 86 actual obligations to the estimated budgets for FY 87 and 88. Some agency budgets showed an increase while others were projected to decrease over the three-year period. Major increases were noted for NASA in support of the Synthetic Aperture Radar facility in Fairbanks.

Mr. Bloch then raised the question of implementation of the Plan. He noted that the staff representatives have proposed an implementation strategy which includes oversight and establishment of interagency groups to integrate and coordinate specific programs across the agencies. Four groups have been proposed initially, commensurate with the major sections of the Plan itself—atmosphere and oceans; land; people, with emphasis on their health needs and social changes; and logistic support and coordination of data, information and international activities. Such groups should ensure fulfillment of the expectations of the Act.

The groups would provide an analysis of existing programs to facilitate design of interagency research and schedules, identify resources, ensure that the total Plan fits together, and design joint programs between appropriate agencies when the need and the opportunity arise. These groups would submit reports on a regular basis.

Mr. Bloch stated that if the Committee agreed with this proposal, the next task would be for the staff representatives to develop the details of an implementation strategy. The proposal was discussed by the Committee, and was strongly supported. The staff representatives were directed to report back to the Committee on their progress in developing the implementation plan.

Richard Gomez of the Department of Defense reported on a symposium and workshop on DOD Arctic sciences, the proceedings of which were scheduled for publication in late 1987.

Mr. Bloch reported that the Office of Management and Budget has approved publication of an information journal called *Arctic Research of the United States*. Agencies were asked to provide written input to the journal.

# *Reports of Meetings*
# *United States Arctic Research Commission*

## *First Meeting: April 5, 1985*

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: W. Timothy Hushen.

Observers: *Albert Chapman, Department of State; James Devine and George Gryc, U.S. Geological Survey; Joseph O. Fletcher, National Oceanic and Atmospheric Administration; Robert Friedheim, University of Southern California; John Talmadge, National Science Foundation; William Westermeyer, U.S. Congress, Office of Technology Assessment.*

*Detailed minutes of Commission meetings and hearings are available directly from the U.S. Arctic Research Commission Office, 3500 South Figueroa, Suite 114, Los Angeles, CA 90007.*

The Arctic Research and Policy Act of 1984 (Title 1 of Public Law 98-373) and Presidential Executive Order 12501 on Arctic research dated January 28, 1985, established the Arctic Research Commission. The members of the Commission were appointed by President Reagan on February 28, 1985, and duly sworn in on March 1, 1985, by Judge Fitzgerald in Anchorage (Zumberge, Rasmuson and Washburn) and Judge Russel Holland in Fairbanks (Roederer and Leavitt). The first open and executive meetings of the Commission were held at the University of Southern California, Los Angeles, California, from 9:00 a.m. to 4:20 p.m. on April 5, 1985.

Dr. James H. Zumberge called the first meeting of the United States Arctic Research Commission to order at 9:00 a.m. in the Board Room, University of Southern California, Los Angeles, California. Following introductions of the Commissioners and attendees, he reviewed the Arctic Research and Policy Act of 1984 and drew attention to Sections 102(b), 104(a), 110(a) and 112 as being particularly relevant to the work of the Commission.

Dr. Zumberge requested comments on the Act from the members of the Commission and observers. Elmer Rasmuson pointed out that the definition of Arctic as used in the Act recognizes that Alaska's Arctic-related environments are not bounded just by the Arctic Circle. Rather the Arctic involves the concept of a natural region with common environmental characteristics transcending latitude. George Gryc noted that historically the concept of a "PYK line" developed during the statehood debate. At that time it was proposed that the area below the PYK become the new State of Alaska, and the area above be maintained as a Federal territory. Dr. Juan Roederer noted that the Polar Research Board uses as a working definition of the Arctic the concept that Arctic-related processes determine what should be considered Arctic. The ensuing discussion emphasized the prevalence of transitional features and indicated the need for some flexibility in employing the term "Arctic."

### *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss, Director, Division of Polar Programs, representing Erich Bloch, Director, National Science Foundation, and Chairman of the Interagency Arctic Research Policy Committee, reported that Mr. Bloch has been very active in supporting implementation of the Act. The National Science Foundation received Office of Management and Budget authorization to reprogram FY 85 funds to begin implementation of the legislation. In addition, John Talmadge has been assigned to the Division of Polar Programs as an Executive Associate for Arctic Research and Policy. Dr. Wilkniss asked Mr. Talmadge to review the steps taken and future plans of the Executive Branch to implement the Act.

The National Science Foundation invited staff level representatives of ten agencies to form an interagency working group that held four informal advance-planning meetings. Only the interagency working group has met prior to the first meeting of the Commission. It has produced a draft of an Arctic research policy, which essentially reviews the current status of Arctic policy, national needs and Arctic research policy.

The interagency working group has made some progress on establishing an integrated budget and on the five-year planning process.

The Polar Research Board of the National Research Council under a cooperative agreement with the NSF is performing the important task of assembling prior research recommendations from the scientific community and establishing priorities among them. The results of the Board's work will provide the Commission and Committee with a solid focus for discussion of needed next steps in Federal Arctic research.

The National Science Foundation has initiated contact with the various groups specified in the Act. Cooperative interaction has been initiated with the following:

The Governor of Alaska and his Science Advisor, Dr. Richard Nevé.

Native Alaskans, highlighted by visits

in March 1985 and planning for a grant to stimulate comment on the emerging five-year plan. In addition, the Mayor of the North Slope Borough, George Ahmaogak, made several important and worthwhile points in a letter to NSF that the interagency staff level group has already begun to take into consideration.

The private sector, including the Alaska Oil and Gas Association and public interest groups.

The Arctic engineering community, including an NSF-sponsored workshop held February 16 to determine priorities and justify special attention in civil engineering.

The first meeting of the senior representatives to the Interagency Arctic Research Policy Committee will be held at the National Science Foundation on April 29, 1985. Commissioner Washburn has agreed to deliver an overview of the Arctic and Arctic research. Vice-Chairman Roederer will represent the Commission. During July 1985, staff members of the Interagency Arctic Research Policy Committee will hold a workshop to develop the five-year Arctic research plan.

Following this review, Mr. Talmadge requested that the Commission consider the draft statement on Arctic research policy and the approach the Interagency Arctic Research Policy Committee had developed. Chairman Zumberge pointed out that if the Commission is to fulfill its "charge" under the Act, it must provide a separate and outside view. Dr. Zumberge further noted that the United States had articulated an Arctic policy and that any statement by the Commission should be consistent with the current policy. Dr. Roederer noted that National Security Decision Directive 90 establishes U.S. Arctic policy and that Arctic research policy as called for in the Act must comply with this Decision Directive. There was general agreement by the Commissioners on this point. After discussion, it was agreed that the IARPC should officially transmit its proposed statement on Arctic research policy to the Commission for its consideration.

### *Future Activities*

Chairman Zumberge stated that all of the Commissioners have other duties and responsibilities and therefore are not full-time Commissioners. All have volunteered their services at the request of the President of the United States and have agreed to provide this service to their country. Because of these other commitments as well as constraints on financial resources available to the Commissioners, it is essential that they maximize the use of their time and resources. The Commission does not need to act as a whole; rather individual Commissioners or groups of Commissioners should hold "hearings," gather information, and report back to the full Commission on their findings. Elmer Rasmuson supported this approach and believes the Commission should serve as a bridge between interested groups. Oliver Leavitt commented that this would be an effective approach; however, it is important that all the Commissioners be aware of, and approve, any individual Commissioner's activities. It was agreed that the Commission Office should serve as the clearing house for all Commission activities, and should be informed before any activities are undertaken on behalf of the Commission.

Dr. Roederer concurred with the above approach and stressed the need to increase interaction between local Arctic residents and the broader scientific community. The Commission needs to embark on an education campaign to alert the broader U.S. scientific and engineering community about Arctic research. He suggested that lectures and articles about Arctic research and the Act be submitted to *Science* and other journals. He also stressed the importance of informing the Alaska State Government and Legislature about the activities of the Commission.

Mr. Rasmuson stressed the need to hold more than one meeting a year in Alaska. He suggested that a seminar format would be the best approach in order to inform the public about the importance of Arctic research. It is necessary to involve and achieve public participation and education in general and the news media in particular. He stressed the need to search out seriously and obtain the opinions of different groups in Alaska, especially the Native population, the University of Alaska, environmental groups, and industry. Without the broadest possible input, the chances of success of the Commission will be diminished. He expressed his disappointment that a representative of the State Government was not at this meeting.

Several observers commented on the role of the Commission. Robert Friedheim noted that the Commission's role is to fit together the different and divergent pieces of Arctic research and policy. James Devine recommended that public hearings and information gath-

ering would serve to inform the broader community of the Commission's existence and interest. Joseph Fletcher suggested that the Act provides the Commission with a clear license to further Arctic research; however, if the Commission is to have significant impact, this license must be visibly exercised. The Commission can provide a big picture and a long-range view of Arctic research—something that is hard for the mission-oriented agencies to provide. The Commission can provide fresh approaches and independent perspectives on Arctic research. George Gryc commented that for the Act to work, close working relationships and feedback mechanisms will be required among all concerned. The IARPC can serve as a fact-finding group and can identify priority research needs. He believes the individual agencies will, over time, reorient their programs to address those needs. The Commission can provide oversight of these activities and point out deficiencies.

### *Other Business*

Albert Chapman, principal staff person for the Interagency Arctic Policy Group (IAPG), reported that the Group is concerned with overall Arctic policy. The Group was established by National Security Decision Memorandum 144 in 1971 and recently became more active, conducting a study on U.S. Government services required in the Arctic. A fact sheet was made available to the Commission. Chapman noted that the results of this study were currently under consideration by the National Security Council.

### *Administrative Activities*

The following actions and discussions took place in Executive Session.

W. Timothy Hushen was selected to serve as Executive Director.

For the remainder of FY 85, the National Science Foundation has contracted with the University of Southern California to serve as the Commission's fiscal and administrative agent until such time as the Commission receives an appropriation from Congress. The budget is very tight, allowing for only a 60% time Executive Director, an administrative assistant, and three meetings of the Commission. Chairman Zumberge has written to Senators Murkowski and Stevens requesting supplemental funding for the remainder of this fiscal year to allow the Commission to become fully functional.

Dr. Zumberge reported that when the Commission becomes fully funded it will open an office in Alaska. The Commission has received several offers of office space, but has not made a decision pending input from the Commissioners. Mr. Rasmuson requested that he be consulted before any decision is made. He pointed out that active involvement by the University of Alaska and the State of Alaska is essential to the success of the Commission. In order to alert the State Legislature, Mr. Rasmuson, Dr. Roederer and Mr. Leavitt will arrange to brief key legislators about the activities of the Commission.

### *Group of Advisors*

Dr. A. Lincoln Washburn stressed the importance of developing a mechanism to involve the broader community in the Commission's work. He suggested that a group of scientific advisors be identified. Mr. Rasmuson believes that representatives of the environmental community, industry, and the State of Alaska should be included on any group of advisors. It was agreed that the concept of a group of advisors should be pursued and considered at the next Commission meeting.

### *International Cooperation*

Dr. Zumberge reported that several international groups and nations have become more active in establishing mechanisms to deal with their Arctic research interests, including Sweden, Denmark and the Nordic Council. Nongovernmental groups have been formed to enhance international cooperation, including the Arctic Ocean Sciences Board, Comité Arctique International, and the International Permafrost Association. The Commission's attention was drawn to the final report on the U.S.-Canada Arctic Policy Forum held in Banff in October 1984.

### *Public Information*

In order to alert the broader scientific and technical community to the work of the Commission, it was agreed that the Commission would prepare and submit to interested scientific journals a notice about its formation and purpose. Journals to be notified include *Arctic*, *Polar Record* and *Science*.

## *Second Meeting: June 25–28, 1985*

The Arctic Research Commission held a series of public meetings in Alaska from June 25–28, 1985, as a step toward fulfilling its

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen.*

charge to develop and recommend an integrated national Arctic research policy and to assist the Federal Government in establishing national Arctic research programs to implement the policy.

Public meetings were held in the Assembly Chambers, Fairbanks North Slope Borough, on June 25; in the Assembly Room, North Slope Borough, Barrow, Alaska, on June 26; and in the Auditorium of the Historical and Fine Arts Museum, Anchorage, Alaska, on June 28. More than 200 people participated. (Presentations, background material, and a list of attendees are available from the Commission on request.)

On June 27 the Commission conducted a site visit to an offshore drilling structure in the Beaufort Sea and to the Kuparuk and Prudhoe Bay oil fields. The Commission met in executive session at Barrow on June 26, 1985. Observers present included James Devine, USGS, and John Talmadge and Dr. Jerry Brown, NSF. The following topics and actions were discussed.

