US ARCTIC RESEARCH COMMISSION

REPORT ON

GOALS AND OBJECTIVES FOR ARCTIC RESEARCH 2009–2010





FOR THE US ARCTIC RESEARCH PROGRAM PLAN

ABOUT THE US ARCTIC RESEARCH COMMISSION

The US Arctic Research Commission is an independent federal agency created by the Arctic Research and Policy Act (ARPA) of 1984, as amended. It consists of a nonpartisan advisory body of scientists, physicians, indigenous leaders, and industry representatives appointed by the President of the United States and supported by staff located in Washington, DC, and in Anchorage, AK. In addition to establishing the goals in this report, the Commission sets US Arctic research policy and builds cooperative links in Arctic research, from the US Arctic research program, to international partners, and to the State of Alaska. The law requires the Commission to comment to Congress on the progress of the Executive Branch in reaching goals set by the Commission and on their adoption by the Interagency Arctic Research and Policy Committee (IARPC). The Commission plays an active role in the work of several interagency committees, including the Arctic Policy Group, chaired by the US Department of State, which oversees US participation in the eight-nation Arctic Council. The Commission is a statutory member of the North Pacific Research Board and the North Slope Science Initiative, and is a member of various committees of the National Ocean Governance Structure, the interagency Extended Continental Shelf Task Force, the Scientific Ice Expeditions Interagency Committee, involving US Navy nuclear submarines in the Arctic, the Alaska Ocean Observing System, the International Permafrost Association, and the Consortium for Ocean Leadership, among others.

HOW THIS REPORT WAS COMPILED

Under ARPA, the US Arctic Research Commission biennially recommends key goals and objectives for the US Arctic Research Program Plan (hereinafter referred to as the "Plan"). The goals report was released after the Commission collected substantial input from scientific researchers, policymakers, and the public in Alaska, throughout the United States, and in the growing number of nations with Arctic interests. The Commission cosponsored a number of scientific meetings and workshops to help define its research goals and policy, including a June 2009 workshop in Anchorage with the National Institutes of Health's Fogarty International Center, to help understand the basis for the remarkably high rate of behavioral and mental health problems in the Arctic, including suicide, alcoholism, and spousal and child abuse. During the last two years, the Commission led special initiatives and reports, including the *Arctic Marine Shipping Assessment*, an Arctic Council agenda for shipping research, and a white paper on oil spill response research. The Commission occasionally writes "white papers" on other subjects as well, which are posted on the Commission's web site, www.arctic.gov.

WHERE THIS REPORT GOES FROM HERE

Under ARPA, IARPC is charged with revising the nation's five-year Arctic Research Program Plan in order to achieve the goals of this report. The recommendations in this report were conveyed, as required by law, in 2009, and this report elaborates upon those goals as a starting point for IARPC's work to revise the Plan. Federal agencies have been identified to lead revisions under each theme in this goals report and to undertake new initiatives; this report contains specific recommendations for federal agencies and other partners in the US Arctic Research Program. The White House Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB) also play major roles in formulating a federal policy and budgets to carry out the plan adopted in response to this goals report.

During 2010, in preparation for the 2011 goals report, the Commission will work closely with OMB, OSTP, and IARPC member agencies to summarize the work of each agency's Arctic research program, including developing the best possible information on the Plan's current budget, estimated at approximately $400 million per year.

COVER PHOTOS

TOP LEFT. USCG Icebreaker Healy *in the Arctic, with cranes extended, conducting research. (Photo credit: PA3 J. Bigelow, USCG)*

TOP MIDDLE. Coastal erosion. (Photo credit: C. Arp, USGS)

TOP RIGHT. Polar bear on Arctic ice. (Photo credit: Digital Vision)

BOTTOM LEFT. Kivalina girl. (Photo credit: J. Farrell)

BOTTOM RIGHT. Last mooring. (Photo credit: M. Dunn)

BACKGROUND. Iceberg close-up at the Arctic North Pole region of Spitsbergen/Svalbard. (Photo credit: iStockphoto)

BACKGROUND PHOTO, THIS PAGE. (Photo credit: M. Dunn)

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REPORT ON

GOALS AND OBJECTIVES FOR ARCTIC RESEARCH 2009–2010

FOR THE US ARCTIC RESEARCH PROGRAM PLAN

Mr. President and Members of Congress:

The Arctic region, and Alaska—America's Arctic—provides tremendous value to the United States. Without a significant Arctic Research Program, however, those things we value in and from the Arctic—energy, food, security, biodiversity, fresh water, carbon sinks, pristine wilderness, more direct transport routes, rich indigenous cultures—cannot contribute as well or be sustained. There is little human activity we know of in the Arctic that is not "knowledge based." The Arctic continues to be rich in mysteries that can only be solved with pioneering, exploration and research. With greater knowledge, the Arctic region can contribute more to both the global economy and the environment. Knowledge about Arctic processes can help protect the world from expensive, unnecessary, and destructive climate change.

The US Arctic Research Commission is pleased to present goals it has established for the nation's Arctic Research Program. In developing these goals, we have listened, widely. We are grateful for the advice we have received from Arctic residents, the American public at large, the State of Alaska, the academic community, federal agencies who manage our Arctic assets, and international partners. Since the basic goals we set here remain the same as those set in 2007, much work has begun at the Interagency Arctic Research Policy Committee to see that this research actually happens. What we present now urges an acceleration of that work, and new emphases to mesh with current national priorities related to energy and climate, ocean policy, health, national and homeland security, and keeping the US competitive in the world economy. To highlight a few:

- Fresh with the completion of the 2007–2009 International Polar Year, the first since 1957, the Arctic science community is better prepared now to establish a sustained Arctic observing network. As the world works to create an effective mitigation scheme to reduce greenhouse gas emissions, monitoring will help us understand potentially overwhelming "feedbacks" in the Arctic that could counter those efforts.

- Federal agencies are paying much more attention to the great health disparities and tragic, alarming youth suicide rates experienced by Arctic residents. We must now begin rigorous research to support US-funded clinical efforts to stem suicide rates in the Arctic. A generation of youth is at risk, and new research initiatives could not be more vital.

- Resource managers are more aware of the need to catalogue all our resources, and to expand efforts to map parts of the Arctic for the first time. These programs, tied with pending US accession to the United Nations Convention on the Law of the Sea, can expand US territory in the Arctic. We must be aware that our neighbors also see the same Arctic opportunities in new territory, expanding fisheries, shipping routes, and oil and gas, and only with an active Arctic presence will the United States help shape new patterns of activity in the Arctic to our liking. When it comes to work related to protection of threatened species, the federal government needs better partnerships with the State of Alaska, indigenous peoples who subsist on these resources, and international partners.

- Federal and state agencies responsible for building infrastructure must direct more research to help Arctic residents adapt to climate change. As the Arctic Ocean becomes more accessible, it is also essential that we meet the promise of the Oil Pollution Act of 1990, and have an oil spill research program that will assure

Arctic residents that meaningful improvements and reduction of risk are underway. The American public pays a tax of eight cents a barrel of oil used to reduce spill risks, yet the government cannot be said to have a competitive research program of the scope we promised ourselves after the Exxon Valdez Oil Spill in 1989.

- An Arctic Ocean baseline science plan will enable the policy goals of ecosystem-based management and marine spatial planning called for by the President's Ocean Policy Task Force. But, appropriate funding is needed for science to provide that essential knowledge from the Arctic Ocean. We also need to work with our neighbors in the Arctic to ensure that we have access for science throughout the Arctic Ocean. Too often in recent years, legitimate science has been denied permission to collect data in vast parts of this ocean, and with new territorial claims in the Arctic, the situation could get worse.

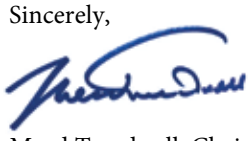
- Finally, we need to light a fire under Arctic research efforts in the humanities: educators, museums, researchers, and native leaders must come together to apply research to the goal of protecting indigenous language, identities, and culture. Without that, we stand to lose huge knowledge—forever—as living generations pass away.

The Commission, the Interagency Arctic Research and Policy Committee, the White House Office of Science and Technology Policy, and the Office of Management and Budget must work together to see that the US Arctic Research Program is better integrated and more transparent, as called for in the Arctic Research and Policy Act of 1984. We are delighted that the United States has, since our recommendation in 2007, reviewed policy at the Presidential level, resulting in US Arctic policy NSPD-66/HSPD-25, and that agencies across the government are paying closer attention to the opportunities and challenges of a newly accessible, rapidly changing Arctic region. It is also good to report that the nation is moving ahead with construction of an Alaska Region Research Vessel, recently named "R/V *Sikuliaq*," funded by the National Science Foundation with stimulus money. Credit is due to many—in the public, the Executive Branch, and the Congress—for making these things happen.

We look forward, soon we hope, to a decision to replace the nation's aging pair of polar icebreakers: with a changed Arctic Ocean, no other platform can provide the nation what it needs for research, law enforcement, environmental protection, emergency response, search and rescue, maritime commerce, national and homeland security.

We thank you for the opportunity to work with some of the most fascinating people in one of the most unique and strategic places on Earth. Our enthusiasm for the Arctic region only grows with what we've been privileged to learn and privileged to do. Godspeed to those who continue to advance the world's knowledge of the Arctic.

Sincerely,



Mead Treadwell, Chair

ABBREVIATIONS AND ACRONYMS

AAAS ..... American Association for the Advancement of Science, http://www.aaas.org
ACF ..... Administration for Children and Families, http://www.acf.hhs.gov
ADEC ..... Alaska Department of Environmental Conservation, http://www.dec.state.ak.us
ADVANCE ..... Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383
AFSC ..... Alaska Fisheries Science Center, http://www.afsc.noaa.gov
AHHI ..... Arctic Human Health Initiative, http://www.arctichealth.org/ahhi
AMAP ..... Arctic Monitoring and Assessment Program of the Arctic Council, http://www.amap.no
AMRAP ..... Alaska Mineral Resource Assessment Program
AMSA ..... *Arctic Marine Shipping Assessment*, http://www.arctic.gov/publications/AMSA_2009_Report_2nd_print.pdf
ANILCA ..... Alaska National Interest Lands Conservation Act of 1980
ANSC ..... Alaska Native Science Commission, http://www.nativescience.org
ANSEP ..... Alaska Native Science and Engineering Program, http://ansep.uaa.alaska.edu
ANTHC ..... Alaska Native Tribal Health Consortium, http://www.anthc.org
AON ..... Arctic Observing Network, http://www.nsf.gov/news/news_summ.jsp?cntn_id=109687
AOOS ..... Alaska Ocean Observing System, http://www.aoos.org
APECS ..... Association of Polar Early Career Scientists, http://apecs.is
ARCUS ..... Arctic Research Consortium of the United States, http://www.arcus.org
ARPA ..... Arctic Research and Policy Act of 1984, as amended, http://www.nsf.gov/od/opp/arctic/iarpc/arc_res_pol_act.jsp
ARRA ..... American Recovery and Reinvestment Act
BASC ..... Barrow Arctic Science Consortium, http://www.arcticscience.org
BEO ..... Barrow Environmental Observatory, http://www.arcticscience.org/researchBases.php
BEST-BSIERP ..... Bering Sea Ecosystem Study (NSF)-Bering Sea Integrated Ecosystem Research Program (NPRB), http://bsierp.nprb.org
BIA ..... Bureau of Indian Affairs, http://www.bia.gov
BIAWG ..... Bering Sea Interagency Working Group
BLM ..... Bureau of Land Management, http://www.blm.gov
CANHR ..... Center for Alaska Native Health Research, http://canhr.uaf.edu
CCHRC ..... Cold Climate Housing Research Center, http://www.cchrc.org
CCSP ..... US Climate Change Science Program, http://www.climatescience.gov
CDC ..... Center for Disease Control and Prevention, http://www.cdc.gov
CDQ ..... Community Development Quota
CEQ ..... Council on Environmental Quality, http://www.ceq.gov
CIMES ..... Center for Island, Maritime, and Extreme Environment Security, http://cimes.hawaii.edu
COMPETES ..... America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science
COSEE ..... Centers for Ocean Science Education Excellence, http://www.cosee.net
CRRC ..... Coastal Response Research Center, http://www.crrc.unh.edu
CRREL ..... US Army Corps of Engineers Cold Regions Research and Engineering Laboratory, http://www.crrel.usace.army.mil
DHHS ..... Department of Health and Human Services, http://www.hhs.gov
DHS ..... Department of Homeland Security, http://www.dhs.gov
DNA ..... Deoxyribonucleic acid
DOC ..... Department of Commerce, http://www.doc.gov
DOD ..... Department of Defense, http://www.defense.gov
DOE ..... Department of Energy, http://www.doe.gov
DOI ..... Department of the Interior, http://www.doi.gov
DOS ..... Department of State, http://www.dos.gov
DOT ..... Department of Transportation, http://www.dot.gov
ECS ..... Federal Interagency Extended Continental Shelf Task Force, http://continentalshelf.gov
ED ..... US Department of Education, http://www.ed.gov
EEZ ..... Exclusive Economic Zone
EPA ..... Environmental Protection Agency, http://www.epa.gov
FAA ..... Federal Aviation Administration, http://www.faa.gov
FDA ..... Food and Drug Administration, http://www.fda.gov
FIC ..... Fogarty International Center, http://www.fic.nih.gov

