

2. *Special Focus*

Interagency Research Programs

The Interagency Committee's research policy states:

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

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

- Study of Environmental Arctic Change (SEARCH)
- Developing a Research Plan for a Sustainable Bering Sea
- Arctic Health Research.

Two new programs will be undertaken during this planning cycle:

- Research on Resource Evaluation
- Research on Civil Infrastructure.

These coordinated, multiagency programs are being designed to:

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

through regionally focused programs;

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

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

Benefits to the Nation from Arctic research include improvements in:

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

2.1 The Study of Environmental Arctic Change

2.1.1 Introduction

The following discussion is drawn from the Science Plan for the Study of Environmental Arctic Change (SEARCH) program, a research program sponsored by the Interagency Arctic Research Policy Committee. The Science Plan was prepared by the SEARCH Project Office, Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle. For more information, see http://psc.apl.washington.edu/search/Library/SEARCH_Science_Plan.pdf.

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

- Reduced sea ice extent [3% per decade (Parkinson et al. 1999)] and thickness [−42% in the last 25 years (Rothrock et al. 1999)].
- Shift in the balance between Atlantic and Pacific waters and changes in salinity and temperature (e.g. Morison et al. 2000). The revealing changes in upper ocean temperatures and salinities are five times the RMS variability in the 1970s and exceed extreme values measured in the corresponding locations in the previous 50 years (EWG 1997, Steele and Boyd 1998).
- Sea level rise in the Russian Arctic. There are 2- to 20-cm increases in sea level in the Russian marginal seas over a 50-year period, with interannual variations on the same order (Pavlov 2001). Proshutinsky et al. (2001) argue that this is driven by changes in atmospheric forcing of the barotropic circulation.
- Permafrost warming (0.5°C) and thawing in the intermittent permafrost region of Alaska (Osterkamp and Romanovsky 1999) and warming and thawing of permafrost in the Russian Arctic (Pavlov 1994) since the late 1980s.
- Decreasing permafrost temperatures in eastern Canada (Wang and Allard 1995).

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

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

2.1.2 Arctic Oscillation

SEARCH scientists hypothesize, and statistical analysis and modeling studies tend to confirm,

that many of the changes listed in Section 2.1.1 are related to a strengthening of the atmospheric polar vortex [e.g., SEARCH Science Plan 2001, Morison et al. 2000, Zhang et al. 1998, 2000, Maslowski et al. 2000] as characterized, for example, by the Arctic Oscillation (AO), which is a natural mode of atmospheric variation. The strengthened west-to-east motion of the atmosphere associated with an increased AO brings more warm air to the Greenland Sea, Scandinavia, and Russia.

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

2.1.3 Goals

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

To be most effective in understanding the Arctic's many systems and their interplay, many resources and kinds of expertise must be brought together. SEARCH is the first interagency effort to combine funding sources, disciplines and knowledge from across the United States and around the world to address an issue of this type. The effort is designed to bring researchers together to share knowledge and learn from one another. It is unique, given the complexity of the Arctic environment.

2.1.4 Critical Science Questions

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

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

2.1.5 Major Activities

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

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

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

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

2.1.6 Observation and Modeling

There is a need for the deployment of a comprehensive and sustained Arctic environmental observing system. This system will require remote and in-situ systems focused on land, sea, air, and ice. It must provide the critical information on the physical and biotic environment needed to meet the needs of SEARCH. The observing system must be strongly coupled to modeling and data assimilation efforts to ensure that the system’s data are useful and used. This comprehensive

system must evolve to meet new requirements, comply with new strategies, and incorporate new technologies. Once new observing technologies have been developed and proven in the field, a pathway will be needed to make these technologies operational. This pathway must include consideration of funding requirements, data quality and continuity, and data application.

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

2.1.7 Summary of Agency Participation

Each participating agency will contribute to SEARCH in ways consistent with its mandates, strategies, and scientific capabilities. Each will undertake specific parts of SEARCH and share data, information, and understanding to achieve the overall SEARCH goals. Results from SEARCH and other programs will provide the scientific underpinning for Arctic regional and global assessments of climate variability and change and associated impacts. Table 2 describes the major types of activity that each agency expects to undertake to support SEARCH. Table 3 lists specific priorities for 2004 and currently known agency funding requests.

2.1.8 Major Programs to be Conducted Under SEARCH

Meeting the goals of SEARCH and providing answers to the critical science questions will require the coordinated application of the capabilities and resources of all of the participating agencies. In addition, collaboration with organizations and scientists from other countries will be required to deal with the pan-Arctic nature of these questions.

The SEARCH Science Plan defines a comprehensive, multidisciplinary approach to understanding environmental change in the Arctic and its connections to other regions. The complexity of the overall plan requires that it be divided into

Table 2. Agency activity areas.

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

smaller thematic areas suitable for effective implementation. A series of “programs” are to be developed that include efforts in one or more of the four thematic areas included under SEARCH (ocean, atmosphere–cryosphere, biosphere, and human society). These programs will develop in their own way with expert scientists preparing the scientific approach and agency managers developing implementation and funding mechanisms.

Ocean Thematic Area

The highest-priority program to be identified under SEARCH is the Arctic/Sub-Arctic Ocean Fluxes (ASOF) program, which has had a year of intense planning and coordination at national and international levels.

The descent of cold, dense waters across the Greenland–Scotland Ridge and in the Labrador Sea is a principal means by which the deep ocean is ventilated and renewed. Most projections of greenhouse-gas-induced climate change anticipate a weakening of the thermohaline circulation (THC) in the North Atlantic in response to increased freshening and warming in the subpolar

seas. The thermohaline circulation is a global process that transports warm surface water from the equator to the higher latitudes and returns cold deep water. A reduction in upper ocean density at high northern latitudes may reduce the rate at which water sinks and thus may weaken the THC and possibly change the climate of eastern North America and western Europe (e.g. Rahmstorf and Ganoploski 1999). Projections of greenhouse-gas-induced climate change indicate a weakening of the THC in the North Atlantic in response to increased freshening and warming in the polar/subpolar region (Delworth and Dixon 2000). These changes reduce high-latitude upper-ocean density and therefore weaken the THC (see, for example, Manabe and Stouffer 1993, Rahmstorf and Ganoploski 1999, Wood et al. 1999). The ASOF program is focused on the response of the ocean’s thermohaline circulation to changes in the flux of Arctic ice or fresh water to the North Atlantic. ASOF is designed to detect changes in freshwater flux and thermohaline circulation and assess the potential for resultant climate change.

In FY 04, NSF, NASA, NOAA, Interior, and

Table 3. Agency priorities and funding for FY04.