## *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported that in an attempt to comply with the Arctic Research and Policy Act reporting schedule, the Interagency Arctic Research Policy Committee plans to submit to Congress by the end of July 1985 a status report that will include a detailed listing of current Federal Arctic research activities, 5-year budget projections by agency, program and national issue, and the Polar Research Board report *National Issues and Research Priorities in the Arctic.*

Mr. Talmadge (NSF) and Mr. Devine (USGS), Interagency Committee staff representatives, provided detailed information on the budget estimates, indicating that they represent a good faith effort by the agencies to identify research conducted in the geographic area defined by the Act, and to estimate the amount expended for each project. Because many Arctic research activities are part of a broader research effort, an estimate of the Arctic-related activity is often difficult to achieve. Therefore, the $83 million estimated for FY 86 Federal support of Arctic research is a "best estimate." The budget is divided into categories for research expenditures and monitoring and surveying activities, and compares research expenditures with national issues. Commission members suggested that the methodology and assumptions should be clearly stated in the report to Congress to alert the reader that the budget is a "good faith" estimate and to indicate the complexity of the task. The NSF representative introduced Dr. Jerry Brown, who will head the NSF's Arctic Research and Policy Staff.

## *Group of Advisors*

Dr. A. Lincoln Washburn reported that he had explored with several individuals and groups the feasibility of and need for a group of advisors. He noted that since by law the membership of the Commission is limited to five individuals, it is not possible for all the research disciplines and interests to be represented. The Chairman emphasized that individuals serving on the Commission do not represent any particular discipline; rather, the Commission represents Arctic research in general. The Commission needs a mechanism to bring the broader scientific and engineering communities into its work. The Chairman requested Dr. Washburn to prepare a slate of categories, with names of individuals who might represent each, for discussion at the next meeting.

## *International Cooperation*

Individuals from several countries and nongovernmental activities have expressed interest in the renewed U.S. efforts in the Arctic region, as reflected in the Presidential Memorandum of 1983 on Arctic policy, the Arctic Research and Policy Act of 1984, and the Presidential Executive Order of 1985 on Arctic research. Since the last meeting of the Commission, some of its members have met individually with the Danish Minister for Greenland, the Greenland Home-Rule Premier, and individuals from Sweden, West Germany, Norway, Iceland and Canada, all of whom expressed interest in furthering international cooperation. Therefore, to assess the possibility of improved international cooperation in Arctic research, the Commission will consider sponsorship of an international meeting to consider research activities and needs in the Arctic. Commission members agreed to consider the possible scope of programs and participation for further discussion at the next meeting.

## *State of Alaska Activities*

The Arctic Research and Policy Act states that the Commission should facilitate cooperation between the Federal Government and State and local governments with respect to Arctic research, and should cooperate with the Governor of the State of Alaska and with

agencies and organizations of the State that he may designate. In addressing the public meeting on June 28, 1985, Governor Sheffield expressed the opinion that the State of Alaska is vitally interested in Arctic research. He extended an invitation to the Commission to hold a joint meeting with both Houses of the Alaska State Legislature in Juneau in January 1986. Elmer Rasmuson reported that the Alaskan Legislature is eager to assist the Commission, and that the Governor has established an office of science advisor. The Commission agreed that it is critically important to establish a firm working relationship with the State, and at its next meeting, it will consider possible locations for a branch office in Alaska. The individual who would staff a Commission Alaska office should have a good working knowledge of Arctic research, and the office should also maintain close ties to the University of Alaska.

### *Future Activities*

Although the Commission made a good start in obtaining public participation in its activities through the public meetings in Barrow, Fairbanks and Anchorage, individuals from areas in western Alaska have not yet had an opportunity to report on their research needs. Therefore, the Commission agreed that it should hold a series of public meetings in that region during the following year. Meanwhile, to start the process of research identification, some members plan to visit Bethel and Kodiak to obtain input into Commission activities.

Mr. Rasmuson alerted the Commission to the need to identify possible problems and disputes arising from conflicting goals and interests. He noted that the meetings to date have emphasized aspects of nonrenewable resource development in relation to subsistence activities. Additional information is required for renewable resources.

### *Public Information*

The Chairman suggested that a report of the Commission's meetings should be submitted for publication in *Arctic*, thereby providing a systematic record of the Commission's activities. The Commissioners endorsed this suggestion and requested the Executive Director to explore the possibility of publication and report his findings at the next meeting.

The Commission considered a preliminary draft of an article prepared by Dr. Washburn for possible publication in *Science*. The Commission endorsed preparation of the article and noted that the timing would be appropriate because of the emergence of two other reports on Arctic research, one by the Polar Research Board and the other by the University of Alaska Foundation.

### *Other Business*

In response to the Commission Chairman's letter to Congress requesting a six-month extension for the Commission's review of the five-year Arctic research plan, Representative Fuqua had agreed to such an extension, citing the relevant sections of the Act regarding the development of the five-year plan.

By law, the Commission does not have access to classified documents. Several members believe that in order to be most effective in carrying out its charge, the Commission should be aware of classified activities. However, it was pointed out that a briefing on such activities might unnecessarily complicate and hinder its interaction. It was agreed that only the Chairman should request a briefing on U.S. defense activities in the Arctic.

## *Third Meeting: September 19–20, 1985*

The Arctic Research Commission held its third meeting in the Board Room of the University of Southern California, September 19–20, 1985. The main emphases of the meeting were on 1) development of an Arctic research policy statement, including goals and objectives, and 2) consideration of the Commission's report to Congress and to the President due January 31, 1986.

### *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported on the activities of the Interagency Arctic Research Policy Committee. He called the Commission's attention to the draft report *Federal Arctic Research: Detailed Listing of Existing U.S. Programs*, and noted that an earlier version of this report had been submitted to the Commission for its consideration. The Interagency Committee has transmitted a draft of this report to the Office of Science and Technology Policy and the Office of Management and Budget. The Interagency Committee plans to submit the package to the Congress. The National Research Council report *National Issues and Research Priorities in the Arctic* will be part of the package submitted to Congress.

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen.*

Observers: *James Devine, U.S. Geological Survey; John Talmadge, National Science Foundation; Robert Friedheim, University of Southern California; Richard Nevė, Science Advisor, State of Alaska; Mark Newell, Ukpeagvik Inupiat Corporation, Barrow.*

The Interagency Committee will hold a series of workshops to begin the identification of research priorities for the five-year Arctic research plan.

## *State of Alaska Activities*

The Commission has received an invitation from Alaska State Senator Arliss Sturgulewski to meet with the Senate Committee on Resources. The Commission requested that the Chairman write to the Governor and Senator Sturgulewski suggesting that meetings with the Alaska State Legislature and the Committee on Resources be scheduled for January 31, 1986.

The Commission received information that Alaska State Senator Frank Ferguson had set up a state liaison office for the Commission. Kathy Hathaway will keep the Legislature informed on the activities of the Commission. The Commission agreed that during its meeting with the Governor and Alaska State Legislature in January it should discuss procedures for formal liaison and an ongoing exchange of information with the Legislature.

## *Future Activities*

The Commission considered a memorandum prepared by Elmer Rasmuson in which he outlined an approach to establishing research priorities and a course of action in relation to them. Mr. Rasmuson stressed that the Commission has no funds to carry out research; rather, it must serve as a focal point for communication and information exchange.

The Chairman indicated that he would prepare a list of possible research priorities for Commission consideration. He emphasized the need to understand the Arctic Ocean and its related air–sea–ice interactions, to protect the health and welfare of the population, to understand and predict weather and climate, to enforce data management, and to provide information necessary for energy and resource development with minimal environmental impact. The Commission requested that Federal research activities described in *Federal Arctic Research: Detailed Listing of Existing U.S. Programs* be compared with the NRC report *National Issues and Research Priorities in the Arctic*, the public testimony provided to the Commission, and the University of Alaska Foundation report.

## *Arctic Research Policy*

The Arctic Research and Policy Act directs the Commission to develop and recommend an integrated national Arctic research policy and to publish a statement of Arctic research goals and objectives to guide the Interagency Committee. Following detailed discussion, the Commission approved in principle a draft statement. The Commission requested that these statements be distributed for additional comment. (The final versions of the Commission's policy and goals statement and objectives statement appear in its January 1987 annual report.)

## *Group of Advisors*

Two approaches to the formation of a Commission advisory group were considered. One approach is to appoint a specific group to serve in that capacity, with their names made available to the public. Another is to develop a list of advisors and solicit their advice as needed. The Commission agreed that the Executive Director should initiate the steps necessary to establish a formal group of scientific and technical advisors. The Commission decided that in some cases it would be appropriate to have a government employee serve on the group of scientific and technical advisors. In executive session, the Commission considered a tentative list of names and related biographical information, and agreed that individuals appointed to the group should have a set term of service.

## *Public Information*

At its previous meeting, the Commission decided that a systematic record of its activities should be published in a widely distributed journal such as *Arctic*. The Executive Director reported that the editor of *Arctic* had expressed interest in this suggestion. Mr. Rasmuson suggested that the Commission would want to have its own publication. After a discussion of the most effective way to inform a broad community of ongoing Arctic research activities, the Commission recommended that the NSF and the Interagency Committee publish a bulletin that would report on the activities of the two groups and related matters. Dr. Wilkniss agreed to explore this possibility.

## *Logistics*

Mark Newell, Associate Director, UIC-NARL, reported that the Barrow laboratory facilities are to be transferred to the Native corporation in the near future. He reported that the UIC plans to have the laboratory facilities available to the research community and that the cost of using the laboratory will be competitive.

### *Administrative Activities*

Timothy Hushen reported that he and the Commission Chairman had worked with the NSF and the Office of Management and Budget, and with members and staff of the House and Senate Appropriations Committees, to secure a budget to support the work of the Commission. The NSF reprogrammed funds to provide the Commission with an initial budget for FY 85. The Commission requested and received, in the FY 85 Supplemental Appropriations Act, an additional $100,000 to support its operation for the remainder of FY 85 and for a portion of FY 86. The Commission and the NSF agreed that the Commission's budget should be in addition to the Foundation's budget request, and that the Commission would justify and defend the budget before the Office of Management and Budget and Congress. The Commission has submitted, through the NSF, a budget request to support its planned activities for FY 87.

The Commission had received letters of invitation to establish an office in Alaska at the Arctic Environmental Information and Data Center located in Anchorage, the Geophysical Institute located in Fairbanks, and Alaska Pacific University in Anchorage. It would serve as a communications center and provide information about the activities of the Commission and about Arctic research within the State. The Commission concluded that the University of Alaska's Arctic Environmental Information and Data Center would be the most suitable place for its office.

Because the Commission does not have funds to fully operate a regional office in the FY 86 budget, the Executive Director was requested to explore the possibility of arrangements whereby the Commission would reimburse the Center on a limited basis for personnel and general office use.

## *Fourth Meeting: November 14–15, 1985*

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Erich Bloch.* Staff: *W. Timothy Hushen.*

The Arctic Research Commission held its fourth meeting in the Board Room of the University of Southern California on November 14, 1985, and held a public meeting at the Applied Physics Laboratory of the University of Washington, Seattle, on November 15, 1985. The main items of business at these sessions were adoption of a statement of Arctic research policy and objectives, the Commission's mandated report to the President and the Congress on January 31, 1986, public testimony on Arctic research policy, and Arctic research priorities.

### *Interagency Arctic Research Policy Committee Activities*

Erich Bloch, Director, NSF, and Chairman, Interagency Arctic Research Policy Committee, noted that from his perspective the working relationship and cooperation between the Committee and the Commission has been outstanding. He stated that the Arctic Research and Policy Act was badly needed and that the Interagency Committee will provide leadership within the Federal Government to ensure that the relationship among the Federal agencies remains good. He expects the Commission to provide policy guidance. He stressed the need to establish priorities and to reorient funds for new programs from ongoing activities. Of the current $55 billion Federal budget for R&D, approximately $6–$7 billion goes into university research. Mr. Bloch believes a greater amount should be allocated to university-based research. Over the next five years he anticipates much closer international cooperation in research. He stressed the need for more joint research between the U.S. and Canadian research communities, especially in the Arctic.

Dr. Peter Wilkniss reported that two issues of concern to Arctic science were raised at the last Polar Research Board meeting: icebreaking research vessels and deep ice coring and drilling. The Board is examining what the United States can do to improve use of icebreakers as platforms for research. Regarding deep ice coring, the Board is developing long-term recommendations on ice drilling, including the need for increased international cooperation. Dr. Wilkniss will brief the Presidential Commission on Space Research about remote sensing needs and opportunities in the polar regions. John Talmadge stated that the Interagency Committee submitted its report to Congress on July 31, 1985. The Interagency Committee is holding a series of workshops on ice and weather dynamics, health, terrestrial ecology, energy and mineral research, and marine ecosystems.

Dr. James Zumberge commended the Interagency Committee especially on its preparation of the report *Federal Arctic Research: Detailed Listing of Existing U.S. Programs.* He also expressed the Commission's appreciation for the NSF's assistance, particularly in obtaining the funds to support Commission activities. Although Commission recommen-

Observers: *James Devine, U.S. Geological Survey; Robert Friedheim, University of Southern California; Richard Nevé, Science Advisor, State of Alaska; John Talmadge, National Science Foundation; Peter Wilkniss, National Science Foundation.*

dations may not be acted on immediately, over the longer term it may be able to get special programs funded through Congress. That the Commission does not seek research funds for itself, but rather for the programs of operating agencies, could be an advantage.