GEOSS .....Global Earth Observing System of Systems, http://www.earthobservations.org
HIPAS .....High Power Auroral Stimulation
HUD.....Department of Housing and Urban Development, http://www.hud.gov
IARC .....International Arctic Research Center, http://www.iarc.uaf.edu
IARPC.....Interagency Arctic Research and Policy Committee, http://www.nsf.gov/od/opp/arctic/iarpc/start.jsp
IASC.....International Arctic Science Committee, http://www.arcticportal.org/iasc
ICCOPR.....Interagency Coordinating Committee on Oil Pollution Research, see Title VII at http://www.epw.senate.gov/opa90.pdf
IHS.....Indian Health Service, http://www.ihs.gov
IODP .....Integrated Ocean Drilling Program, http://www.iodp.org
IPCC.....United Nation's Intergovernmental Panel on Climate Change, http://www.ipcc.ch
IPY .....International Polar Year, http://www.ipy.org
ISAC.....International Study of Arctic Change, http://www.arcticchange.org
IUCH.....International Union for Circumpolar Health, http://iuch.net
LOSI .....Loss of Sea Ice, http://www.afsc.noaa.gov/Publications/ProcRpt/PR2007-05.pdf
MARAD.....Department of Transportation/Maritime Administration, http://www.marad.dot.gov
MEDEA .....Measurements of Earth Data for Environmental Analysis
MMS.....Minerals Management Service, http://www.mms.gov
MOU .....Memorandum of Understanding
NASA .....National Aeronautics and Space Administration, http://www.nasa.gov
Navy SupSalv.....Naval Sea System Command Supervisor of Salvage and Diving, http://www.supsalv.org
NCMHD.....National Center on Minority Health and Disparities, http://www.ncmhd.nih.gov
NCRR.....National Center for Research Resources, http://www.ncrr.nih.gov
NEH .....National Endowment for the Humanities, http://www.neh.gov
NGA .....National Geospatial-Intelligence Agency, http://www.nga.mil
NIAAA.....National Institute on Alcohol Abuse and Alcoholism, http://www.niaaa.nih.gov
NICHD .....National Institute on Child Health and Development, http://www.nichd.nih.gov
NIH .....National Institutes of Health, http://www.nih.gov
NIMH.....National Institute of Mental Health, http://www.nimh.nih.gov
NIST .....National Institute of Standards and Technology, http://www.nist.gov
NMFS.....National Marine Fisheries Service, http://www.nmfs.noaa.gov
NOAA .....National Oceanographic and Atmospheric Administration, http://www.noaa.gov
NPCREP .....North Pacific Climate Regimes and Ecosystem Productivity, http://www.pmel.noaa.gov/foci/NPCREP
NPFMC.....North Pacific Fisheries Management Council, http://www.alaskafisheries.noaa.gov/npfmc
NPRB.....North Pacific Research Board, http://www.nprb.org
NRC.....National Research Council, http://nationalacademies.org/nrc
NREL.....National Renewable Energy Lab, http://www.nrel.gov
NSF.....National Science Foundation, http://www.nsf.gov
NSSI.....North Slope Science Initiative, http://www.northslope.org
NSTC.....National Science and Technology Council, http://www.ostp.gov/cs/nstc
ONR .....Office of Naval Research, http://www.onr.navy.mil
OPA90.....Oil Pollution Act of 1990
OSRI.....Oil Spill Recovery Institute, http://www.pws-osri.org
OSTP .....Office of Science and Technology Policy, http://www.ostp.gov
PICES .....North Pacific Marine Science Organization, http://www.pices.int
PMEL .....Pacific Marine Environmental Laboratory, http://www.pmel.noaa.gov
RUSALCA .....Russian-American Long-term Census of the Arctic, http://www.arctic.noaa.gov/aro/russian-american
SAMHSA .....Substance Abuse and Mental Health Services Administration, http://www.samhsa.gov
SAON.....Sustaining Arctic Observing Networks, http://www.arcticobserving.org
SBIR.....Small Business Innovation Research, http://www.sbir.gov
SCICEX.....The Scientific Ice Exercises Program, http://www.scicex.org
SDMI.....Statewide Digital Mapping Initiative, http://www.alaskamapped.org
SEARCH.....Study of Environmental ARctic CHange, http://www.arcus.org/search/index.php
SFOS.....UAF's School of Fisheries and Ocean Sciences, http://www.sfos.uaf.edu
SI.....Smithsonian Institution, http://www.si.edu
SINTEF (Norwegian).....Stiftelsen for industriell og teknisk forskning, http://www.sintef.no/Home
TEK .....Traditional Ecological (or Environmental) Knowledge
UAF.....University of Alaska Fairbanks, http://www.uaf.edu
UNCLOS .....United Nations Convention on the Law of the Sea, http://www.un.org/Depts/los/index.htm
UNESCO .....United Nations Educational Scientific and Cultural Organization, http://portal.unesco.org
USACE.....US Army Corp of Engineers, http://www.usace.army.mil
USARC.....US Arctic Research Commission, http://www.arctic.gov
USCG .....US Coast Guard, http://www.uscg.mil
USDA .....US Department of Agriculture, http://www.usda.gov
USFWS.....US Fish and Wildlife Service, http://www.fws.gov
USGS.....US Geological Survey, http://www.usgs.gov

ABOVE. Bearded Seal. (Photo credit: M. Dunn)

RIGHT. Exploring Kivalina. (Photo credit: J. Farrell)

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This report is dedicated to Mr. Duane Laible, a USARC Commissioner from 2003 to 2007.

CONTENTS

Arctic ice valley sunset.
(Photo credit: M. Dunn)

Walrus (Odobenus rosmarus) *hauled out on the ice of the Bering Sea, seen during the April 2006 US Fish and Wildlife Service (USFWS) walrus survey. (Photo credit: USFWS/Brad Benter)*

Arctic sun.
(Photo credit: M Dennett)

EXECUTIVE SUMMARY

This report conveys to President Barack Obama, Congress, and the American people the nation's highest-priority goals and objectives for Arctic research. These goals are established by the US Arctic Research Commission (USARC) under the authority of the Arctic Research and Policy Act (ARPA) of 1984, as amended.

THE STRATEGIC ARCTIC

Arctic assets are strategic to our nation. Without a strong Arctic research program, the United States cannot be the best steward of these assets. Arctic research plays a key role in addressing fundamental scientific issues and in helping the nation meet its security needs, its economic aspirations, and its responsibilities as an Arctic nation. Polar research allows the nation to exercise global leadership in adapting to and mitigating climate change.

RESEARCH GOALS

The US Arctic Research Program must strengthen its efforts on five central and crosscutting themes.

1. Environmental Change of the Arctic, Arctic Ocean, and Bering Sea

- With international partners, we must continue to develop and "operationalize" SAON (Sustaining Arctic Observing Network) to gain greater understanding of pan-Arctic change. Relevant entities: NOAA, NSF, DOI, DOD, NSSI, DOS, USCG, NPRB, AOOS, OSRI, and BASC.
- The federal interagency initiative, SEARCH (Study of Environmental ARctic CHange), must further address the causes, and global implications of Arctic sea ice reduction, melting ice sheets and glaciers, ocean acidification, methane flux to the atmosphere, and black carbon deposition. These factors can "make or break" the effectiveness of a global climate change mitigation regime. Relevant entities: NOAA, NSF, DOI, DOD, NSSI, DOS, USCG, NPRB, AOOS, OSRI, and BASC.
- President Obama has indicated that the United States will be a leader in global efforts to mitigate climate change and new national initiatives are underway to bolster US adaptation strategies. Arctic research in these areas needs to be mindful of and a contributor to national and global adaptation and mitigation efforts.
- The "newly accessible" Arctic Ocean is inviting to commercial fishing, shipping, tourism, mineral, and energy extraction interests. The United States has barely begun the baseline oceanographic research necessary to support US and Arctic Council goals for ecosystem-based management in the Arctic Ocean. This research should move ahead, patterned to support "marine spatial planning," a tool that enables integrated, forward-

looking, and consistent decision making on the use of the sea. Relevant entities: NSF, NOAA, NPRB, OSTP, NSTC, CEQ, Federal Ocean Governance Structure, DOT/MARAD, USFWS, DOS, and local subsistence-based co-management groups.

2. Arctic Human Health

- Arctic residents face a number of health issues, but in this report, and as a gateway to other topics, we focus on suicide, given the extraordinarily high and increasing rates. The rate is greatest among indigenous youth, and is higher than in any other select population within our nation. Clinical and community intervention researchers must be brought together to better address this epidemic. The Commission proposes support for the National Academy of Sciences (Institute of Medicine and Polar Research Board) to convene a meeting of health researchers, caregivers, indigenous leaders, and experts from a wide range of disciplines to develop a rigorous, evidence-based, and recurring assessment of scientific research and intervention efforts to reduce suicide and other severe and related behavioral problems, including alcoholism, and spousal and child abuse. To be most effective, this assessment must be repeated every decade to enhance Arctic mental health research, to review intervention results, and to guide the scaling up of successful efforts within Arctic communities.

- Domestic abuse is another serious problem that is over-represented in Alaska's rural communities. It is strongly linked to child abuse and is often associated with alcohol abuse. Women in isolated, rural communities are especially vulnerable. Developing a multidisciplinary, coordinated approach to addressing domestic violence and child abuse is critical to improve Arctic human health and social stability in rural Arctic villages. Behavioral and mental health are just one aspect of Arctic human health; other foci include chronic, infectious, and zoonotic diseases, food safety and contaminants, and diet and lifestyle changes, among others. Relevant entities: DHHS (CDC, NIH, SAMHSA, ACF, IHS, and others) NIMH, tribal organizations (e.g., ANTHC and Southcentral Foundation), and the State of Alaska.

3. Civil Infrastructure

- The State of Alaska has developed an adaptation research agenda to respond to the dramatic effects of climate change. The emerging federal research program in this area should integrate with and support these efforts, which include protecting communities from erosion, and adapting buildings and civil infrastructure to thawing permafrost. Relevant entities: Denali Commission, USACE, DOT, HUD, State of Alaska, and USGS.

- The Interagency Coordinating Committee on Oil Pollution Research (ICCOPR) has not met the promise of the Oil Pollution Act of 1990 (OPA90). The Commission urges a significant new funding stream to support improvements in prevention, response, and remediation of oil spills in ice-covered waters. IARPC and ICCOPR must work together. Relevant entities: USCG, NOAA, OSRI, CRRC, MMS, Navy SupSalv, NIST, EPA, and OSTP.

- The *Arctic Marine Shipping Assessment* (AMSA, 2009), completed by the eight Arctic nations in spring 2009, identifies the research necessary to address the opportunities and challenges of Arctic shipping. IARPC, in conjunction with the Committee on Marine Transportation Systems and USARC, should develop an implementation plan. Relevant entities: DOT, USCG, DOS, NOAA, and the State of Alaska.

- Conventional and renewable energy potential in the Arctic has recently been assessed and is considerable. In 2009, the first comprehensive assessment of Arctic oil and gas deposits revealed that the region accounts for about 13% of the undiscovered oil, 30% of the undiscovered natural gas, and 20% of the undiscovered natural gas liquids in the world (Gautier et al., 2009). On the renewable side, over 90% of the United States' tidal energy potential is in Alaska. The Commission recommends that the Department of Energy prepare an Arctic research plan that addresses the nation's energy security interest in developing Alaska's huge renewable and nonrenewable energy potential for export to the lower 48 states, and that also recognizes the importance of providing affordable energy to Alaska's remote villages. Given the links between energy and the environment, the plan should

also address DOE's climate research interests in the Arctic, such as the Atmospheric Radiation Measurement Program. The Commission further urges continued support for the DOE Arctic Energy Office, with emphasis on methane hydrate research (both onshore and offshore), and on tundra travel research, such as the impacts of water withdrawal from tundra for ice road construction, lake recharge, and ground hardness and elasticity over a range of temperatures. The DOE National Renewable Energy Laboratory has established a research program in Alaska that can examine the substantial wind, wave, tidal, geothermal, and biomass potential for serving the many Arctic communities "off the grid" with stable-cost power, with the possibility of exporting renewable energy from the Arctic. Relevant entities: DOE, DOI/USGS, State of Alaska, USDA, and CCHRC.

4. Natural Resource Assessment and Earth Science

- The Commission applauds the leadership taken by the federal government's interagency Extended Continental Shelf (ECS) Task Force to identify claims that the United States may make to considerably increase its territory in the Arctic Ocean. The Commission has urged Senate ratification of the United Nations Convention on the Law of the Sea. If the United States is not party to this treaty, US scientists may not formally review and assess the claims of other nations in the Arctic. Relevant entities: ECS Task Force agencies, US Congress.

- The Alaska Mineral Resource Assessment Program, required by the Alaska National Interest Lands Conservation Act of 1980, should be funded in core agency budgets.

- Federal and state efforts to cooperate in providing an imagery database and digital elevation model are promising and could be successful in bringing Alaska's maps up to the standard of the rest of the nation. Both federal and state governments are urged to agree upon and fund a coherent plan for mapping the US Arctic that federal and state agencies, the research community, and the public can rely on. Relevant entities: DOD/NGA, DOI/BLM/USGS, State of Alaska, DHS, and NASA.

5. Indigenous Languages, Cultures, and Identities

- The Commission recommends that federal agencies continue, through IARPC, to develop and fund a research plan to help prevent extinction of the diverse languages spoken by Arctic peoples. In two meetings of IARPC principals, a commitment to this goal has been agreed upon. It is time to develop an integrated plan that is funded. Relevant entities: NSF, NEH, SI, BIA, HHS, ED, USDA, the State of Alaska, and Native Alaskan organizations.

RIGHT. Snow-and-ice-patterns.
(Photo credit: M. Dunn)
BELOW. Close up of a Northern Fulmar.
(Photo credit: M. Dunn)

LEFT. Chryasora melanaster.
(Photo credit: K. Raskcoff and E. Kristof)
BELOW. A sun dog at sunrise.
(Photo credit: M. Dunn)

RESEARCH INFRASTRUCTURE

To have an effective Arctic research program, the United States must invest in human capital, research platforms, and infrastructure, including new polar class icebreakers, and sustained sea, air, land, space, and social observing systems. The value of Arctic research is based on the quality of its researchers and the support of the public. Our research programs must work hand in hand with educators, support improved Arctic and ocean "literacy," and support training of young scientists with a focus on the Arctic. We must also enhance the educational "pipeline" that renews and sustains the research community examining Arctic problems and helps keep America competitive. The United States must renew international partnerships, strengthen and stabilize competitive funding for academic research, and build closer ties with the Arctic's indigenous residents. Relevant entities: OSTP, NSF, NOAA, NASA, USCG, Navy, and Native Alaskan organizations.

The Commission urges the President and Congress to commit to replacing the nation's two polar class icebreakers. Further, we call upon all agencies involved in Arctic research, through IARPC, to restore support for the Alaska Native Science Commission (ANSC) and the Barrow Arctic Science Consortium (BASC). NSF previously funded these programs to support its own logistics needs, but the benefits of both are enjoyed by many federal agencies that conduct Arctic research. Both served as key vehicles for involving Alaska Natives in the US Arctic Research Program. The Commission also encourages additional US and Japanese government support for the International Arctic Research Center (IARC), which serves as an international nexus for integrating and synthesizing Arctic climate change research. Relevant entities: NSF, DOC/NOAA, USCG, DOS, NASA, DOI, and DOD/USACE.

RESEARCH POLICY

The Arctic Research and Policy Act (ARPA) of 1984, as amended, established Arctic scientific research policy for the United States. This law promises much that has yet to be delivered. USARC, IARPC leadership, and the White House Offices of Science and Technology Policy and Management and Budget must work together, with Congress, to see that Arctic research policy is robust, and is translated into an effective, integrated, and forward-looking national Arctic Research Program Plan and associated budget as promised in ARPA. The new US Arctic policy (NSPD-66/HSPD-25) is a good start, but much work remains.

As called for in the Arctic Research and Policy Act of 1984, the Commission will continue to work for greater cooperation and coordination with other nations and the State of Alaska. Simply put, IARPC needs to meet regularly and produce the integrated plans and reports called for in ARPA.

As the federal government fulfills its responsibilities to manage lands, oceans, wildlife, and resources under its jurisdiction in the Arctic, we urge full funding of the North Slope Science Initiative (NSSI) and the Alaska Ocean Observing System (AOOS) as mechanisms for bringing appropriate stakeholders to the table. Appropriate federal-state scientific cooperation can help avoid expensive lawsuits over matters such as offshore drilling and Endangered Species Act determinations.