National Science Foundation	Field measurement programs for improving models and understanding processes; develop new technologies; implement environmental observatories (facilities for making measurements, with a changing mix of measurements); develop new models and data assimilation techniques; lead the interagency effort on human dimensions research	\$6.0 million
National Aeronautics and Space Administration	Provide the perspective from space under the NASA Earth Science Enterprise; evolve from observation only to include modeling and data assimilation; recalibrate existing sensors for use in the Arctic; build long-term, consistent data sets and support data management and rescue efforts; in the future, aim for more analysis and modeling with targeted in-situ field campaigns to support existing or already planned satellites	\$4.0 million SEARCH related*
Department of Commerce/ National Oceanic and Atmospheric Administration	Focus on sustained observations of atmosphere, sea ice, ocean, and marine biota; undertake related data management and data rescue efforts; support modeling and data assimilation; develop applications and products for the public and policy/decision makers	\$2.0 million
Department of Defense/ Office of Naval Research, Cold Regions Research and Engineering Laboratory	Continue DOD mission-focused research with secondary objective of supporting SEARCH when possible; continue tracking and modeling sea ice and snow; analyze historical Arctic Ocean and terrestrial data and recent Arctic atmospheric and hydrological data; develop new observing technologies; continue observations in the Bering Strait region; evaluate future DOD missions under possible future environmental conditions in the Arctic and globally	Will use existing funds to begin
Department of Energy/ Atmospheric Radiation Measurement Program— North Slope of Alaska/ Adjacent Arctic Ocean Site	Continue Atmospheric Radiation Measurement Program at the North Slope/Adjacent Arctic Ocean site; investigate flux of thermal and solar radiation through the atmosphere with emphasis on the role of clouds; build and maintain database; apply knowledge to climate models; maintain facilities at Barrow and Atqasuk; complete original site design to include Barrow, Atqasuk, and Oliktok Point as funds permit	\$3.2 million SEARCH related*
Department of the Interior/ Bureau of Land Management, Fish and Wildlife Service, National Park Service, U.S. Geological Survey, Minerals Management Service	Conduct studies to understand impacts of environmental change on the lands and resources managed by DOI; discriminate natural from anthropogenic causes and determine need for management actions; provide protected locations and facilities for establishment of environmental observing sites; continue research on conservation of trust species under conditions of a changing Arctic; undertake long-term ecological observations; perform associated data management and rescue tasks	\$10.8 million
Department of Agriculture/ Agricultural Research Service, Natural Resource Conservation Service, Forest Service	Conduct research on environmental changes occurring in high latitudes that may affect the sustainable production of food, fiber, and other renewable resources; contribute information concerning impacts on these resources and resource use to interagency human dimensions research	\$2.9 million SEARCH related*
Smithsonian Institution	Develop mechanisms to present the SEARCH program and results to a broad national audience, communicate scientific discoveries and understanding, advertise needs and capacities to the public; enhance existing programs and activities to include Arctic science elements; entrain commercial and charitable organizations to develop educational and outreach materials	Will use existing funds, donations and contributions from other agencies to begin
Department of Homeland Security/U.S. Coast Guard	Provide icebreaker, helicopter, and other logistic support for SEARCH scientific activities in the Arctic	Will use existing funds and cost reimbursements

* Funds appropriated for activities other than SEARCH but whose results can contribute to the SEARCH hypotheses and science questions.

DOD/ONR will support ASOF, as will several international collaborators.

Atmosphere/Cryosphere Thematic Area

In November 2001 the agencies participating in SEARCH sponsored a major science workshop to develop the purpose and scope of a proposed new program, now titled Atmospheric and Cryospheric Change in the Arctic (ACCA).

The Arctic atmosphere and cryosphere have undergone changes during the last thirty years that include a lowering of surface atmospheric pressure, increases in surface air temperature in large regions, decreased ice extent [3% per decade (Parkinson et al. 1999)], and a decrease in ice thickness [42% in 25 years (Rothrock et al. 1999)] (Walsh et al. 1996, Serreze et al. 2000), but our present level of knowledge is inadequate to understand, quantify, or predict the interactions among these changes. Changes over the past decade have resulted in a trend toward increasing strength of the Icelandic low. The positive phase of the NAO is associated with mutual strengthening of the Icelandic Low and Azores High, with corresponding impacts on Northern Hemisphere climate. As discussed above and in the SEARCH Science Plan, the simultaneous increase in NAO or AO and the arguably related changes in the Arctic indicate that changes in the Arctic are connected to the atmospheric circulation of the whole Northern Hemisphere.

The ACCA program will seek to improve understanding of these interactions, leading to formulation of effective strategies to minimize the impacts of climate change. In FY 04, NSF, NASA, NOAA, DOE, and DOD will provide support for the ACCA program.

Biosphere Thematic Area

The SEARCH Science Steering Committee (SSC) is developing a framework for a science program focused on environmental change and associated impacts on marine and terrestrial biota. Key objectives of the biospheric component of SEARCH will be to understand how climate variability and change affect ecosystems and key species and to understand how human management and use of living resources may have to adapt.

In 2004 the NSF, NOAA, and DOI will develop and undertake an implementation plan that will coordinate and enhance biospheric research in the Bering Sea, in cooperation with the interagency Bering Sea research program (see page 21). Simultaneously, NSF, NOAA, DOI, and NASA will evaluate how to transform existing terrestrial ecologi-

cal monitoring sites, such as an existing north-south transect in the Alaska National Wildlife Refuge, into more comprehensive terrestrial environmental change monitoring sites.

Human Society Thematic Area

To assess the effects of environmental change on indigenous people and other residents, a research program examining the dynamics of linkages between human populations and the biological and physical environment of the Arctic is required. Under SEARCH, experts in the social and economic sciences are leading a dialogue with physical and biological scientists to develop the needed research effort. In addition, the NSF will support research activities in two areas: the study of societal conflicts that arise when "common pool" Arctic resources are affected by environmental changes such as changes in ice extent, increased temperatures, thawing permafrost, and ecological changes that result from physical changes; and pilot projects to involve networks of local residents in performing and documenting environmental change observations.

Synthesis, Integration, and Outreach Activities

In 2004 the agencies that comprise SEARCH will begin what will become a continuing set of activities designed to address the complex goals of SEARCH. By bringing together the data, information, and understanding that each has achieved, the inherently multidisciplinary SEARCH hypotheses and science questions can be addressed. The Smithsonian Institution will organize and lead an interagency task team that will develop outreach activities based on information supplied by the various agencies.

Currently the United States, through both NOAA and the National Science Foundation, is providing leadership and financial support to the Arctic Climate Impact Assessment (ACIA), a whole-Arctic activity under the auspices of the Arctic Council. SEARCH will support the ACIA assessment to be completed in 2004 and also will participate in future assessments undertaken by the Intergovernmental Panel on Climate Change (IPCC) in 2005 and beyond.