## *Arctic Research Policy and Priorities*

The Arctic Research and Policy Act directs the Commission to develop and recommend an integrated national Arctic research policy and to publish a statement of goals and objectives of Arctic research to guide the Interagency Committee. Mr. Bloch stressed that the Commission should take a long-term look, and that there should be close linkage between Arctic research policy and research goals and objectives.

The Commission reviewed the statement of Arctic research policy, and of goals and objectives, that it had approved in principle at its last meeting, and it considered a revised version reflecting suggestions received since that meeting. After additional discussion, the Commission unanimously approved the statements of Arctic Research Policy and of Goals and Objectives as the guiding principles upon which a detailed research plan can be based. [See Commission Annual Report dated January 1987 for complete text.] The Commission requested its Chairman to officially transmit the policy statements to the Interagency Committee.

The Arctic Research and Policy Act calls for the identification of research priorities. Based on the comments from public meetings and on the reports *National Issues and Research Priorities in the Arctic* and *Federal Arctic Research: Detailed Listing of Existing U.S. Programs*, Commissioners Washburn and Roederer had developed approaches to Arctic research and identified high-priority research needs. After discussion of criteria for establishing priorities, the Commission concluded that different criteria should be employed, depending on circumstances. For example, in regard to State and Federal cooperation, fisheries and health research should receive high-priority attention. The Commission urged the Chairman to emphasize the importance of joint Federal–State cooperation in fisheries research (food chain ecosystem research) and health research when he addresses the Governor and Legislature of Alaska in January.

## *Commission Reports*

The Arctic Research and Policy Act states that not later than January 31 of each year the Commission shall submit to the President and to Congress a report describing its activities and accomplishments during the immediately preceding fiscal year. The Commission reviewed a preliminary draft and suggested that the report cover only the first seven months of the Commission's existence, March–September of FY 86. Mr. Bloch noted that this report will be primarily a historical document, and that policy recommendations can be made separately. In addition, a transmittal letter of two or three pages should be prepared, highlighting Commission activities. A package containing transmittal letter, report of activities, and public testimony received should be submitted to the two Congressional Committees having oversight authority over the Commission.

## *State of Alaska Activities*

The Commission requested the Chairman to write Governor Sheffield reconfirming its acceptance of the invitation to meet with him and members of his cabinet and transmitting the statements of Arctic Research Policy and Goals and Objectives that the Commission had endorsed. Dr. Richard Nevé, Science Advisor, State of Alaska, said that he would arrange for the Commission to meet with the House and Senate Committees on Resources and encourage the Governor to suggest to the Speaker of the House and President of the Senate that a joint meeting of the Legislature be held with Dr. Zumberge as a speaker. The Alaska State Governor's Advisory Committee on Science and Engineering will also meet with the Commission on January 31. Dr. Nevé is compiling a detailed list of Arctic research programs conducted by the State of Alaska. Elmer Rasmuson emphasized the need to notify the heads of several of the State agencies of this meeting and request that they attend.

## *Future Activities*

The Commission reviewed a list of activities and possible actions to achieve its legislatively mandated tasks.

1. Assisting the Interagency Committee in establishing a five-year plan: The Commission requested its Chairman to write to the Chairman of the Interagency Committee commenting on the progress made to date and the need for continued cooperation.
2. Cooperation between the Federal Government and State and local governments: The public meetings in Alaska and the

meetings scheduled with the Governor and the State Legislature are major steps toward fulfilling this objective.

3. Improving logistic planning and support for research: The Commission requested its Chairman to write to the Chairman of the Interagency Committee suggesting that the Committee consider undertaking a study to assess capabilities of current Arctic research platforms and logistic systems for support of research. To obtain information on which to base recommendations for improvements in logistic planning and support of research, the Commission believes that such a study is needed. The study should include bases, ships, satellites, buoys, aircraft, and the like.
4. Improving access to and use of the data and information resulting from Arctic research: The Commission believes that current efforts such as the Conference on Northern Science Data Networks, to be held in Anchorage November 18-21, should be encouraged and assisted in the development of an overall Arctic data system.
5. Review of the President's annual budget request and a report to Congress on adherence of the request to the five-year plan.

### *Group of Advisors*

Following review of a proposed slate of nominees in executive session, the Commission authorized the Chairman to appoint 24 individuals to a Group of Advisors. Members of the Group will provide advice on Arctic research policy, goals and objectives of Arctic research, national needs in the Arctic, and research programs to address such needs. They will also act as additional points of contact with the research community and will inform the Commission about problems and concerns related to Arctic research. The Group of Advisors will conduct its work primarily through correspondence and by telephone. The membership will be made public as soon as written acceptance from each nominee has been received.

### *Other Business*

On November 15, 1986, nine speakers provided verbal comments on Arctic research policy and Arctic research programs at the University of Washington. A list of participants and related documents and a transcript of the discussion are available from the Commission.

## *Fifth Meeting: January 31, 1986*

The Arctic Research Commission held its fifth meeting jointly with Alaska State Governor Sheffield and his cabinet and with the members of the Alaska State Legislature Senate and House Committees on Resources in Juneau, Alaska, on January 31, 1986. The main emphasis of the meeting was on furthering Federal/State cooperation in Arctic research. The Governor and the Commission took concrete action to recommend Federal/State research efforts in the areas of fisheries, health and data exchange. Chairman Zumberge and Governor Sheffield jointly signed a letter requesting development of a protocol for data exchange. In addition, the Governor announced that he will introduce legislation to create a State Research Policy to complement the Arctic Research and Policy Act. The Governor hosted a luncheon for the Commission attended by members of the Legislature and the State Advisory Committee on Science and Engineering. The meeting with the joint Senate and House Committees on Resources reviewed the Commission's current activities and future plans. The Commission held a short meeting with members of the Governor's Science and Engineering Advisory Committee.

The Commission, at a breakfast meeting, modified and approved Chairman Zumberge's remarks to the Governor and Legislature and the draft report *National Needs and Arctic Research: A Framework for Action.*

### *State of Alaska Activities*

Governor Sheffield noted that Alaska is the United States' only Arctic state, and that its public health, economy, weather, and attitudes are profoundly influenced by the Arctic. The State has a strong commitment to scientific and engineering research. The specific goals and policy objectives of Alaska's Arctic research programs are:

- Improve the public health and well-being of Alaska's people.
- Adopt new technologies and adapt them to Alaska's needs and conditions.
- Investigate natural hazards such as earthquakes, volcanoes and permafrost, and find ways to protect against those potential dangers.
- Develop and manage Alaska's abundant natural resources.
- Protect and preserve the unique features of wilderness resources.

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo.*

State of Alaska: *Governor Bill Sheffield; Cabinet Members: Eleanor Andres, Commissioner, Department of Administration; Loren H. Lounsbury, Commissioner, Department of Commerce and Economic Development; Emil Notti, Commissioner, Department of Community and Regional Affairs; Representative, Department of Corrections; Harold Reynolds, Jr., Commissioner, Department of Education; Bill Ross, Commissioner, Department of Environmental Conservation; Don W. Collinsworth, Commissioner, Department of Fish and Game; John R. Pugh, Commissioner, Department of Health and Social Sciences; Jim Robison, Commissioner, Department of Labor; Hal M. Brown, Attorney General, Department of Law; Representative, Department of Military and Veteran Affairs; Esther C. Wunnicke, Commissioner, Department of Natural Resources; Robert J. Sundberg, Commissioner, Department of Public Safety; Mary A. Nordale, Commissioner, Department of Revenue; Representative, Department of Transportation and Public Facilities; Donald D. O'Dowd, President, University of Alaska; Staff: Ray Gillespie, Chief of Staff for the Governor; Richard A. Nevé, Science Advisor, Office of the Governor.* Legislature: *Senate Committee on Resources: Arliss Sturgulewski, Chairman; Bettye M. Fahrenkamp, Vice-Chairman; John B. Coghill, Richard I. Eliason, Vic Fischer, Rick Halford, Fred F. Zharoff; Staff: McKie Campbell. House Committee on Resources: Adelheid Herrmann and Richard Schultz, Co-Chairmen; F. Kay Wallis, Bette Cato, Roger Jenkins, Mike W. Miller, Drue Pearce, John Sund, Dave Thompson; Staff: Debra Greenberg.*

- Build and maintain transportation and communications systems.
- Identify and address social and economic challenges.
- Put scientific knowledge to practical use in the towns, villages, and lives of the Alaskans.

To help reach those goals, the Governor stated that he has taken these three important steps:

1. Appointed a Senior Science Advisor, Dr. Richard Nevé.
2. Named a Science and Engineering Advisory Committee to work with Dr. Nevé and coordinate State agency research needs with industries and the University of Alaska.
3. Asked the State Legislature to provide partial funding for the Arctic Research Commission's office in Anchorage to ensure that the State's efforts enhance and complement those of this Federal Commission.

He stressed how important it was for the Arctic Research Commission to maintain an active presence in Alaska. The Governor recommended three basic areas for Federal/State cooperation: health, fisheries and information systems.

Chairman Zumberge summarized the major provisions of the Arctic Research and Policy Act and pointed out that the Commission is not an operating agency but must count on the power of persuasion. He noted that with respect to Arctic research directed towards problem solving, the Commission had identified three areas that constitute the basis for joint efforts by the State of Alaska and the Federal Government:

1. The fisheries of the Bering Sea.
2. The health and welfare of humans who live and work in the Arctic.
3. An Arctic information network.

To demonstrate the new partnership between the Commission and State, Governor Sheffield and Chairman Zumberge signed a letter requesting that the Committee for Natural Resource Information Management (CONRIM) increase its efforts to produce an Arctic information network design and plan which will provide for the sharing of information in health, oceans, atmosphere, fisheries and other fields.

The Commission met with the Senate and House Committees on Resources from 2–4 on January 31 in the State Capitol Building. Senator Arliss Sturgulewski, Chairman of the Senate Committee, presided. The Commission and Committees had a wide-ranging discussion of Arctic and Alaskan research needs and opportunities. Senator Fischer strongly supported the Commission's interdisciplinary approach to problem solving. Members of both Committees expressed support for the Commission's activities, requested that it call on them if it needed their help, and invited it to meet with them again next year.

## *Federal/State Cooperation*

To build on the momentum developed during the meeting with the Governor and Legislature, the Commission at its dinner meeting agreed to request Governor Sheffield to join with it in requesting both NOAA and the Public Health Service to nominate individuals to serve on joint Federal/State task forces to develop specific research agendas in the areas of fisheries and health.

The letter to the Department of Health and Human Services and the Alaska Department of Health and Social Services should encourage the establishment of a joint task force to identify health research needs and recommend priority Federal/State cooperative research programs to address those needs. Other items that should be examined include data and information systems and identification of opportunities and needs for international cooperation. The letter to the Administrator of NOAA and to the Commissioner of the State Department of Fish and Game should stress the need for the joint task force to identify specific research needs and recommendations in the Bering, Chukchi and Beaufort Seas. The Commissioners requested Dr. Juan Roederer and Timothy Hushen to report on and discuss these recommendations at the Interagency Arctic Research Policy Committee meeting to be held in Washington on February 3, 1986.

## *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported the Gramm–Rudman–Hollings budget reduction act requires a 4.3% reduction across the board for FY 86. The budget of the National Science Foundation and the Commission have been reduced by this amount.

The Interagency Committee continues to hold planning workshops. A workshop on ice and weather dynamics was held at the Cold Regions Research and Engineering Laboratory, Hanover, N.H., in November 1985. Terrestrial and marine ecosystem workshops are scheduled for March 1986, and an energy and

Observers: *Governor's Science and Engineering Advisory Committee: John J. Kelley, Stan Moberly, Donald E. Pickering, Larry Sweet. University of Alaska: David Hickock, Beverly Beeton, Donald Behrend.*

minerals workshop for May 1986. Draft recommendations will be available for public comment prior to a workshop to be held in Anchorage, Alaska, in November 1986.

The next Interagency Committee meeting will be held at the National Science Foundation on February 3, 1986. Major items will include formal adoption of an Arctic research policy, comments from the Arctic Research Commission, a work plan for dealing with research priorities, agency budget requests for FY 87, and educational items.

### *Commission Reports*

As called for by the Arctic Research and Policy Act, the U.S. Arctic Research Commission made an initial assessment of national needs and research in the Arctic and developed the statement *National Needs and Arctic Research: A Framework for Action*, which recommends an interdisciplinary research approach and broad priorities as a basis for development of the Arctic Research Plan. It is anticipated that recommendations on specific projects of basic and problem-oriented research will evolve from the broad framework.

The report identifies the Arctic Ocean, including the Bering Sea and other marginal seas and their seabeds, as a top priority target for quantitative understanding. Other research priorities identified include research on the coupled land–atmosphere components of the Arctic system, research on the high-latitude upper atmosphere and its extension into the magnetosphere, and research on the health–cultural–socioeconomic system. From a regional viewpoint the latter is of highest priority. After discussion of the document and suggestion of some minor language changes, the Commission unanimously approved the report as a "working document." The Commission believes that the document will be of great assistance in the forthcoming workshops sponsored by the Interagency Committee.