Internationally, USARC particularly emphasizes strengthening Arctic science cooperation with Russia. We urge the United States to continue its initiative to assure access to the Arctic Ocean for scientific researchers and to be mindful in its visa and immigration policy of the needs of students and researchers to cross national borders, regularly and predictably, to conduct their work.

USARC intends, as it develops its 2011 goals report, to further discuss and revise US Arctic research policy. Solid efforts are now underway to include local and traditional knowledge in US Arctic research. Support for marine mammal co-management programs will benefit by developing a joint USARC/IARPC research policy. The federal government spends approximately $400 million per year on Arctic research, and the results have helped identify important changes in the Arctic environment, enabling policymakers to respond to them.

The US Arctic Policy (NSPD-66/HSPD-25) has helped agencies identify their roles in America's new Arctic policy. Each of those agencies is likely to find new research needs as a result of those efforts. USARC looks forward to working with IARPC, OMB, and OSTP to bring about the integrated Arctic research program plan and budget called for in the ARPA.

Ice flats. (Photo credit: Digital Vision)

Pacific walrus.
(Photo credit: M. Dunn)

INTRODUCTION

THE STRATEGIC ARCTIC

Arctic assets are strategic to our nation. Without a strong Arctic research program, the United States cannot be the best steward of these assets. Arctic research plays a key role in addressing fundamental scientific issues and in helping the nation meet its security needs, its economic aspirations, and its responsibilities as an Arctic nation. Polar research allows the nation to exercise global leadership in adapting to and mitigating climate change.

America became an Arctic nation in 1867, with the purchase of Alaska. Although Arctic assets such as whale oil and seal fur helped fuel the US economy before 1867, history recounts that bringing Alaska into the United States, and later into the Union, was not without controversy. Many citizens thought that Alaska had no value at all, or, at the time of Statehood, no capability to support itself.

Today, the value of the Arctic is much more evident to Americans. Arctic assets help defend our continent, and are key to the security of European and Asian nations as well. In global commerce, the Arctic region helps feed our nation and the world with its robust fisheries. The Arctic fuels life on three continents with its oil, natural gas, and, increasingly, its huge potential hydro, wave, wind, tidal, geothermal, and biomass resources. Likewise, the Arctic plays a strategic role in global air and sea transport, and telecommunication, and as the Arctic Council's recently completed *Arctic Marine Shipping Assessment* (AMSA, 2009) showed, shipping might play an even greater role in the future.

Life on Earth itself might not exist without the shielding of solar radiation provided by the magnetosphere, created by the North and South magnetic poles. Global climate is moderated by Arctic cold. Polar sea ice and adjacent snow cover on land reflect major amounts of solar radiation back into space, cooling the planet. Boreal forests and permafrost underlying the taiga and tundra are major storehouses of carbon that might, in a warmer climate, be released into the atmosphere, exacerbating warming.

In addition to feeding, powering, defending, and protecting us, Arctic assets inspire us and teach us. From the smallest organisms at the base of the food chain, to the larger seals, birds, walrus, and bears at the top, Arctic living resources are diverse, sought after, and appreciated, and they are a popular tourist attraction. The Arctic's indigenous peoples contribute to global culture and knowledge in ways that are increasingly necessary and valuable. Today's Arctic residents continue to consider themselves pioneers, and are known in popular circles for exploration and discovery, and also in television shows such as the History Channel's "Ice Road Truckers," and the Discovery Channel's "The Deadliest Catch."

These Arctic assets are strategic, useful, and sustainable, but only if they are understood. To this end, the United States and other nations are engaged in research in Arctic science, history, medicine, social science, law, and other disciplines. In this US Arctic Research Commission report, we demonstrate that further, important research is required to better understand and protect our Arctic assets.

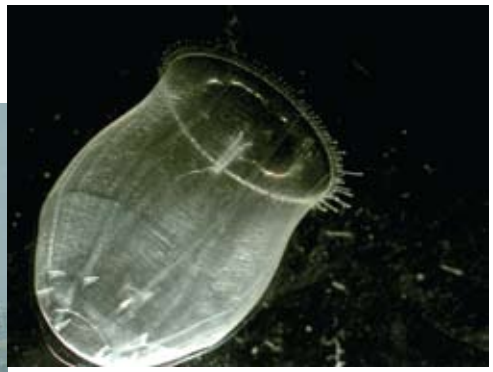
RESEARCH GOALS

The US Arctic Research Program must strengthen its efforts on five central and crosscutting themes:

1. *Environmental Change of the Arctic, Arctic Ocean, and Bering Sea*
2. *Arctic Human Health*
3. *Civil Infrastructure*
4. *Natural Resource Assessment and Earth Science*
5. *Indigenous Languages, Cultures, and Identities*

The Commission identified these five themes for the US Arctic Research Program in its 2007 goals report. The Interagency Arctic Research and Policy Committee (IARPC) adopted this report in 2007, and since then, the Commission and IARPC have been working together to revise the US Arctic Research Program's Five Year Plan that is called for in the Arctic Research and Policy Act of 1984, as amended. This plan will have up-to-date, integrated objectives in five areas outlined below. The development of each of these programs is at a different level of maturity. The Commission has modified the environmental change theme to include a new emphasis on the Arctic Ocean, which requires a new plan and commitment of resources.

The dramatic environmental changes occurring in the Arctic, which result from a changing climate, impact all five of these goals. Thus, USARC calls for a commitment to long-term and stable funding of research to ensure that appropriate observations are made in Arctic networks, and that the resulting time-series data are collected, distributed, and analyzed. These data will allow scientists to identify and better understand longer-term trends in climate, and to differentiate them from annual variability in weather. Although NSF and international partners have made progress in designing SAON, a strong need remains for further institutional commitment by NOAA and NASA, among other agencies, to finance and operate the system in the long term within the context of the Global Ocean Observing System and Global Climate Observing System. Such a need, on a broader scale, could be addressed by creating a National Climate Service, analogous to the National Weather Service, as has recently been proposed.



ABOVE. Aglantha. (Photo credit: R. Hopcroft)

LEFT. Bow and Ice, Herald Canyon. (Photo credit: S. Thornton)

RESEARCH INFRASTRUCTURE

To have an effective Arctic research program, the United States must invest in human capital, research platforms, and infrastructure, including new polar class icebreakers, and sustained sea, air, land, space, and social observing systems. The value of Arctic research is based on the quality of its researchers and the support of the public. Our research programs must work hand in hand with educators, support improved Arctic and ocean "literacy," and support training of young scientists with a focus on the Arctic. We must also enhance the educational "pipeline" that renews and sustains the research community examining Arctic problems and helps keep America competitive. The United States must renew international partnerships, strengthen and stabilize competitive funding for academic research, and build closer ties with the Arctic's indigenous residents. Relevant entities: OSTP, NSF, NOAA, NASA, USCG, Navy, and Native Alaskan organizations.

The Commission finds that the US Arctic Research Program's core asset—its people—needs attention and greater support. Comparing the first half of this decade (2001–2004) with the preceding one (1991–1995), NSF found that although 11% more bachelor's degrees were awarded in the earth, atmospheric, and ocean sciences in the most recent period, the number of doctoral degrees in these fields fell by 11%. Science and engineering doctorate production has depended heavily upon foreign students, who earn 33% of the total science doctorates and more than half of those in engineering (National Science Board, 2006).

As we complete the International Polar Year (2007–2009), we hope the nation will develop a new generation of polar researchers to carry on this vital work. The Commission calls on federal agencies and Congress to address this goal head on, with clearer, sustainable commitments to extramural funding of Arctic research programs. Outreach and education programs, which saw new initiatives during the International Polar Year, should be continued. Programs such as the Alaska Native Science and Engineering Program (ANSEP) at the University of Alaska help mentor native Alaska Native students of high-school age to join undergraduate and graduate programs at the university level. The Centers for Ocean Science Education Excellence (COSEE), including, COSEE Alaska, also play a critical role in bringing together the ocean sciences research community with educators and the general public, thereby encouraging new collaborations to create and disseminate knowledge, increase public understanding of scientific discovery, and enhance educational opportunities.

The Commission also acknowledges the success of two other programs. The NSF ADVANCE program, designed to recruit and retain women in science and engineering careers within universities, has significantly addressed the gender balance in academia. On an international scale, the Commission acknowledges the success of the Association of Polar Early Career Scientists (APECS). APECS is an international and interdisciplinary organization for young researchers (ranging from undergraduates to early faculty members, educators, and others with interests in polar regions) that stimulates research collaborations and develops leadership by facilitating networking, providing opportunities for professional development, and promoting education and outreach.

In addition to people, Arctic research relies heavily upon infrastructure such as satellites with sophisticated sensor packages, icebreakers with research equipment and laboratories, field stations and laboratories, networks of monitoring stations, buoys and cabled marine observatories, permafrost boreholes and tunnels, and autonomous unmanned vehicles.

Since the Commission's 2007 goals report, significant new investments have been made—or commitments are in place—for a new Alaska Region Research Vessel (R/V *Sikuliaq*), SAON, and new laboratories, including the Barrow Global Climate Change Research Facility on Alaska's North Slope, and NOAA's $51M Ted Stevens Marine Research Institute in Juneau, Alaska.

LEFT. Growlers. (Photo credit: K. Crane)

BELOW. Ice crystals. (Photo credit: M. Dunn)

The US government owns and operates three icebreakers capable of operating in the Arctic Ocean, two of which (*Polar Sea* and *Polar Star*) are considered "polar class." These vessels, essential platforms from which to conduct Arctic research, as well as to conduct many other critical missions, are both over 30 years old, beyond their service lives, and many reports (e.g., NRC, 2007a) have called for them to be replaced. The Chair of the National Academies study, Dr. Anita Jones wrote, "Our committee reaffirmed the value and efficacy of the USCG/research community partnership and recommended replacing the aging icebreakers with new ships, designed with research community involvement. The Coast Guard should be funded to build and operate the new ships" (Jones, 2007). A more recent report, from the Congressional Research Service (O'Rourke, 2009), recommends that Congress do the following:

- Approve the Coast Guard's current plan to study requirements for future icebreakers and then derive an acquisition strategy based on the results of these studies—a plan that might result in an initial replacement icebreaker entering service 8 to 10 years from now.
- Hold hearings to solicit additional information on the issue of polar icebreaker modernization; or direct the Coast Guard to provide such information.
- Direct the Coast Guard to include the option of nuclear power in its studies of requirements and design options for future icebreakers.

The Commission also highlights the need for stronger international and interagency partnerships. In some cases, US-Russian programs are failing due to a lack of high-level commitment and attention, and because of difficulties experienced by scientists in gaining access to certain areas, such as the offshore Russian Exclusive Economic Zone. Although important bilateral research programs exist with many nations, this report highlights the value of improving our joint work with Japan (which has put a strong priority on Arctic research climate change and in methane hydrates), Iceland (whose experience in alternative energy can help the United States achieve climate goals and sustain US Arctic residents), Norway (where government and industry supported oil-in-ice programs are vital to improving the safety of transportation and energy development throughout the Arctic), and Canada (where common work on ocean floor bathymetry and geology are helping both nations prepare extended continental shelf claims under the United Nations Convention on the Law of the Sea).

RESEARCH POLICY

The Arctic Research and Policy Act (ARPA) of 1984, as amended, established Arctic scientific research policy for the United States. This law promises much that has yet to be delivered. USARC, IARPC leadership, and the White House Offices of Science and Technology Policy and Management and Budget must work together, with Congress, to see that Arctic research policy is robust, and is translated into an effective, integrated, and forward-looking national Arctic Research Program Plan and associated budget as promised in ARPA. The new US Arctic policy (NSPD-66/HSPD-25) is a good start, but much work remains.

The Arctic Research and Policy Act requires federal agencies and the White House to present a clear, integrated Arctic research budget to the Congress and the public. The Commission is taking steps to see that this requirement is realized. Greater transparency of our Arctic science programs should quantify the balance between the government's internally conducted science, and that of extramural competitive science—and help the Commission, IARPC, and Congress determine whether that balance should shift.

The Commission calls for a strengthening of IARPC's ties to the National Science and Technology Council. It calls upon the US Coast Guard to reactivate the moribund Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), created by Congress in the Oil Pollution Act of 1990 (OPA90). It calls for continued work on the US Ocean Action Plan, predicated on the work of the US Commission on Ocean Policy, and on the new results from President Obama's Ocean Policy Task Force. And throughout, the Commission urges federal agencies to clearly identify and sustain competitive funding opportunities for the academic research sector, the nation's most vital resource in Arctic research.

With respect to international aspects of Arctic research, the Commission continues to encourage the US Senate to ratify the United Nations Convention on the Law of the Sea and the Stockholm Convention on Persistent Organic Pollutants treaty. The work of the eight-nation Arctic Council has been, and remains, vital to international collaborative efforts on scientific research. The call for research cooperation in the 2008 Ilulissat Declaration, issued by the five Arctic coastal States (United States, Canada, Russia, Norway, and Denmark), is also strongly supported by the Commission. The declaration states:

The five coastal states currently cooperate closely in the Arctic Ocean with each other and with other interested parties. This cooperation includes the collection of scientific data concerning the continental shelf, the protection of the marine environment, and other scientific research. We will work to strengthen this cooperation, which is based on mutual trust and transparency, inter alia, through timely exchange of data and analyses.

Inherent in the ability to conduct international research in the Arctic is the issue of access. If scientists are denied the ability to enter to the Exclusive Economic Zones of Arctic coastal states to conduct marine scientific research, or face insurmountable obstacles associated with national visa and immigration policies, or in the ability to bring equipment into and out of countries, then research is stymied, to the benefit of none. The Commission has witnessed many examples where international cooperation and coordination of Arctic research not only successfully addresses key scientific issues, but also serves as a means of building positive relationships among countries, furthering understanding, and improving diplomacy among nations. The 2004 Arctic Coring Expedition of the international Integrated Ocean Drilling Program is a perfect example.

CONCLUSION

The Commission's 2009–2010 report coincides with the conclusion of the first International Polar Year (IPY) in 50 years. Although the 2007–2008 IPY has drawn to a close, we must continue the research momentum begun during this period. Scientific results are still coming in, and will be reported at upcoming international conferences. Cooperation must be maintained. Infrastructure, as well as knowledge and understanding, must be the IPY legacy.

This Commission strongly endorses President Obama's address to the members of the National Academies, on April 27, 2009, where he called science "more essential for our prosperity, our security, our health, and our environment than it has ever been," and promised to make major investments—more than 3% of the gross domestic product—in research and innovation, exceeding what was invested in 1964, at the height of the space race. He also emphasized the importance of using funds to encourage high-risk, high-return research and to support researchers at the beginning of their careers.

