

United States Arctic Research Commission



Report on Goals and Objectives for Arctic Research

2003

A MESSAGE FROM THE CHAIR

The Arctic Research and Policy Act of 1984 (as amended) directs the United States Arctic Research Commission to publish its Report on Goals and Objectives for Arctic Research every two years to guide the Interagency Arctic Research Policy Committee, and thus, the member Federal Agencies as they prepare their revision of the National Arctic Research Plan. This report for the year 2003 reflects the best judgement of the Commission based upon information gathered at our formal meetings, from other arctic research community meetings, the Commission's Group of Advisors, through reading and from our daily interactions with those involved in Arctic research - US and foreign researchers, researches administrators, Alaskan natives and others living and working in the North.

The Commission has studied the research programs of both the United States and other nations with Arctic interests. We have attempted to synthesize them into a focused set of goals that meet what we understand are federal, state, local and native needs. At the same time we have tried to be sensitive to the dynamics of the Arctic which are affecting the international as well as the national landscape of politics, economics, sociology, security and the environment. Because this is a far reaching and diverse effort, completed on its own schedule, these goals and objectives may not exactly coincide with the research priorities articulated in the President's budget which must sometimes respond to requirements outside the Commission's purview.

In recent years our country's focus on Arctic research has increased significantly. This, in turn, has resulted in numerous advancements that will enable additional research and greatly increase our understanding of the least studied and most poorly understood area on Earth in the years ahead. Examples of these are:

- The highly successful data collection efforts of the SHEBA Program.
- The stunning revelations of the history and current state of the Arctic ocean gained from the SCICEX Program.
- The establishment of the Study of Arctic Rapid Change (SEARCH) Program.
- The impact of the Arctic Research Logistics Program at NSF as a vital adjunct to more cost-effective research.
- Continuous upgrades at the Toolik Lake and Barrow Environmental Observatory research facilities in Alaska and the several facilities in Greenland.
- The continuation of NOAA's Arctic Research Initiative.
- The development of the International Arctic Research Center at the University of Alaska.
- The continuing increase in active international cooperation in Arctic research.
- The success of the US Coast Guard research icebreaker *Healy*, WAGB 20 on its first two deployments.

But as we advance in our ability to conduct research and we understand what has been observed, we find unanswered questions. In response, we are compelled to continue to study the Arctic, perhaps more intensively now than ever. Specifically:

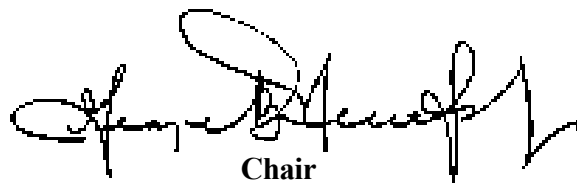
- The Arctic Ocean is undergoing rapid change. Is it the result of man-induced global climate change or part of a natural decadal cycle? Can we expect to exploit these changes in the Arctic Ocean for commercial purposes? What is the potential impact on world climate of this change? What are the national and homeland security impacts.
- The permafrost which underlays roughly 80% of the State of Alaska is decreasing. What engineering will mitigate the degradation of the State's infrastructure? Will the change foster new commercial opportunities?

- The Bering Sea fishery provides 50% of the table fish for our nation and is in obvious decline. Why? Can it be reversed? What are the social and economic impacts?
- As climate changes so do the habitats and ranges of animals and plants. What is happening to the terrestrial ecology of the Arctic as the climate changes? What will be the effects on human activities such as subsistence hunting, forestry and agriculture?
- The availability of public services in remote and harsh Alaskan conditions remains severely limited. Can applied research solve the needs for telecommunications, health care delivery, education, efficient electric power, water and waste disposal that are routinely met in the other 49 states?

It is incontrovertibly clear that the Arctic is becoming more accessible by land and sea. For the first time in history, in the summer of 2002, three sailing vessels completed high latitude transits successfully; one through the Northwest Passage and two west-to-east along the Northern Sea Route (Russian Littoral). These unprecedented passages presage an open Arctic in the summer, another ocean to oversee; and another US coastline to protect. Stated directly, our nation is ill prepared for such changes. Some research and planning must be considered now to orient correctly our approach to emergent National and Homeland Security issues. Although these trends may not be exploitable for another 10 - 15 years, this is approximately the same time span required to develop and field new concepts and systems in today's world of government programs.

For these reasons this report is being distributed for the first time to the Department of Defense, Military Service Secretaries, the Department of Transportation and the Department of Homeland Security.

The continuing trends in Arctic warming, accelerating since our last *Report on Goals and Objectives for Arctic Research* published in 2001, make a compelling argument for more relevant and effective research at all levels - from basic through applied engineering. Though the Arctic is remote and complex, the fact that nine out of ten people on Earth live on the continents that border the Arctic demands that we continue our studies. The goals and objectives recommended in this report show the way toward new and needed accomplishments in Arctic research.

A handwritten signature in black ink, appearing to read "James B. McHugh". The signature is fluid and cursive, with a large loop at the beginning and a long tail at the end.

Chair

US Arctic Research Commission

MEMBERS OF THE ARCTIC RESEARCH COMMISSION

Chairman

Mr. George B. Newton, Jr.
Management Support Technology Inc.
9990 Lee Highway, Suite 300
Fairfax, VA 22030

Mrs. Mary Jane Fate
750 Farmers Loop Road
Fairbanks, AK 99712

Dr. Jacqueline M. Grebmeier
Department of Ecology and
Evolutionary Biology
University of Tennessee
Knoxville, TN 37996

Dr. John E. Hobbie
The Ecosystem Center
Marine Biological Laboratory
7 MBL Street
Woods Hole, MA 02543

Mr. Jim O. Llewellyn, Esq.
BellSouth Corporation
1155 Peachtree Street, N.E., Ste. 1800
Atlanta, GA 30309

Mr. John R. Roderick
1620 Hidden Lane
Anchorage, AK 99501

Mr. Mead Treadwell
Institute of the North
Alaska Pacific University
PO Box 101700
Anchorage, AK 99510

Ex-Officio

Dr. Rita Colwell
National Science Foundation
Arlington, VA 22230

Staff

Executive Director

Dr. Garrett W. Brass
4350 N. Fairfax Drive, Suite 630
Arlington, VA

Deputy Executive Director

Dr. Lawson Brigham
4350 N. Fairfax Drive, Suite 630
Arlington, VA

Administrative Officer

Ms. Kay Brown
4350 N. Fairfax Drive, Suite 630
Arlington, VA 22203

Alaska Office Director

Mr. Lyle D. Perrigo
707 A Street
Anchorage, AK 99501

ARCTIC RESEARCH AND POLICY ACT OF 1984 AMENDED 1990

Finding, among other facts, that "Arctic research expands knowledge which can enhance the lives of Arctic residents, increase opportunities for international cooperation, and facilitate the formulation of national policy for the Arctic," the United States Congress passed the Arctic Research and Policy Act in July 1984 (Public Law 98-373), and amended it in October 1990 (Public Law 101-609).

The main purposes of the Act are:

To establish national policy, goals and priorities to provide a federal program plan for basic and applied scientific and engineering research in the Arctic;

To establish an Arctic Research Commission to promote Arctic research and to recommend Arctic Research policy and priorities;

To establish an Interagency Arctic Research Policy Committee to develop with the Commission a national Arctic Research policy and to prepare a five-year plan to implement that policy;

To designate the National Science Foundation as the lead agency responsible for implementing Arctic Research policy.

The Act assigns specific duties to the Commission and the Interagency Committee, and specifies procedures for the development of the five-year Arctic Research Plan and its periodic revision. The Commission reports to the President and to the Congress and consists of seven voting members appointed by the US President. By law, four are from academic or research institutions, two from private industry undertaking Arctic resource development, and one from among indigenous residents of the Arctic. The Director of the National Science Foundation serves as a nonvoting *ex-officio* member.

**U.S. Arctic Research Commission
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INTRODUCTION

The United States is an Arctic nation. Since the purchase of Alaska in 1867, the United States has been bounded by the Arctic Ocean and the Bering Sea and been bordered by Arctic Russia and Arctic Canada. As a consequence of the national presence in the Arctic, we have both opportunities and responsibilities in the region. It is the purpose of this report to indicate the potential for research efforts to address Arctic and indeed global questions by studies carried out in and around the Arctic region.

RESOURCES

The Arctic region is rich in resources both in the US Arctic and in Canada and Russia. Russia, for example, has the largest continental shelf of any nation with many geological similarities to the petroleum bearing regions on Alaska's North Slope and in the western Canadian Arctic. Alaska contains the majority of US proven coal reserves. In addition to large potentials for energy exploitation in the Arctic, mineral products of great value also abound in the region. The Red Dog Mine in the Alaskan Arctic is the largest Lead-Zinc producer in the world and recent diamond discoveries in the Siberian and Canadian Shields have overtaken African producers as well. But the resource potential in the US Arctic suffers from a serious lack of exploration, identification, understanding and evaluation. These studies are essential if the nation is to take the fullest advantage of our own natural resources. Environmentally sound exploitation of these resources requires research into the potential for new and cleaner extractive processes with reduced environmental effects. This knowledge is essential for effective regulation of these resource industries.

At the same time, living and renewable resources from the Arctic affect lives throughout the nation and the world. Alaska produces more than half of the nation's table fish and Alaskan forests are major producers of timber products for both domestic use and international trade. It is essential that these resources be harvested in sustainable ways which will assure that they are available for future generations. Research in both their individual behavior and the ecosystems in which they are embedded is essential for prudent and sustainable management.