2.1.9 Resource Requirements for Continuing Implementation of SEARCH

The SEARCH program is planned as a long-term effort to document and understand environ-

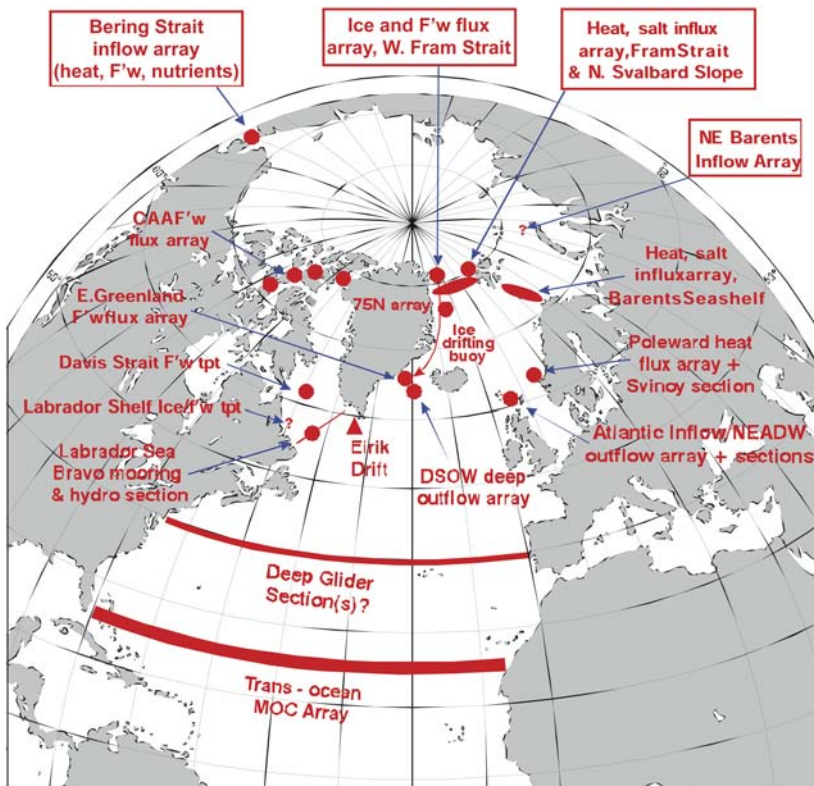
mental change and associated impacts. Given this long-term perspective, SEARCH can be successful even though all activities do not begin at the same time. Agency planning processes are complex and require coordination. Over the next several years the participating agencies will further define their individual roles in SEARCH and seek to obtain the resources needed to implement those roles.

2.1.10 Interagency Management of the SEARCH Program

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

- Approve membership and “terms of reference” for the Science Steering Committee (SSC);
- Review and approve science and science implementation plans prepared by the SSC and its subsidiary bodies;
- Solicit science advice from the SSC and develop responsive programs and plans;
- Discuss and coordinate agency plans for budget requests to support activities related

Distribution of the observing sites that make up the prototype ASOF Array. The justification for each is described on the SEARCH website (<http://psc.apl.washington.edu/search/>).



to SEARCH and provide appropriate inter-agency assistance;

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

The SEARCH SSC will continue to provide scientific planning. In particular, it will develop the scientific bases for the thematic programs to be implemented under SEARCH and will be instrumental in devising means for synthesizing and integrating the diverse information that SEARCH will generate. The SSC will provide scientific liaison to international science groups and aid the IWG’s efforts to achieve international implementation mechanisms.

2.1.11 Initial Focused Programs to be Conducted as Part of SEARCH

Arctic/Sub-Arctic Ocean Fluxes

The intention is to establish a coordinated, circum-Arctic system of ocean flux measurements to cover all of the gateways that connect the Arctic Ocean with sub-Arctic seas. Because decreases in the flow through one Arctic gateway may be balanced or reinforced by changes in the transport through another, it is necessary to make measurements in these critical passages at the same time.

The research should not be entirely restricted to “Arctic gateways,” however. The proposed ASOF observing system extends south to 25°N. At least initially the appropriate emphasis in making long observational series is seen to lie in generating the data sets and time series needed to develop the predictive skill of climate models.

Atmospheric and Cryospheric Change in the Arctic

Purpose and Rationale. Atmospheric and Cryospheric Change in the Arctic (ACCA) will focus

on integrating the following three topics:

- Improved predictive understanding of Arctic atmospheric and cryospheric processes through continued model development and data assimilation;
- Coordination, maintenance, and enhancement of Arctic climate and radiation measurement networks; and
- Variations in the fluxes of heat, fresh water, and contaminants into, within, and out of the Arctic and sub-Arctic regions.

ACCA is motivated by the need to understand the climate change that has been observed in the Arctic and to identify the impacts that this change may have on the global climate system. The primary means for addressing the need will be through model development. The data needed for model validation require the establishment and maintenance of field measurement networks adequate to assess regional meteorological and radiation parameters and to detect variations in the regional fluxes of heat, water vapor, fresh water, and climatically active atmospheric contaminants. The models and measurement systems are inherently linked, inasmuch as each system drives the others. Hence, coordination will be essential.

Science Drivers. ACCA will address the above concerns by focusing research on the following key climate-related questions:

- Which of the atmospheric and cryospheric changes that have occurred in the Arctic during recent decades reflect long-term, as compared to interannual or decadal, changes?
- Which of these changes reflect significant teleconnections with lower-latitude climate?
- What mechanisms have driven the recent and ongoing atmospheric and cryospheric changes?
- What are some future Arctic climate change scenarios and their probabilities of occurrence?
- What are possible, or probable, impacts of Arctic climate change on the global ocean and on lower-latitude climate?

Strategy. An integrated approach based on enhanced observational systems, field-based process studies, numerical modeling, and data assimilation will be necessary to address these issues. Climate models can be used to assess future climate change, but they must be able to simulate past and present conditions. This requires the assimilation of long-term data sets into the models and an improved understanding of the relevant processes. Currently, ongoing climate change can

only be documented and characterized through observations obtained over decadal time periods and large geographical regions. A minimal strategy to accomplish this will require the following:

- A distributed observation network to obtain long-term observations of sufficient quality and continuity to address questions of climate; this includes satellite observations and distributed networks of climate and radiation measurements;
- Modeling and data analyses using climate models that adequately represent Arctic processes, coupled with assimilation techniques that optimize the integrated information return from models and observations;
- Process studies that are based on field data and assess processes that impact climate and whose understanding is essential to successful development and application of climate models; and
- Coordination activities to maintain a focus on key issues and to ensure that policy makers and the public are informed in a timely fashion about key findings.

These topics can be grouped into general categories, falling under observation network, and modeling and data analyses.

Reliable long-term measurements are limited in the Arctic. Technological advances now make it possible to greatly enhance new data acquisition using existing facilities, such as drifting and land-based remote stations, through the use of telemetry. New technologies also allow the use of satellites in enhanced data acquisition. Several such facilities, supported by Federal agencies, exist in the Arctic:

- The International Arctic drifting Buoy Program (IABP) provides measurements of sea level pressure, ice drift, and surface temperature.
- The Barrow Alaska Environmental Observatory (NOAA Climate Monitoring and Diagnostics Laboratory, DOE Atmospheric Radiation Measurement Program, and NSF Arctic System Science Program) measures UV, visible, and IR radiation; cloud cover and height distribution; aerosols; heat and water vapor fluxes; CO₂; and other air chemistry parameters.
- The Greenland Climate Network assesses climate and glaciological parameters across the Greenland ice sheet.
- The North Pole Environmental Observatory, a remote drifting station, measures meteorological, snow, sea ice, and upper ocean parameters.