The Arctic Research and Policy Act states that not later than January 31 of each year the Commission shall submit to the President and to Congress a report describing its activities and accomplishments during the immediately preceding fiscal year. A draft report has been prepared. The Commissioners approved the report *U.S. on the Arctic Rim: Report of the U.S. Arctic Research Commission to the President and the Congress of the United States of America, for the Period 1 March–30 September 1985* for publication with minor modifications.

Chairman Zumberge reported that *Oceanus* would publish a volume dedicated to Arctic research in spring 1986. He has prepared the introductory paper which describes the Arctic Research and Policy Act and the work of the Commission. The Commission will distribute copies to key government officials at the State and Federal levels, decision makers in industry, and members of concerned public interest groups. Mr. Hushen reported that the Commission staff will prepare a short 1- or 2-page newsletter which will report on the Commission's activities.

### *Group of Advisors*

At its last meeting, the Commission agreed to establish a group of advisors. After the meeting, Elmer Rasmuson suggested in a memorandum that the Commission establish another group to identify research needs of concern to the State of Alaska. After discussion of this suggestion, the Commission unanimously agreed that rather than establish its own group it would look to the State Science and Engineering Advisory Committee to play this role. After a final review of the slate of nominees, the Commissioners instructed the Chairman to appoint the Group of Advisors.

### *Administrative Activities*

Mr. Hushen reported that the Commission had negotiated an agreement with the University of Alaska to open an office at the Arctic Environmental Information and Data Center in Anchorage, Alaska. Lyle D. Perrigo will staff the office on a half time basis with the title of Staff Officer.

## *Sixth Meeting: April 28–29, 1986*

The Arctic Research Commission held public meetings in Kodiak and Anchorage, Alaska, on April 28 and 29, 1986, respectively. The meeting in Kodiak focused on research needs in the area of fisheries and marine ecosystems. The Anchorage meeting featured a lecture by Oran Young on "Arctic Geopolitics and Their Impact on Research." The meeting in Anchorage was also open to public comment on Arctic Research Policy. In all, over 150 people participated in the meetings and discussions. In addition to the public meetings, the Commission met with members of the City and Borough Government of Kodiak and participated in a demonstration of a cold water survival suit, visited a *surimi* production facility, and held discussions with mem-

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo.* Commission Advisory Group Members: *Robert L. Friedheim, University of Southern California; Roger Herrera, Standard Oil Production Company; David M. Hickok, University of Alaska; Oran Young, Center for Northern Studies.*

Observers: *Vera Alexander, University of Alaska; Eddie Bernard, National Oceanic and Atmospheric Administration; James Branson, North Pacific Fisheries Council; Max C. Brewer, U.S. Geological Survey; Donald Collinsworth, Alaska Department of Fish and Game; James Devine, U.S. Geological Survey; David Garman, Office of Senator Frank Murkowski; George Gryc, U.S. Geological Survey; Thomas Laughlin, National Oceanic and Atmospheric Administration; Richard Nevé, Alaska State Science Advisor.* Participants in Public Meeting: *names available from Commission.*

bers of the Fisheries Industry Technical Center. The testimony and documents received in the Kodiak and Anchorage public meetings are available from the Commission on request.

## *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported that the Interagency Committee has held workshops to develop components of the five-year Arctic Research Plan. Thomas Laughlin, NOAA, then reported on the Workshop on Arctic Marine Ecosystems Research, held in March 1986. James Devine, USGS, announced that a Workshop on Energy and Minerals will be held on May 1 in Anchorage. Other workshops have dealt with health, land-based environments, and weather and ice dynamics. The reports of these workshops will be reviewed at an Interagency Committee staff meeting in May 1986, and a draft report will be assembled. A preliminary draft of the five-year Arctic Research Plan will be distributed for public comment in late July 1986. A follow-up workshop for additional review and comment will take place in Anchorage in November 1986.

## *State of Alaska Activities*

Dr. Richard Nevé, Science Advisor to the Governor, reported that the Alaska Research Policy Act was passed by the House of Representatives by a 23–6 vote. The purpose of the Act is to establish State research policy, priorities, and goals, and to provide a plan for basic and applied research for the State, including natural resources and materials; physical, biological and health science; and social and behavioral science. Elmer Rasmuson commented that it is important for the State Legislature to pass this Act as a demonstration of its willingness to work with the Federal Government in developing research programs to benefit both the State and the Nation.

## *Congressional*

David Garman, representing U.S. Senator Frank Murkowski (R.-Alaska), reported that the Senator is committed to work with his colleagues to make the Arctic Research and Policy Act a powerful tool to support Arctic research. The Senator hopes that a new Federally funded initiative in the Arctic can be tied to the Act.

## *Group of Advisors*

The 24 individuals have accepted the invitation to serve on a Group of Advisors to the Commission. The Commissioners requested that the list of members and their affiliations be made public. [The names are published in Commission reports.]

## *Fisheries Research*

The Commission has selected as its highest priority, research to understand the Arctic Ocean (including the Bering Sea and other marginal seas, sea ice, and the seabed), and how the ocean and the Arctic atmosphere interact. The Commission believes that this priority presents a special opportunity to develop both an understanding of the ecosystem and other conditions affecting the Bering Sea fisheries and their fluctuations, and a new cooperative relationship among Federal, State, and industrial groups. Such understanding and cooperation could help to cope with such problems as the dramatic and unexplained decrease of shellfish stocks. The Commission and Alaska Governor Sheffield have requested the Administrator of NOAA and the Commissioner of the State Department of Fish and Game to develop a detailed research program to promote this effort.

At the Commission's public meeting in Kodiak, local fishermen emphasized the need for such research, and they agreed to participate in the effort, including the donation of ship and crew time to it. However, to develop and implement a detailed research plan will take about a year. In the interim, the Bering Sea surveys conducted by NOAA must be continued to provide the necessary, uninterrupted flow of baseline research, resource management and resolution of management issues.

The Commission instructed the Chairman to write to the President, to Senators Stevens, Murkowski and Roth, and to Congressmen Young and Fuqua requesting that the proposed $4,014,000 reduction in support of Bering Sea fisheries ecosystem research be restored in the FY 87 budget. Specifically, the FY 87 budget calls for $4,671,000 to support fisheries research in the Bering Sea, which is reduced from the FY 86 level of $8,685,000. The Bering Sea fishery is a national economic asset that provides 40% of the seafood harvested from U.S. waters, as well as employment for some 50,000 people, with fishermen from over 20 states participating in the harvest.

## *International Cooperation*

The Commission staff compiled a draft document entitled *Arctic Cooperative Research Agreements and Major Arctic-Rim Re-*

*search Organizations: Initial Compilation.* The document identifies and provides an overview of:

1. Current international cooperative agreements on scientific research, including governmental bilateral and multilateral agreements and nongovernmental projects and organizations.
2. Domestic Arctic research organizations.

The draft compilation identifies what is taking place in international Arctic research at both governmental and nongovernmental levels and "who and what" are some of the key organizations in the United States and other Arctic-rim countries.

After discussion of possible courses of action, it was agreed that both multinational and bilateral arrangements are needed and should be encouraged. A U.S. polar research institute might strengthen U.S. participation in multinational research programs. There is a special need to involve scientists from the Soviet Union in discussions and efforts to enhance cooperative exchanges of scientific information. The Commission Chairman stated that he would take advantage of the forthcoming Scientific Committee on Antarctic Research meeting to hold informal discussions on Arctic international cooperation with key individuals from several Arctic-rim nations.

### *Logistics*

The two Polar class icebreakers operated by the U.S. Coast Guard are the only U.S. flag ships capable of supporting science in ice-covered seas. The proposed new polar icebreakers with enhanced science support capabilities will offer greater opportunities for Arctic research. Chairman Zumberge plans to schedule a meeting with the Commandant, U.S. Coast Guard, to discuss what can be done to maximize the use of the current icebreaker fleet in the best interest of the United States and its research community.

## *Seventh Meeting: July 23, 1986*

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Elmer E. Rasmuson; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo.*

The Arctic Research Commission held its seventh meeting in the Board Room, University of Southern California, on July 23, 1986. The meeting focused on the draft five-year Arctic Research Plan and the public review workshop, Arctic health activities, international cooperation in Arctic research, and future activities of the Commission.

### *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported that the NSF National Sciences Board is conducting a review of its programs. The review is expected to involve representatives from the Office of Science and Technology Policy, Office of Management and Budget, Department of Defense, and the Commission. A global ice coring program is expected to be included as a new initiative in the NSF's FY 88 budget request. Member agencies of the Interagency Committee have held workshops to develop components of the five-year Arctic Research Plan.

John Talmadge and Dr. Jerry Brown provided a review of the Interagency Committee activities in developing the draft Plan, and distributed copies to the Commission. A public Interagency Consultative Workshop is to be held in Anchorage from November 17–19, 1986, to review and refine the draft Plan. The final version will be submitted to the President in July 1987. The Consultative Workshop will involve representatives from the five groups specifically named in the Act: the Commission, the Governor of the State of Alaska, residents of the Arctic, the private sector, and public interest groups.

The Plan consists of two parts: 1) *Federal Arctic Research: Draft Recommendations for Necessary Programs*, including the Commission statement *National Needs and Arctic Research: A Framework for Action*, and the research plans for weather and ice dynamics, marine ecosystems, energy and minerals, land environments, and health and culture; and 2) *Federal Arctic Research: Detailed Listing of Existing U.S. Programs.* In the discussion that followed, Commission members pointed out that the Plan does not include research on the upper atmosphere.

Elmer Rasmuson commented that the Committee and Commission are not taking a problem-oriented approach. To accomplish the goals of the Act, Mr. Rasmuson believes that the research plan must be problem-specific; the budget process should also be problem-oriented. Dr. Juan Roederer pointed out that Mr. Rasmuson had identified the major dilemma that faces the Commission: it must consider practical problems that are urgent, short-term and pragmatic, but the research that is needed to answer such questions is mostly long-term, often esoteric, and multidisciplinary in nature.

Chairman Zumberge commended the Interagency Committee on its careful adherence to

Commission Advisory Group Members: *Robert L. Friedheim, University of Southern California; Ben C. Gerwick, University of California, Berkeley; John P. Middaugh, Alaska State Epidemiologist; Howard A. Slack, San Marino, California.*

Observers: *Jerry Brown, National Science Foundation; James Devine, U.S. Geological Survey; David Garman, Office of Senator Frank Murkowski; George E. Hardy, Department of Health and Human Services; C.W. Sullivan, University of Southern California; John Talmadge, National Science Foundation.*

the Arctic Research and Policy Act in preparation of the draft five-year plan. He will write to Erich Bloch, on behalf of the Commission, to express its appreciation of the tremendous effort that has gone into the draft plan. The Commission agreed that its Group of Advisors should be requested to review the draft plan. Oliver Leavitt, Mr. Rasmuson and Dr. Lincoln Washburn indicated that they will participate in the Consultative Workshop.

### *State of Alaska Activities*

Timothy Hushen reported on behalf of Dr. Richard Nevé, State Science Advisor, that the Alaska Research Policy Act was signed into law by Governor Sheffield on May 24, 1986, and that it will come into effect on August 22, 1986. The purpose of the Act is to establish State research policy, priorities, and goals, and to provide a plan for basic and applied research for the State, including natural resources and materials; physical, biological and health science; and social and behavioral science.

### *Congressional*

David Garman, representing U.S. Senator Frank Murkowski, reported that the FY 87 budget is extremely tight; however, the Senate supports Arctic programs that are contained in the President's budget request.

### *Arctic Health*

Dr. George Hardy, Assistant Director of the Centers for Disease Control, and Dr. John Middaugh, State of Alaska Epidemiologist, Cochairmen of the joint Federal/State Task Force on Arctic Health, reported to the Commission on its work. In a letter to Chairman Zumberge and Governor Sheffield, dated July 11, 1986, Robert Windom, Assistant Secretary for Health, indicated that the Federal working group will be pleased to confer with their Alaska State counterparts on this important research agenda and to work together to expeditiously develop a joint research program. Dr. Hardy noted that several components of the U.S. Public Health Service—the National Institutes of Health, Centers for Disease Control, Food and Drug Administration, Alcohol and Drug Addiction Agency, and Indian Health Service—developed the Arctic health plan, which is part of the five-year Arctic Research Plan.

Dr. Middaugh, Chairman, State Task Force, and a member of the Commission's Group of Advisors, reviewed ongoing activities in Arctic health research. The American Medical Association supports Arctic health research as they are convinced of its potential application to national needs. The International Union for Circumpolar Health has been established, based on the successful cooperation developed during the International Conferences on Circumpolar Health. The first meeting of the Union will be held in Sweden in June 1987. International cooperation with the Soviet Union has resulted in an exchange program between the University of Alaska and the Soviet Medical Workers, which represents about six million health workers. The joint task force planned to meet during the American Public Health Association meeting in September 1986. The Commission strongly supports the work of the task force, and the Chairman will write to the Governor stressing the importance of the work of this task force and encouraging Dr. Middaugh's participation.