SOCIAL AND ECONOMIC ISSUES

The US Arctic is rich in natural resources. The exploitation of these resources brings value to the nation and employment and wealth to the population of the region. But these activities are new to the local residents, especially the indigenous population, and bring with them new phenomena of social and economic change. The wise stewardship of these resources requires a depth of understanding of the environments from which they are taken that can only come from careful and penetrating research. The difficulties which might be caused by inappropriate and unsustainable use of these resources can be avoided and the populations affected can be protected but only in the presence of careful study and broad application of the essential products of research. Sustainable and

environmentally sound use of fisheries, forests and mineral and energy resources can't be achieved without

GLOBAL CHANGE

At the same time that new ventures are seeking to use the natural resources of the North, changes in the environment are taking place which have major effects on the residents of the Arctic and are reflected globally. Atmospheric and oceanic processes in the Arctic are changing. Model studies suggest that climate change will be largest and earliest in the Arctic. At the same time, the residents of the Arctic live closer to and in more intimate contact with the natural environment than in any other part of the nation. Climate change is already upon us in the Arctic. Beaches are eroding and permafrost is becoming destabilized. Sea level is rising and sea ice is melting earlier and re-freezing later leaving longer periods of open water and resulting in excess erosion on beaches; beaches where most of the country's Arctic population live. Because of the retreat of sea ice along the coasts of Alaska, the indigenous subsistence whalers are facing increasing challenges to their lifestyle.

NATIONAL SECURITY

For many years, the Arctic was a place for confrontation with adversaries of the United States. With the end of the Cold War these tensions have been eased but there remain important national security concerns in the region. Our northern border is unmanned and insecure. In the past there was little attention paid to the security of this vacant and mostly wilderness border but with current concerns for homeland security the enormous coastline of Alaska (fifty percent of the entire US coastline) becomes a potential opening for unwanted intrusions into the United States. At the same time, the role of the US Arctic in missile defense strategies has recently appeared. The installations under construction in Alaska on the edges of the Arctic region require an advanced state of knowledge about the environmental conditions where they will be required to perform their sophisticated functions. The effects of permafrost, sub-arctic climate, auroral activity and many other special features of the region will play a role in the functioning of these technologically advanced defense systems.

The Arctic is changing. Changes in the world's climate are leading in turn to changes in the Arctic Ocean. These changes bear implications for the role of the US Navy in the region. The material changes in ships, aircraft and other systems require forethought as these changes have very similar time scales. A ship takes about ten years from the beginning of the design effort to operations at sea and predictions of changing conditions on ten year time scales are substantial. Planning for a new Navy response in the Arctic must be undertaken now and research efforts to improve and refine predictions of changing conditions and to characterize the environment in which the Navy will be expected to function must also be active now.

THE ARCTIC OCEAN AND THE BERING SEA

The Arctic Ocean is the least well known ocean on the planet. We know more about the topography of the planets Venus and Mars than we do about the bathymetry of the Arctic Ocean. Recent developments in Arctic Ocean research facilities have allowed us to get a first glimpse of the changes taking place in the Arctic Ocean in real time. We now know that the penetration of warmer, saltier Atlantic Ocean water into the Arctic basin through the Fram Strait between Svalbard and Greenland has accelerated in the last decade bringing in more warm water, eroding the cold halocline and threatening the stability of the sea ice. Changes farther south in the Greenland-Iceland-Norwegian Seas (the GIN Seas) are causing changes in the character of the production of cold deep water at the start of the global “conveyor belt” which drives the entire circulation of the deep ocean and the chemistry and biology of both the deep and shallow ocean around the globe. Research in the region is essential if we are to understand changes in climate and ocean circulation which affect the entire planet and all of its people.

CIVIL INFRASTRUCTURE

As climate changes and as new economic activities occur in the North, civil infrastructure in the form of airports, pipelines, roads, ports, bridges, buildings and water/waste water facilities begin to suffer from the effects of the Arctic climate and the changes taking place. The Arctic Research Commission has outlined the scope of this problem and the research efforts necessary to cope with these changes. In addition, the Commission has held hearings in Alaska which have illustrated the needs for new information which forms the basis for civil infrastructure. The Commission has encouraged the creation of new building codes appropriate for the Arctic. Similarly, new technologies, standards and practices in water and waste water, heating ventilation, energy and air conditioning and many other systems appropriate for the region are required. The Commission notes that these and other applied research topics have been neglected by federal agencies and that more efforts will be required in the future.

RUSSIA

The Russian Federation exercises dominion over a larger land mass in the Arctic than any other nation. The opportunities for cooperation and collaboration with Russia in the Arctic are extensive and hold great potential for advances in knowledge. At the same time, economic conditions in Russia have starved their research apparatus of resources to the point that serious shrinkage appears to be underway. This presents an opportunity for the US to build cooperative relationships with Russian scientists in the Arctic. Some steps have already been taken. The NSF’s RAISE Program, atmospheric monitoring programs by NSF, NOAA and EPA, and the Interior Department’s BERPAC Program are ongoing projects of great potential but the dedication of resources by the federal government to these programs is weak. Others, particularly the European Union and, especially Germany have supplanted the United States leadership in collaborative research activities in Arctic Russia.

Among the most valuable efforts needed is the rescue of data, collected by the former Soviet Union during the Cold War years. This data can provide a vital data base for many studies. For example, river flow data collected by Roshydromet can be used to estimate the frequency and severity of the annual spring floods in Russian rivers. These, in turn, are vital for understanding the probability and magnitude of re-mobilization events which can take the serious contamination of the Russian environment caused by many years of poor practices. These contaminants, if mobilized into the Russian rivers will enter the Arctic Ocean and circulate in relatively rapid fashion throughout the marine environments of all of the Arctic nations. With several billion curies of Sr⁹⁰ and Cs¹³⁷ loose in the Russian environment these are not trivial concerns.

INTERNATIONAL COOPERATION

The Arctic is an important arena of international cooperation. There have been a number of icebreaker expeditions to the vicinity of North Pole in the last decade and a half, and each has been an international expedition with at least two ships from different nations. Similarly, circumpolar cooperation in organizations such as the Arctic Council, the International Arctic Science Committee, the Arctic Ocean Studies Board, the International Union for Circumpolar Health and the International Arctic Social Science Association coordinate research activities and promote communications among the international Arctic research community. Given the necessity for collaboration in facilities and the requirement that the Arctic be studied as a complete system, international cooperation is essential and flourishing. In a similar fashion to our cooperation with Russia, however, budget support for our international cooperation are often notably less than many of our collaborators. Perhaps the most notable weakness in international cooperation is the low level of our collaboration with our Canadian neighbors.

As the Arctic Ocean becomes more accessible and researchers exploit the accessibility to better understand the ocean, the Arctic Research Commission has requested the National Imagery and Mapping Agency to construct a system to prevent mutual interference between maritime interests and the research community the Arctic Ocean. Heretofore none had existed. In early 2003 an *ad hoc* Arctic Ocean Maritime Hazards database will be unveiled and available to all nations.

RESEARCH FACILITIES

Facilities in the Arctic are crucial for research. The lack of infrastructure in the Arctic makes dedicated facilities essential. The advent of the Coast Guard's new research icebreaker HEALY has opened a new era in Arctic research by the United States. The outstanding success of the AMORE expedition to the Gakkel Ridge in the Arctic Ocean in concert with the Alfred Wegener Institute's icebreaker, POLARSTERN, demonstrated that the US is a new contributing partner in Arctic Ocean research. This capability combined with the occasional opportunities to make measurements from US Navy nuclear submarines operating under the Arctic pack ice has allowed the US to move into

the forefront of marine research. But much remains to be done. The ability to conduct systematic geophysical surveys and sea ice measurements has been notably diminished by the end of the SCICEX “dedicated” cruises. These measurements must be continued and new autonomous facilities will be required to conduct these surveys.

Arctic research facilities in Alaska are currently limited to the research station at Toolik Lake and the modest facilities at Barrow. Congressional efforts to support a new major research facility at Barrow are more than welcome, but funds not only for its construction but also for its maintenance and upkeep will be required. It will be inappropriate to expect these activities to be supported solely by user fees, as this may price the facility out of the financial reach of many potential users and will absorb hard won research funds just to keep the lights on and the floors swept.

The arrival of the Coast Guard’s HEALY does not finish the task of providing oceangoing research capacity for the region. The University of Alaska, with the blessings of the University National Oceanographic Laboratory System and the Federal Oceanographic Fleet Committee, have proposed the Alaska Regional Research Vessel, an ice strengthened replacement for the ALPHA HELIX, a ship in its thirties and fast approaching the end of its useful life. This new vessel, capable of operations in light ice, near the margins of the ice pack, is essential for the study of marine ecology, fisheries oceanography, environmental contamination, marine geology and geophysics and coastal processes in the Bering Sea and those parts of the Beaufort and Chukchi Seas with seasonal open water or light pack ice not requiring the massive capabilities of HEALY.

While physical facilities are essential, high quality analytical instrumentation is similarly crucial. Samples collected in the Arctic need to be analyzed as soon as possible and by specialists close to the environments and processes being studied. The expectation that high quality analytical facilities in distant laboratories, working on other high priority research, are adequate for these purposes is incorrect and will not contribute to the level of new knowledge necessary for research in the region. High quality analytical instrumentation close to the primary researchers is often neglected, but essential to capacity building for Arctic research.

MAJOR RESEARCH PROGRAM RECOMMENDATIONS

This edition of the Arctic Research Commission's Report on Goals and Priorities for Arctic Research focuses on five Major Interagency Projects: Climate Change, The Bering Sea, Arctic Health, Resource Evaluation and Infrastructure Research. These projects run the gamut between basic and applied research. The Arctic Research Commission believes that there must be a continuous flow of ideas and priorities between basic and applied research. The Commission has added two applied research projects (Resource Evaluation and Infrastructure) to our recommendations.