The Commission urges enhanced levels of stable funding, especially for large interdisciplinary research facilities in the Arctic. These facilities form the long-term base of cutting-edge scientific research in these inhospitable areas. Antarctic research has profited from such a base of support for facilities and equipment, allowing initial laboratory analyses of collected samples to be conducted in the field. The Arctic needs a similar US science commitment. Such funding is also needed to remediate the unfunded mandates of several federal agencies, with the notable exception of NSF, to participate in supporting the IPY's legacy. The last Polar Year, which expanded into the International Geophysical Year in 1957, initiated decades of sustained scientific research on Earth processes and provided the data and technologies responsible for revealing the magnitude of our current environmental changes. Sadly, the recently completed IPY is unlikely to repeat this achievement, as the funding not only did not increase, but for many agencies it decreased.

ABOVE. Ice-edge. (Photo credit: M. Dunn)

LEFT. Ice boulders at sunset. (Photo credit: M. Dunn)

ARCTIC BOUNDARY AS DEFINED BY THE ARCTIC RESEARCH AND POLICY ACT (ARPA)

All United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi seas; and the Aleutian chain.[1]

ACKNOWLEDGEMENT: Funding for this map was provided by the National Science Foundation through the Arctic Research Mapping Application (http://armap.org) and Contract #0520837 to CH2M HILL for the Interagency Arctic Research Policy Committee (IARPC).
MAP AUTHOR: Allison Gaylord, Nuna Technologies. May 27, 2009.

[1] The Aleutian chain boundary is demarcated by the "contiguous zone" limit of 24 nautical miles.

(Photo credit: M. Dunn)

Ridge peaks in the late-day sun.
(Photo credit: M. Dunn)

MAJOR RESEARCH PROGRAM RECOMMENDATIONS

The US Arctic research program must strengthen its efforts on five central and crosscutting themes.

1. Environmental Change of the Arctic, Arctic Ocean, and Bering Sea
2. Arctic Human Health
3. Civil Infrastructure
4. Natural Resource Assessment and Earth Science
5. Indigenous Languages, Cultures, and Identities

In 2007, the USARC *Report on Goals and Priorities for US Arctic Research* focused on building a robust and effective interagency program based on these five major themes. They span a wide range of basic and applied research topics, from Earth system science, to human health initiatives, to the social sciences, to engineering and technology development. Arctic change and its relation to global climate change is a thread that weaves these five themes together. In 2007, we added theme five—research related to indigenous languages, cultures, and identities. It represents the first research goal brought forward in the Commission's history with a basis in the humanities and social sciences rather than in the physical, biomedical, or geophysical sciences, or in applied engineering.

In 2009, we urge IARPC to continue its work to revise and strengthen the US Arctic Research Program's five-year plan along the same five themes. We applaud IARPC's work to make a new start on themes two through five, and its work to develop SAON as a major contribution to theme one. As noted above, we modified the first theme to include a new emphasis on the Arctic Ocean. In this report, we also recommend a series of new or renewed initiatives under each of the five themes, several of which have a strategic, immediate impact upon the nation. Our recommendations are included below in the discussion of each theme.

1 ENVIRONMENTAL CHANGE OF THE ARCTIC, ARCTIC OCEAN, AND BERING SEA

INITIATIVES RECOMMENDED BY THE COMMISSION

- With international partners, continue to develop and "operationalize" SAON to gain greater understanding of pan-Arctic change.

- SEARCH must further address the troubling lack of understanding of global climate impacts from processes such as Arctic sea ice reduction, melting glaciers and ice sheets, ocean acidification, methane release, and black carbon deposition. These factors can make or break the effectiveness of a global climate change mitigation regime.

- The "newly accessible" Arctic Ocean is inviting to commercial fishing, shipping, tourism, mineral, and energy extraction. The United States has barely started the baseline oceanographic research necessary to support US and Arctic Council goals for ecosystem-based management in the Arctic Ocean. This research should move forward, patterned to support marine spatial planning, a tool that enables integrated, forward-looking and consistent decision making on the use of the sea. Although legislation is pending in Congress to help plan this study effort through a National Research Council process, we urge IARPC to work with its members, the North Pacific Research Board, the Alaska Ocean Observing System (AOOS), and the North Slope Science Initiative (NSSI) to develop a plan and new sources of funding for an Arctic Ocean initiative similar to the Bering Sea Ecosystem Program-Bering Sea Integrated Ecosystems Research Program (BEST-BSIERP), the historic partnership between the National Science Foundation and the North Pacific Research Board. In this vein, the President's Ocean Policy Task Force heard widespread calls for better Arctic Ocean baseline research during its field visit to the Arctic and first regional public meeting in Anchorage, August 18, 2009.

Within the US Arctic Research Program Plan, the largest focus of current work is on understanding climate change. Work in the Arctic has made major contributions to global climate change science, both through the US Climate Change Science Program (CCSP) and the United Nation's Intergovernmental Panel on Climate Change (IPCC). Observing systems established in the Arctic are set to make major data set contributions to the Global Earth Observing System of Systems (GEOSS). Likewise, these observing systems have contributed to and have benefitted from emerging local observing systems and science programs, such as AOOS, NSSI, and the Barrow Environmental Observatory (BEO).

Below, we suggest ways to further improve the process of building SAON and we suggest ways SEARCH can put those observations to work with immediate benefits to global efforts to mitigate climate change.

SUSTAINING ARCTIC OBSERVING NETWORK (SAON)

In April 2007, and in response to the recommendation of this Commission, IARPC called for the development of a government-wide Arctic Observing Network to observe key parameters of Arctic climate and society, and to allow us to begin to understand the causes and consequences of Arctic change. As a basis for this work, in 2006, the National Academy of Sciences prepared a report, *Toward an Integrated Arctic Observing Network* (NRC, 2006). In 2007, with leadership from NOAA and NSF, IARPC prepared a summary, *Arctic Observing Network (AON): Toward a US Contribution to Pan-Arctic Observing* (Jeffries et al., 2007), which reviewed ongoing and future federal Arctic observing activities and developed a strategy to enhance, coordinate, and integrate US observing efforts.

Twice now, foreign ministers of the Arctic Council's eight nations committed support for an international SAON effort; the US participates in an international initiating group to enhance cooperation. The greatest source of extramural funding for US principal investigators to develop projects in support of pan-Arctic observing has been NSF's Office of Polar Programs, which initiated this support prior to the present IPY, and continues it from the core NSF budget and the 2009 economic stimulus package. Enhanced coordination and integration of observing activities, and management of data and information, are now enabling scientists to respond with increased agility to many of the questions posed by SEARCH, IPCC, and others.

RECOMMENDATIONS

The Commission recommends that IARPC make a long-term commitment to an operational SAON. To date, most of the AON/SAON work has been conducted through NSF-funded short-duration research grants, with specifically designed, hypothesis-driven research objectives. For the long-term, AON/SAON needs a "home" and a commitment to provide continuing funding because the power and value of Arctic observations are inherently linked with the consistency and length of time over which they are made. The question of how this enduring effort will be structured and financially supported has yet to be fully answered within the United States, specifically within IARPC, or within the international SAON initiating group. All of the following entities need to be part of the enduring picture: NOAA, NASA, NSF, the State of Alaska, the University of Alaska's facilities, including Toolik Field Station, research programs such as the NPRB, and core interagency efforts in Alaska, such as AOOS, BEO, NSSI, and the Prince William Sound Oil Spill

ABOVE. Polar bear. (Photo credit: E. Kristof)
LEFT. Reindeer. (Photo credit: M. Dunn)

LEFT. Belugas in the Bering Sea seen during the April 2006 US Fish and Wildlife Service (USFWS) walrus survey. (Photo credit: USFWS/Brad Benter)
BELOW. Drilling through ice. (Photo credit: M. Dunn)

Recovery (OSRI). For example, support for AOOS would be a valuable US investment in ocean research and monitoring that would help us understand sea ice variability, cross-shelf ecosystems, and climate change.

To help achieve sustained funding, both in the United States and internationally, AON/SAON organizers need to develop a specific list of gaps in their capability to monitor high-priority science objectives. How many rivers are yet to be gauged for water flow? How many buoys are needed to define Arctic Ocean circulation patterns, sea ice thickness and distribution, and changing atmospheric temperatures and pressures? What new satellites are needed to collect required data sets? The Commission is prepared to advocate funding or partnerships to fill these gaps, when such a list is produced. We recommend that the next revision of the US Arctic Research Plan include specific, hard sensor and data management targets to make capitalization and operating cost targets of the observing network far more transparent.

When fully implemented, AOOS will be able to detect changes in the marine environment, in marine ecosystems, and in living resources. These abilities will be critical in the Arctic, such as in the Bering Strait region and off the North Slope of Alaska. The information from this system will also be used to predict future changes and their consequences. Because of the pivotal role of the Bering Strait in AON and in the nation's ocean monitoring network within the highly productive Bering Sea ecosystem, the Commission stresses the need for long-term support for AOOS as a line item in either the NOAA or ONR budget.

From a scientific standpoint, the Commission further recommends that AON/SAON work closely with predictive modeling efforts, marine spatial planners, and resource and wildlife managers to ensure that the data being collected meet the needs of these downstream users. A working group empaneled by the Commission to look at scaling issues has identified a set of questions to be considered as data collected on a small, local scale are extrapolated to form regional or global predictions. Also, model predictions on large or even global scales need to be modified to provide output on smaller scales. The working group report on scaling issues will be posted at http://www.arctic.gov after publication in 2010.

STUDY OF ENVIRONMENTAL ARCTIC CHANGE (SEARCH)

SEARCH is a comprehensive US national initiative to study Arctic climate change (SEARCH SSC, 2001). To date, it is the most robust interagency program convened by IARPC in response to Commission goals, and the program has made major contributions. Over 70 projects have been funded by several different agencies. These projects are focusing on the nature, extent, and possible future system-scale change in the Arctic environment by observing, understanding, and ultimately responding to environmental change. The science conducted by SEARCH spans terrestrial, oceanic, atmospheric, and social systems in the Arctic. Given the nature of the initiatives, SEARCH and AON are closely linked. Some consider AON the "front-end" observing component of SEARCH, which includes understanding and responding as two major programmatic goals.

SEARCH focuses on four major activities:

- Long-term observations to detect and monitor environmental change
- Modeling to synthesize observations, test hypotheses, and attempt to predict future change
- Process studies to understand the science behind environmental forces, interactions, and feedback
- Helping citizens and governments respond to the impact of change on ecosystems and societies by providing an understanding of what has been learned

Careful planning of SEARCH was required given the broad interdisciplinary science agenda, interagency interests, long time horizon, and international aspects. These program attributes have permitted evolution of a science advisory structure comprised of a committee with three panels: (1) Observing Change, (2) Understanding Change, and (3) Responding to Change. Thus, while the initiative is fundamentally science-driven, it also informs policymakers. The implementation blueprint is presented in *SEARCH: Plans for Implementation During the IPY and Beyond*, published in 2005. Each panel's agenda is distilled into a series of specific tasks and actions:

OBSERVING. Activities include: data rescue; improving observation density, collocation, and integration; improving coverage to close observation gaps; developing optimal observation and sampling strategies; observing key processes and studying feedbacks; acquiring paleoclimate and paleoenvironmental data over critical time periods; developing networks; developing data archival and distribution systems; and using innovative technologies.

Caribou trophies.
(Photo credit: J. Farrell)

UNDERSTANDING. Types of activities include: model-based assimilation of currently available observations; improving and expanding model capabilities; model simulations for forecasting and for guiding observing system design; developing and using of proxy records; diagnostic analyses of synthesized observations and paleoreconstructions; and studying interactions between the Arctic environment and socioeconomic and cultural changes.

RESPONDING. Types of activities include: providing stakeholder-driven guidance to observe and identify useful predictions; interpreting modeling/analysis results in the context of local knowledge; assessing responsiveness and effectiveness of institutions in addressing social and economic concerns about climate change; and developing community-based networks and cooperatives to facilitate these activities.

RECOMMENDATIONS

First, expeditiously, SEARCH must further address the lack of understanding of the global climate impacts from Arctic sea ice reduction, melting glaciers and ice sheets, ocean acidification, methane release, and black carbon deposition. These factors significantly impact the effectiveness of any global climate change mitigation regime. These questions gain importance as the United States prepares for future Conferences of the Parties in the United Nations Framework Convention on Climate Change, such as the recently held conference in Copenhagen.

Key science questions include: What is the contribution to Earth's heat budget from lost reflection of Arctic sea ice? Is it true that "Arctic amplification," where temperatures rise in northern latitudes to a much greater degree than global averages, means a large volume of greenhouse gases are set to be released from decomposing organic matter in warming permafrost? If so, will those gases "overpower" any mitigation scheme adopted to reduce anthropogenic greenhouse gas emissions? Do scientific results back up the hypothesis, embodied in the Arctic Council's Task Force on Black Carbon and other short-term forcers of climate change, that reducing methane and black carbon emissions could help slow the retreat of sea ice?

Second, SEARCH is the best example of both the success and the shortcomings of the current coordination process of US Arctic research. Although the Arctic Research and Policy Act requires an integrated Arctic research budget, IARPC, OMB, and OSTP have not produced one. That breach should be rectified, not only to gauge SEARCH's progress toward its objectives, but also to provide greater transparency for this important program. Lacking this information, neither the Commission nor Congress can conclude what kind of further funding is needed.

Third, US agencies supporting climate related research in the Arctic region should make sure that their Arctic programs are integrated with SEARCH. NSSI, NPRB, and AOOS activities, conducted outside direct agency command and control, should also be included. Likewise, SEARCH activities should be clearly recognized and integrated into any upcoming revisions of national climate change science programs and ocean science programs, as well as international, pan-Arctic climate research programs such as the International Study of Arctic Change (ISAC), under the aegis of the International Arctic Science Committee (IASC) and the Arctic Council's Arctic Monitoring and Assessment Program (AMAP).

Fourth, the Commission commends the process used to date by IARPC's lead agency, NSF, to outsource coordination of SEARCH activities to the Arctic Research Consortium of the United States (ARCUS). ARCUS leadership of SEARCH efforts has helped keep extramural climate research (that performed by academic institutions rather than government agencies) strong, and has supported a bottom-up, rather than top-down, process for setting research priorities. We urge the continuation of this leadership model, and its replication, where possible, with IARPC's other thematic

LEFT. Mountains from above. (Photo credit: J. Farrell)
BELOW. Sea ice. (Photo credit: J. Farrell)

programs. It is also critical to engage the private sector, which has commercial interests in the nature of Arctic change, for example, through policy forums and funded research avenues (e.g., Small Business Innovation Research).

Fifth, we urge SEARCH to respond further to the increasing need for more precise modeling of climate change in the Arctic region. Resource management decisions ranging from the Endangered Species Act status of polar bears, oil and gas development, fisheries openings and closures, shipping regulations, and onshore tundra travel, among others, rely on high-quality regional as well as global assessments and predictions.

Sixth, the Commission applauds the active, continuing synthesis and outreach components of SEARCH embodied in the *State of the Arctic Report* (Richter-Menge et al., 2008) and the continuing Arctic Report Card, annual Web-based updates (e.g., Richter-Menge and Overland, 2009). SEARCH findings played an important part of IPY outreach programs as well, and those outreach programs should continue. We recommend regular SEARCH synthesis workshops to help integrate SEARCH efforts across the government.