### *International Cooperation*

Chairman Zumberge reported that he took advantage of a recent meeting of the Scientific Committee on Antarctic Research to hold informal discussions with key individuals from several nations engaged in Arctic activities on mechanisms for international cooperation in Arctic research. Scientists from Poland, Sweden, the United Kingdom, the Federal Republic of Germany, Japan, France, Finland, Norway, the Soviet Union and the United States participated in the meeting. The Group concluded that there is not an effective organization to facilitate cooperation among all the nations active in Arctic research. There was general support for holding an Arctic international forum, and the group agreed that O. Rogne (Norway) would take the lead in exploring with the Soviets their interest in participating in such a forum. The Swedish Academy would probably agree to host such a forum. The following individuals were identified as points of contact for planning: Rogne (Norway), Zumberge (U.S.A.), Roots (Canada), Taagholt (Denmark), Avsiuk (U.S.S.R.), Mansukoski (Finland) and Bolin (Sweden).

Mr. Rasmuson noted that Soviet scientists had participated in a recent meeting held in Alaska on the oceanography and fisheries of the North Pacific and stressed the importance of working with them on specific projects under bilateral arrangements. Dr. Roederer suggested that Soviet participation would be facilitated if any proposed meeting were held under the sponsorship of the International

Council of Scientific Unions. Further, the Commission might want to propose an International Year of the Arctic.

### *Polar Research Centers*

Commissioner Washburn suggested that the United States should consider the need for some type of polar institute to provide a focus for international cooperation in Arctic research. The Danes have established an institute, and a Canadian task force is examining the issue. Dr. Roederer commented that the proposed institute should focus on the Arctic; Dr. Zumberge was not convinced that a new organization was needed at this time. There was consensus that any new institute should not require a new facility. The Commission agreed to explore this topic in greater detail at future meetings.

### *Logistics*

The Commission reviewed a staff paper that outlined options in assessing logistic capabilities and needs. It decided to sponsor a workshop in conjunction with the Interagency Consultative Workshop in Anchorage in November 1986 that would deal with requirements for both land- and marine-based logistic systems, with emphasis on the Commission's highest research priority, "research to understand the Arctic Ocean... ."

Dr. Zumberge reported that he had met with Admiral Yost, Commandant, U.S. Coast Guard, to discuss ways to maximize the use of Coast Guard icebreakers by the U.S. scientific community. Admiral Yost stated that Coast Guard officers are trained in the support of scientific research at the Coast Guard Academy and that it considers such support to be one of its important missions. Dr. Zumberge stressed the need to institutionalize the Coast Guard's commitment to the support of science, so that it will remain an important part of the mission. Cornelius Sullivan, Chairman, Polar Research Board Committee on Polar Ocean Platforms, reported that the Board, in response to a request from the Coast Guard, had surveyed over 100 researchers from industry, government, and universities who utilize Coast Guard icebreakers. The Commission agreed to work with the appropriate agency representatives to obtain ice-capable vessels to support research in ice-covered waters.

### *Future Activities*

The Commission would like to hold a meeting to foster awareness of the United States as an Arctic nation. The Chairman will explore with the President of the National Academy of Sciences its interest in participating in such a meeting. Mr. Rasmuson stressed the need for support for the Arctic in the President's Office, and Dr. Zumberge agreed to ask appropriate individuals in the White House to identify a high-level member of the Administration to be the keynote speaker for the meeting.

### *Public Information*

An article entitled *Arctic Research in the National Interest* by A. Lincoln Washburn and Gunter Weller will appear in *Science* in August. *Arctic Research Priorities: Arctic Research Commission Gets Down to Business* by Juan Roederer appeared in *EOS* in June. The Commission endorsed publication by the Interagency Committee of a journal that would provide a record of Commission, Interagency Committee, and other activities pertaining to Arctic research.

## *Eighth Meeting: December 4–5, 1986*

The Arctic Research Commission held its eighth meeting at its Alaska Offices (707 A Street, Anchorage, Alaska). The meeting focused on the Interagency Consultative Workshop (November 1986) to review the draft five-year Arctic Research Plan, the interest of the new State administration in research, reports from Federal/State task groups, a preliminary assessment of Arctic research logistic needs, international cooperation in Arctic research, and future activities of the Commission.

In conjunction with this meeting, Chairman Zumberge addressed two Anchorage audiences. The first address, titled "U.S. Interest in Polar Regions," was delivered to the National Science Teachers Association. The second was a presentation on the role of research in Arctic resource development given at a luncheon arranged by the Superintendent of the Anchorage School District.

### *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss reported on the status of the National Science Board (NSB) review of NSF Arctic and Antarctic programs and responsibilities. The results should be wider understanding of research needs in both polar regions and greater programmatic support.

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo.* Commission Advisory Group Members: *David M. Hickok, University of Alaska; John P. Middaugh, Alaska State Epidemiologist, Anchorage.*

Observers: *Johnny L. Aiken, UIC-NARL; Thomas F. Albert, North Slope Borough; Vera Alexander, University of Alaska; Earl Comstock, Bering Sea Fishermen's Association; Patti Epler, Anchorage Daily News; David Garman, Office of Senator Murkowski; Anne Lanier, Alaska Centers for Disease Control, Anchorage; George Lapiene, Raven Systems and Research, Inc.; Brian McMahon, Indian Health Center, Anchorage; J. Irene Murphy, North Slope Borough School District; Richard A. Nevé, Consultant, Juneau.*

State of Alaska: *Henry Cole, Office of the Governor; Donald Pickering and Jack Colonell, Alaska Science and Engineering Advisory Commission.*

Commissioner Washburn gave the opening address at the NSB review meeting at Stanford University and Chairman Zumberge will address the NSB committee in December on "Policy Concerns of the Arctic Research Commission."

Dr. Wilkniss reported that over 200 people participated in the Interagency Committee's Consultative Workshop in Anchorage, November 17–19, 1986. Participants provided many comments and suggestions on the draft five-year plan. After the workshop, the Interagency Committee staff met in Washington, D.C., to consider how to respond. Information given on existing Federal programs will be included in the revised Arctic Research Plan. The revised draft will include research in upper-atmosphere physics, additional material on engineering, and a more detailed section on social, behavioral and cultural sciences. It was noted that the Anchorage Chapter of the League of Women Voters had done an outstanding job as facilitators of the working sessions of the consultative workshop.

Chairman Zumberge was concerned that steps be taken to incorporate the Plan in the current Federal budgeting process. To wait until FY 90 budget preparation would be counterproductive; immediate efforts to influence allocations in FY 89, or even FY 88, are needed.

## *State of Alaska Activities*

Dr. Henry Cole, representing Governor Cowper's office, indicated the new Administration's interest in research in Alaska. Of particular importance is the operation of the three Federal/State task groups identifying research needed in health, fisheries and information systems. Those three groups are addressing needs that are of particular significance to Alaska. Governor Cowper also hopes that research emphasis can be placed on cultural and social issues.

## *Federal/State Cooperation*

Dr. John Middaugh, Alaska State Epidemiologist and Cochairman of the Federal/State Task Force on Arctic Health, presented three proposals to the Commission for its consideration and possible endorsement: Injury Control Research, Cancer, and Diet and Atherosclerosis. All three are national, as well as Arctic, problems, cover topics that are neglected, and were developed by a group of knowledgeable peers. Anne P. Lanier, Director, Alaska Centers for Disease Control, and a member of the Federal/State Task Force, supported the need for the work outlined in the proposals. Donald Pickering, member of the Alaska Science and Engineering Advisory Committee, supported the three proposals, particularly the proposed research on diet and atherosclerosis. Benefits could accrue from the use of commercially available natural fish oil concentrates in reducing the risk of heart attacks.

Timothy Hushen reported on the letter from Joseph O. Fletcher, Assistant Administrator of Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration (NOAA) reporting on the initiative of the task force on fisheries ecosystem research. Because neither of the task group Cochairmen could be present, the letter provided a report of the formation of the task force, the minutes of its first meeting, and a proposal for research entitled "Ice: Role of Sea Ice in Controlling Arctic Ecosystems."

David Hickok, Director of the Arctic Environmental Information and Data Center (AEIDC), reported on data and information matters, the work on CONRIM, the status of an NSF-funded information networking project, and the future of some AEIDC services utilized by the Arctic science community. CONRIM operates under a Memorandum of Understanding signed by the Commission Chairman and Alaska Governor Sheffield in early 1986, as well as agreements with other agencies. CONRIM functions for the Commission as a Federal/State task force on data and information matters. The mission of CONRIM was expanded recently, and the acronym CONRIM now stands for Council on Northern Resource Information Management. Its focus continues to be on data acquisition and information transfer in Alaska. CONRIM has three ongoing projects: the preparation of an on-line directory of directories of natural resource information, an examination of the correlation of terrestrial ecosystem and natural resource data bases, and an examination of ways and means for making scientific and resource libraries in Alaska more efficient. Mr. Hickok also reported on the uncertain future of AEIDC and some of its services such as preparation and publication of *Current Research Profiles for Alaska*.

## *Logistics*

Lyle Perrigo reported that over 80 people attended the Commission-sponsored logistics workshop on November 18, 1986, in Anchorage, and that valuable information had been acquired. The primary objective of the work-

shop was to secure a broader background on logistic capabilities to support Arctic research, on the current status of U.S. efforts, and on what might be done to satisfy logistic needs.

Dr. Vera Alexander, Director of the Institute of Marine Science, University of Alaska-Fairbanks, reported on a survey in the oceanographic community on the need for an ice-capable research vessel. The survey produced information suggesting that there is sufficient demand for research in ice-covered Arctic waters to justify one ice-capable ship plus one icebreaker–research vessel.

Johnny Aiken, UIC-NARL, presented a report titled *Home Porting the Arctic Science Submarine at Barrow, Alaska* to the Commission and asked for its consideration. The concept will be considered in the Commission's study.

Oliver Leavitt brought to the attention of the Commission a concept developed at the Barrow October interagency workshop for the formation and use of regional centers to conduct or otherwise aid Arctic research. Thomas Albert added that experience at Barrow with the Naval Arctic Research Laboratory (NARL) suggests that a regional science center plays an important educational role in the community. North Slope residents, as a consequence, have a positive picture of science and scientists. This favorable attitude resulted in the support of bowhead whale research by the Borough. Mr. Aiken distributed copies of a resolution by Mayor George Ahmaogak supporting the concept of a regional center. Others present, including Richard Nevé, consultant, Irene Murphy, North Slope teacher, and Mr. Hickok of AEIDC, also supported this concept. Henry Cole noted that it provided a means of getting more science activity into rural Alaska; however, he noted that the current administration does not favor subsidies for support facilities.

Commissioner Roederer summarized the advantages of regional science centers as a means of providing facilities for scientists who normally reside elsewhere to readily undertake scientific research; a means of transferring scientific information to local residents; and a source of employment for a limited number of local residents.

George Lapiene from Raven Systems & Research, Inc., representing the Alaska office of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), National Oceanic and Atmospheric Administration, spoke on the need for a centralized Arctic logistic planning and support function. Local OCSEAP experience shows that substantial savings in time and money can result from improved planning and coordination.

### *International Cooperation*

The Commission's Chairman and Executive Director will attend a meeting in Oslo, Norway, on February 13, 1987, to discuss interest in establishing a research forum to improve cooperation in Arctic research.

### *Arctic National Wildlife Refuge*

The Commission discussed what role, if any, it might play in discussions of the relative merits of oil and gas exploration and development on a part of the coastal plain in the Arctic National Wildlife Refuge (ANWR). The Commission has no authority to adjudicate or resolve the dispute between the proponents of different ANWR uses; however, it might be able to ensure that the findings of research and/or the need for additional research are brought to the attention of decision-makers, as a basis for whatever action might be taken. The Commission agreed to maintain awareness of the debate on ANWR use and directed the staff to gather information about the public review process in Alaska.

### *Administrative Activities*

The Commission reached agreement with the NSF Director that the Commission's budget should be an addition to the NSF budget. The Commission will justify its budget submission to the Office of Management and Budget and to members of Congress. It has submitted through NSF a budget request of $500,000 to support its FY 87 activities. Congress is acting on the NSF's FY 87 budget request, and has reduced the Foundation's budget for research and related activities by about 5%. This reduction would also apply to the Commission.

Dr. Wilkniss reported that in reality the reduction for Arctic activities in the NSF would be closer to 9%, because Congress had chosen to protect certain programs from the 5% cut; thus other programs would be reduced by a greater amount. A Commission budget of $475,000 would reflect the 5% reduction. To offset reductions in other Arctic activities of NSF, Chairman Zumberge agreed to reduce the administrative charges of the University of Southern California by $10,000. This reduction in overhead costs would not reduce the amount available for the Commission's work. The overall Commission budget for FY 87 would be $465,000.

### *Public Information*

The Commission conducted a press conference on December 4, 1986. Reporters from *The Anchorage Daily News*, *The Anchorage Times*, Channel 11 TV, and KSKA Radio attended. Their coverage resulted in four newspaper articles, a five-minute broadcast on radio, and a short statement on the 6:00 pm TV news about the activities of the Commission. The Commission also held a reception following its Thursday business sessions for members of the Anchorage research community; about 45 persons attended.