STUDIES OF THE ARCTIC REGION AND GLOBAL CHANGE

Global change, particularly climate change, is expected to have its most pronounced effects in the Arctic. A significant amount of data has already been gathered on such phenomena as the thinning of Arctic Ocean sea ice (Rothrock *et al.*, 1999) and reductions in its extent, the reduction of the thickness of the distal parts of the Greenland ice cap (Krabill *et al.*, 2000) and changes in the circulation of the Arctic Ocean (Morison *et al.*, 1998). These and other data strongly suggest that rapid and important changes are occurring in the Arctic environment. The albedo of snow-covered sea ice is the highest of any natural surface and the albedo of open sea water is the lowest. Thus, changes in sea ice cover caused by climate change have a dynamic and profound effect on the energy balance of the region.

Reductions in sea ice cover will affect the productivity and probably the community structure of the marine flora and fauna of the Arctic seas reaching up to the highest trophic levels such as birds, seals, sea lions, walrus, whales and polar bears.

Model studies indicate that temperature changes induced by increases in atmospheric carbon dioxide will be several times greater in the Arctic than elsewhere on the planet. Such changes will modify the hydrologic regime of the Arctic including changes in precipitation, river runoff, permafrost and the mass balance of glaciers. The impacts on Arctic soils and their plant and animal communities may be profound. Studies already underway indicate an increase in the rate of carbon release to the atmosphere in the form of methane and carbon dioxide, two gases with major impacts on the radiative balance of the atmosphere. If the Arctic has a positive feedback on climate warming, the results will be to amplify warming everywhere on the planet.

The earth is a fragile planet and, because it is our home, we may not conduct experiments on it which might have serious consequences for its habitability. Our only approach to understanding the complex phenomena of climate change is to learn as much as we can about the processes causing and responding to these changes, to apply our growing computational capabilities to model studies, and especially to study diligently the record of climate change in the past. Recent insights derived from the study of the climate record in the Greenland ice cap have shown that our previous ideas of slow steady change at the end of the last ice age were wrong and that climate change can occur in

rapid transitions from one climate state to another. Other studies of fossil climate records in lake sediments have been used to test the predictions of numerical models for climate during the most recent ice age and have shown them to require further refinement. Without the ability to experiment on the planetary systems which sustain us, we must rely on the record of the experiments that nature has conducted in the past to test and refine our understanding and our ability to predict the future. The cause of these phenomena and the question of their relationship to potential permanent changes in the climate of the Arctic region is of vital importance both to residents of the Arctic and as early indicators of change for the rest of the planet.

But, it is also clear that environmental change is always with us. There are few recent changes in climate that compare with the difference between summer and winter regimes in the Arctic. Because of these stupendous changes in temperature, precipitation, wind, light and other annually varying environmental properties subtle changes on longer time scales are not easy to detect. Processes such as the North Atlantic Oscillation which appear to have episodic time scales of the order of a decade have been causing climate changes for many centuries. Other changes with similar time scales indicate that the circulation patterns in the surface waters of the Arctic Ocean change regimes on similar time scales. It is essential that we understand the current changes in the Arctic environment and that we seek to separate those which represent oscillations about a stable state from those which indicate that the Arctic may be undergoing significant, long-term changes in its climate regime. To do so requires a broad based attack on the question which seeks to understand the particular mechanisms of environmental change. The Arctic is an apt place for this study as changes in environment are magnified by the extremes of the natural cycle. The common observable boundaries in the Arctic (such as the edge of the polar ice pack, the marginal permafrost zone and the tree line) are particularly sensitive to these changes. The movements of these boundaries are not only sensitive indicators of environmental change but also have major effects of the lives of Arctic residents, particularly on native people endeavoring to continue their subsistence lifestyle in the face of major cultural and material stresses.

Environmental change has important consequences for human activity in the Arctic. As climate changes the means by which life goes on in the Arctic will also change. In particular, the physical infrastructure will sense these changes. Roads, bridges, buildings and other aspects of civil infrastructure will react to changes in the environment. These changes will affect human activities in many ways including local energy consumption, housing design and construction, transportation, water and waste water management and subsistence activities. These in turn will lead to changes in the social milieu which depends on interactions between people living in the Arctic and on the stresses imposed on their lives by the Arctic environment.

At its meeting in March, 2000 the Interagency Arctic Research Policy Committee (IARPC) agreed to organize an interagency program of research on the Study of Environmental Arctic Rapid Change (SEARCH). The emphasis of the SEARCH project is on those changes occurring rapidly enough to be evident today in climate and

oceanographic data -- changes which are affecting Arctic ecosystems and the modes of living of Arctic residents now.

The SEARCH program has drawn on many agencies and on a broad spectrum of Arctic researchers in constructing its program. Early efforts for Fiscal Year 2001 have begun using budget requests submitted during calendar year 2000. These activities have, of necessity, significant gaps in the program which could not be addressed using established funding levels. The Commission expects that subsequent years will lead to a unified approach and that the Office of Management and Budget will consider the SEARCH program in a unified manner recognizing the interdependence of the research programs of each of the agencies. Similarly, the Congress must consider budget requests for the SEARCH program in the light of the effects of budget decisions for each of the agencies individually on the efforts of the program as a whole. While we expect this will be difficult, we believe that an integrated rather than a piecemeal approach is essential for success.

The Arctic Research Commission strongly supports the Interagency SEARCH program and encourages it to grow into a fully developed program with a common research agenda and an integrated budget approach.

Included within the SEARCH program is the US effort in the Arctic Climate Impact Assessment (ACIA), a study sponsored jointly by the International Arctic Science Committee and the Arctic Council. This study will attempt to collate the current state of knowledge about the climate of the Arctic and its changes and use this knowledge to predict the impacts of climate change in and beyond the Arctic region. In particular, ACIA will illuminate the environmental challenges to be faced by Arctic residents and the time scale and severity of the impacts of climate change on individuals and communities. ACIA will serve to alert policy makers to the magnitude of the changes occurring now and in the future and to encourage early action to prevent, ameliorate or accommodate to these changes. In addition, ACIA will produce a "road map" of the gaps in our knowledge about Arctic climate and guide the future of climate change research in the region.

The Arctic Research Commission supports the Arctic Climate Impact Assessment and urges its swift completion in order to support policy decision on accommodating climate change effects in the Arctic region.

STUDIES OF THE BERING SEA REGION

In 1998 Alaska led all states in the amount of fish and shellfish landed with 4.9 billion pounds. Louisiana with 1.1 billion pounds was its nearest competitor. Alaska also led all states in the value of landings with \$951.2 million followed again by Louisiana at \$291.9 million. Much of Alaska's fish come from the Bering Sea. Dutch Harbor-Unalaska is the leading US port in terms of value landed. In addition to its commercial value, the Bering Sea is home to an array of animal life including sea birds, whales, walrus, seals and sea lions unprecedented in the rest of the nation. The inhabitants of the Bering Sea region include Inuit, Aleut and Yupik people who have lived by and from the Bering Sea for many ages.

The health of the Bering Sea ecosystem is of vital importance to the United States, to the State of Alaska and to the residents of the region. Changes in the ecology of the Bering Sea have major impacts not only on fisheries but on the everyday lives of thousands of people who rely on it for their sustenance. Human activity has had its impact in the region but it is not the sole, nor perhaps the most important cause of many of these changes. Changes in climate, in ocean circulation, in weather patterns and the behavior of sea ice in fall and spring are all major actors on the Bering Sea stage. The Arctic Research Commission is concerned that our knowledge of the Bering Sea is not sufficient to support the important decisions which must be made for the safe and effective management of the resources of the region.

In 1996, the Polar Research Board of the National Research Council published a study of the Bering Sea Ecosystem (NRC, 1996). This study noted the complex interaction of the various parts of the Bering Sea ecosystem and the potential for unexpected effects in the structure of the biological community resulting from human actions as well as the unknown connections between these and natural environmental change. Their recommendations for research were:

- C Adopt a broader ecosystem perspective for both scientific research and management of Bering Sea resources.
- C Adopt an adaptive or experimental approach to management actions concerning the Bering Sea ecosystem.
- C Conduct research on the structure of the Bering Sea ecosystem, including the nature and causes of the dynamics of pollock populations in the northeastern Pacific and Bering Sea over the past 50 years.
- C Conduct research on how well the management and institutions of the Bering Sea are structured to address problems and provide appropriate management solutions.

Under the heading of "Management and Institutional Recommendations" the report recommended:

- C Develop a research program to increase understanding of the Bering Sea ecosystem (keeping international issues and cooperation in mind), to fulfill the research needs identified by the committee to help future policy makers solve both short-term management and longer-term ecological problems.

While these recommendations constitute an important guide for action, they fail to make specific recommendations for agencies and organizations. They do not indicate in these direct recommendations which agencies or institutions should carry them out.

In the 1997 version of the US Arctic Research Plan, a new initiative was introduced entitled, “Beringian Systems Studies” (USARP-97, p. 11-18). This initiative was directed toward the following Goals and Objectives:

- C Assess the magnitude of changes in the Beringian system as a consequence of global change;
- C Assess and predict the consequences of these changes on the physical, biological and socioeconomic systems in the region and determine the cumulative impacts of these changes on the region including assessment of past impacts;
- C Promote studies addressing the modern socioeconomic conditions of Beringia’s rural residents and in particular problems of environmental quality, education and human health;
- C Increase baseline documentation and synthesis on Beringian paleoenvironments and landscape history and distributions of marine and terrestrial flora and fauna for use in global change modeling;
- C Develop baseline documentation of cultural, biological and linguistic variation in historical and modern times, and inventory and assess the status of these resources;
- C Develop integrated syntheses of human-environmental interactions with regional and global perspectives;
- C Establish baseline documentation on contaminants and their pathways in Beringian food chains and their environmental, health and economic impacts;
- C Develop modeling capabilities and relate the results of regional Beringian studies to larger global patterns of climatic and environmental change; and
- C Develop coordination and infrastructure by enhancing regional research centers, by promoting the spread of scientific knowledge and by encouraging cooperative and international research and education programs that include representation of northern residents and communities.