RUSSIAN-AMERICAN LONG-TERM CENSUS OF THE ARCTIC (RUSALCA)

The RUSALCA program makes long-term observations in US and Russian territorial waters to better understand the causes and consequences of the reduction in sea ice cover in the northern Bering and Chukchi seas. Among the "consequences" is the rapid change in the marine ecosystem that is being observed, coincident with the retreat of sea ice. The program is based on a memorandum of understanding (MOU), beginning in 2003, between NOAA and the Russian Academy of Sciences.

Support for RUSALCA Bering Strait oceanographic moorings (that monitor currents, temperature, salinity, productivity, and nutrients) in Russian and American waters are funded annually by NOAA, NSF, and Russia's Roshydromet. As an integral part of AON, long-term support for these moorings is an essential part of our IPY legacy. Scientific data derived from this effort help us understand how climate change will affect storms in our coastal communities, how marine mammal and fisheries resources will vary, and how transportation needs in the Arctic will evolve.

The RUSALCA program began in summer 2004 with a multidisciplinary cruise on the Russian R/V *Khromov* to investigate seawater-column physics, nutrient chemistry, and biology. Moorings deployed in the western Bering Strait in 2004 have been recovered and redeployed annually. Beginning in 2007, the RUSALCA program has planned joint annual cruises focusing on the physics in the Bering Strait region, and an even more extensive multidisciplinary cruise was carried out in 2009 and will be repeated in 2012. The 2008 field program successfully recovered and redeployed eight moorings across the entire Bering Strait and retrieved oceanographic data confirming a record warm Pacific water flux in 2006 and 2007. On August 22, 2009, the RUSALCA mission embarked from Nome, Alaska, on the R/V *Khromov* for a 40-day voyage into the Bering Strait and northward to the Pacific side of the Arctic Ocean. Due to the severe reduction in sea ice cover, the expedition was able to take the first fish trawl at 77°N above the Chukchi Plateau, about 300 km north of the 2004 northernmost site.

RECOMMENDATION

USARC strongly urges an immediate appropriation of funding to NOAA's Arctic and Ocean Exploration programs, including a line item for the RUSALCA program, to honor the MOU between the governments of Russia and the United States, through NOAA. Failure to regularly fund the American contribution to this joint research effort jeopardizes future access to Russian territorial waters and opportunities to share sampling platforms. Elsewhere in this report, the Commission recommends further work to strengthen US-Russian cooperation in Arctic research.

LEFT. Fish drying rack on Kotzebue Sound. (Photo credit: J. Farrell)
BELOW. Arctic tundra. (Photo credit: B. Molnia)

BERING SEA AND ARCTIC OCEAN ECOSYSTEM STUDIES

In every biennial USARC *Report on Goals and Objectives for Arctic Research* (herein referred to as USARC Goals Report) since 1995, a key priority has been research in the Bering Sea. For several reasons, most related to the greater accessibility and human use of the Arctic Ocean, we expand that priority to include the Arctic Ocean, especially the Chukchi and Beaufort seas off the US coast.

BERING SEA

Information from the Bering Sea research effort helps support management decisions associated with this highly productive ecosystem. The Bering Sea contains vast numbers of marine birds and mammals as well as productive commercial fish and shellfish species that total to more than 50% of all landings (by volume) in the United States. The Bering Sea also provides over 25 million pounds of subsistence foods used by nearly 55,000 Alaskan Native residents, primarily in small rural communities.

Prior USARC goals reports expressed concern about the deficiency of integrating observations and data from many projects and programs, and emphasized our lack of ability to predict changes occurring in the Bering Sea system resulting from natural and human factors. Since then, considerable attention has been directed toward these priorities. Many of the key agencies and institutions that support such research joined in a Bering Sea Interagency Working Group (BIAWG), created by IARPC, which meets annually. BIAWG has drafted a strategy to coordinate and integrate research of the Bering Sea ecosystem and its living marine resources. The working group report (BIAWG, 2006) focused on four core questions:

1. How does the Bering Sea ecosystem respond to climate change and variability?
2. Is the current warming of the Bering Sea due to decadal variability, or a result of a long-term secular trend?
3. Can we predict the effects that the warming and changing sea-ice dynamics will have on the biological resources of the Bering Sea (commercial, subsistence, ecological, and protected)?
4. What measurable factors (physical, chemical, and biological) serve as the best indicators of ecosystem change at different trophic levels and different spatial/temporal scales?

Organizations represented on the BIAWG, their areas of interest or responsibility, and their budgetary commitments are:

- ALASKA OCEAN OBSERVING SYSTEM (NOAA/AOOS) anticipates a Bering Sea monitoring program expenditure of > $1M per year (subject to congressional approval).

- BERING ECOSYSTEM STUDY (BEST, NSF) has $21M of extramural research, including $11M for ship time over four years of expeditions, and resources for a subsequent year of analysis and reporting. During the expeditions, support is budgeted for two to three months of icebreaker time and three to four months of ice-strengthened ship time annually.

- ALASKA FISHERIES SCIENCE CENTER (AFSC, NOAA NMFS) conducts studies mandated by the Magnuson-Stevens Fishery Conservation and Management Act, the National Environmental Policy Act, and the Marine Mammal Protection Act. AFSC conducts routine surveys and assessment studies on Bering Sea living marine resources, including groundfish, rockfish, juvenile salmon, forage fish, crab, Steller sea lion, northern fur seal, harbor seal, ice seal, gray whale, northern right whale, and humpback whale. NOAA provides ship time on its research vessels *Miller Freeman* and *Oscar Dyson*. AFSC scientists are also responsible for two interagency coordinated research efforts:

  - NORTH PACIFIC CLIMATE REGIMES AND ECOSYSTEM PRODUCTIVITY (NPCREP) project (FY07 $2M, FY08 $4M, level funds thereafter) detects and measures ecosystem changes. NPCREP will expand existing, and initiate new, long-term observing sites on the Bering Sea shelf and, upstream, in the Gulf of Alaska.

  - LOSS OF SEA ICE (LOSI), proposed in FY08 ($2M), extends fish assessment surveys farther north, initiates annual assessments for ice-dependent seals, and models the population dynamics of new species that may be managed if fishing is extended northward. Scientists from AFSC, PMEL, and NPRB drafted the LOSI implementation plan with a targeted start date of spring 2009.

- PACIFIC MARINE ENVIRONMENTAL LABORATORY (PMEL, NOAA) PMEL scientists partner with AFSC scientists and compete for NPRB and NOAA grants.

- NORTH PACIFIC RESEARCH BOARD (NPRB) provided $16M in extramural funding for the Bering Sea Integrated Ecosystems Research Program (BSIERP), including funds for ship time for six fiscal years starting in 2007. NPRB anticipates a planning year, three major field seasons during calendar years 2008–2010, and two years of analysis and reporting.

- UNIVERSITY OF ALASKA FAIRBANKS (UAF), School of Fisheries and Ocean Science (SFOS) faculty members, among others in the nation, compete for BEST, NPRB, and NOAA funds to support researches on the Bering Sea ecosystem.

- US FISH AND WILDLIFE SERVICE (USFWS) has management responsibilities for sea otters, Pacific walrus, and polar bears, and manages refuges in and adjacent to the Bering Sea. USFWS is also the trust agency for all migratory birds and regulates and monitors their spring and sport harvest. USFWS also manages threatened, endangered, and at-risk species. USFWS and USGS conduct seabird counts.

- NORTH PACIFIC FISHERIES MANAGEMENT COUNCIL (NPFMC) has implemented an Arctic Fisheries Management Plan that covers the offshore area from 3–200 miles into the Chukchi and Beaufort seas. We recognize the growing contributions of community-based groups earning funds through the North Pacific Fishery Management Council's Community Development Quota (CDQ), and urge their integration into the science program.

- USARC provides advice and makes recommendations to the President and Congress on Arctic research needs.

In 2007, NSF and NPRB formalized a $52M joint management plan for a six-year study of the Bering Sea ecosystem, a partnership to support a comprehensive, vertically integrated study, during 2007–2012, through NSF's BEST and NPRB's BSIERP programs. The plan concentrates research efforts on the eastern Bering Sea shelf between the Aleutian Islands and St. Lawrence Island. NSF provides support for the lower trophic levels, up to and including macrozooplankton and benthic infauna, and supports social science projects focusing on the relationships between a changing marine environment and the adjacent communities. NPRB supports studies of the upper trophic levels, macrozooplankton and benthic fauna, up the food

ABOVE. US Airforce Long Range Radar Site near Kotzebue. (Photo credit: J. Farrell)
RIGHT. Kivalina resident. (Photo credit: J. Farrell)

chain to include humans, their communities, and social and economic impacts. Protocols for jointly considering the scientific proposals to the two organizations, as well as coordinated planning efforts and data sharing protocols assure coordinated research.

Recommendations

USARC applauds this ground-breaking cross-agency collaboration between NSF and NPRB, and now urges Congress and NSF to support the alignment and overall synthesis of the BEST and BSIERP programs, such as through an NSF announcement of opportunity, to ensure the greatest return on the initial investment.

In response to a NPRB request for proposals, the North Pacific Marine Science Organization (PICES) released PICES Scientific Report No. 33 (Kruse et al., 2006), which addressed the previously articulated USARC need for research on the ability to predict changes occurring in the Bering Sea from natural and human-induced causes. Some recommendations resulting from the workshop echo concerns shared by USARC, and include:

1. Ecosystem-level and community-level conservation thresholds are relatively new ideas in marine conservation. Because they will require new kinds of indicators, research is needed to develop and apply them in the Bering Sea.

2. New research is needed to understand how to synthesize the large set of Bering Sea data records into a reasonable number of ecosystem status indicators.

3. Enhancements to the ocean/ecosystem monitoring network are needed to fill ecological data gaps at several points (plankton, benthic infauna and epifauna, seasonal species interactions and movements, small pelagics, and cephalopods) to improve predictive models and the development of ecosystem indicators.

4. A healthy relationship between Alaska Native communities and the marine ecosystem requires a high level of attention. Socioeconomic objectives related to the marine environment should be developed for the region, along with their indicators and reference points. Effective solutions will likely require policy that is formulated from the integration of traditional ecological knowledge (TEK) with complementary scientific research from a variety of disciplines, such as biology, ecology, economics, political science, and sociology. Co-management groups funded by NOAA and USFWS, including the Alaska Sea Otter and Sea Lion Commission, the Alaska Nanuuq (polar bear) Commission, the Eskimo Walrus Commission, the Alaska Eskimo Whaling Commission, and other marine

USARC Chair Mead Treadwell and USCG Avionics Electrical Technician First Class Jody Sullens on a USCG Hercules C-130 Arctic Domain Awareness flight over the Beaufort Sea. (Photo credit: J. Farrell)

mammal commissions, can provide important observational data through TEK, which is crucial to maintaining and incorporating Alaska Native involvement and partnership, and closely link scientific research to support socioeconomic and social-ecological goals.

5. Plans should be developed to better communicate results to scientists, policymakers, and decision makers, and the general public.

USARC welcomes the lead that NPRB has taken in soliciting international input in developing ecological indicators for the Bering Sea and in reiterating the need for dedicated federal funding to each of the collaborating BIAWG programs. NPRB is also commended for successful outreach activities and encouragement of TEK.

Finally, USARC recommends support to develop AOOS in the Bering Strait region as described in the Bering Strait Regional Case Study in the *Arctic Marine Shipping Assessment* (AMSA, 2009).

ARCTIC OCEAN

Significant research in the Arctic Ocean has been funded by DOI's Minerals Management Service (MMS), NOAA, NSF, private oil and gas exploration enterprises, and others. NPRB and AOOS are poised to provide funding for Arctic Ocean research, subject to developing an integrated science plan. The North Pacific Fisheries Management Council's moratorium on commercial fishing in the US Arctic Ocean Exclusive Economic Zone points out the need for good baseline ecosystem studies in the area. Oil and gas exploration plans, and greater shipping use of this ocean, further point out the need for solid understanding of the biology of this region to avoid adverse impacts. Internationally, many policy analysts and decision makers have suggested the Arctic Ocean is a good place to apply marine spatial planning and ecosystem-based management across national jurisdictions and in the high seas. Such an effort requires an enhanced understanding of the Arctic ecosystem rooted in multiyear data sets.

How do we get there? The Commission thanks AOOS and NPRB for its leadership in convening experts on this question. A workshop on Arctic Research and Monitoring on January 23, 2009 followed an initial Arctic Research and Monitoring Collaboration Roundtable held in the summer of 2008 (Dorman, 2009). The goal was "*to share information and promote collaboration among the many entities with increasing activities in marine research and monitoring in the Alaska maritime Arctic (Chukchi and Beaufort Seas), including the oil and gas industry, local, state and federal agencies, and nongovernmental and academic organizations.*"

Two researchers presenting at the workshop, Russ Hopcroft and John Walsh, were cited in the workshop report as having a common conclusion: "*…although the anthropogenic and natural forces driving climate change in the Chukchi and Beaufort largely come from outside the area, the impacts have*

already started, will be large, fundamental, and irreversible, will require more precise coupling of models (atmosphere, snow, sea ice and ecosystem), and will necessitate significant adaptation by virtually all trophic levels in the ecosystem, from microbes to man."

A number of organizational steps were discussed at the workshop. Most current "investors" in Chukchi and Beaufort research from federal, state, private industry, and academic institutions were present, and collaboration in data sharing was increased as a result. An integrated science plan should be produced by an active group of stakeholders who represent these broad constituencies.

USARC has cosponsored several workshops, symposia, conferences (such as the annual Alaska Marine Science Symposium), and other efforts on Arctic Ocean research, and will continue to do so.

Recommendations

First, IARPC, in the context of the national review of ocean policy called for by President Obama, should establish an umbrella science plan for the Arctic Ocean, and put a structure in place with clear research objectives. As a guide, we recommend that IARPC use the report from the workshop on Arctic Research and Monitoring sponsored by AOOS and NPRB (Dorman, 2009) and the NPRB Arctic synthesis report by Hopcroft and others (Hopcroft et al., 2006).

Second, a research plan for the Arctic Ocean should be patterned to support marine spatial planning. We recognize the newly accessible Arctic Ocean is inviting to commercial fishing, shipping, tourism, mineral, and energy extraction. The United States has barely started the baseline oceanographic research necessary to support US and Arctic Council goals for ecosystem-based management in the Arctic Ocean.

Third, USARC recommends that NSF and NPRB move forward together and obtain support from other groups such as AOOS and NSSI to create and support an initiative to understand the Arctic Ocean marine ecosystem similar to their joint effort on the Bering Sea ecosystem through the six-year, $52M BEST-BSIERP effort.