- Manned and autonomous surface and upper air stations measure a broad variety of atmospheric parameters.
- Satellite monitoring documents the vertical structure of the atmosphere in addition to snow and ice cover (SSM/I and others).
- The Network for the Detection of Stratospheric Change (NDSC) measures stratospheric parameters.

These facilities need to be expanded and coordinated, and the measurements prioritized, in order to support a set of core Arctic measurements.

Understanding Arctic climate sufficiently to allow prediction depends on the use of climate models. These depend in turn on the availability of observations for model validation. Establishment of data priorities for assimilation into models is essential. The following issues will be paramount in ACCA.

- Application of statistical techniques to data sets in order to test hypotheses concerning high-latitude climate processes;
- Inclusion of realistic cryospheric behavior, including sea ice rheologies and cloud radiation feedback, in climate models;
- Development of optimal techniques for data assimilation into models;
- Quantitative comparisons of the existing ocean–ice–atmosphere models; and
- Evaluation of the role of air chemistry in Arctic change, with an emphasis on aerosols, CO₂, and ozone.

Process studies address deficiencies in our modeling of large-scale climate processes and should be selected based both on model deficiencies and on observed conditions. These studies are likely to involve a combination of field observations and theoretical research and require well-defined strategies for assimilation of the results into models. Cloud radiation feedback mechanisms and upper ocean turbulent heat fluxes, neither of which are well documented in the Arctic but both of which are crucial to understanding climate, are examples of such processes.

Future Programs

Terrestrial Biotic Systems. As discussed in the SEARCH Science Plan and above, changes have occurred in non-glaciated terrestrial biotic systems in response to a predominately warmer physical environment during the past decade (Mynemi et al. 1997).

The changes in terrestrial environmental variables are by no means a simple, direct response to regionally warming atmospheric temperature

trends. There is a high degree of biocomplexity inherent in the myriad direct and indirect climate, hydrologic, soil, and ecosystem feedback mechanisms. Increased understanding of the vulnerability of Arctic terrestrial systems to projected continued warming is important for making decisions concerning changes in land use, maintenance of existing and future infrastructure, mitigation of environmental impacts, and the sustainability of Arctic communities, particularly those depending on a subsistence lifestyle.

A central question arises from the recent trend of climate warming and terrestrial system change: Are the changes related? How much of the changes are due to natural variability and how much is human-induced? There have been cycles of atmospheric temperature change for thousands of years and fluctuations in terrestrial systems on the same time scale. The difficulty in making connections is twofold: correlating the most recent warming trend to observed changes in terrestrial systems and tying either the warming or the terrestrial changes to anthropological causes. The data simply do not exist, and the understanding of the feedback processes is insufficient to produce reliable evidence of either relationship. Having admitted that the problem is unsolvable at present does not exclude the possibility that it can be solved with a coordinated approach using available techniques and in a reasonable time frame. SEARCH provides the framework for accomplishing that goal because it allows coordinated observations of changes within the system while taking a system-level view of the biocomplexity of the Arctic on a sufficiently long time scale to begin to identify feedback processes acting in response to both natural and anthropogenic causes and effects.

SEARCH will facilitate the needed coordination to produce a research outcome that builds on the earlier efforts. The research program will include:

- Long-term data collection from environments on the decadal time-scale, e.g., existing ecological monitoring sites in the Alaska National Wildlife Refuge (DOI/FWS);
- Limited manipulative experiments to induce changes in terrestrial processes in response to climate change; and
- Modeling studies designed to integrate knowledge about processes and feedbacks in order to build a predictive capability.

Marine Biotic Systems. The Bering Sea ecosystem is among the most productive of high-latitude seas. SEARCH-related activities in the Bering Sea are described in Section 2.2. Bering Sea research

has a regional focus, while the SEARCH effort takes a pan-Arctic approach.

The approach to implementing the marine biotic systems research effort will focus on three principal tasks:

- Build an interdisciplinary, integrated observation and knowledge base for the Bering Sea region;
- Synthesize available information into conceptual models that identify potential linkages among natural and human-induced stressors to achieve new insights and guide future research; and
- Perform integrated, ecosystem-level assessments for the Bering Sea region that link ecological, cultural, economic, and health challenges to physical change in the environment, recognizing both natural phenomena and human activities that impact marine ecosystems and indigenous populations.

Human Social and Economic Systems. Where researchers have studied evidence of past and contemporary cultures, it is clear that survival in the Arctic has depended on adaptability. Changes in the Arctic have been tied historically to both local and global processes. In addition to changes driven by seasonal extremes and variability, human activity within the region has caused significant environmental, economic, social, and cultural change (for example, colonization, marine mammal hunting, the fur trade, the gold rush, and urbanization). Arctic residents today have the capacity to foster or discourage some of the most extensive and precipitous changes in the region (for example, large-scale oil development, logging, alteration of fire regimes, and the redirection of freshwater flow to the Arctic Basin).

Some physical changes that originate in the Arctic could propagate to lower latitudes, changing air and sea temperatures and affecting economies. For example, major Atlantic and Pacific fisheries could depend on ocean conditions that are influenced by Arctic processes that are

affected, in turn, by changes in climate.

The Arctic is extremely vulnerable to climate change and its potential impacts. The special report on the regional impacts of climate change by Working Group II of the Intergovernmental Panel on Climate Change (IPCC) noted that over the period of IPCC assessment, climate change will contribute to major physical, ecological, sociological, and economic changes already begun in the Arctic. A considerable interdisciplinary effort is needed to collect and analyze information on the implications of these environmental changes for human populations.

To assess the effects of observed environmental change on indigenous people and other residents, a research program examining the dynamics of linkages between human populations and the biological and physical environment of the Arctic is required. That research program should incorporate an integrative, interdisciplinary approach including the following:

- The biophysical basis for future human impacts on the functioning of the Arctic system;
- Recent and past patterns of habitat use (including land, water, and ice) and resource use (including subsistence, land tenure, domestication, farming, fishing, and resource extraction) where human consequences of global change are expected;
- Patterns of human response and adaptation to environmental change (including settlement decisions, shifts in resource use, migration, diversification, impacts of environmental change on human health, and economic transitions);
- The basis for sustainability, viability, resilience, and vulnerability in future interactions between humans and their environment; and
- Development and implementation of an educational framework that offers feedback and learning opportunities for local stakeholders, scientists, and decision makers.