While these recommendations are applauded by the Commission, we see substantial gaps in this current state of affairs with regard to Bering Sea studies. The Commission met in Anchorage in December 1999 and conducted a forum on Bering Sea research with participation from many of the principal participants (see ARC Annual Report for CY 1999). Two lessons were drawn from this and other activities of the Commission. First, there appeared to be a notable lack of integration in the approaches of the various programs. This was particularly notable in the lack of integration between basic

oceanographic data collection and analysis and studies of population effects at higher trophic levels such as marine mammals, birds and fish. Indeed there seemed to be little connection between the efforts of researchers studying particular populations and the work of others on other populations. This lack of integration has been likened to the parable of the blind men describing the elephant. Each project appeared to see the Bering Sea system from its own limited perspective but did not adequately integrate the observations of others into a complete picture.

The second lesson drawn from our examination of Bering Sea research was the absence of emphasis on the ability to predict changes in the Bering Sea system, particularly in the population dynamics of the higher trophic levels. The analysis of data appeared to be almost entirely *post hoc*. Management decisions were based on records of past behavior in the system but the ability of the system to see ahead, to produce scenarios reflecting changes and to act to preempt negative effects before they occurred and to avoid crisis management, were not in evidence. Scientists are always reluctant to engage in prediction. There are many pitfalls in predicting natural systems not the least of which is the high potential costs of incorrect predictions. Nevertheless, careful and concise predictions with carefully stated confidence limits are essential for the effective management of our interaction with the Bering Sea ecosystem. In order to build predictive capacity two approaches are useful. The first is to conduct predictions testable by historical data, *i.e.*, use the data from the past to predict more recent years and compare the predictions to the actual data. This approach allows continual refinement of the predictive system and can indicate the limits of reliability of predictions of the future. The second approach is to study intensively the processes linking the various phenomena occurring in the system. This approach requires abundant detailed study and provides guidance to modeling and predicting the behavior of the system by characterizing the essential links in need of further study. The use of these two approaches in tandem, empirical modeling guiding detailed study and detailed study improving the empirical models by emphasizing the data most useful for predictions is the most effective means for predicting complex systems. While such systems are common in various aspects of science, they appear to have been avoided by the programs studying the Bering Sea. They need to be applied, improved and implemented.

All in all, there appears to be no comprehensive plan for the study of the Bering Sea. One of the reasons for this lack is the absence of a vision of what a comprehensive plan should contain. It would be extremely helpful if a description of an integrated study of the Bering Sea could be produced which indicated the essential elements and their connections to the improvement of the ability to predict changes in the system, particularly at the most sensitive parts of the system such as endangered or threatened and economically important species.

The Arctic Research Commission has recommended that a study be conducted by the National Research Council's Polar Research Board and Ocean Studies Board to recommend an integrated research plan for the Bering Sea system. The North Pacific Research Board (NPRB) has commissioned the NRC to conduct a study along these lines of their entire region of responsibility in the North Pacific Ocean, Bering Sea and Arctic

Ocean and adjacent seas. The Arctic Research Commission applauds the action of the NPRB in undertaking this very important study and looks forward to using the results of the study as a basis for its recommendations in the Commission's next Report on Goals and Objectives.

The planning and construction of the SEARCH program discussed above has built a model for interagency cooperation in the study of important Arctic research questions. The Arctic Research Commission believes that the study of the Bering Sea requires an equivalent interagency program, based on the results of the NRC study recommended above, which can produce predictions of the important changes in the Bering Sea based upon an integrated application of the research tools of all the relevant agencies acting in concert. While the study of change in the Bering Sea is currently an element of the SEARCH program, the Commission believes that the importance of the Bering Sea system to the resident populations, to other users of Bering Sea resources and to the nation's economy justifies a stand-alone interagency program which can command the attention of all contributing agencies and lead to assurances that critical parts of the study do not fail for lack of visibility during the budget process.

IARPC has organized an interagency program for the study of the Bering Sea and some research planning has already begun. While the elements of a study of the physical and ecological relationships in the region are relatively straightforward, the values needed to make management decisions are much more difficult and include substantial incompatibilities in the goals and aspirations of the many stakeholders involved. The Environmental Protection Agency has begun efforts to assess stakeholders needs. The Commission expects that this survey and evaluation of needs will become an essential component of decision making by both regulators and users of the regions resources.

The Commission applauds and encourages the IARPC planning activity and, in particular, the EPA stakeholder assessment.

In order to fully understand the Bering Sea, studies must be carried out on the western side of the basin which will require the active participation of Russian scientists. Such a program exists in the Department of the Interior. This program, known as BERPAC, has conducted sporadic cruises in recent years in various parts of the Bering and Chukchi Seas with Russian collaborators often using Russian research vessels. This program offers an outstanding opportunity for increasing our understanding of the Western Bering Sea.

The Arctic Research Commission recommends an immediate expansion of the BERPAC program to include annual research cruises and appropriate support for related research both within the Department of Interior and by extramural funding paths.

Of all the Bering Sea fish species, the several pacific salmon species hold a unique position as they are collectively unrivaled both for their commercial value and as a subsistence resource to US Arctic coastal and upriver communities. The Bristol Bay

salmon fishery is the largest salmon fishery in US waters. Dramatic fluctuations in salmon returns are poorly understood, yet affect the lives of all residents of western and interior Alaska. These fluctuations and the classification of some populations as “stocks of concern” have raised awareness of the complexities of the management of an anadromous fish stock where populations may be mixed together in some regions, but separated and subjected to different conditions at other parts of their life cycle. Preliminary results indicate that the identification of particular stocks within mixed populations may be possible using mitochondrial DNA analysis. This technique should be studied and, if effective, rapidly developed for the identification of fish from over-harvested stocks for more effective management and restoration.

The Commission recommends an accelerated program of research on problems in the Bering Sea region with an emphasis on the distribution of Pacific Salmon.

HEALTH OF ARCTIC RESIDENTS

The United States assumed the Chair of the Arctic Council at the conclusion of its first ministerial meeting in the fall of 1998 and passed it on in the fall of 2000. During this era of US leadership, substantial progress has been made in bringing the results of US research in the Arctic to bear on important problems identified by the Arctic Council. The Arctic Monitoring and Assessment Program (AMAP) continues its work on environmental health concerns in the Arctic.

The questions surrounding environmental health effects in the Arctic are many and varied. Potential sources of effects on human health include radionuclides, heavy metals and Persistent Organic Pollutants. Residents of the Arctic are concerned that contaminants are transported to the region from industrial sources in developed and developing nations farther south and that they are entering the food chain causing effects on both wildlife and humans, especially on those engaged in subsistence hunting and fishing. Research is needed to identify the abundances of these contaminants throughout the environment and in humans, especially the young. Arctic residents need guidance on coping with these problems and it is the responsibility of the research community to supply them with the information they need to live safe and healthy lives. Substantial research progress is being made through programs such as NOAA’s Arctic Initiative, research on PCBs and mercury by the EPA and NSF’s new Contaminants Program, but much remains to be accomplished.

While environmental health concerns play an important role in AMAP deliberations, they do not (at least not yet) constitute the major causes of morbidity and mortality in the US Arctic. Infectious diseases, chronic diseases such as diabetes, cancer, heart attack and stroke as well as behavioral problems such as alcoholism, drug use and suicide are the most frequent causes of ill health and death in Arctic populations. These must also be studied with an eye toward relieving the Arctic population of as much of this sad burden as possible. Such a program falls predominantly within the purview of the National Institutes of Health and the Indian Health Service. Collaboration with health officials in the State of Alaska is essential as is coordination with local organizations and native

groups. The Arctic Council will also focus on sustainable development in the Arctic, a focus which will include studies of health concerns in the North.

The health of Arctic residents depends on many factors. It is clear that life in the Arctic, particularly in small communities, is affected by the complexities of the provision of the essential infrastructures of community life. The Arctic environment requires an approach to housing, water, waste-water, energy and transportation systems far more difficult than those of temperate regions. This country can put a man on the moon but, as yet, cannot find a cost effective way to dispose of human waste in a cold, remote environment. While the State of Alaska has made substantial progress in improving sanitation in the villages, these problems must be addressed by the application of the best technologies and practices available.

At the same time, the relative obscurity of these problems in the larger context of US engineering research must be overcome. Partners are available and willing to attack these problems. The Commission has opened discussions with the American Society of Civil Engineers on how they can assist in developing new initiatives in Arctic infrastructure. The Denali Commission was established in 1998 to attack the problems of rural infrastructure in Alaska. The Arctic Council's Program on Sustainable Development is considering a new program on Arctic Infrastructure. These initiatives should be used to bring the considerable talents and abilities of the US engineering community to bear on those systems directly affecting health in the Arctic.

At the IARPC Staff Retreat in May, 2000, it was agreed that IARPC would consider the planning of an interagency program of studies on Arctic health. Lead agencies would be somewhat different from those most involved in the SEARCH and Bering Sea programs. The National Institutes of Health, the Centers for Disease Control, the Public Health Service, and the Indian Health Service will be the most prominent participants with applied engineering research and environmental measurements programs in other agencies contributing as noted above.

The Arctic Research Commission recommends that IARPC commence planning for a third focused, interagency program to coordinate and emphasize research on health concerns in the Arctic.

The Arctic Research Commission takes special note that the National Institute of Occupational Safety and Health has established a research unit in Anchorage, Alaska to examine occupational injuries. Substantial progress has resulted from this program especially in reducing injuries and fatalities in such dangerous occupations as fishing and helicopter lumbering. This unsung program has already saved many lives and stands to realize further advances in safety and protection of workers in the most dangerous occupations.