Fourth, recent studies have begun examining the impact of environmental pollutants, bioaccumulation, and climate change on food safety and health. Because the Arctic is a unique and to a great extent an unexplored or measured environment with regard to health issues, it requires a specialized research approach to meet the health care needs of its people. To the end, the Commission calls on the US Senate to ratify the Persistent Organic Pollutants treaty. Arctic indigenous residents unfairly endure multiple health disparities; research into such ailments should appeal to a wide variety of institutes and centers at NIH and NIMH as well as the Fogarty International Center. For example, infectious diseases, cancer, heart disease, obesity, diabetes, and various mental health issues are overrepresented in Arctic populations.

Fifth, consistent with the recommendations from the first International Arctic Fisheries Symposium, held in Anchorage in October 2009, the Commission calls for increased cooperative research as a basis upon which decisions will be made for future Arctic fisheries. The symposium should also be reconvened regularly so that scientists and policymakers from several countries, representing different perspectives, may come together and discuss common issues.

Sixth, international focus on ocean acidification must include the current and potential impacts on the ecosystems of the Bering Sea and the Arctic Ocean, which contain waters that are already more corrosive to carbonate (i.e., lower carbonate ion concentration) than in the equivalent Arctic water masses in the Atlantic sector. What is the current impact of acidification on species that are particularly susceptible to dissolution, such as pteropods (among the food sources for salmon), or on larval blue king crab, or on shellfish, such as scallops? In the United States, funding has been provided to NOAA, NSF, and EPA to focus greater attention on ocean acidification, and the National Academy of Sciences and The Oceanography Society recently released publications on this topic (see December 2009 issue of *Oceanography* at http://tos.org/oceanography/issues/issue_archive/22_4.html). The impacts of acidification on Arctic waters must be an integral part of these activities and reports.

Prized catch of bowhead whale in Barrow, Alaska. (Photo credit: C. Rosa)

2 ARCTIC HUMAN HEALTH

US Arctic residents suffer from a wide range of severe physical and behavioral health issues with a far higher incidence in comparison to their counterparts in the lower 48 states. Life expectancy among the Alaskan indigenous population (approximately 15% of the total Alaskan population, or 100,000 people, according to the US Census Bureau) can be short and tragic. Death rates due to accidents and suicides of young adults are the most frequent and infant mortality rates are higher (Wigle et al., 2005) than for natives in the lower 48 states. Over one-third of rural Alaskan women become victims of an intimate partner (Wagner et al., 1995). Although the transition from a traditional subsistence lifestyle and socioeconomic system toward a cash economy has brought rapid economic change and new technologies, it has also markedly increased the prevalence in the native population of acute and chronic diseases such as cancer, diabetes, hypertension, obesity, cardiovascular diseases, alcoholism and drug abuse, as well as domestic violence, child abuse, accidents, and mental illness, including mood disorders, and suicide.

The US Arctic Research Program needs to make a generational commitment to conduct research to improve the plight of Alaska's native people, described in the Pulitzer Prize winning series, "A People in Peril" (1988, *Anchorage Daily News*). Despite over 20 years of public awareness of the health problems of indigenous people in Alaska, and meritorious attempts at prevention and control of some of these diseases by the health agencies of the State of Alaska, the Indian Health Service, and more recently the empowered tribal health consortia, there are precious few examples of improvement and, instead, there has been a progressive increase in the rates of suicide, alcoholism, and accidents in Alaska Natives. In addition, their death rate from lung cancer is increasing. The Arctic's First People have many threats and challenges before them.

As IARPC establishes its priorities for US Arctic Human Health research, DHHS has designated the Fogarty International Center at the National Institutes of Health (NIH) as the point of contact for Arctic health research matters. We applaud the leadership Fogarty has given in responding to the Commission and the IARPC mandate to develop an Arctic Health Research Program Plan. We encourage other federal agencies dealing with Arctic health research issues—the Department of Health and Human Services (e.g., Centers for Disease Control and Prevention [CDC], individual NIH institutes, the Substance Abuse and Mental Health Services Administration [SAMHSA]), EPA, DOI, and others—to dedicate more resources to Arctic health research.

CDC and the various institutes and centers at NIH spend approximately $24M annually on research activities in Alaska, and a portion is directed to assessing and improving human health. For example, studies of the weight, nutrition, and health of Alaska Natives are conducted by the UAF Center for Alaska Native Health Research (CANHR), which was established through a grant awarded by NIH's National Center for Research Resources (NCRR). Because Arctic residents unfairly endure multiple health disparities, and are considered "underserved" in the majority of rural areas, research into such ailments should appeal to a wide variety

of institutes and centers at NIH. For example, infectious diseases, cancer, heart disease, and mental health all have their unique aspects within Arctic populations.

There is a growing circumpolar collaboration in Arctic health research, supported by the work of the International Union for Circumpolar Health (IUCH), the Arctic Council's Sustainable Development Working Group, and the individual efforts of Arctic nations and research institutions. Unfortunately, despite the enormous toll on the people of Alaska and the Arctic, there are no NIH-sponsored studies of depression, alcoholism, suicide, or cancer in Alaska Natives. The Commission has identified several research approaches to improve health in Native communities. These include expanding the understanding of traditional healing methods and improving more clinically based approaches. Further investigation of genetic factors may assist in identifying and understanding any propensity that may exist for cancer, other chronic diseases, or mental health problems in indigenous populations.

Inupiat living in Northwest Alaska have one of the highest youth suicide rates in the world (Wexler, 2006). This situation is an unacceptable expression of the depression and alcoholism caused by a variety of known and unknown malignant factors, including cultural and language devaluation, loss of cultural identity, climate change, and the lack of jobs and work in native communities. Other countries (e.g., New Zealand) have faced similar problems in their native population and have succeeded in reducing the suicide rates. We need to make Alaska a healthier place for Alaska Natives to live in. The Commission has found that the nation's medical researchers, with specific expertise in these health problems, do not have enough awareness of the health challenges faced by Alaska Natives. NIH and the National Institute of Mental Health (NIMH), while sympathetic to these problems, have told the Commission that more proposals are necessary from the national medical research community in order to see more funding directed to research in this area. The Commission calls upon NIH and NIMH to work together with the NAS/IOM and the research community as a whole and Alaska Native researchers and practitioners to expand Arctic health research.

Toward this end, and at the request of and with support from the Commission, on June 2 and 3, 2009, the Fogarty International Center of the National Institutes of Health convened a workshop on suicide and other behavioral health issues in Anchorage, and the proceedings from this workshop were published in early 2010 (Levintova et al., 2010). Specialists from a variety of Arctic disciplines, indigenous leaders, and representatives from various NIH institutes and centers attended.

Part of the discussion focused on a Commission recommendation, stated below, that NIH, NIMH, the National Institute on Alcohol Abuse and Alcoholism (NIAAA), the National Center on Minority Health and Disparities (NCMHD), the National Institute on Child Health and Development (NICHD) and other appropriate government agencies support a "decadal" review on Arctic human mental health research to be conducted by both the National Academies' Institute of Medicine and Polar Research Board. This review and Institute of Medicine report would empanel experts from many different disciplines. It would work closely with the Arctic region's indigenous leaders, health researchers and practitioners, state officials and others to bring research, intervention, and clinical work together. The workshop discussion showed that an appropriate review would focus on the epidemiology and causes of the excessive morbidity and mortality caused by suicide, domestic violence, addictions, and other mental and behavioral conditions so frequent among Arctic populations. This review should also identify methods for future genetic, genomic, and functional imaging studies of natives living at high latitudes to learn if the strategies for enhancing the resilience of the native population can benefit from preventive and interventional methods that are more developed and successful with other at-risk populations elsewhere.

RECOMMENDATIONS

First, the Commission recommends that IARPC follow through on its commitment to develop an overarching US Arctic human health research plan. This plan should include state-of-the-art advances in genomics and genetics. Further, it should encourage the study of high-latitude physiological

differences, improve the knowledge of Arctic epidemiology, and integrate work across the various centers and institutes of NIH, with the work funded by other agencies, such as CDC, SAMHSA, EPA, DOI (including USGS, BIA, USFWS), Food and Drug Administration (FDA), NOAA, and Alaska and tribal healthcare providers

Second, we must immediately bring research to bear on a deadly problem with causes and treatments that may be unique to the Arctic. Suicide rates in the Arctic are appalling, and greater among indigenous Arctic youth than any other group within our nation. Clinical research and community intervention efforts must come together to address this epidemic. The Commission urges the National Academy of Sciences, through the Institute of Medicine and Polar Research Board, to bring together health researchers and practitioners, indigenous leaders, and experts from a wide range of disciplines to develop a rigorous, evidence-based, iterative, and recurring assessment of intervention efforts. To be most effective, this effort must be decadal, to establish research priorities, review results, guide the scaling up of successful pilot programs into widespread clinical interventions, and to track the progress and success of the research agenda.

Third, the Arctic Human Health Initiative (AHHI), a US-led contribution to IPY has been a significant contributor to international coordination of Arctic health research. The Commission calls for continuation and greater funding of this CDC-affiliated initiative so that it may conduct, to a much greater extent, the research that the proposal calls for. Leadership from NIH, CDC, and SAMHSA will be essential in this effort. Because the Arctic is a unique and to a great extent an unexplored or unmeasured environment with regard to health issues, it requires a specialized research approach to meet the health care needs of its people. Genetic analysis has shown that Arctic indigenous peoples are significantly different from those at lower latitudes. An IARPC health plan needs to coordinate closely with each working group of the Arctic Council toward this objective.

Fourth, recent studies have begun examining the impact of environmental pollutants and climate change on food safety and health. We applaud work that EPA has done in this area, and also the Alaska Department of Environmental Conservation (ADEC), Division of Environmental Health, through a new initiative to monitor fish for heavy metals such as mercury. State and federal research and mission agencies need to strengthen cooperation with Alaska tribes and subsistence communities as these efforts continue.

Fifth, the Arctic presents itself as an ideal location for the development of innovative technologies for medicine-at-a-distance or telemedicine and telepsychiatry. The Commission recommends supporting and promoting such innovation by grants from NIH and other agencies. These innovations could have broad value to other parts of the nation and the world. Initial work on this subject, supported by the State of Alaska and the US Department of State, and conducted by Hild et al. (2000), should be updated, advanced, and implemented.

LEFT. After the hunt. (Photo credit: C. Rosa)
BELOW. Kotzebue graveyard. (Photo credit: J. Farrell)

Kivalina revetment.
(Photo credit: J. Farrell)

3 CIVIL INFRASTRUCTURE

Arctic climate and conditions have always called for unique methods in transportation, housing, telecommunications, sanitation, energy production, navigation, and mapping. As climate change impacts the Arctic, thawing permafrost, reducing sea ice, strengthening storms, and eroding coastlines, civil infrastructure is facing new challenges. Long-held engineering standards assumed that the permafrost regime would be perpetually stable. Realization that permafrost might thaw significantly during the lifespan of a building, a pipeline, or a road system requires research to develop new methods of design and construction. Seasonal restrictions adopted to protect tundra and permafrost during road construction, pipeline building, and oil exploration have expanded as winters have become milder or shorter; that, too, has caused a need to reexamine methods.

As protective winter sea ice retreats from the coastlines, storm surges reach the shore, making it vulnerable to erosion. For example, in the village of Shishmaref, inhabited for 400 years, climate change is destroying homes, water, sanitation systems, and other infrastructure, which requires relocation of the entire village. Shishmaref is not an isolated example; the village of Kivalina is another case where, for example, fuel depots are perilously close to the approaching erosional front.

Research and innovative engineering solutions are needed to create new infrastructure to accommodate the demands of an Arctic that is increasingly accessible, whether by land, sea, or air. The Commission has long recommended infrastructure research within the US Arctic Research Program. Since the 2007 goals report, and with the leadership of the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL), IARPC has committed to develop an integrated plan. At the start, the Commission recommended that infrastructure research cover a wide variety of topics, such as permafrost, shoreline erosion, construction techniques, and building codes, methods to reduce the cost of living (primarily housing) in Alaska, oil spills, energy use, and marine transportation. Such a program plan will serve as intellectual underpinning for broad research on civil infrastructure in the Arctic.

CRREL, in coordination with the University of Alaska Fairbanks and the Denali Commission, conducted a USARC-sponsored workshop toward an infrastructure research program plan in April 2010, in Fairbanks, Alaska. The focus of the workshop was to identify state, national, and international partners, prioritize actions in each field, and identify pilot projects and other opportunities to test the feasibility of larger research efforts.

USARC has encouraged the participation and cooperation of other agencies to work with CRREL in this process. For civil work, sanitation, and housing, we will continue to discuss the roles that the Department of Transportation (DOT), Federal Aviation Administration (FAA), Denali Commission, State of Alaska, Department of Housing

and Urban Development (HUD), Department of Energy (DOE), NSSI, and USGS can play. For oil spill research, in this report, we are recommending a second set of collaborations. Two interagency entities created by law, IARPC, and the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), chaired by the US Coast Guard, in the Department of Homeland Security, have responsibility to work in this area. Specific recommendations on ways to better ways to implement oil spill research are described in a USARC white paper (see http://www.arctic.gov for the white paper). The scientific community has suggested that one of the greatest needs in responding to oil spills is understanding where the oil will go (e.g., spill trajectories, ocean circulation models) in the event of a spill. Clearly, current research has just begun, and a more comprehensive initiative is needed by entities such as AOOS, MMS, other ICCOPR agencies, and industry.

For shipping research identified by the *Arctic Marine Shipping Assessment* (AMSA, 2009), we recommend a third collaboration, with the participation of DOT, MARAD, the Committee on Marine Transportation Systems, the National Academies Transportation Research Board, the US Coast Guard, and others.

For energy research unique to Arctic assets and conditions, we have encouraged DOE to maintain funding for the Arctic Energy Office, and to remove restrictions to allow work on renewable energy as well as fossil fuels. DOE has responded by staffing a representative of the National Renewable Energy Laboratory (NREL) in Alaska and has begun developing a renewable energy research plan. Such a plan will become an integral component of a climate mitigation strategy.

For telecommunications, we convened a workshop on the use of the Iridium network in high Arctic research (no other system is available to civil users at high latitudes), and we encouraged the Arctic Council's Arctic telecommunications assessment.

For Alaska's Arctic mapping needs, the Commission encouraged collaboration among the Statewide Digital Mapping Initiative (SDMI), federal geographic data committees, and the Civil Applications Committee, which is a "window" for the use of classified assets such as spy satellites by civil government agencies.

CRREL and IARPC are encouraged to work together with two centers addressing civil infrastructure research that have been established on the UAF campus. The Alaska Center for Climate Assessment and Policy, funded by NOAA, is one of a national group of Regional Integrated Sciences and Assessments programs. It is a partnership among scientists at UAF and University of Alaska Anchorage, state and local planners, including those at the National Weather Service and United States Army Corps of Engineers, and stakeholder groups, including Alaska Native tribal governments, industries, and nongovernmental organizations. A third civil infrastructure center at UAF, focused on energy, is authorized but not funded.