## *Ninth Meeting: March 5–6, 1987*

Commission Members Present: *James H. Zumberge, Chairman; Oliver Leavitt; Elmer E. Rasmuson; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo, Lisa Ramirez.* Commission Advisory Group Members: *William Fitzhugh, Smithsonian Institution; Robert L. Friedheim, University of Southern California; David M. Hickok, University of Alaska; Howard Slack, San Marino, California; Dael L. Wolfle, University of Washington.*

Observers: *Eddie Bernard, National Oceanic and Atmospheric Administration; Craig Black, Los Angeles Museum of Natural History; Jerry Brown, National Science Foundation; Frank Carsey, National Aeronautics and Space Administration; Henry Cole, Office of the Governor, State of Alaska; Oswald Girard, U.S. Geological Survey; Robert Gilmore, U.S. Fish and Wildlife Service; Thomas Laughlin, National Oceanic and Atmospheric Administration; Ted Stevens, U.S. Senator from Alaska; Cornelius Sullivan, University of Southern California; Gunter Weller, University of Alaska.*

The Arctic Research Commission held its ninth meeting in the Board Room, University of Southern California, Los Angeles, California, on March 5–6, 1987. The meeting focused on a review of the revised U.S. Arctic Research Plan, logistic requirements to support Arctic research, Federal/State cooperation in fisheries ecosystems research, data and information systems, social science research, and the Arctic National Wildlife Refuge.

### *Interagency Arctic Research Policy Committee Activities*

Dr. Peter Wilkniss stated that the Interagency Committee recently completed the interim draft of the U.S. Arctic Research Plan. In a letter dated March 4 to Dr. James H. Zumberge, Chairman Bloch invited the Commission to comment on the draft Plan and to participate in the Interagency Arctic Research Policy Committee meeting scheduled for March 23, 1987.

Dr. Wilkniss reported on the National Science Board (NSB) review of the NSF's role in the polar regions. Craig Black (member of the NSB review committee) stated that a draft of the Committee's report is in preparation after five months of hearings and that the report will be presented to the NSB at the May 1987 meeting. He also stated that the NSB Committee comments on the Arctic Research Plan will carry a considerable amount of weight. Dr. Wilkniss noted that the Committee is not only conducting hearings, but some members visited Antarctica, and some will visit the Arctic in April. He also reported that Alaska Governor Cowper met with the Director of NSF and that the Governor stated that his administration will give a high priority to science and technology. Dr. Wilkniss further reported that with the deactivation of the U.S. Coast Guard icebreaker *Glacier*, the United States will have only two Polar class icebreakers. The U.S. Congress desires that the Navy, Coast Guard and NSF reach agreement on an icebreaker package that the Office of Management and Budget and Congress can support.

### *State of Alaska Activities*

Henry Cole stated that Governor Cowper is trying to identify funding for an Alaska Science Foundation. Chairman Zumberge said that if the foundation turned out to be a reality, its establishment would send a strong signal to the Federal Government that the State is no longer "a ward" of the Federal Government.

### *Arctic Research Plan*

The Commission reviewed the document that had been revised based on the Anchorage Consultative Workshop and found it to be a highly comprehensive plan for Arctic research. Dr. Jerry Brown stated that the Interagency Committee meeting will hopefully approve the Plan at its March 23, 1987, meeting.

Chairman Zumberge posed the question as to how we can be assured that the Plan is looked at by those who make decisions for budgetary dollars. Dr. Brown indicated the budgets reported in the Plan are consistent with agencies' requests and that each agency requests and justifies its budget based on mission needs. OMB is an observer on the Interagency Committee and is aware of the contents of the present draft Plan.

David Garman commented that the Plan appears to have been successful in promoting interagency cooperation and coordination and that the next step should be for Congress to provide enthusiastic oversight of the Plan.

Oswald Girard stated that DOI hoped to use the Plan to justify additional Arctic research efforts. As a result of the Plan the DOI has taken a hard look at its Arctic programs, and the Geological Survey is considering an Arctic Geological Program initiative for FY 89.

Thomas Laughlin commented that the existence of the Plan has assisted in furthering Arctic programs within NOAA. What is now needed is for the Congress, with advice from the Commission, to select a series of priority research thrusts from the overall Plan. The Commission agreed that it should take a more aggressive stance to make sure the Plan's recommendations are implemented.

In the spirit of cooperation that has developed between the Commission and the Interagency Committee, the Commission requested the Chairman to provide the Committee with the following comments on the interim draft Plan:

1. From the Commission's perspective, the letter and spirit of the Arctic Research and Policy Act are indeed being implemented through this document.
2. Some emphasis should be given up front to the fact that this is the *first* five-year Plan ever produced, and that therefore it is only the *first* step in the Arctic research planning process.
3. The Commission specifically noted that the comprehensive social science section should become part of the Federal Arctic research program. This research will have a direct impact on the residents of the U.S. Arctic. Therefore, any implementation of the social science plan must involve the Arctic residents and Alaskan institutions. This involvement should therefore start in the planning phase and carry through to the reporting of results.

## *Logistics*

The Commission is charged with recommending to the President and Congress research to address national needs in the Arctic and the attendant logistic facilities required to support such research. As a follow-up to the Anchorage logistics workshop the Commission staff is conducting a survey of the facilities that are available. Chairman Zumberge stated that there is a need for a polar research vessel to operate in the Arctic. After a lengthy discussion of the actions it should take, the Commission requested that the Chairman prepare a letter to the President and members of Congress pointing out that at the present time the United States does not have a polar research vessel to operate in the ice-covered seas of the Arctic. The letter should point out that the situation is further aggravated by the recent deactivation of the U.S. Coast Guard icebreaker *Glacier*. The Commission urges that the United States lease, or lease with an option to buy, a polar research vessel to alleviate the short-term need for such a vessel in the Arctic. Over the longer term, however, upgrading at least one of the planned U.S. Navy additions to the national research fleet or some other approach to acquiring a dedicated ice-worthy Arctic research vessel, planned and equipped for a variety of scientific missions, is needed in the national interest and is strongly recommended by the Commission.

## *International Cooperation*

Chairman Zumberge reported that following a preliminary, exploratory discussion in June 1986, scientists and observers from Canada, Denmark/Greenland, Finland, Iceland, Norway, the Soviet Union, Sweden, and the United States met in Oslo on February 13, 1987, to discuss the need for an international Arctic science organization. The objectives would be to facilitate international cooperation in Arctic science, including exchange of information and data, and furthering research of mutual interest and benefit. A small working group was formed to prepare a paper summarizing the arguments for and against the creation of a new international Arctic science forum and outlining the ways in which it might be organized. This paper will be circulated for discussion within each country, after which the representatives plan to meet again to discuss whether and how to proceed.

## *Federal/State Cooperation*

Former Alaska Governor Sheffield and the Commission had identified three areas in which Federal/State cooperation in research could be especially beneficial and pay long-term dividends in the areas of fisheries ecosystem research, health, and data and information exchange. The charge to each was to identify research needs and to recommend cooperative Federal/State programs.

Eddie Bernard, Federal Co-Chairman of the Task Force on Fisheries Ecosystem Research, presented a briefing on a high priority NOAA research initiative titled "Ice: The Role of Sea Ice in Controlling Arctic Ecosystems." It deals with the effects of sea ice on Arctic marine ecosystems and recommends research to test the hypothesis that interannual variation of maximum ice extent and seasonal ice retreat accounts for the major year-to-year variability in the biological productivity of the Bering and Chukchi Seas. This research was identified as being of critical importance by local Alaskan fishermen at a Commission public meeting held in Kodiak in April 1986. The Commission found the proposed research initiative to be a well-thought-out program and would recommend that resources be made available to support its implementation.

The Task Force on Health identified three high-priority research initiatives: injury control, cancer, and the relationship of diet to

atherosclerosis and cardiovascular disease. The Task Force calls for development and integration of data into a comprehensive injury-surveillance system that could serve as a model for other State and Federal programs. In regard to cancer, study of patterns of the occurrence of cancer among Native Alaskans could yield clues to possible genetic, viral, environmental, and other causes and improve strategies for prevention and treatment. The third research initiative would focus on possible reasons for the low rate of cardiovascular disease among Alaska Natives in comparison to the high incidence in the lower 48 states and Western Europe.

David Hickok, member of the Commission's Group of Advisors, reported on the information systems for the U.S. Arctic. The Council on Northern Resource Information Management (CONRIM) provides Federal/State and university linkage in Alaska. There is still a problem of making information from industry available in the public domain. Hickok stated that the Federal/State Task Force on Data and Information Exchange would make recommendations to the Commission in the near future.

### *Social Sciences Research*

Dael Wolfle, member of the Commission's Group of Advisors, provided an analysis of the Arctic social science section of the draft Plan. The report identifies 116 high-priority recommendations in three broad areas: social pathology, land transfer and archeology. William Fitzhugh, member of the Commission's Group of Advisors, described the evolution of the social science section of the Plan. There was general agreement that social science research was neglected throughout the government agencies.

Elmer Rasmuson commented that he believes social science research should be problem-oriented. Oliver Leavitt pointed out that social science research benefited when problems were identified by the Native communities. The Commission concluded that to help resolve the issues facing social science research, a lead agency should be designated for social and behavioral research on Arctic topics. In addition, the Commission noted that social science research is of great importance to the residents of the Arctic and will have a direct impact on them. Therefore, any social science research must involve the Arctic residents and Alaska institutions. This involvement should start in the planning phase and carry through to the reporting of results.

### *Arctic National Wildlife Refuge*

The Commission received a briefing from the Department of the Interior on the current status of the ANWR Environmental Impact Statement and from the Wilderness Society on possible environmental impacts and effects of oil and gas exploration, and especially impacts on the Porcupine caribou herd. The Commission has no authority to adjudicate such issues, but it believes strongly that the best scientific information needs to be made accessible to decision-makers.

### *Other Business*

Mr. Leavitt suggested that the Commission brief Senators on the importance of the Arctic to the United States. Senator Stevens strongly supports this idea and offered to arrange a seminar with other key Senators in September 1987.

## *Tenth Meeting: July 6–10, 1987*

The Arctic Research Commission held its tenth meeting in Arctic Alaska and Canada from July 6–10, 1987. The purposes of the public meetings and site visits were to report on the status of implementation of the Arctic Research and Policy Act, identify research needs of the residents of the Arctic, visit ongoing and proposed development sites in the Arctic, and assess the logistic requirements to support Arctic research.

Public meetings were held in Kotzebue on July 6 and Kaktovik on July 9. The Commission visited the Red Dog Mine development on July 7, visited the Endicott offshore oil facility, held a meeting with officials from the oil and gas industries and State of Alaska representatives, and received a guided tour of the Arctic National Wildlife Refuge on July 8. The Commission received a briefing by representatives of the Canadian Polar Continental Shelf Project at Tuktoyaktuk and the Department of Indian and Northern Affairs Laboratory in Inuvik, Northwest Territories, Canada, on July 10, 1987.

### *Kotzebue Public Meeting*

Chairman Zumberge called the public meeting to order at the Northwest Arctic Borough offices in Kotzebue, Alaska, on July 6, 1987.

Mayor Chuck Greene, Northwest Arctic Borough, stated that he looked forward to establishing a good relationship with the Commission, and explained that most often the re-

Commission Members Present: *James H. Zumberge, Chairman; Juan G. Roederer, Vice Chairman; Oliver Leavitt; A. Lincoln Washburn; Peter Wilkniss representing Erich Bloch.* Staff: *W. Timothy Hushen, Lyle D. Perrigo, Lisa Ramirez.* Attendees: *lists available from Commission.*

search activities which have taken place in the Borough have excluded the local community, and it is time that the community becomes involved in order to enhance the research done.

David Garman spoke on behalf of Senator Frank Murkowski, stating that the Senator wished to draw attention to the fact that the Commission was appointed to advise the President and Congress on Arctic research, and that it had held several public meetings in Alaska to date, although it was only required to hold one per year. He commended the Commission for strengthening its Alaska presence with its Anchorage office.

Jerry Covey, Superintendent, Northwest Arctic Borough School District, stated that the school district would like to become more involved in the area of research and cooperate with the Commission. Alaska State Senator William Hensley stated that he was supportive of the Commission's efforts in Arctic research, but would like the permanent residents of the Arctic to become more involved in research, not only be the subjects of these studies.

Generally, the recurring theme of the testimonies presented in Kotzebue was that of cooperation. The local residents stressed that any agency conducting research on the local people should involve them in that research. Specifically, the Natives should be involved in the planning and conduct of the research, and a complete cooperative effort should exist.

Oliver Leavitt commented that the concerns of the residents of the North Slope Borough were the same as those of the residents of Kotzebue and the Northwest Arctic Borough, and that he was glad to see the people of Kotzebue accepting research and realizing the need for it.

Vice-Chairman Roederer noted the common denominator in the testimonies presented and said that the Commission needs to help solve the problem of scientific isolation. The basic points expressed by those presenting testimony were: 1) need for a better understanding between the scientific community and the local residents; 2) support of a Commission office in Alaska, particularly Kotzebue; and 3) encouragement of scientific education and the need for scientists to emerge from the Native communities.