2.2 Developing a Research Plan for a Sustainable Bering Sea

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

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

2.2.1 Changes in the Bering Sea

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

Recent and rapid changes in the physical and biological characteristics of the Bering Sea have raised concerns (Overland et al. 2004). Changes in the abundance of salmon, crab, and groundfish may result in significant economic impacts. Continuing declines in some populations of marine birds and pinnipeds have prompted protective measures such as fish trawling closures around critical feeding areas used by the endangered Steller's sea lion. There have been unexplained blooms of phytoplankton never before recorded in the Bering Sea, and between 1989 and 2000 an

exponential increase in the biomass of large gelatinous zooplankton occurred, which has since collapsed (Hunt et al. 2002).

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

2.2.2 Arctic Research Commission Charge

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

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

2.2.3 Enhancing Research

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

Since natural ecosystems, science, and management are all dynamic processes, an iterative

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

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

Building an Iterative Bering Sea Research Strategy

The Interagency Arctic Research Policy Committee authorized the establishment of a Bering Sea Interagency Working Group to work toward an integrated assessment, and it subsequently reaffirmed this commitment by expanding the focus on research. The Bering Sea IWG is benefiting from past efforts in defining research goals and establishing a conceptual framework. In addition, an NSF-sponsored meeting (Bering Sea Research, September 2002 in Laguna Beach, California) included members of the SEARCH and North Pacific Research Board leadership to ensure coordination among groups during the development of the research recommendations presented above.

Components of Strategic Integrated Research

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

- Definition of a sustainable Bering Sea: Based on dialogue among interested parties, key concerns, common interests, and desired outcomes from management actions will be determined. In this process the essential characteristics of the Bering Sea are defined. This will provide the necessary framework around which to structure integrated assessments. Interviews were conducted with Federal and

state officials and commercial and environmental interests.

- Conceptual synthesis: Existing data will be integrated to identify potential relationships among forcing functions, ecosystem changes, sources of stress, and ecological end points of concern identified in the goals. The process is interactive, iterative, and interdisciplinary, and it addresses the influences of multiple natural and human stressors on ecological and human systems. The purpose is to learn more from existing data, generate multiple working hypotheses about likely causal relationships, and define essential research needs.
- Research Plans: Based on the conceptual synthesis, research questions will be refined and further research designed to produce integrated research and assessments. The expected outcome is a dynamic research plan available to Federal agencies and others that capitalizes on existing research efforts and defines new research within a structured framework for integrating research activity and interpreting results.
- Research implementation: New research will be initiated to evaluate predictive relationships among natural and human influences on key values to be sustained. The research will investigate processes, trends, and effects, as well as monitor the impacts of management decisions. New information is fed back into goal setting, synthesis, and planning for re-evaluating goals, refining conceptual models, and developing updated research plans.
- Ecological forecasting: To be useful to living-resource managers, the results of research must lead to the ability to provide forecasts of future ecological states. Research will be conducted to build coupled physical–biological models and to develop science-based products that provide value to resource managers. A long-term goal of this research is to specify an ecological forecasting system that could be used in an operational setting for resource management.

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

2.3 Arctic Health

The Arctic Research Commission has recommended:

“a comprehensive, inter-agency study of Arctic Health. NIH has agreed to be the focal point for this effort focused primarily on the environmental health questions outlined by the Arctic Monitoring and Assessment Program and on the study of incidences and trends in the major causes of morbidity and mortality in the Arctic. NIH should lead this effort with the assistance of other agencies especially EPA and NOAA. The potential effects of anthropogenic contaminants such as persistent organic pollutants, heavy metals and radionuclides are a growing concern in the Arctic. The effects of both communicable diseases such as tuberculosis, systemic diseases such as diabetes and cancer and external causes of illness and death such as alcoholism and accident likewise have profound effects in the Arctic.” (*Report on Goals and Objectives for Arctic Research*, U.S. Arctic Research Commission, 2003.)

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

2.3.1 Epidemiology and Health Surveillance

Research Goal: To understand the epidemiologic parameters of diseases important to Arctic residents, providing data that will inform and guide programs to prevent, diagnose, and treat such diseases, ranging from acute infectious illnesses to chronic conditions dependent on diet and life-style.

Infectious Diseases

Centers for Disease Control and Prevention's Arctic Investigations Program. The Arctic Investigations Program, Anchorage, Alaska, is a division of the National Center for Infectious Diseases. Its mission is prevention and control of infectious diseases, with a focus on diseases of high incidence and concern among the indigenous populations of the Arctic and sub-Arctic regions and on emerging and re-emerging infectious disease problems. The Centers for Disease Control's long-term plan, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*, focuses on four goals:

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

The plan targets certain high-priority categories of emerging infectious disease problems and special groups of people who are at increased risk for antimicrobial resistance, food- and waterborne diseases, vector-borne and zoonotic diseases, diseases transmitted through blood transfusions or blood products, chronic diseases caused by infectious agents, vaccine development and use, people with impaired host defenses, diseases of pregnant women and newborns, and diseases of travelers, immigrants, and refugees. For the 2004–2008 planning period, the Arctic Investigations Program will target vaccine-preventable diseases, antimicrobial resistance, chronic diseases caused by infectious agents, and bioterrorism response.

National Institute of General Medical Sciences. The National Institute of General Medical Sciences, through a partnership with the Indian Health Service, is supporting several projects by the Alaska Native Tribal Health Consortium. Three studies, funded in part by the National Institute of Allergy and Infectious Diseases, examine infectious diseases:

- Determine the prevalence and serotype of chronic hepatitis B, which may aid in understanding modes of communication of the disease;
- Determine the rates of re-infection with *Helicobacter pylori* after treatment, since infection rates are high among Alaska Natives; and
- Work to prevent pneumococcal disease, which is a high priority because of the incidence of otitis media in Native populations.

National Institute on Drug Abuse. The National Institute on Drug Abuse supports efforts to enhance Alaska's research capacity. One current initiative examines women's health and gender differences among Alaska Native women. Recent drug abuse research suggests that the identification of subtypes of women drug users based on individual and contextual variables may

be essential to understanding unsafe sexual practices among drug-using women.

Other future research plans include expanding the substance abuse and health and social consequences research portfolio, including infectious diseases, violence, and crime, and the development of prevention and treatment strategies.

National Institute of Dental and Craniofacial Research. The National Institute of Dental and Craniofacial Research goals and objectives include support that will lead to the prevention and control of dental caries among children in the Pacific Northwest and Alaska. Alaska Native children are disproportionately affected by early childhood caries, compared to all U.S. children. The cultural practice of pre-mastication of solid food for infant feeding amplifies the transmission of oral secretions from adult to child. The prevention of early *S. mutans* acquisition and subsequent caries in infants and toddlers requires efforts starting at birth. A community-based controlled clinical trial will determine if the serial use of chlorhexidine and xylitol in mothers can reduce the vertical transmission of cariogenic bacteria between Alaska Native mothers and infants. The treatment regimen is coordinated with medical care to perinatal Alaskan Native women. If successful, this novel preventative intervention could impact the prevalence of caries among population groups at high risk for childhood caries.