The Alaska Aviation Safety Project, funded at Alaska's Department of Transportation through NASA, is a second source of collaboration in research to improve mapping, aviation safety, and use of new telecommunications and navigation techniques. Its sister project, Capstones, funded by FAA, used remote Arctic conditions to develop a new method of air-traffic control, automatic dependent surveillance-broadcast, which is being implemented over time across the United States and in other nations. In 2008, the National Aeronautic Association awarded the academic, government, and industry team (Commercial Aviation Safety Team), which pioneered this technology, aviation's highest honor, the Robert J. Collier Trophy, joining the ranks of others who had reached aerospace milestones, including Orville Wright, Howard Hughes, Chuck Yeager, and the crew of Apollo 11. The Commission congratulates these applied research programs for their work, and encourages further research by DOT and NASA to improve safety of aviation in the Arctic. The Cold Climate Housing Research Center (CCHRC) is a partnership between the university and industry to conduct research to advance understanding and application of cold climate housing principles. CCHRC's own research plan can support the IARPC approach.

The Commission includes baseline mapping of the Arctic in the topic of "civil infrastructure" for obvious reasons, such as the impact, over time, of erosion, storm surge, and inundation of coastlines. Maps provide essential data necessary to conduct scientific research in support of civil infrastructure. The State of Alaska created SDMI and charged it with developing and implementing a plan to upgrade the state's digital imagery and elevation data. Currently, these framework data sets for Alaska are well below national quality standards and are outdated; the most recent statewide aerial imagery acquisition occurred in the early 1980s. New and higher-quality imagery is essential for understanding landscape changes that have occurred due to climate warming and development, and provide a needed current baseline against which future change can be assessed. The only statewide digital topographic data for Alaska was generated by digitizing 1950s vintage USGS quadrangle-scale map products and have local horizontal errors that exceed 1 km. SDMI received state support over the last three years during which it collected all available digital high-resolution imagery and elevation data and lifted licenses so that all state and federal agencies, native organizations, educators, and researchers have access to these data sets through the Web. Given the early and significant success of this program, USARC encourages Alaska to continue to fund SDMI and to broaden the program's scope such that it becomes an integral component of SAON and AON activities as appropriate.

With respect to oil spills, the Commission has worked not only to identify a research agenda, but also a potential source of funding—the Oil Spill Liability Trust Fund—which is authorized to support US oil spill research programs but is seldom used to any great degree. We also learned that the OPA90's ICCOPR, chaired by USCG, seldom meets, does not publish its meeting agenda or minutes, and does not have an updated national research plan, as called for by OPA90. Yet, when an Arctic Ocean offshore lease sale commands $2.7 billion in bids, as it did in early 2008, the nation should certainly find the means to improve spill prevention and response techniques and to have better baseline research on the fate and effects of oil spills, and the restoration of Arctic environments.

The Commission has engaged in constructive dialogue with many players, and concludes that an oil spill research agenda would be relatively easy to put together if funding for research is made available (see white paper on this topic at http://www.arctic.gov). Participants that would be involved in such a program include USCG, NOAA, NSSI, MMS, OSRI, NOAA, DOT's Office of Pipeline Safety, and the State of Alaska.

ABOVE. Coastal erosion.
(Photo credit: C. Arp, USGS)
LEFT. Wind power near Kotzebue.
(Photo credit: J. Farrell)

Retrogressive thaw slump.
(Photo credit: B. Molnia)

The Commission chair and staff visited with principal investigators at the Joint Industry Program at SINTEF, Trondheim, Norway, where oil spill response techniques were tested in spring of 2009 in ice-covered waters, with the support of the US government and industry. Former Commissioner Walter Parker attended the 2009 Arctic Marine Oil Pollution conference, hosted by Canada, on the Commission's behalf. In March, 2008, as part of the *Arctic Marine Shipping Assessment* (AMSA, 2009), the NOAA Coastal Response Research Center (CRRC) at the University of New Hampshire held a workshop, "Opening the Arctic Seas: Envisioning Disasters, Framing Solutions," with the encouragement and support of the Commission and other agencies. The Commission helped organize a US-Canadian conference held in Anchorage in October 2008 called, "Northern Oil and Gas Research Forum '08, Current Status and Future Directions for the Beaufort Sea, North Slope and Mackenzie Delta," to bring researchers on this topic and others together.

And, finally, on the topic of marine transportation, USARC has devoted a significant amount of time to identifying needs for Arctic research. We have held extended conversations with MARAD, USCG, and others, and worked with MARAD on a 2008 Arctic Transportation Conference. We have worked extensively with the US Navy/NOAA/USCG Joint office and the National Ice Center to sponsor three symposia on "Impacts of an Ice-Diminishing Arctic on Naval and Maritime Operations." The Commission is proud to have provided, with our former Deputy Director Dr. Lawson Brigham, leadership for the Arctic Council Protection of the Arctic Marine Environment Working Group's *Arctic Marine Shipping Assessment*, available at the USARC Web site http://www.arctic.gov. We have been briefed by Congressman Don Young on his sponsorship of implementing legislation for the *Arctic Marine Shipping Assessment*, and appreciates how it would support research for "safe, secure, and reliable" Arctic shipping.

The creation, by the Department of Homeland Security, of a new Center of Excellence for Island, Maritime, and Extreme Environment Security (CIMES) is a promising step toward ensuring security and disaster mitigation as marine transportation continues to expand across trans-arctic routes. CIMES is a partnership among the University of Hawaii, UAF, and University of Puerto Rico Mayagüez, with UAF holding the role of developing monitoring capabilities to discriminate and track marine vessels and oil spills in ice-laden waters and under extreme conditions of cold and dark.

RECOMMENDATIONS

First, USARC commends IARPC for commissioning and CRREL for leading the development of an integrated Arctic infrastructure research plan. We urge that process to continue to completion with the broad participation discussed in this report, and to provide good targets for congressional funding in years to come. Infrastructure research should include government staff scientists, engineers, and contractors, "extramural" competitively funded university researchers, and private industry. As government agencies fund much of the infrastructure needs of the Arctic, we encourage these agencies to adopt research findings through pilot projects in their normal course of business.

Second, the Commission recommends IARPC work with the State of Alaska to support the State's adaptation research agenda to respond to the dramatic effects of climate change.

The emerging federal research program in this area should integrate with and support these efforts, which include protecting communities from erosion, and adapting buildings and civil infrastructure to thawing permafrost. Information on the process and findings can be reached at http://climatechange.alaska.gov.

Third, the Commission recommends the President, Congress, NOAA, and USCG take steps to ensure the US oil spill research program meets the promise of the Oil Pollution Act of 1990. The Commission urges use of the Oil Spill Liability Trust Fund, which collects eight cents per barrel on domestic oil production and imports, as authorized, to support a significant new funding stream for oil spill research in the Arctic. We recommend a target of at least $10M per year, to be made competitively available, for Arctic/Subarctic spill research on an agenda to be adopted jointly by IARPC, ICCOPR, with the participation of the State of Alaska, the North Slope and Northwest Arctic Boroughs, OSRI, CRRC, and industry operating in the Arctic region. This research should support improvements in prevention, response, and remediation of oil spills in ice-covered waters and help resource management agencies integrate spatial planning into spill prevention and response in the Arctic Ocean.

We have urged Congress to "inflation proof" the OSRI "endowment" in the Oil Spill Liability Trust Fund, to raise its principal from the $23 million set aside in 1990 to at least $35 million.

We urge Congress not to change the leadership of the ICCOPR, but to use its oversight to make sure it meets regularly, is transparent in its deliberations and decisions, and that a national plan as well as an Arctic regional plan are developed and funded. If Congress chooses to create a Regional Citizens Advisory Committee for the Arctic Region, as it has with Prince William Sound and Cook Inlet, we would urge that committee to include USARC representation, to have a science budget, and to work closely with entities planning and carrying out oil spill research in the Arctic region.

Fourth, the *Arctic Marine Shipping Assessment*, completed by the eight Arctic nations in spring 2009, identifies the research necessary to address the opportunities and challenges of Arctic shipping (AMSA, 2009). IARPC should include this research in its infrastructure research plan, and US DOT and other agencies should identify means to provide competitive extramural funding to carry out the research.

Fifth, since the Commission's 2007 goals report, the conventional and renewable energy potential of the Arctic has been further assessed and shown to be dramatic. The Commission recommends that DOE include the Arctic Energy Office in its core budget, and that it be placed within the DOE organization such that it has authority to continue sponsoring fossil energy research as well as to expand its role into sponsoring renewable energy research. (The Commission was not consulted by DOE when it cut funding for the Arctic Energy Office, though that consultation is required by law.) Through this office and other DOE programs, the Commission urges research related to capture and production of Arctic methane and methane hydrates (both onshore and offshore). Five of the eight Arctic nations, including the United States, are members of the International Partnership for the Hydrogen Economy. Given the challenges of dealing with Arctic marine oil spills and black carbon in the Arctic, and given that Arctic shipping requires specialized vessels to begin with, the Commission urges the United States and its partners to institute pilot projects on alternative-fueled fishing and commercial vessels in the Arctic region. Finally, the Commission acknowledges that NREL has established an Alaskan research program that can further address the dramatic wind, wave, tidal, geothermal, and biomass potential to serve the many "off the grid" Arctic communities with stable-cost power and to provide new methods to export energy from the Arctic. We urge appropriate funding of that program once a plan is developed.

Sixth, federal and state efforts to cooperate in providing an imagery database and digital elevation model are promising and could be successful in bringing Alaska's maps up to the standard seen by the rest of the nation. Federal and state governments are urged to agree upon and fund a coherent plan for mapping the US Arctic that federal and state agencies, the research community, and the public can rely on.

Red Dog Mine.
(Photo credit: J. Farrell)

4 NATURAL RESOURCE ASSESSMENT AND EARTH SCIENCE

As has been clear since the 1968 discovery of North America's largest oil and gas reservoir at Prudhoe Bay in the Alaskan Arctic, subsequent discoveries and a recent assessment of oil and gas potential by the USGS, the Arctic is rich in conventional energy. Arctic tidal, geothermal, wind, wave and biomass energy potential are also strong. There are large deposits of mineral deposits in the Arctic, including gold, diamond, lead, zinc, nickel, iron ore, and molybdenum. The Arctic's living resources are diverse, with some the largest mammals (Moore and Huntington, 2008), biggest herds, richest fisheries (as the Bering Sea is in the "Arctic"), and longest migrating species of birds making their homes there. Most of these resources are found on public lands. As a significant owner of Arctic resources, the United States has a responsibility to know what it owns, to understand basic biology, geology, and natural history of its assets, and to understand the population dynamics of the living resources it manages—alone, or in concert with the State of Alaska and other nations.

Toward this end, the Commission recommended first in its 2003 goals report that IARPC adopt a Resource Assessment Theme in the US Arctic Research Program. In later reports, the Commission amended this theme to include basic earth science. Leadership within IARPC for developing this research plan was taken on since the last goals report by USGS.

The Commission, in its deliberations with the public, industry, government, and academic community, finds at least three elements that should be in a resource assessment and earth science research plan, including:

- An assessment of the mineral and energy resources of the Arctic region, especially those on public lands of the United States and Alaska
- An assessment of the living resources of the Arctic region, especially those on the public lands of the United States and Alaska, and those that migrate across national borders
- An earth science plan that takes into account the major geographic and geophysical "unknowns" of the Arctic region, including the geology and tectonics of the Arctic Ocean and the Bering Sea, and studies of the magnetic pole and the magnetosphere

The Commission finds that the US government has a spotty record of keeping one research promise required by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. That act, which ended one of the loudest environmental debates in Congress, set aside large areas in Alaska for national parks, monuments, wildlife refuges, and wild and scenic rivers. Set as a compromise while millions of acres were set aside from development, ANILCA calls for a continuing Alaska Mineral Resource Assessment Program (AMRAP) to determine the mineral potential of Alaska's public lands. Our recommendation that DOI restore core

funding for this program, and that IARPC include AMRAP in an Arctic Research Program Plan, is based on the requirements of this law.

Earth science initiatives should continue to incorporate fundamental geophysical and geological research (especially in the Arctic Ocean) so that as a nation, we understand our land, its value, and the extent of our offshore sovereignty beyond the current EEZ. The United States and the four other Arctic coastal nations are currently in the midst of drawing new sovereign borders in the Arctic Ocean, and the United States may gain an area of Arctic undersea territory that is roughly the size of California. In this vein, USARC supports US accession to the United Nations Convention on the Law of the Sea, and the interagency Extended Continental Shelf Mapping Initiative.

The Commission continues to urge the Obama Administration, the Department of Defense (especially the Navy), and affiliated entities to continue efforts to declassify military data for civilian scientific purposes. Declassification of bathymetric (water depth) data, collected by US nuclear submarines, has significantly improved our understanding of the Arctic Ocean, and the construction of maps, and to help define the nation's offshore sovereign boundary. The Central Intelligence Agency's recent resurrection of the scientific group MEDEA (Measurements of Earth Data for Environmental Analysis), which searches intelligence data archives for information that can be publicly released in order to shed light on environmental change, is also an encouraging development.

While we have addressed Arctic mapping and gas hydrates research in the Arctic Infrastructure portion of this report, it may be appropriate for those research objectives to join the Resource Assessment and Earth Science program plan as well. Our recommendation for core DOI and congressionally created long-term funding for NSSI will support resource assessment and earth science under this theme, as well as the climate and infrastructure research programs covered by other themes. The Commission was not consulted, as the Arctic Research and Policy Act requires, when the government's FY 2009 spending plan for NSSI was revised down and the 2010 budget for NSSI was significantly cut.

Since the last USARC goals report, the Commission has worked with and heard from leaders of the Integrated Ocean Drilling Program (IODP), which conducts deep ocean drilling for earth science and deep biosphere science objectives around the world. The Commission notes with dismay the challenges IODP has had in gaining access to Bering Sea drill sites within the Russian Arctic EEZ to conduct

RIGHT. Picking berries. (Photo credit: B. Molnia)
BELOW. Piloting C-130. (Photo credit: J. Farrell)

marine scientific research, and in the science infrastructure recommendations, the next section of this report, we recommend diplomatic approaches to solving this problem.

In 2008, the Commission visited the HIPAS Observatory, outside of Fairbanks. There, we were briefed on magnetosphere and aurora studies, including research on the exchange of ionized particles to and from the atmosphere though the workings of lines of force emanating from the magnetic north pole. The Commission has also been briefed during its field visits to Svalbard and meetings on the Oregon State University campus on other magnetosphere research being conducted into the Arctic. The polar regions are the only venue on Earth where some of this research may be conducted. Development and incorporation of a magnetosphere research plan under this theme will be useful in determining our research infrastructure and funding goals for the coming years.

DOI committed USGS employees in Anchorage to take a leadership role in developing this thematic research plan for IARPC. Their effort is supported within the larger DOI. To obtain information from others, USGS will send survey letters to the appropriate federal and state agencies to better understand each organization's 20-year vision for resource assessment, the level of support for such assessment, partnerships, staff levels, and the requisite infrastructure. The results of this information-gathering effort were discussed at DOI meetings in 2009, and will be turned into an integrated plan to report to IARPC.