## *Site Visits*

Cominco Alaska, operator of the Red Dog Mine development on behalf of the NANA Regional Corporation, provided the Commission with a briefing and tour of the proposed mine site. Members of the Commission were also briefed on and provided an overflight of the Noatak National Preserve and the Kobuk Valley National Park by the National Park Service based in Kotzebue.

Representatives of Standard Alaska Production Company provided a tour of the Endicott oil production facility located on man-made islands in Prudhoe Bay, the first offshore oil production facility in the U.S. Arctic. The current drilling practice of reusing drilling mud has essentially eliminated the need for a spoil site.

In order to obtain a first-hand understanding of the Arctic National Wildlife Refuge and its wildlife population, and the potential effects that oil and gas exploration might have, the Commission toured the refuge with Department of the Interior officials. Congress is considering whether or not to open the refuge to oil and gas leasing. As stated previously, while the Commission does not have the authority to adjudicate such issues, it believes strongly that the best scientific information needs to be made accessible to decision-makers.

## *Kaktovik Public Meeting*

Chairman Zumberge called the public meeting to order on July 9, 1987. Mayor Loren Ahlers, City of Kaktovik, shared observations about research in their geographic area and stated that residents found no problem with research *per se* but were troubled by the failure of scientists to apprise local residents of study results and significance.

Testimony was provided in both Inupiat and English. It was stressed that the indigenous people want to participate in research programs.

Other points made by those presenting testimony were that 1) the causes of alcoholism, as well as ways to avoid alcohol and drug abuse on the North Slope, should be investigated; 2) research should be undertaken on how to allow hunting in development areas; 3) more research should be undertaken to define the interrelationship between muskoxen and caribou and other species in northern Alaska. Special emphasis was placed on the integral role that subsistence culture plays in the local ecosystem.

## *Logistics*

Arctic logistics was the topic of several meetings during the course of the Commission's meetings in Alaska and Canada. The Commission is charged by the Arctic Research

and Policy Act to recommend research to address national needs and the attendant logistic facilities required to support such research. Information is needed on the location of all airfields in Alaska, the existence and condition of bunkhouses, the presence of and equipment in field laboratories, and the details needed to assure efficient land-based logistics. Henry Cole, Science Advisor to the Governor of Alaska, provided a status report on the efforts of his office to compile and publish information about the location and capabilities of terrestrial logistics facilities in Alaska. This catalogue of facilities should be completed by late 1987. Andrew Robinson, NOAA, reported on the research logistics support system that NOAA had developed to support outer continental shelf research. He believes that the system could be modified to support other research efforts in the Arctic.

Lyle Perrigo described the status of the Commission's study of research logistical support systems, planning and coordination processes. Analysis of the literature, input from a November workshop, and results from a number of interviews all suggest a need for a planning and coordination process for Arctic research logistics, especially in the field of land-based systems. Three options for coordination and planning were described: 1) a national system, 2) a system of two or more autonomous regional groups, and 3) the status quo.

Dr. Juan Roederer commented that any change in the status quo should be done in such a manner that bureaucracy and arbitrariness are avoided. Perhaps the first step in promoting increased efficiency and lower costs should be to establish and operate a national/regional referral system.

Joseph Bell, supervisor of the Barter Island DEW Line complex, briefed the Commission on July 9, 1987, about DEW Line installations in Alaska, commented on their use by various parts of the Department of Defense, and provided a tour of their facilities at Kaktovik. The Barter Island and Barrow installations routinely accommodate visitors and DOD research groups. Four of the six Alaska sites have hangars and supporting facilities; currently those installations are used primarily for storage purposes. Dew Line complexes in Alaska have quarters, storage space, and other facilities that might be used to support Arctic research. Some coordinating mechanism with the Air Force must be emplaced, however, before those logistical assets can be used by the research community.

## *Administrative Activities*

The business meeting at Kaktovik focused on discussion of Commission operations, membership, and leadership. Dr. Zumberge announced plans to resign as Chairman later in the summer. He indicated that Executive Director Timothy Hushen, who is on a leave of absence from the National Academy of Sciences, will need to return to the Academy. The salient points of the discussion were: 1) the need for continuity in the work of the Commission, and 2) the future location of the headquarters of the Commission. Two sites were discussed as future locations: Washington, D.C., and Alaska. It was felt that the new Chairman should state his preference regarding office location.

# *Arctic Research and Policy Act of 1984*



Public Law 98-373
98th Congress An Act

July 31, 1984
[S. 373]

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 I—ARCTIC RESEARCH AND POLICY

Arctic Research and Policy Act of 1984.

### SHORT TITLE

15 USC 4101 note.

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

### FINDINGS AND PURPOSES

15 USC 4101.

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;

98 STAT. 1243

(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

Establishment.

15 USC 4102.

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

(b)(1) The Commission shall be composed of five 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) three 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

98 STAT. 1244

(C) one member 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-16 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.

5 USC 8101 *et seq.*
28 USC 2671 *et seq.*

(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.

Public meeting

### DUTIES OF COMMISSION

15 USC 4103.

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;

98 STAT. 1245

(4) review Federal research programs in the Arctic and suggest 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) suggest 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; and

(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.

(b) Not later than January 31 of each year, the Commission shall—

(1) 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; and

(2) submit to the President and to the Congress a report describing the activities and accomplishments of the Commission during the immediately preceding fiscal year.

Report.

COOPERATION WITH THE COMMISSION

15 USC 4104. 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.

Confidentiality (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 552 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

15 USC 4105. SEC. 106. The Commission may—

5 USC 5331 (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; and

(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.

LEAD AGENCY AND INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

15 USC 4106. 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.

Establishment. (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

15 USC 4107. 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;

98 STAT. 1247 (4) develop a 5-year plan to implement the national policy, as provided for 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. Public information

(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— Report.

(1) a statement of the activities and accomplishments of the Interagency Committee since its last report; and

(2) a description of the activities of the Commission, detailing with particularity the recommendations of the Commission with respect to Federal activities in Arctic research.

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. 15 USC 4108

(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 98 STAT. 1248

(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— 15 USC 4109.

(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 Science and 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. Report.

(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. 15 USC 4110.

(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. 2 USC 651.

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. 15 USC 4111.

# Executive Order 12501

*Executive Order 12501. January 28, 1985*

By the authority vested in me as President by the Constitution and laws of the United States of America, including the Arctic Research and Policy Act of 1984 (Title I of Public Law 98–373) ("the Act"), it is hereby ordered as follows:

*Section 1. Establishment of Arctic Research Commission.* There is established the Arctic Research Commission.

*Sec. 2. Membership of the Commission.*

(a) The Commission shall be composed of five members appointed by the President, as follows:

(1) three 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;

(2) 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 resources development; and

(3) one member appointed from individuals familiar with the Arctic and representative of the needs and interests of private industry undertaking resource development in the Arctic.

The Director of the National Science Foundation shall serve as a nonvoting *ex officio* member of the Commission. The President shall designate a Chairperson from among the five voting members of the Commission.

(b) In making initial appointments to the Commission, the President shall designate one member to serve for a term of two years, two members to serve for terms of three years, and two members to serve for terms of four years as provided by Section 103(c) of the Act. Upon the expiration of these initial terms of office, the term of office of each member of the Commission shall be four years.

(c) Each of the Federal agencies represented on the Interagency Committee established by Section 7 of this Order may designate a representative to participate as an observer with the Commission. These representatives shall report to and advise the Commission on the activities of their agencies relating to Arctic research.

*Sec. 3. Meetings of the Commission.*

The Commission shall meet at the call of the Chairman or a majority of its members. The Commission annually shall conduct at least one public meeting in the State of Alaska.

*Sec. 4. Functions of the Commission.*

(a) The Commission shall:

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

(2) assist, in cooperation with the Interagency Arctic Research Policy Committee established by Section 7 of this Order, 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 suggest improvements in coordination among programs;

(5) recommend methods to improve logistical planning and support for Arctic research as may be appropriate;

(6) suggest 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 Arctic Research Policy Committee as it may find appropriate; and

(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.

(b) Not later than January 31 of each year, the Commission shall:

(1) submit to the President and Congress a report describing the activities and accomplishments of the Commission during the immediately preceding fiscal year; and

(2) publish a statement of goals and objectives with respect to Arctic research to guide the Interagency Arctic Research Policy Committee in the performance of its duties.

*Sec. 5. Responsibilities of Federal Agencies.*

(a) The heads of Executive agencies shall, to the extent permitted by law, and in accordance with Section 105 of the Act, provide the Commission such information as it may require for purposes of carrying out its functions.

(b) The heads of Executive agencies shall, upon reimbursement to be agreed upon by the Commission and the agency head, permit the Commission to utilize their facilities and services to the extent that the facilities and services are needed for the establishment and development of an Arctic research policy. The Commission shall take 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.

*Sec. 6. Administration of the Commission.* Members of the Commission who are otherwise employed for compensation shall serve without compensation for their work on the Commission, but may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by law for persons serving intermittently in the government service. Members of the Commission who are not otherwise employed for compensation shall be compensated for each day the member is engaged in actual performance of duties as a member, not to exceed 90 days of service each calendar year, at a rate equal to the daily equivalent of the rate for GS–16 of the General Schedule.

*Sec. 7. Establishment of Interagency Arctic Research Policy Committee.* There is established the Interagency Arctic Research Policy Committee (the "Interagency Committee"). The National Science Foundation shall serve as lead agency on the Interagency Committee and shall be responsible for implementing Arctic research policy.

*Sec. 8. Membership of the Interagency Committee.*

The Interagency Committee shall be composed of representatives of the following Federal agencies or their designees:

(a) National Science Foundation;

(b) Department of Commerce;

(c) Department of Defense;

(d) Department of Energy;

(e) Department of the Interior;

(f) Department of State;

(g) Department of Transportation;

(h) Department of Health and Human Services;

(i) National Aeronautics and Space Administration;

(j) Environmental Protection Agency;

(k) Office of Science and Technology Policy; and

(l) any other Executive agency that the Director of the National Science Foundation shall deem appropriate. The Director of the National Science Foundation or his designee shall serve as Chairperson of the Interagency Committee.

*Sec. 9. Functions of the Interagency Committee.* (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 of the Act;

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

(6) facilitate cooperation between the Federal government and State and local governments in Arctic research, and recommend the undertaking of neglected areas of research;

(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 the Act; and

(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.

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

(1) its activities and accomplishments since its last report; and

(2) the activities of the Commission, detailing with particularity the recommendations of the Commission with respect to Federal activities in Arctic research.

*Sec. 10. Public Participation.* The Interagency Committee will provide public notice of its meetings and an opportunity for the public to participate in the development and implementation of national Arctic research policy.

*Sec. 11. Administration of Interagency Committee.*

Each agency represented on the Committee shall, to the extent permitted by law and subject to the availability of funds, provide the Committee with such administrative services, facilities, staff, and other support services as may be necessary for effective performance of its functions.

Ronald Reagan

The White House,
January 28, 1985.

[*Filed with the Office of the Federal Register, 4:20 p.m., January 28, 1985*]

# *Forthcoming Meetings*

*Listed here is a compilation of some forthcoming 1988 meetings, workshops and conferences on Arctic or northern topics and activities. Readers are invited to submit information on additional meetings to J. Brown,* Arctic Research, *National Science Foundation, Room 620, 1800 G St., NW, Washington, D.C. 20550.*

**Seventh (1988) International Conference and Exhibit on Offshore Mechanics and Arctic Engineering, OMAE'88**
**7–17 February 1988, Houston, Texas, U.S.A.**
Contact: Dr. Jin S. Chung, OMAE Symposium Committee, Colorado School of Mines, 1500 Illinois Street, Golden, CO 80401, U.S.A.
Phone (303) 273-3673 or 420-8114
Telex 910-934-0190 CSM GLDN

**Third International Symposium on the Okhotsk Sea and Sea Ice**
**14–16 February 1988, Mombetsu, Hokkaido, Japan**
Contact: Mr. Yoshio Onishi, Symposium on the Okhotsk Sea and Sea Ice, Mombetsu City Hall, Saiwacho 2, Mombetsu, Hokkaido, 094 Japan

**Symposium on Ice Dynamics**
**14–20 February 1988, International Glaciological Society, Hobart, Australia**
Contact: The Secretary General, IGS
Lensfield Road, Cambridge CB2 1ER, England
Telephone: Cambridge 355974
Facsimile: Cambridge 336543

**Advancing Sustainable Development Through Northern Conservation Strategies—Policy Conference**
**16–19 February, 1988, Vancouver, British Columbia, Canada**
Contact: Felicity Edwards, Program Manager
The Banff Centre School of Management
P.O. Box 1020, Banff, Alberta, Canada T0L 0C0
Telephone (403) 762-6137
Telex Artsbanff 03-826657
Fax (403) 762-6444

**The 7th Northern Research Basins Symposium/ Workshop: Applied Hydrology in the Development of Northern Basins**
**May 25–June 1, 1988, Ilulissat/ Jakobshavn, Greenland**
Contact: Danish Society for Arctic Technology
c/o Greenland Technical Organization
Hauser Plads 20
DK 1127 Copenhagen K, Denmark

**Northern Libraries Colloquy 12: Northern Information:The Global Connection**
**5–8 June 1988, University of Colorado, Boulder, Colorado, U.S.A.**
Contact: Ann Brennan, WDC-A for Glaciology, CIRES, Campus Box 449, University of Colorado, Boulder, CO 80309, U.S.A.