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

NIAID is supporting a three-year pilot intervention trial in three Alaska Native villages with high numbers of asymptomatic carriers to determine if *Haemophilus influenzae* type b vaccine can be given to persons of all ages to eliminate or reduce colonization in Alaska Native villages in a region with high rates of *Haemophilus influenzae* type b, despite ongoing vaccination of children. The researchers hope to determine what treatment most effectively eliminates the *Haemophilus influenzae* type b reservoir from a village, such as *Haemophilus influenzae* type b conjugate vaccine with and without rifampin (the standard treatment). Mass vaccination with *Haemophilus influenzae* type b conjugate vaccine may be possible.

Occupational Injuries

National Institute for Occupational Safety and Health. The Centers for Disease Control and Pre-

vention's National Institute for Occupational Safety and Health, Division of Safety Research Alaska Field Station, in collaboration with the Indian Health Service, the State of Alaska, the Alaska Native Tribal Health Consortium, and the Alaska Native Health Board, will continue studies on the epidemiology, risk factors, and prevention strategies for occupational injuries in Alaskan communities. It has mounted two other initiatives in Arctic research. The commercial fishing industry contributes high numbers of fatal and severe non-fatal injuries. The National Institute for Occupational Safety and Health is examining vessel stability and the deck environment surrounding the deployment and retrieval systems of fishing equipment (including the use of cranes, winches, lines, nets, crab pots, and crab pot launchers) from a mechanical and safety engineering perspective.

Alaska experienced a downward trend in occupational fatalities during the 1990s (from 78 in 1990 to 42 in 1999, a decrease of 46%). The U.S. Congress supported a Federal initiative beginning in FY 00 to reduce aviation-related injuries and fatalities and to promote aviation safety in cooperation with the air transportation industry in Alaska, a partnership of four Federal agencies: the Federal Aviation Administration (FAA), the National Transportation Safety Board (NTSB), the National Weather Service (NWS), and the National Institute for Occupational Safety and Health (NIOSH). The goal is to reduce the number of aircraft crashes and injuries in Alaska by at least 50% by the end of 2009. The initiative involves five objectives:

- Gather and analyze aircraft crash, injury, and fatality data involving Alaska commuters and air taxis, and identify risk factors;
- Bring together aviation industry groups to characterize the problems;
- Develop aviation safety education plans for pilots, companies, and the flying public;
- Evaluate the effectiveness of and changes in flight safety practices; and
- Evaluate progress and suggest additional improvements.

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

Nutrition

National Institute of General Medical Sciences. The National Institute of General Medical Sciences, through a partnership with the Indian Health Service, is supporting two projects by the

Alaska Native Tribal Health Consortium regarding nutrition:

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

Disabilities

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

Chronic Diseases

National Institute of Alcohol Abuse and Alcoholism. The goal of the National Institute of Alcohol Abuse and Alcoholism is to identify the causes and consequences of abusive and chronic alcohol consumption and to develop effective treatment and prevention strategies for adverse consequences of drinking. In the next five years NIAAA plans to:

- Test the efficacy of several pharmacological adjuncts to alcoholism treatment and examine genetic, biological, and behavioral characteristics of Alaska Natives receiving treatment for alcoholism;
- Involve Alaska Natives in developing and conducting research projects;
- Learn if there are specific differences in the development of alcohol problems in various Alaska Native groups;
- Study maternal drinking and fetal alcohol spectrum disorders in the Arctic, working with local communities, the Substance Abuse and Mental Health Services Administration, and the Department of Education;
- Determine whether and how alcohol availability and other control policies affect alcohol-related consequences in communities of the Arctic region;
- Identify risk and protective factors as predictors of sobriety and the sobriety process in Alaska Natives, particularly as influenced by the indigenous culture;
- Develop culturally and linguistically appropriate psychometric instruments for prevention strategies with Alaska Natives; and
- Support forums to identify strategies for moving validated scientific research findings into clinical practice.

National Institute of Child Health and Human Development. The National Institute of Child Health and Human Development and the National Institute of Alcohol Abuse and Alcoholism recently started a program to support community partnerships to investigate the role of prenatal alcohol exposure in the risk for sudden infant death syndrome and adverse pregnancy outcomes. The program is aimed at communities at high risk for prenatal maternal alcohol consumption, such as American Indian and Alaska Native communities.

National Cancer Institute. The National Cancer Institute is involved in several Arctic health research projects:

- Alaska Native Tumor Registry. The Alaska Native Tumor Registry was initiated in 1974 as a collaboration between the National Cancer Institute, NIH, and the CDC using procedures developed by the National Cancer Institute's Surveillance, Epidemiology and End Results Program. From 1984 to 1988 the Alaska Native Tumor Registry functioned as a hospital registry for the Alaska Native Medical Center. In 1989 the National Cancer Institute entered into an interagency agreement with the Alaska Native Medical Center through the Indian Health Service, with technical assistance provided by the University of New Mexico. In 1999 the Alaska Native Tumor Registry became an official part of the Surveillance, Epidemiology and End Results Program. All patients are tracked and notified of recommended follow-up appointments. Accurate information on the unique cancer patterns occurring in this population is useful for provider education and training, program planning, studies of cancer etiology, evaluation of screening programs, and the development of interventions to improve patient care and programs for cancer prevention and risk reduction. Research studies in progress related to the Alaska Native Tumor Registry include:
 - Serum polychlorinated by-phenyl levels in breast cancer patients and controls;
 - Prospective study of breast cancer and organochlorines in serum and fat tissue in the breast;
 - *Helicobacter pylori* and cancer and other diseases of the stomach;
 - Prevalence of colorectal cancer genes in (formalin-fixed) tissue among colorectal cancer patients;
 - Familial aggregation of nasopharyngeal cancer; and

- Biomarkers expressed in tumor tissue of Alaska Native breast cancer patients.
- Network for Cancer Control Research among American Indian and Alaska Native Populations: The National Cancer Institute, through its Surveillance Research Program, Division of Cancer Control and Population Sciences, supports the Network for Cancer Control Research between American Indian and Alaska Native Populations. Established in 1990, this network of researchers working among American Indians and Alaska Natives developed a National Strategic Plan for Cancer Prevention and Control Research in 1992. The National Cancer Institute shares support for network meetings with the Mayo Comprehensive Cancer Center.

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

The primary goals of the Alaska Native Stroke Registry are to:

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

National Heart, Lung, and Blood Institute. A study supported by the National Heart, Lung, and Blood Institute is a working partnership between the Native-owned corporation that manages the health care of the Native Alaskans of Norton Sound and investigators from the Strong Heart Study, a 14-year study of cardiovascular disease in American Indians. These Eskimo villages are remote and isolated, and traditional lifestyle is

being eroded by mechanization and a westernized diet. There has been relatively little outside genetic influence, and they, like the American Indians of the lower 48 states, are beginning to show a marked increase in the prevalence of atherosclerosis and coronary artery disease.