The Commission supports the continuation and expansion of the NIOSH program for reduction of injury and death in Alaska's important industries.

RESEARCH ON RESOURCE EVALUATION

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 (- 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.

RESEARCH ON CIVIL INFRASTRUCTURE

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 US 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 US 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

US Arctic region at high precision (1m x 1m x 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 US Arctic

OTHER RESEARCH PRIORITIES

APPLIED RESEARCH IN FISHERIES

The exploitation of the resources of the Bering Sea region are conducted in a rigorous climatic regime under difficult and often dangerous conditions. The technologies employed in these activities are in need of research to improve the success of resource extraction activities, to reduce the environmental impacts of these activities and to provide for the safety and welfare of workers and residents in the region. Research on effective fishing techniques, on the development of new products, on the improvement of current products, on the use of harvesting byproducts and the reduction of effluents are all vital to sustaining the fishing industry in the Bering Sea region. As the Arctic region becomes more accessible, research on the development of ports, factories, navigation and Search and Rescue facilities are similarly needed with an additional emphasis on the impacts of all of these activities on socio-economic activities in the region.

The Commission recommends an accelerated program of applied research on problems in the Bering Sea region with an emphasis on the fishing industry.

NATURAL RESOURCES

The US Arctic is a vital source of renewable and non-renewable resources. Over 66% of the land in the State of Alaska is managed by federal agencies. The extraction of these resources requires high levels of technological innovation. At the same time, the environmentally sound use of these resources require industry to limit the environmental damage cause by resource utilization on to be prepared for the restoration of site after their resources have been exhausted.

Federal agencies play an important role in identifying options and promoting the development of innovative technologies for resource exploration; extraction of oil, gas, and minerals; long distance energy transmission; fisheries; and marine transportation, usually as regulators and sometimes as owners of the resources in question. An integrated approach to the study of all those issues involving Arctic resources is required.

The Commission's highest priority is to develop an oil spill prevention and response capability, including innovative containment and cleanup operations in ice-infested waters and on permafrost terrain. Three types of research are needed: a) applied work to perfect *in situ* burning techniques in ice covered seas, b) more basic and applied research to identify and develop alternatives to combustion on land, and c) policy analysis and associated information transfer activities related to the testing and acceptance of new pollution abatement processes.

The development of oil resources in the Arctic, particularly the US and Canadian Arctic, are proceeding currently. Offshore drilling and production activities have occurred in both US and Canadian offshore waters. In addition, the possibilities for marine transport

of Arctic oil are growing. The Commission has been informed of Canadian interest in shipping oil from their Arctic region by sea from the MacKenzie delta region to ports in the Pacific.

The Arctic Research Commission has been briefed on the special research needs for the response to oil spills in ice covered waters. In particular, the Commission has consulted with Alaska Clean Seas and Environment Canada on their research efforts and the gaps in our knowledge of oil in sea ice. Alaska Clean Seas has, for example, reported that there is no vessel capable of an adequate response to an oil spill in ice covered waters in the US Arctic. The only ships capable of responding to such an event are US Coast Guard icebreakers *Healy*, *Polar Sea* and *Polar Star* and these ships are generally either operating in the Antarctic or stationed in Seattle, unless by chance, performing specific tasks in the Arctic. Alaska Clean Seas also indicated that it was likely that burning was the method of choice for the disposal of oil in ice. They also stated that the use of emulsion breaking chemicals was generally prohibited as they are considered flammable. Since this restriction is in conflict with their use (to promote burning) there appears to be a need to revise this prohibition. In April of 2000 an International Oil and Ice Symposium was held in Anchorage and Prudhoe Bay, Alaska. The Commission expects to publish the proceedings of this workshop as a special report containing an agenda for research on oil in ice. The Commission recommended a comprehensive attack by agencies participating in the interagency oil spill response program on these problems in its 1997 and 1999 Reports, but NO ACTION has been forthcoming.

The Arctic Research Commission recommends that Federal agencies immediately commence a comprehensive program of research on oil in ice and suggests that the Oil Spill Research Institute (OSRI) be designated to take the lead in organizing this program.

RESEARCH ON VALUE ADDED PRODUCTS

The development of value added products derived from the extraction of both petroleum and non-petroleum resources also requires an accelerated research approach. We have already discussed applied research in fisheries. Similar advances are needed in such other industries as timber and mineral use. New and improved products, produced in the North not only increase the value of the resource but also retain more of the economic benefits of the resource industries in the region where new economic activity is vitally needed.

The Arctic Research Commission recommends an expansion of the research base for the development of value-added products and recommends that the Alaska Science and Technology Foundation focus on this particularly important and valuable need.

RESEARCH ON TECHNOLOGIES FOR REMOTE COMMUNITIES

The technologies developed to cope with the problems of living in the Arctic are often valuable for other communities with a similar distribution of rural residents. The use of such technologies as distance education and telemedicine are not by any means restricted to the Arctic nor are water, waste-water and energy technologies developed for small, remote communities. Rural regions throughout the rest of the world can profitably employ these techniques and developers may find much broader markets for these products than expected from a purely Arctic perspective. In order to achieve expanded developments, research must continue to supply the new technologies for continued growth.

RESEARCH ON COMMUNICATIONS TECHNOLOGIES AND THEIR APPLICATIONS

The Arctic includes some of the most remote settlements in the modern world. Communication technology provides the potential to bring the delivery of services to these remote settlements. In particular, distance education and telemedicine are valuable providers of services to remote settlements that can not otherwise be supported. Distance education can bring the educational resources of the world to the most distant villages. Telemedicine has the potential to provide expert medical care to patients who are unable to go to a medical facility to consult with a physician and can support local medical personnel by supplementing and supporting their efforts in medical care. The Commission is pleased to see the expanded efforts in these two vital fields which are currently underway and notes that these technologies are not only valuable in the Arctic but represent a potential economic base for Alaskans in providing technology for remote settlements all over the world..

The Arctic Research Commission supports the current efforts in distance education and telemedicine and supports further efforts to improve the provision of these services.

EDUCATION

The Commission's priorities for education can be divided into three parts: (1) General scientific and technological literacy; (2) Education of professional researchers; and (3) Education of Arctic residents, particularly native peoples, about scientific advances in understanding the Arctic. The Arctic Research Commission lacks a direct mandate for action in general education, but notes the role of the NSF Directorate for Education and Human Resources in this vital task. The Commission also notes the commendable efforts of the Arctic Research Consortium of the United States (ARCUS) in education.

GENERAL SCIENTIFIC AND TECHNOLOGICAL LITERACY

Better education of the citizenry, particularly in science and technology, is a continuing national priority. In this modern, technologically complex world the education of the nation is essential if democracy is going to cope with the increasingly technical nature of public debate on such matters as environmental protection, ozone depletion, nuclear waste disposal and many more. The Arctic is a particularly important topic for educational activities as it is considered by many to be both remote and exotic. For example, a very large proportion of the population is unaware that an ocean exists at the top of the world. The relationship of events and processes in the Arctic to the well being of the entire nation is very poorly or not at all understood.

The Commission supports efforts by Arctic researchers to make their results available to interested citizens.

The Commission is pleased to take note of the Teachers Experiencing the Arctic (TEA) program at the National Science Foundation. This program takes teachers to the Arctic for research experiences during their summer recess. The result is that teachers gain a new understanding of the modes of research, the importance of the Arctic, and an excitement which can only result from actually participating in the research endeavor. This enthusiasm is then transmitted to all the student influenced by these teachers over the ensuing years with the result that research in the Arctic is understood and appreciated by a growing number of citizens.

The Commission approves of the NSF-TEA program and urges its continuation and expansion.

EDUCATION OF PROFESSIONAL RESEARCHERS

In the past the Commission has noted the slow growth in the number of young scientists and engineers with Arctic expertise in our nation. In recent years the rapid growth in the Arctic research account at the National Science Foundation has afforded many new opportunities for graduate education in the Arctic as have more recent developments at NOAA.

The Commission is pleased that the cadre of new Arctic researchers currently in training is growing and encourages the NSF and NOAA to continue the good work they are accomplishing.

EDUCATION OF AND BY ARCTIC RESIDENTS

The US Arctic, in the State of Alaska, is characterized by small, remote communities. The provision of adequate educational opportunities is difficult and the financial base for the support of education is usually small, and smallest in the most remote communities. The support of education in these communities is a serious problem. The National Science Foundation is providing support for rural education in Alaska through its Rural Systemic Initiative. This effort combined with advances in the technology of distance education have the potential for dramatic improvements in the provision of education and hence the potential for economic improvements in Alaska's rural communities and the upward mobility of their youth.

The Commission supports the NSF's Rural Systemic Initiative in Alaska.

The education of Arctic residents, particularly native people, about scientific advances in understanding the Arctic is vital to the continued success of Arctic research. Citizens of the Arctic, particularly the native people, experience the research endeavor more directly than most. Indeed, they are often subjects of the research effort and, if not, their fragile support systems for food, water, shelter, health, energy and transportation are often the subject of study. It is incumbent upon Arctic researchers to return to these communities in order to inform and involve the Arctic citizenry in the mutual benefits of our increasing knowledge.

At the same time it is essential that the scientific community absorb the vital and hard-won knowledge that only many years and even generations of residence in the Arctic can produce. The absorption of traditional knowledge into the scientific endeavor serves to sharpen the focus of the research effort and to bring into the research system the observations and experience of the native community.

RESEARCH INFRASTRUCTURE

Arctic research responsive to national needs requires responsible management and adequate support services. Because of the extremely high cost of support systems in the Arctic environment, coordination of logistic services and cooperation in their use are essential in achieving maximum cost effectiveness.