**POLARTECH '88**
**15–17 June 1988, Norwegian Institute of Technology Studies Administration, Trondheim, Norway**
Contact: Norwegian Institute of Technology
Studies Administration, N-7034
Trondheim-NTH, Norway

**Fifth International Symposium on Ground Freezing**
**July 26–28, 1988, Nottingham, England**
Contact: R.H. Jones
Dept. of Civil Engineering
University of Nottingham
NG72RD, England
Phone 44 602 50 61 01 Ext. 3518/2676
Telex 37346 (UNINOT G)

**V International Conference on Permafrost**
**2–5 August 1988, Trondheim, Norway**
Contact: V International Conference on Permafrost (VICOP), Norwegian Institute of Technology
Studies Administration, N-7034
Trondheim-NTH, Norway
Phone 47 7 59 52 54
Telex 55637 nth ad n

**2nd International Symposium on Cold Regions Development**
**9–13 August 1988, Hokkaido Development Engineering Centre, Harbin, China**
Contact: Harumi Sasaki
Hokkaido Development and Engineering Center
6-1, South 1, West 9
Chuu-Ku, Sapporo, Hokkaido, 060, Japan
Phone (011) 271-3028
FAX (011) 271-5115

**Offshore Northern Seas Conference and Exhibition**
**23–26 August 1988, ONS, Stavanger, Norway**

**Ninth IAHR Symposium on Ice**
**23–27 August 1988, Hokkaido University, Sapporo, Japan**
Contact: Hiroshi Saeki, Dept. of Civil Engineering, Hokkaido University, Kita 13, Nishi 8, Kita-Ku, Sapporo 060, Japan
Fax: 011-717-4745
Telex: 932302 Hokuen J

**Arctic Division AAAS, Science Education**
**7–10 October 1988, Fairbanks, Alaska**
Contact: Neal B. Brown, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800
Phone (907) 474-7558

**Sixth Inuit Studies Conference**
**17–20 October 1988, University of Copenhagen, Copenhagen, Denmark**
Contact: Jens Dahl, Institute of Eskimology, Fiolstraede 10, 1171 Copenhagen K, Denmark
Phone 01-159166

**Second National Student Conference on Northern Studies**
**24–25 November 1988, Conference Centre, Ottawa, Ontario, Canada**
Contact: National Student Conference on Northern Studies, Association of Canadian Universities for Northern Studies, 130 Albert Street, Suite 1915, Ottawa, Ontario, Canada K1P 5G4
Phone (613) 238-3525

## *Notice*

*The former Naval Arctic Research Laboratory in Barrow, Alaska, has been reactivated by its new owner, the Ukpeagvik Inupiat Corp., to support scientific research, education and industrial development. The facility is now known as the Ukpeagvik Industrial Center–National Arctic Research Laboratory (UIC/NARL). It offers logistical support, including laboratory, office, and warehouse space as well as hotel and cafeteria services. For more information, contact:*
*Johnny Aiken, Director*
*Ukpeagvik Industrial Center–National Arctic Research Laboratory*
*Pouch UIC/NARL*
*Barrow, AK 99723, USA*
*Telephone: (907) 852-7800*

# *Contributors and IARPC Staff Representatives*

*Other than the lead articles, this issue of* Arctic Research of the United States *is based primarily on information provided by the staff representatives of the Interagency Arctic Research Policy Committee (names italicized) or agency staff members.*

**Department of Defense**—*Colonel Ted S. Cress*
Army—Edmund A. Wright (CRREL)
Navy—Thomas B. Curtin (ONR)
Air Force—LTC James P. Koermer

**Department of Interior**—*James F. Devine* and *Oswald Girard, Jr.*
Minerals Management Service—John Gregory and Fred Sieber
Geological Survey—Oswald Girard
Fish and Wildlife Service—Larry Pank (Anchorage)
Bureau of Land Management—John Haugh
National Park Service—Al Lovaas (Anchorage) and John Dennis
Bureau of Mines—Priscilla Young

**National Science Foundation**—*Charles E. Myers* and *Jerry Brown* (Staff Chairman)

**Department of Commerce**—*Thomas L. Laughlin* (NOAA)

**National Aeronautics and Space Administration**—*Kenneth Jezek*
Ocean Science—Kenneth Jezek
Atmospheric Science—Timothy E. Eastman
Land Processes—Diane E. Wickland and Miriam Baltuck

**Department of Energy**—*Helen C. McCammon*
Ecological Research—George Hendrey
Carbon Dioxide Research—Tom Gross

**Department of Health and Human Services**—*Deane A. Johnson*
Centers for Disease Control—Anne P. Lanier and Deane A. Johnson
National Institutes of Health—Susan B. Spring and David L. Klein

**Smithsonian Institution**—*William W. Fitzhugh* and *Stanwyn G. Shetler*

**Department of Transportation**—*Richard Miller*
Coast Guard—Richard Hayes, LCDR P. Tebeau
Maritime Administration—Frederick Seibold

**Environmental Protection Agency**—*Kenneth Hood*
Cold Climate—James C. McCarty

**Department of State**—*Harlan K. Cohen* and *Raymond V. Arnaudo*
Man and the Biosphere—Charles W. Slaughter (Forest Service, Fairbanks)

**Department of Agriculture**
Forest Service—Calvin Bey
Soil Conservation Service—Burt Clifford (Anchorage)

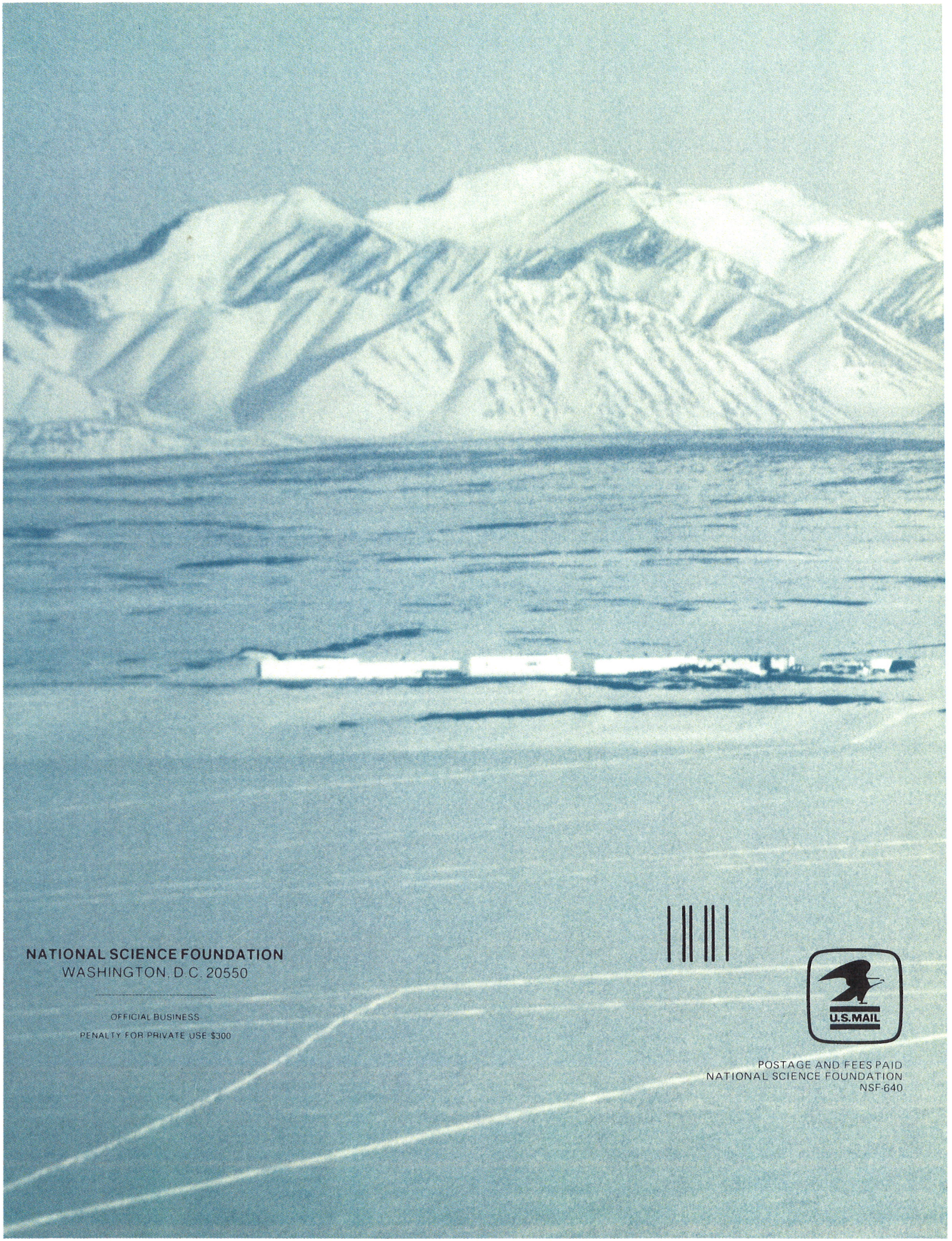
**Reports of Meetings**
Interagency Arctic Research Policy Committee—*Charles E. Myers*
United States Arctic Research Commission—W. Timothy Hushen and Lisa Ramirez

**Editors**
Stephen L. Bowen and Donna R. Valliere, Cold Regions Research and Engineering Laboratory

Interagency Arctic Research Policy Committee staff representatives with Chairman Erich Bloch (August 27, 1987). *Seated, left to right:* Harlan Cohen, Department of State; Kenneth Hood, Environmental Protection Agency; Chairman Erich Bloch; Deane Johnson, Department of Health and Human Services; Thomas Laughlin, Department of Commerce. *Standing, left to right:* Robert Thomas, National Aeronautics and Space Administration; Valery Lee, formerly Department of Commerce; William Fitzhugh, Smithsonian Institution; James Devine, Department of the Interior; Edward Harrison, Department of Defense; Jerry Brown, National Science Foundation; Charles Myers, National Science Foundation; Raymond Arnaudo, Department of State; Ozzie Girard, Department of the Interior; John Talmadge, National Science Foundation; George Martin, U.S. Coast Guard, Department of Transportation.

## *Photo Credits*

Page 16: Soil Conservation Service, Anchorage, Alaska. Pages 17, 18 and 19: Minerals Management Service, Anchorage, Alaska. Pages 20 and 21: U.S. Geological Survey, Anchorage, Alaska. Page 22: U.S. Geological Survey, Menlo Park, California (from *Marine Geology*, vol. 76, 1987). Page 23: U.S. Geological Survey, Anchorage, Alaska. Pages 25, 26 and 27: U.S. Fish and Wildlife Service, Anchorage, Alaska. Pages 28 and 29: Bureau of Land Management, Anchorage, Alaska. Pages 30 and 31: National Park Service, Anchorage, Alaska. Page 32: Bureau of Mines, Alaska Field Operations Center. Page 34: Stanford Research Institute International, Palo Alto, California. Page 35: Marine Institute, University of Alaska–Fairbanks. Page 36: Marine Biological Laboratory, Woods Hole, Massachusetts. Page 37 (upper): Polar Ice Coring Office, University of Nebraska–Lincoln. Page 37 (lower): Pat Anderson, University of Washington. Page 38: Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Pages 40, 41 and 42: Office of Naval Research, Arlington, Virginia. Pages 44 and 45: Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Pages 46 and 47: Cold Regions Test Center, Ft. Greely, Alaska. Page 48: Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Page 49: Geophysical Institute, University of Alaska–Fairbanks. Page 50: Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts. Pages 51, 52, 54, 55, 56 and 57: National Oceanic and Atmospheric Administration. Pages 59 and 60: National Aeronautics and Space Administration. Page 61: National Aeronautics and Space Administration (from *EOS*, vol. 68, no. 25, 1987). Pages 62 and 63: Geophysical Institute, University of Alaska–Fairbanks. Page 65: Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Page 67: EROS Data Center, Sioux Falls, South Dakota. Page 68: K.R. Everett, Ohio State University, Columbus. Page 69 (upper): Institute of Arctic Biology, University of Alaska–Fairbanks. Page 69 (lower): Walter Oechel, San Diego State University, California. Page 70: U.S. Geological Survey, Menlo Park, California. Pages 72 and 73: Centers for Disease Control, Anchorage, Alaska. Pages 74, 75, 76, 77 and 78: Smithsonian Institution, Washington, D.C. Pages 79, 80, 81, 82 and 83: U.S. Coast Guard, Washington, D.C. Pages 84 and 85: D.A. Walker, University of Colorado–Boulder. Page 86: Polar Ice Coring Office, University of Nebraska–Lincoln. Pages 87, 88 and 89: U.S. Forest Service, Fairbanks, Alaska. Pages 90 and 91: Soil Conservation Service, Anchorage, Alaska.



**NATIONAL SCIENCE FOUNDATION**
WASHINGTON, D.C. 20550

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE $300

U.S.MAIL

POSTAGE AND FEES PAID
NATIONAL SCIENCE FOUNDATION
NSF-640