The aims of the five-year (FY 00–04) \$7.8 million study are to document cardiovascular disease and cardiovascular disease risk factors among 1200 Alaska Natives who are members of approximately 40 families. This family-based, cross-sectional study will document recognized and emerging risk factors and prevalent cardiovascular disease in each individual through a standardized interview, a physical exam, laboratory measurements, and a review of centralized medical records. The investigators will assay contemporary samples and serum specimens, which have been stored at the Anchorage Centers for Disease Control and Prevention office antedating this study by 10–20 years, for specific markers of inflammation and serologic responses to six measures of infection (*Chlamydia pneumoniae*, hepatitis A virus, herpes simplex virus types 1 and 2, *Helicobacter pylori*, and cytomegalovirus). This is the first project to identify and map genes that contribute to the risk of cardiovascular disease in this unique and understudied population.

Substance Abuse and Mental Health Services Administration. Since the Substance Abuse and Mental Health Services Administration does not do research, the information provided here describes the HHS's research agenda. Currently there are five programs/projects to report:

- Circles of Care Program: Supported by SAMHSA's Center for Mental Health Services, this program provides grants for tribes and urban Indian communities to plan, design, and assess culturally specific mental health service system models for American Indian and Alaska Native children and their families.
- Child Mental Health Initiative: This is the Cooperative Agreement for the Comprehensive Community Mental Health Services for Children and Their Families Program. Community Mental Health Services provides grants for state and tribal governments to develop systems of care for children (and their families) with serious emotional disturbances.
- Anchorage Comorbidity Services Project. This project, funded through a \$15 million congressional earmark and jointly administered by the SAMHSA's Center for Substance Abuse Treatment and Community Mental

Health Services, supports the development and evaluation of an optimally integrated system of emergency and long-term services for individuals in south-central Alaska who have co-occurring substance abuse and mental disorders.

- Alaska Fetal Alcohol Syndrome/Alcohol-Related Birth Defects Program. The overall goal of this program is to improve the practice of identifying, preventing, and treating fetal alcohol syndrome and alcohol-related birth defects by improving Alaska's system of care for those individuals already affected by prenatal exposure to alcohol.
- National Center for Excellence. Supported by the Center for Substance Abuse and Prevention and funded at \$3.8 million per year for five years, the Center for Excellence coordinates activities to ensure that advances in both science and practice are synthesized and efficiently disseminated to the field.

Agency for Toxic Substances and Disease Registry. Environmental contamination in the Great Lakes continues to be a threat to human health. The present concern is atmospheric transport of toxic chemicals to the Great Lakes from various sources, specifically the Arctic region. This research program will continue, with more emphasis on developing biomarkers for exposure and health effects. These studies will provide valuable information on exposure pathways, body burden levels, and potential adverse health outcomes from exposure to toxic chemicals in the environment. The lessons learned from the Great Lakes can be useful for researchers as they continue their work in the Arctic.

2.3.2 Information: Acquisition, Assembly, and Dissemination

Research Goal: To develop a responsive system for handling health information transfer in the Arctic, ranging from telemedicine systems utilized in health care delivery, to an Internet-based health information network for researchers and the general populace, especially Native and other populations (such as the Circumpolar Health Information Center).

National Institute of General Medical Sciences

The National Institute of General Medical Sciences, through a partnership with the Indian Health Service, is supporting several projects by the Alaska Native Tribal Health Consortium.

One applied study investigates the degree of concordance of diagnosis of effects of telemedicine vs. live diagnosis. This study is important because of the challenges of delivering care to rural Alaska.

National Institute of Mental Health

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

- Development of a web-based treatment manual system: Working with the Cook Inlet Tribal council, the nonprofit arm of the Cook Inlet Region Corporation, a manual is being developed to address the continuum of care needed for Alaskans with alcohol, drugs, and mental disorders. Care programs address the range of needs from the homeless to women at risk of having their children taken away for abuse or neglect.
- A research evaluation to examine factors associated with success in disseminating the State of Alaska-funded rural human service program for serious emotional problems or disturbances.

National Cancer Institute

In 1997 the National Cancer Institute assisted the Network and Mayo in establishing the Native CIRCLE, a clearinghouse for information and resources developed through research. Many useful, culturally sensitive materials, including school curricula, videos, pamphlets, and survey instruments, are catalogued and made available to researchers and communities for application in the areas of smoking prevention, cancer screening, and dietary change.

National Institute of Child Health and Human Development

The National Institute of Child Health and Human Development will identify and develop strategies for designing outreach programs to increase sudden infant death syndrome awareness and to reduce sudden infant death syndrome risk in American Indian communities. The meeting will provide a forum for health care professionals to interact with

community leaders, including small group discussions with public health nurses, community health representatives, elders, and fathers. Some of the issues and strategies to be discussed include:

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

The National Institute of Child Health and Human Development plans to use information gleaned from these meetings to develop materials, coalitions, and an infrastructure that the communities can use when developing and conducting the outreach programs. As a result of these interactions, representatives from the tribes and individual communities are expected to tailor informative action plans for community-driven SIDS risk reduction strategies that meet the unique needs of their own members.

National Institute of Diabetes and Digestive and Kidney Diseases

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

National Center for Research Resources

To educate and inform the Alaskan public about health science research so they can make healthier lifestyle choices, the National Center for Research Resources supports the Imaginarium's Health Outreach Caravan, which forms partnerships with the scientific, public health, educational and cultural communities; develops mobile, hands-on, interactive, and culturally appropriate health-related programs; and develops a Health Science Teen Volunteer Corps across remote, culturally unique regions of Alaska to facilitate linkages between biomedical scientists, village elders, and local community and school programs.

Health Resources and Services Administration

From FY 00 through FY 02, the Health Resources and Services Administration funded the Alaska

Federal Health Care Access Network to support the creation and operation of a tele-health network that provides 230 village clinics in Alaska with the capacity to conduct telemedicine consults. These clinics serve more than 200,000 residents in remote areas throughout Alaska. As well as clinical services, the network provides access to continuing education of the indigenous population, with videoconferencing, transmission of data, and voice communications.

National Institute on Drug Abuse

Since 1994 the National Institute on Drug Abuse has been funding projects at the University of Alaska Anchorage dealing with the spread of AIDS and other infectious diseases, substance abuse, and related mental health problems. Out of this work has come a large five-year project, in conjunction with the University of New Mexico, the first-ever systematic study of ethically important aspects of rural health care for stigmatizing illnesses. Key concepts in this research include rurality, ethics, psychosocial issues, stigma, and barriers to optimal care. The project will make significant contributions to health services research in the Arctic and other frontier and rural areas, as well as leading to a better understanding of rural health problems and their solutions. The National Institute on Drug Abuse plans to include studies of a previously unseen problem—rural runaway youth—a group at extreme risk for substance abuse, mental health, and infectious diseases, as well as violence and other forms of abuse.

National Institute of Dental and Craniofacial Research

The National Institute of Dental and Craniofacial Research, through the University of Washington Northwest's Alaska Center, supports the development of a web-based tool (EthnoDent) that focuses on reducing cultural barriers between providers and multicultural patients (including Native Americans and Alaska Natives) in the area of children's oral health. This instructional tool will reduce disparities in children's oral health by enhancing the provider's attitudes and skills in communicating with multicultural families.