LOGISTIC SUPPORT

In order to form a consensus on the logistic needs of the research community, the Commission, with additional financial support from the National Science Foundation, engaged the Arctic Research Consortium of the United States (ARCUS) to consult with the community of Arctic researchers and construct a report indicating the scientific needs and the logistics systems and facilities needed to support these science needs now and in the future. This report entitled *Logistics Recommendations for an Improved U.S. Arctic Research Capability* (Schlosser *et al.*, 1998) was published in 1998. As part of an ongoing review of Arctic logistics needs, ARCUS is now engaged in updating this report. The Commission looks forward to the revised Logistics Report. There are many recommendations for logistics improvements in the 1998 report with varying degrees of urgency in their implementation. All agencies should consider these recommendations and collaborate in supporting logistics improvements for Arctic Research.

The Commission is pleased to note the continuing efforts by the National Science Foundation to upgrade and improve research facilities in the Arctic. Their collaboration with the Barrow Arctic Science Consortium in improving facilities and services at Barrow and the establishment of the Barrow Environmental Observatory are laudable efforts which the Commission hopes will continue to grow and prosper. The conclusion of a cooperative agreement with the University of Alaska for support and expansion of the research facilities at Toolik Lake is similarly a positive step in the support of the basic infrastructure of research in the region. The establishment of a year-round research facility at the summit of the Greenland ice cap in the facilities constructed for the Greenland Ice Sampling Program is especially noteworthy. This is the first US Arctic facility which approaches the level of difficulty readily assumed for Antarctic research. Winter access is difficult to impossible and the environment is extreme. The Commission commends the National Science Foundation for their efforts in establishing Summit as a permanent research facility. It is, however, notable that the National Science Foundation is called upon to shoulder the entire burden of these facilities without financial aid or participation from other agencies of the Federal Government.

The Commission has encouraged cooperative use of US military logistic capabilities to support civilian research in the Arctic. Following the successful Arctic science cruise of the Navy's nuclear submarine USS *Pargo* in the summer of 1993 the National Science Foundation, the US Geological Survey, the National Oceanic and Atmospheric Administration, the Office of Naval Research, the Director, Submarine Warfare Division in the Office of the Chief of Naval Operations, and the Commanders of the Atlantic and

Pacific Submarine Forces signed an historic, multi-agency Memorandum of Agreement (MOA) for continuing use of submarines of opportunity for scientific studies of the Arctic Ocean.

The Program resulting from this initial demonstration cruise and the MOA was called the Science Ice Exercise (SCICEX) Program and resulted in valuable extended research cruises in 1995, '96, '97, '98 and '99. Unfortunately, changes in the number and configuration of the US Navy's submarine fleet have ended the opportunity for annual "dedicated" cruises with civilian scientists aboard Navy nuclear submarines in the Arctic.

The Arctic Research Commission has initiated the study of new ways to approach the Arctic Ocean with the capabilities which can replace those lost with the end of the "dedicated" cruises. Other cruise opportunities referred to by the Navy and the research community as "opportunity" and "accommodation" cruises may, from time to time, become available on US submarines (For details see *Arctic Science from Submarines - A Report Based on the SCICEX 2000 Workshop*, Rothrock *et al.*, 1999). The Commission has opened discussions with the Royal Navy on the use of their nuclear submarines and has begun exploring the availability and capabilities of Swedish and German submarine with "Air Independent Power" systems which carry both fuel and oxidizer for extended operations while submerged. With the advent of *Healy* requirements for deep sampling and surfaced operations from a submerged platform have subsided. It became clear in the latter days of the SCICEX dedicated cruises that submerged operations were the most appropriate use of the submarine's capabilities. This has led to discussions of the capabilities of unmanned or autonomous vehicles for survey research in the Arctic. Discussions continue on all of these fronts as well as continuing discussions with the Navy about the possibilities for another "dedicated" cruise to the Arctic.

The NSF is now supporting an Internet site for logistics information called the Arctic Logistics Information Access Service (ALIAS, <http://www.nsf.gov/od/opp/arctic/logistic/start.htm/>). This web site is expanding rapidly and is becoming an important reference for researchers seeking Arctic logistics information.

The NSF's Arctic Science Section has made great strides in coordination with the US Coast Guard on the utilization of Coast Guard icebreakers and the design and construction of science facilities aboard *Healy*, the Coast Guard's new icebreaking research vessel. NSF and the Coast Guard has engaged the University National Oceanographic Laboratory System (UNOLS) to operate the Arctic Icebreaker Coordinating Committee (AICC) to build a communications and cooperation bridge between the US academic oceanography community and the Coast Guard's design, construction and operating teams. Now that *Healy's* rugged capabilities have been demonstrated, the AICC continues to oversee execution of and improvements in research operations and forms focal point for expeditionary planning.

The Arctic Research Commission is pleased that the National Science Foundation is commencing regular support for research aboard *Healy* in the coming year. Other Federal Agencies including NOAA, MMS, FWS and others have research needs

which require icebreaking research vessels such as ecosystem research in the Bering Sea in winter. The Commission recommends that these agencies become involved in Healy scheduling and operations through the AICC.

ALASKA REGIONAL RESEARCH VESSEL

The Alaska Region Research Vessel (ARRV) has been approved by the University National Oceanographic Laboratory System and leads the list of new vessels recommended for procurement in the report on the UNOLS research vessel fleet by the Federal Oceanographic Fleet Committee. The design studies and model tests conducted by the University of Alaska and the Woods Hole Oceanographic Institution with support from the National Science Foundation indicate that this ship will be an extremely vital and more capable replacement for *Alpha Helix*, the University of Alaska's current research vessel which is over thirty years old.

The Commission recommends that the National Science Foundation fund the final design and construction of the Alaska Regional Research Vessel at the earliest opportunity.

ENGINEERING RESEARCH

The Commission has not made any special recommendations for logistics support for engineering research. Nevertheless, these needs are present and are not necessarily appropriate for the logistics facilities available for basic research. Studies on such topics as road and airstrip construction, housing technology, corrosion under Arctic conditions, construction techniques in cold climates, coating technology and permafrost engineering require special facilities which were not addressed in the Commission's previous report. As ARCUS prepares the revision and update of this report, the Commission recommends that they seek input from the engineering research community

DATA AND INFORMATION

In 1997 the Commission identified and negotiated the declassification of Arctic bathymetry data collected by US Navy submarines between the inception of nuclear submarine operations in the Arctic and 1988. This data was released for public use in early 1998 and formed the basis for a revised and much improved bathymetric chart of the Arctic Ocean, the first such chart based on a comprehensive data set. The Commission is pleased that these data are now accessible to the research community and believes that, along with unclassified data gathered by the SCICEX program, this will permit new insights into many branches of marine and earth science in the Arctic.

The Commission supports the continued declassification of bathymetric, ice and other oceanographic data collected in the Arctic Ocean as appropriate.

INTERNATIONAL COORDINATION

International cooperation is an integral component of many scientific endeavors in the Arctic, linked to, and often inseparable from, the normal process of research planning and execution. The Commission is charged with advising the President and Congress on Arctic Research policy and priorities, and with recommending the means for developing international scientific cooperation. Scientific cooperation among the circumpolar nations, as well as among other countries with scientific activities in northern latitudes, is accelerating. Quite generally, the increasing number of international bilateral and multilateral agreements for Arctic research (now about 450) signals the rising importance and breadth of both governmental and non-governmental international collaboration.

The Government of Japan has developed an interest in the Arctic region which has led them to a cooperative project with the University of Alaska entitled the International Arctic Research Center (IARC). The first part of this collaboration has been the construction of a very substantial new building on the University of Alaska Fairbanks campus. In Fiscal Year 1999 the IARC received new funding from the United States government in the amount of \$5 million which is expected to continue for several more years. In the summer of calendar year 2000 a cooperative agreement was signed between NSF and IARC for support of the Center using these funds. IARC is now fully established, supported and operating. It will proceed to make notable advances in Arctic research.

The US and Denmark have had a long and successful logistical cooperation in support of research in Greenland. The support of ski equipped C-130 Hercules aircraft of the New York Air National Guard has been a mainstay of research in Greenland. The National Science Foundation has recently negotiated a new research agreement with Greenland/Denmark for continuing research activities in Greenland. In September 1998, the International Arctic Science Committee (IASC) held an informal meeting of “Arctic Operators” in Tromsø, Norway. At this meeting, logistics providers in the Arctic formed the Forum of Arctic Research Operators (FARO) to work on the means for sharing information on logistics opportunities in the Arctic. FARO has since met in Tromsø in 1999, in Cambridge, UK in 2000, in Iqaluit, Nunavut, Canada in 2001 and in Groningen, the Netherlands in 2002. The Executive Director of the Commission is one of the US representatives to FARO.

The Arctic Research Commission has been engaged in a discussion of logistics opportunities with the Canadian government through an annual meeting between the Commission and the Canadian Polar Continental Shelf Project. These meetings are the result of a framework agreement between Canadian Prime Minister Chretien and US President Clinton. The first of these meetings was held in April in Cambridge, UK followed by meetings in Iqaluit, Nunavut, Canada in 2001 and Groningen, the Netherlands in 2002. Opportunities for collaborative research using Canadian facilities presents a timely and cost effective means to expand both the efforts of US researchers in the Arctic and their Canadian colleagues.

Research in collaboration with our Russian colleagues is growing and the Commission encourages this process. Difficulties in conducting Arctic research in collaboration with colleagues at major institutions in European Russia are surmountable by diligent efforts on both sides. Obstacles to research in the Russian Far Eastern Region are, however, much larger. The Commission has received a considerable amount of information on these difficulties and considers them a serious threat to research collaboration which is, in fact, in the interests of both nations. Communications with political entities in the Russian Far East are difficult and some means to alleviate these problems would make an important contribution to progress and research and in understanding the challenges of living in the Arctic. Collaboration with Russian colleagues represents an opportunity for the International Arctic Research Center.