2.3.3 Infrastructure and Capacity Building

Research Goal: To build up the capacity of Arctic institutions and organizations for competitive participation in the research enterprise (their ability to

obtain research grants) through training efforts, and support of facilities or center-type grants.

National Institute of Mental Health

The National Institute of Mental Health, along with the National Institute of Neurological Diseases and Stroke and the National Center for Research Resources, is presently collaborating in the joint sponsorship of the Alaskan Basic Neuroscience Program at the University of Alaska Fairbanks. This program is part of the Specialized Neuroscience Research Program at Minority Institutions initiative, intended to establish and enhance competitive research programs in basic neuroscience at minority institutions. The research projects will examine themes of interest to Alaskan peoples, including circadian rhythms, hibernation mechanisms, and neural development and repair.

National Cancer Institute

The National Cancer Institute supports the Native American Student Research Program, a collaboration between the Indian Health Service, the Oregon Health Sciences University, and the tribe-operated Northwest Portland Area Indian Health Board. Spanning six years, this cancer control research and training program for American Indian and Alaska Native graduate and post-doctoral students, has provided training to 53 trainees of diverse Native groups, including Alaska Natives. A substantial proportion of the trainees have been awarded National Cancer Institute funds to carry out community-based cancer control activities among Native groups.

National Institute of Neurological Diseases and Stroke

A specialized neuroscience research program at the University of Alaska establishes an Alaskan Basic Neuroscience Program to expand, facilitate, and stimulate neuroscience research, to facilitate the development of collaborative research, and to stimulate the active participation of Alaska Native students.

National Center for Research Resources

The National Center for Research Resources continues to develop Alaska's research capacity through the funding of the Institutional Development Award program, a science education health outreach program, and co-funding of a neuroscience research program. The NCRP is supporting the University of Alaska's Center of Biomedical Research Excellence. The Alaska Native Health

Research Center has formed a partnership with the University of Alaska research faculty and Alaska Native communities and tribal health corporations to increase the university's research capacity. The specific goals are to enhance research productivity and increase community education by identifying risk and protective factors affecting the weight and health of Alaskan Natives, and the relationship between genetics, healthy behavior, and obesity, an important risk factor for cardiovascular disease and non-insulin-dependent diabetes.

Fogarty International Center

The Fogarty International Center is soliciting grant applications for its new program entitled Health, Environment and Economic Development. The program, co-funded by the Fogarty International Center, four other NIH institutes and centers, and the U.S. Geological Survey (USGS), intends to support research collaborations to examine the relationships among health, significant trends in economic development, and the natural environment. The first planning grants will be awarded by the end of FY 03, followed by specific projects in FY 05.

National Institute of Allergy and Infectious Diseases

The National Institute of Allergy and Infectious Diseases supports a demonstration and education outreach program at the University of Washington aimed at increasing organ donation and transplantation among Alaska Natives.

2.3.4 International Circumpolar Collaborations

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

The Fogarty International Center is continuing to support a Fogarty International Research Collaboration Award, awarded to researchers at Stanford University and the Vavilov Institute of General Genetics of the Russian Academy of Sciences, to study diversity in human DNA sequences. The purpose of the study is to characterize the genetic ancestry of Native American

groups to provide insight into the migration of populations to the New World from northeast Asia. The grant aims to develop models of molecular variability in individuals from a worldwide array of samples, including approximately 50 previously collected samples from six different Siberian peoples (Buryats, Tuvinians, Yakuts, Evenks, Chukchis, and Eskimos). This will help explain the rate and distribution of genetic mutation, genetic divergence, and eventually, demographic changes.

Finally, NIH, together with NSF and the Department of State, will continue to support collabora-

tive research projects, some of which are relevant to the Arctic, between U.S. scientists and their counterparts from the Former Soviet Union through the U.S. Civilian Research and Development Foundation. During 2002–2004, two projects related to the Arctic bring together researchers from the Shirshov Institute of Oceanology of the Russian Academy of Sciences, Oregon State University, and Science Applications International Corporation to study the interrelationships between marine biology, geology, and environmental sciences.

2.4 *Research on Resource Evaluation*

This is a new section of the U.S. Arctic Research Plan. In its 2003 *Report on Goals and Objectives for Arctic Research*, the Arctic Research Commission provided the following statement and recommendation:

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

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

The Department of the Interior has continued to assess the energy and minerals of Alaska, and its bureaus have published numerous reports on this subject. However, with the renewed interest in information on the oil, gas, and other mineral potential on public lands in the State of Alaska, the Department of the Interior will initiate discussions with Interior bureaus and other departments to determine the feasibility of resuming publication of an annual report on these topics. IARPC expects to work with the Department of the Interior to develop this initiative in the context of funding that is made available during the period of this revision to the U.S. Arctic Research Plan (2004–2008).

2.5 *Research on Civil Infrastructure*

This is a new section of the U.S. Arctic Research Plan. In its 2003 *Report on Goals and Objectives for Arctic Research*, the Arctic Research Commission provided the following statement and recommendations:

“Understanding climate change in the Arctic is an important goal, as the SEARCH Program has recognized. It is at least equally important, however, to begin the task of finding ways to cope with the

effects of climate change, particularly on Arctic infrastructure. The effects of infrastructure problems on human life in the Arctic are particularly noted above in the section on Arctic Health. These difficulties are compounded by climate change. The destabilization of structures by changes in permafrost, changes in coastal communities caused by changing in sea level and in the frequency and strength of storm induced wave action, changes in weather patterns requiring changes in aircraft operation and many others require

a strong commitment to engineering research in the Arctic. The Commission is encouraged by arrangements between the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL) and the University of Alaska to bring the nation's most able engineering talent to bear on these problems. CRREL is recognized around the world as an international treasure of expertise in Arctic engineering.

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

Accurate and precise geospatial (map) data are essential for many purposes including air navigation, wilderness travel, and mineral and energy exploitation. Similarly, they are fundamental requirements for the effective construction of civil infrastructure projects. The Department of the Interior through its USGS Geospatial Data Clearinghouse provides geospatial data and, in particular, digital elevation models based on a variety of measurement techniques, primarily observations from aircraft and spacecraft. Complete coverage of the 48 contiguous states has been available for years. Full coverage of the U.S. Arctic region at high precision (1m × 1m × 1m) does not exist and is critically needed.

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

The USGS has initiated the National Map

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

In FY 03 the USGS and BLM expanded the coverage over NPRA. The strategy is to focus the work on areas of the state where high-resolution data are required to support priority DOI and AGDC member's planning and management needs. IARPC and the Department of the Interior will work to develop this program in the context of funding that is made available during the period of this revision to the U.S. Arctic Research Plan (2004–2008). IARPC also will encourage continuing support for the U.S. Army Cold Regions Research and Engineering Laboratory's participation in infrastructure research in Alaska.