RECOMMENDATIONS FOR AGENCIES

1. The Interagency Arctic Research Policy Committee (IARPC). The Commission is pleased to note the initiative by IARPC to organize and support the SEARCH Program and to be prepared to commence planning on similar initiatives on the Bering Sea and Arctic Health. The response of IARPC to the Commission's recommendations is heartening and the Commission wishes to commend the participating agencies and their staffs for their commitment. The Commission expects continued progress and cooperation in bringing the Bering Sea and Arctic Health initiatives forward.
2. The National Science Foundation (NSF). The NSF has made great strides in their support for Arctic Research. Funding has grown as has the enthusiasm with which Arctic research is considered inside the Foundation. The Commission encourages continued cooperation and growth.
3. The Department of Defense (DOD). A number of activities fall under the Department of Defense. Chief among these is the SCICEX Program of the Department of the Navy. The 109th Airlift Wing of the New York Air National Guard provides LC-130 support for both Arctic and Antarctic research operations. In addition, DOD is conducting a program entitled Arctic Military Environmental Cooperation (AMEC) jointly with the Norwegian and Russian ministries of defense. The Commission encourages the Department of Defense to continue to provide support for Arctic research and environmental studies and to communicate with the Commission on any new programs

Global climate changes poses new challenges for defense agencies. Changes in the Arctic are occurring sooner and faster than elsewhere. In addition, the water-ice boundary which characterizes many Arctic environments creates the need for systems and facilities which can operate in environments where ice is a frequent and even a constant obstacle. These environmental challenges require new thinking by defense planners. The Commission recommends that the Department of Defense support workshops and other studies focused on climate change and the consequent changes in the battle space environment.

A. Department of the Navy. The level of interest in Arctic research at the Office of Naval Research is uncomfortably low. Recent developments, however, suggest that changes in the climate of the Arctic may result in new roles and missions for the Navy in the Arctic. The Commission believes that these changes in the Arctic environment require an increase in research levels in the Arctic in order to maintain the national security in the region. The knowledge base created and maintained by research in the region may be of vital national interest in the future, particularly as access to the Arctic Ocean improves; a fact made likely through the observed thinning and retreat of Arctic sea ice. Rapid environmental changes in the region dictate mission changes, and thus, suggest that research efforts based on Navy needs should be substantially increased. The

emergence of the Department of Homeland Security cannot help but increase concerns for the area.

With this in mind, the Commission commends the efforts of the Navy in carrying out the SCICEX dedicated cruises. The Commission notes the substantial effort made by the Navy to support this program in the face of shrinking resources and facilities. These expeditions into the Arctic Ocean aboard operational fast attack nuclear submarines show an extraordinary interest in the support of science by the Navy. The retirement of the last of the Sturgeon Class submarines and the difficulties in finding resources for future dedicated cruises are of great concern to the Commission. The Commission recommends that the Navy continue to explore with the scientific community the means to continue this invaluable access to the Arctic Ocean.

The SCICEX Program began in 1998 to collect swath bathymetric data in the Arctic for the first time from a submarine. This instrument known as the Seafloor Characterization And Mapping Pods (SCAMP) has been made possible by the enthusiastic support of the National Science Foundation's Office of Polar Programs. This data collected by SCAMP will be of great value for students of the region from many disciplines. The regions surveyed in 1998 and 1999 comprise only a moderate fraction of the area of the deep water portion of the Arctic Ocean. The value of this data is indicated by the importance attached to it by the international community in connection with the revision of the International Bathymetric Chart of the Arctic Ocean (IBCAO). Navy data more than double the data base available for the next IBCAO update. The means to continue gathering swath bathymetry with the SCAMP system should be identified for the future. Navy nuclear submarines are the preferred platform for these investigations and the Commission continues to explore these possibilities but other opportunities may also emerge. Under the new Memorandum of Agreement between the participating agencies the SCICEX Program will continue with "opportunity cruises" using occasional time slots provided during other Navy Arctic visits. While these opportunity cruises will not allow for scientist "rider" or the installation of specialized equipment, they will offer the opportunity to observe many characteristics of the Arctic environment. The Commission wishes to express our gratitude for the opportunities past and future provided by the Navy for study of the Arctic Ocean from Navy nuclear submarines.

A corollary issue is the declassification of archived bathymetry data collected on previous operations. These data are a valuable resource for the research community. A continuing program should be established to bring these data out from the classified realm respecting the security concerns which may surround the collection of this data. The construction of the new US-Russian Arctic Ocean Atlas CD shows that these difficulties may be overcome.

As a further indication of the high degree of cooperation demonstrated by the Navy and the utility of Navy nuclear submarines for research in the Arctic Ocean, the Commission notes the attempt to carry out a test of the submarine as a receiving ship for seismic refraction measurements. The test, though not executed, remains precedent setting. The Commission encourages further investigation of this concept.

B. Department of the Army. The Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover is a national center of excellence in Arctic science and engineering research. In the current climate of budget stringency the pressure on Army labs is growing. The Commission wishes to be on record in support of the vital resource that is CRREL. Serious reductions at CRREL might be helpful in the short term but clearly would be a detriment to the national well being over the long term. The Commission encourages continued support for CRREL. The Commission is also pleased to note the continuing cooperation between the University of Alaska and CRREL which brings the essential experience and talent of CRREL researchers to bear on the infrastructure needs of the State of Alaska.

4. The National Oceanographic and Atmospheric Administration (NOAA). NOAA has been the leading US agency for Arctic Monitoring and Assessment Program (AMAP). In this role, NOAA has supplied both staff efforts and funding to the AMAP. These efforts have been largely conducted on a goodwill basis without organized programs or a satisfactory funding base. NOAA deserves great credit for these efforts and the Commission commends and supports their efforts. NOAA has supported the Arctic Research Initiative which began in 1996 at a funding level of approximately 1.5 million dollars. The Commission supports this initiative and recommends that it continue in the coming fiscal year with expanded funding.

NOAA along with the Navy operates the National Ice Center. This center provides ice imagery and mapping for the national and international polar community. As climate change effects the Arctic regions, the ability to predict ice conditions grows ever more important and urgent. These essential services depend largely on satellite imagery. The imminent projected end of the current Radarsat and the changes planned for the distribution of images from the next generation of Radarsat instruments will, if not modified, have serious effects on the National Ice Center's ability to provide detailed images, maps and forecasts of polar ice conditions. The Commission recommends that NOAA move immediately to ensure that the National Ice Center receives an adequate supply of high resolution, synthetic aperture radar images.

NOAA will play an important role in a new program of Ocean Exploration. The Commission hopes that the Arctic Ocean will continue to be noted as part of the world ocean with a special place as an important source region for deep convection in the world ocean and as a region where air-sea interactions influence both the world's climate and ocean circulation. The Commission strongly encourages NOAA to include intensive studies of the Arctic Ocean in its World Ocean Exploration plans.

NOAA operates a suite of National Data Centers including the National Snow and Ice Data Center, the National Oceanographic Data Center, the National Geophysical Data Center and the National Climate Data Center. These data centers are charged with the responsibility for data rescue in the Former Soviet Union. The Commission recommends that the national data centers communicate the nature of their data rescue activities to the Commission and expand them as necessary to collect data vital to our understanding of the Arctic, especially the dispersal of contaminants in the region.

5. The Environmental Protection Agency (EPA). The native residents of the Arctic live in a close relationship their environment (roughly 50% of their annual caloric intake comes from native plant and animal species). The stresses of village life (almost 50% of Alaskan villages use the “honey bucket” system for human waste disposal is still a common practice) and their vast and ancient store of traditional knowledge of the Arctic environment make their continued well being a matter of great concern. At the same time, the Arctic native community is probably more closely coupled to their environment and to new stresses introduced by human activity and natural variations than any other community in the United States. This suggests that, although their numbers are small relative to the rest of the nation, they are in the front lines of environmental susceptibility. For this region, the Commission commends the recent activities of the EPA, especially its Alaska office, in involving Alaska natives in agency activities. The results of the AMAP study indicate that there is still much to learn about contaminant stressors in the Arctic. The interagency program on Arctic Health recommended above will require serious efforts by EPA if questions concerning environmental health are to adequately attacked. The Commission notes that the Alaska governor’s office has mounted a new initiative on contaminants and that EPA is a participant. As the Arctic Health Program goes forward, the Arctic Research Commission encourages EPA to play a major role.

There are important efforts in the Arctic sponsored by the EPA’s Office of International Programs. EPA’s Office of International Activities (OIA) has supported the study of contaminants in umbilical cord blood samples from Arctic residents and projects to assess and reduce sources of Mercury and polychlorinated biphenyls (PCBs). The Commission commends EPA-OIA for their efforts and urges support for there activation and expansion.

6. The Department of State. The Department of State is responsible for the negotiation and operation of our international agreements in the Arctic. The Department seeks input from the IARPC agencies and others through the Arctic Policy Working Group which meets monthly with the Polar Affairs Section at State. Matters concerning US participation in the Arctic Council are the principal topics for discussion at these meetings. The United States has finished a two year term as Chair of the Arctic Council in 2002. Hard work by the State Department and close cooperation, particularly with the *ad hoc* working group organized in the State of Alaska has resulted in a successful two years. The Commission commends the State Department’s efforts.

It has become likely that the US will soon accede to the UN Convention on the Law of the Sea (UNCLOS). When the US does so the Nation will have ten years to submit a claim for “submerged extensions” of the US continental margins under the requirements of UNCLOS Article 76. While there are some gaps in the data necessary for maximizing our claim in the temperate and tropical seas, these bathymetric gaps are relatively easy to fill in. There is, however, virtually no data in the Arctic Ocean north of Alaska, where ironically the prospects of fossil fuel resources are considered quite high. The US Arctic Research Commission in collaboration with Arctic Ocean researchers and the Interagency *ad hoc* Committee on Article 76, has created a plan for the conduct of the

necessary surveys. The Navy has indicated to us that they are able and interested in conducting these surveys but that no submarine asset is currently assigned or available for this task. The operational Navy has indicated that they will be happy to carry out the necessary surveys if directed to do so by the National Command Authority. The Government of the United States needs to consider the value of an extended Article 76 claim in the Arctic and, assuming a claim is considered in the national interest, direct the Navy to include this survey effort in its mission planning activity as a requirement. The State Department should convey to the national command authority as a national priority that the Navy should be directed to include an Article 76 survey in its operational plans.

7. The Department of Transportation.

A. The United States Coast Guard (USCG). The US Coast Guard is the principal provider of research time on icebreakers for US scientists not collaborating with other nations. The communication and understanding between the scientific community which will be using *Healy*, Coast Guard ship operators has substantially improved. The Arctic Icebreaker Coordinating Committee (AICC) is proactive and has resulted in substantial improvements in the design of research facilities aboard *Healy*. The need for liaison and coordination has now changed from the construction of the ship to the planning and scheduling of effective research operations. The Commission is gratified that the Coast Guard has been willing to work closely with the AICC drawing upon the US academic community's substantial level of experience in oceanographic operations generally and in Arctic studies in particular.

The high cost of transit to the "Eastern Arctic" makes coordination of research plans in the Eurasian Basin of the Arctic Ocean an essential feature of the role of the AICC. In order to justify the substantial transit costs, an efficient program of high quality research must be organized. The AICC must continue to make every effort to bring interested researchers together to submit coordinated proposals for this hard-to-reach area.

There is a substantial dearth of knowledge about oil spills in Arctic conditions. The Commission has recommended a substantial research program on the behavior of oil in ice infested oceans for more than ten years. In addition, the Commission has had substantial discussions with the Oil Spill Recovery Institute. The Commission, in collaboration with the Alaska Clean Seas Association and others, has recommended test burns in the Arctic Ocean to study the variety of questions associated with this highly effective method of disposing of oil on the sea. The Commission recommends that the Coast Guard in cooperation with the EPA, OSRI, the State of Alaska and others commence such a program soon, before the question is made imperative by an accident in the Arctic. The Commission also notes that the only US vessels capable of responding to an oil spill in the presence of substantial sea ice coverage are the Coast Guard icebreakers. The Commission is concerned that there is inadequate contingency planning for a spill in the Arctic ice off the north slope of Alaska.

B. The Federal Aviation Administration (FAA). The FAA is the principal sponsor of the CAPSTONE Project which is enabling aircraft traffic control and enhancing safe air operations in the remote regions of Arctic Alaska. The Arctic Research Commission

applauds the FAA's efforts to implement the CAPSTONE Project and recommends that they also work with Commissioners and others to support the Arctic Council's Civil Infrastructure Task Force (CITF) in their international efforts to unify and improve transportation infrastructure in the north.

8. The National Aeronautics and Space Administration (NASA). The Commission has been briefed on the Programs undertaken by NASA in the Arctic or having a substantial component in the Arctic. These programs are clearly of a high caliber but inadequately described to the research community. The Commission recommends that NASA carry out a program of outreach to the Arctic Research Community to publicize these programs and to encourage broader participation. NASA is always at risk for the engineering side of their programs to overwhelm scientific uses and needs. The Commission believes that by broadening the participation of the research community in their programs, NASA can benefit from the resulting community support.

The Commission notes with particular interest the participation of NASA in the planning for the SEARCH Program. Clearly, remote sensing data with its broad area coverage and frequent collection of data will be essential for this and other coordinated studies in the region. We urge NASA to continue its interagency communication and coordination efforts with a particular emphasis on planning for the Bering Sea Study recommended above by the Commission.

The Commission also notes that NASA is a participating agency in the International Arctic Research Center and supports the Alaska Synthetic Aperture Radar Facility at the University of Alaska. The Commission supports these efforts and looks forward to their continuation and expansion.

Images of the polar region from satellite borne synthetic aperture radar (SAR) are unique in their ability to image sea ice at very high resolution while being able to penetrate cloud cover without difficulty. Canadian plans for the next generation of their RADARSAT satellites, which are the principal providers of this data, is of great concern. The commercialization of RADARSAT images at very high prices and the end of the current policy of free distribution of a portion of the RADARSAT data stream to the US in compensation for the launch of the first satellite will make their availability extremely difficult. In addition, the US National Ice Center (NIC) may not be funded at a level sufficient to maintain its current level of image acquisition. The Commission urges NASA and NOAA to negotiate actively with RADARSAT to continue the current level of availability of images at the NIC. In addition, the Commission recommends a two tiered pricing structure where older data and images, which have lost most of their timeliness and hence their commercial value, be made available to researchers at a substantially reduced price.

9. The National Institutes of Health (NIH). The 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 (see comments above on the efforts of the State of Alaska). The effects of both communicable diseases such as tuberculosis, systemic diseases such as diabetes and cancer and external causes of illness and death such as alcoholism and accident likewise have profound effects in the Arctic. The Commission eagerly awaits the organization of this multi-agency effort under NIH's leadership.

10. The Department of the Interior.

A. The United States Geological Survey (USGS). The US Geological Survey has led the effort by IARPC agencies in the assembly of a data structure for Arctic research. Unfortunately, there has never been a satisfactory funding base for this program. In the past, many IARPC agencies have contributed to this effort but these contributions have faded. Only NSF continues to provide support. The Commission recommends that the USGS and the Department of the Interior accept that this program belongs to them and should be fully supported. The USGS should have the full support of the other IARPC agencies. It is particularly important that an effort be staged to save important earth science data from the former Soviet Union. Much useful data is collected in old paper records which are even more vulnerable now that fuel has become scarce in many places. The Commission has recommended that the NOAA National Data Centers undertake a data rescue project coordinated with the USGS.

The USGS Water Resources Branch has recently reduced the number of hydrologic monitoring stations in the Arctic. Data from these stations are urgently needed for testing and improving the predictions of large-scale of fresh water runoff in the Arctic. In addition, fresh water runoff affects the stratification of the Arctic Ocean and the distribution of nutrients, tracers and contaminants brought to the Arctic Ocean from the land. The World Climate Research Program - Arctic Climate System Study maintains and Arctic Runoff Data Base for these purposes. The Commission recommends that the USGS rebuild a strong program of Arctic hydrologic measurements.

The Biological Resource Division of the USGS participates along with the Fish and Wildlife Service in the BERPAC program, a US-Russia collaborative program for the study of the Bering-Chukchi-Beaufort Sea ecosystems. The Arctic Research Commission expects this program to play an important role in the interagency program for the study of the Bering Sea and encourages its support and expansion.

The Commission has noted above its concerns for Alaska public lands resource evaluation and for the lack of precise geospatial data in Alaska. The Commission recommends that the USGS take immediate action to procure/provide this essential data.

B. The Fish and Wildlife Service. The Fish and Wildlife Service has been a stalwart in the work of the Arctic Council's working Group on the Conservation of Arctic Flora and Fauna (CAFF). The Commission recommends that other divisions of the Department follow the example of the Fish and Wildlife Service in their support of Arctic Council Activities. See also the Commission's comments on BERPAC, above.

C. The Minerals Managements Service (MMS). The MMS has responsibilities for offshore natural resources and, as a result, is a principal participant along with the State Department, USGS and NOAA in the preparation of a US claim under Article 76 of the UN Convention on the Law of the Sea. This provision allows nations to claim submerged extension of their continental margins for the purpose of the exploitation of resources on and under the sea bed. While data is somewhat more abundant and certainly easier to collect in the temperate and tropic waters under US jurisdiction, the state of knowledge about the Arctic is so limited that new efforts at bathymetric and geophysical measurements may be required for the US to submit a successful claim. The Commission is observing this process with great interest and stimulating it wherever and whenever we can and urges all agencies to contribute as possible to a successful US claim.

11. The Department of Energy (DOE). The energy needs of Arctic villages in Alaska are extreme. Poor transportation to remote villages, small communities unable to take advantage of the economies of scale usually associated with municipal energy systems, a mixed economy with only modest cash flow and the lack of a sophisticated technical infrastructure all make the provision of adequate energy resources in the Arctic difficult. The Commission notes the activities of the DOE in developing fuel cell technology. Fuel cells may become a principal source of energy at appropriate scales but the Commission is concerned about cost/benefit ratios and encourages further development of small scale appropriate technology systems for village energy systems in the north.

The Department of Energy has been an important source of technology transfer to the Russian nuclear power reactor program. Unfortunately, budget reductions threaten this vital activity. The Commission is concerned that the future of US participation is in jeopardy and that in the future, nuclear energy production particularly in the Russian Arctic may proceed without the support of the Department of Energy. The budget for interaction with Russia on nuclear power systems should be supported and reinforced.

The Commission has long held serious concerns about radioisotope contamination in Russia derived from atmospheric nuclear weapon testing and nuclear fuel reprocessing systems. While national concern focuses on the remaining stockpile of Russian nuclear weapons, the reprocessing cycle which produces the basic fissile material for these weapons has had a far greater actual (as opposed to potential) effect on the environment and the people living in it. The Commission encourages the DOE to continue its interaction with the Russian nuclear power infrastructure and to consider potential environmental remediation, restoration or at least sequestration efforts pointed toward the Russian fuel reprocessing system.

The Commission fully supports the activities in the Arctic under the DOE's Atmospheric Radiation Measurement (ARM) Program. The ARM Program is an important research effort and is also an outstanding example of close cooperation between researchers and native communities and stands as an example for other research programs.

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