RECOMMENDATIONS

First, the Commission commends the DOI's USGS for its leadership in assembling a research plan under the theme Resource Assessment and Earth Science, and urges it to include assessments of Arctic energy and minerals, assessments of Arctic onshore living resources, and an Arctic earth science plan, with clear goals allowing appropriate funding decisions to be made.

Second, the Commission applauds the leadership taken by the federal government's interagency ECS Task Force to identify claims the United States may make to dramatically increase its territory in the Arctic Ocean. The Commission has urged ratification of the United Nations Convention on the Law of the Sea so that US scientists may be part of reviewing other nations' claims in the Arctic.

Third, the AMRAP, required by ANILCA, should be funded in core agency budgets of the nation's public land management agencies within the Departments of Interior, Agriculture, Defense.

Fourth, the Commission urges DOI to institute and maintain a basic level of funding for this NSSI program. Congress created NSSI as a collaborative research program to support integrated, ecologically sensitive land management on the North Slope of Alaska. The Commission thinks the government should find a "dedicated" source for NSSI as it has for the NPRB, the Prince William Sound OSRI, and the Denali Commission so that long-term science commitments can be made.

Transporting zinc ore at the Red Dog Mine port. (Photo credit: J. Farrell)

ABOVE. Nikaitchuat Ilisagvik school children singing Inupiaq songs in Kotzebue, Alaska. (Photo credit: J. Farrell)
RIGHT. Life is good. (Photo credit: M. Robards)

5 INDIGENOUS LANGUAGES, CULTURES, AND IDENTITIES

Language helps us define the cultural diversity of our planet and serves as the strongest pillar to our diverse cultural heritage. Language is a fundamental indication of who we are, that is, of our identity. Although critical, language is one of the most vulnerable elements of our cultural being. Some languages expand and grow, so that their speakers number in many millions, whereas many minority languages decline and even become extinct, such as when the last native speaker of the Alaskan language Eyak died in January 2008. Of the thousands of known languages, fewer than 10 are used by nearly 60% of the global population and more than 500 are extinct. When speakers of endangered minority languages switch to other languages as their mode of communication and education, huge amounts of cultural information can be lost forever, including historical data, place names, and clues to changing natural phenomena, such as climate conditions or wildlife population levels. A peoples' cultural identity is endangered by language loss.

In the US Arctic, language vulnerability is especially acute in the current generation. Indigenous people are being separated from their cultural past. As many indigenous languages do not have long-standing written traditions, the cultural legacy they carry—as well as the languages themselves—are poorly recorded.

Languages passed down by the spoken word, rather than the spoken and written word, cannot be easily enhanced via the most common societal means, such as formal education, public programs, book printing, and writing. This creates a volatile mix, and the loss of language invariably impacts cultural tradition, human history, and traditional ecological knowledge. These losses prompt a shift in the cultural and identity of younger generations.

Without a research plan to address Arctic language, cultural preservation, and revitalization, the path to language extinction in the North is likely to shorten. The thematic addition of languages, identities, and cultures to the US Arctic Research Program Plan should address the following goals, originally proposed in the Commission's 2007 goals report:

- Regular, permanent census processes to understand the diversity of languages spoken by Arctic people, and the viability of those languages for future generations
- Documented procedures to ensure that languages and place names spoken and given by Arctic people are recorded, preserved, and transmitted
- Defined policy options and processes for language preservation that have succeeded in the Arctic and elsewhere are made available to Arctic policymakers and residents

RECOMMENDATIONS

First, the Commission applauds IARPC for the attention it has given the goal of developing a research plan and program for indigenous languages, identities, and cultures. The Commission urges one agency among likely participants—NSF, the National Endowment for the Humanities, the Department of Education, DOI's Bureau of Indian Affairs, the Smithsonian Institution—to take clear leadership in establishing this research plan. IARPC is behind in meeting even its initial target of a status report on common goals and objectives in the area of indigenous languages and cultures, set for September 2007. A research program plan can take advantage of congressional initiatives supporting immersive language study of indigenous languages in the nation's schools, an Arctic Council initiative to derive best practices around the North, and other efforts by United Nations agencies such as UNESCO to help preserve cultural heritage in the North.

Second, to better achieve these goals, the Commission proposes the following new tactics and strategies:

- DEVELOP NEW APPROACHES: Promote new interdisciplinary and cross-agency initiatives that integrate language documentation with language support, education, heritage preservation, cultural and museum research, outreach and public programs. An excellent example of this is the "Endangered Languages and Indigenous Knowledge" initiative of the National Museum of Natural History and the Smithsonian Institution. With respect to research, this effort will coordinate the study and promotion of indigenous languages by Smithsonian scholars in understanding the world's cultural and natural diversity, its origins, and functions on a variety of scales, focusing specifically on indigenous systematics, classifications, and natural world observations; the analysis of language structures, especially the general principles of human language and most clearly seen in endangered languages; and documentation and broadly accessible databases.

- COLLABORATE AND SHARE: Create a database of current programs run by various federal agencies in support of northern indigenous languages, cultures, community health and wellness, sustainable ways of living; expand interagency and inter-program collaboration, data and resource sharing; make information about ongoing efforts and opportunities at the federal (and state) level available to prospective users, researchers, and communities.

- MAKE GOOD USE OF AVAILABLE RESOURCES AND BEST-WORKING PROGRAMS: Identify resources that are critical to the efforts in support of indigenous languages, cultures, and identities (e.g., certain libraries, museums, archives, heritage databases, public programs, individual elders, and knowledge keepers); research policy options and processes for language/culture preservation that have succeeded in the Arctic and elsewhere, so that they can be made available to Arctic policymakers and residents.

- INCREASE VISIBILITY: Put support for local languages, cultures, identities, and community well-being firmly among the priorities of federal programs focused on the North; measure program success by the products with the lasting impact on the ground rather than by the amount of money spent.

- INCLUDE STAKEHOLDERS IN THE DECISION MAKING: Expand the role of local/indigenous advisers to federal programs in support of northern languages, cultures, and community well-being; use local offices of federal agencies for public outreach and feedback, including tribal consultation, to the many ongoing efforts.

Bowhead whale jawbone arch in Kivalina, Alaska.
(Photo credit: J. Farrell)

ABOVE. Sun dog. (Photo credit: M. Dunn)

RIGHT. Surveying sea ice conditions. (Photo credit: J. Farrell)

INITIATE RESEARCH ON EMERGING TOPICS

The rapidly evolving Arctic region presents a wide variety of important topics that require scientific research in order to provide information to decision makers. Such topics include:

- ALASKA NATIVE POPULATION STATISTICS. What are the key causes of death in Alaska Natives and especially in youth? What is the true incidence of suicidal behavior, self-destructive acts, and alcoholism? What is the death rate of Alaska Natives and the rate of migration to urban settings? Why is the incidence of alcoholism so high in indigenous peoples? What are the effects when multiple stressors, such as socioeconomic pressures and high-latitude conditions, that are evolving in response to climate change? What are the best counter-measures to reduce alcoholism and suicide in this vulnerable population? What techniques are most successful throughout the world to sustain native populations and how might they best and most expediently be adapted to the US Arctic population?

- CARBON SINKS, SOURCES, AND FLUXES IN THE ARCTIC. Given the large and increasingly active reservoirs of carbon in the Arctic, such organic carbon locked in permafrost, and methane sequestered in gas hydrate deposits, scientists need to develop a better understanding of carbon cycling, and its associations with climate and environmental change. Attention must also be paid to understanding and mitigating the impacts of black carbon in the Arctic and to quantifying, by monitoring, the efflux of carbon to the atmosphere from Arctic environments.

- ARCTIC FISHERIES. Climatic-induced changes in ocean temperatures and other properties are changing the ecosystem, and may be contributing to the migration of fish stocks. Our understanding of the standing stock of fish in the Arctic is minimal. What's there now? What stocks are moving in, or out? What is the health of the stocks and what threats do they face? What are the needs of subsistence fishermen?

- AUTONOMOUS UNMANNED SYSTEMS. Application of these aerial and marine technologies has great promise in the Arctic given the remoteness of the region, and the difficult and dangerous operating environment. Specific applications include surveying for forest fires, observing marine mammals in a nonintrusive manner, and making environmental observations over much greater areas than previously possible. Research into increasing endurance, expanding operational environments, developing sensors and detectors, and developing novel deployment and retrieval methods are a few lines of inquiry.

- RENEWABLE ENERGY. Energy costs are volatile in the short run, but are increasing overall, which places greater emphasis on developing renewable energy, particularly in remote Arctic environments. Research needs to be conducted on how to adapt renewable technologies, such as solar power, wind power, hydroelectricity, micro hydro, hydrokinetic, biomass, and biofuels, to and for Arctic environments. Research is also needed to address issues such as "next generation" batteries that can work effectively in cold weather conditions, and the effective electrification of off-road vehicles such as all-terrain vehicles, snow machines, and small boats and outboard motors.

- NOVEL APPROACHES TO FOSSIL ENERGY. Fossil fuel development is core to the economies of most Arctic nations, and directed research can reduce the impact of Arctic fossil fuel development on the environment. Promising new or alternative methods of exploration, production, transportation, and carbon sequestration that were presented to the Commission in the last two years include advances in directional drilling, efforts to reduce noise or change the seasons for seismic surveying, prospects for using tunneling and other mining techniques to take oil development underground, eliminating the need for above-ground facilities in wildlife refuges, and an expanding practice in offshore Arctic underwater oil and gas production facilities. Transport improvements that may be attainable include novel means to protect subsea pipelines from ice scour, the use of rigid airships (developed, in part so far, with NASA and DOD funds) to move heavy equipment and materials into remote sites, and use of remotely piloted vehicles for wildlife monitoring. Potential Arctic-specific carbon capture and sequestration techniques have also been shown to the Commission. Given that much of the oil, heavy oil, gas, shale gas and gas hydrates, coal, and coalbed methane deposits to be found in the US Arctic are on federal lands, the Commission thinks research into these promising techniques should be undertaken in concert with industry, the State of Alaska, and international partners in producing and consuming countries.

- EMERGING INFECTIOUS DISEASES. The risks from an avian flu, and from other new, previously unknown, and in some cases drug-resistant infectious diseases pose a significant threat to global health. Such diseases have emerged in Alaska, and elsewhere in the Arctic, and in some cases vector through the Arctic via migrating populations. Some Arctic birds are thought to harbor bacteria that carry antimicrobial drug-resistant determinants.

- BIOACCUMULATION OF TOXINS. Research is required to assess and monitor the levels of toxins, such as mercury, and other contaminants in game and fish stocks, most recently halibut, heavily relied upon by Alaskans for food, and ultimately to determine methods to minimize such contamination.

ABOVE. Seal hole. (Photo credit: M. Dunn)
RIGHT. Bering Strait starfish. (Photo credit: K. Crane)

- ARCTIC BIOPROSPECTING. A report by the United Nations University Institute of Advanced Studies reports that private entities are searching for and developing products and treatments from DNA found in Arctic plants and animals. New products include ice cream and anti-stroke medications. One company has used "antifreeze proteins" collected from Arctic organisms to improve the texture, taste, and safety of frozen foods. Another company is attempting to use proteins from the arctic squirrel, which can lower its temperature to below freezing, to help stroke victims recover more quickly.

- MARINE MAMMAL RESEARCH. Biologists contend that the rapid decrease in summer sea ice extent and thickness, particularly over the last few years, is negatively impacting marine mammal populations. Research is needed to better understand whale, walrus, polar bear, and seal populations, and how they are responding to their changing environments. Issues that need to be addressed include: determining populations, their sustainability, and "take" levels; developing better means to collaborate and cooperate with indigenous peoples in marine mammal research; developing new methods to track the movements of individuals and populations; better projecting climate change, environmental conditions, migration routes, and food habitats; and obtaining more frequent population counts.

- GLACIER AND ICE SHEET DYNAMICS. Recent observations of smaller glaciers and the larger Greenland ice sheet suggest that climate warming is resulting in a much more complex set of dynamical processes than previously thought. Because the melting of this ice has the capacity to significantly impact global sea levels, research needs to address questions regarding the processes and rates of the dynamics in this part of the global cryosphere.

- SCALING ARCTIC RESEARCH. The scientific community has a rich legacy of studies focused on local, place-based studies. Although these studies are an important foundation for scientific understanding of the Arctic, there are a growing number of techniques and approaches that enable researchers to observe, simulate, and analyze trends over much large spatial scales, including the domain of the full pan-Arctic. Tangible strategies to bridge scales and to ensure a consistency of conclusions obtained from studies cast over often disparate temporal and spatial domain scales will be necessary before a full understanding of the behavior of the full Arctic system can be secured.

- ARCTIC EARTH SYSTEM MODELS. Many of the most critical strategic decisions facing policymakers involve the behavior of a highly coupled Arctic system, in terms of its biogeophysical as well as its human dimension elements. How well the scientific community can develop a coherent picture of how the full system behaves in response to continued greenhouse warming, loss of sea ice, and the implications of potential interventions associated with geoengineering—among many other rapid changes—will dictate the capacity of policymakers to mitigate, respond, and adapt to change. Due to its richness of processes, close coupling of subsystems, and sharp time and space boundaries, the Arctic portion of the Earth system becomes a particularly challenging one to simulate. Next-generation Arctic Earth System Models are stimulating new advances in process field studies, observational network deployments, and numerical and cyberinfrastructure capabilities, which together will improve the fidelity of these computer simulations and also enhance their capacity to create policy-relevant scenarios of the future.

- OBSERVING AND MODELING ARCTIC SEA ICE. Although this subject is not necessarily new, it demands greater attention given the overall decline, and the dramatic changes in sea ice extent and thickness over the past 30 years.

- GEOENGINEERING. We encourage and support international efforts to conduct research into the potential of climate intervention techniques, more commonly referred to as "geoengineering," for example, methods for carbon capture and storage and for solar radiation management. Research needs to assess how such techniques may be used to respond to climate change, and how to reduce the risks of deployment. It is imprudent to wait until there is a crisis before identifying potential climate intervention processes. Advanced study will help reduce the risk of such techniques, if and when it is necessary to use them. Such research does not alleviate the need to conserve resources, reduce greenhouse gas emissions, or to create clean technologies.

USCG Icebreaker Healy *in the Arctic, with cranes extended, conducting research. (Photo credit: PA3 J. Bigelow, USCG)*

Last mooring.
(Photo credit: M. Dunn)

RESEARCH INFRASTRUCTURE

REINVEST IN ARCTIC RESEARCH

FEDERAL AGENCY SUPPORT FOR EXTRAMURAL RESEARCH

Sustaining a strong and vital government-sponsored Arctic research program requires federal agencies to set clear goals and objectives, establish robust leadership, and develop long-term, coordinated extramural support for research conducted by academic scientists. In light of budget challenges, however, many of the mission-focused government agencies have retrenched, and have cut support for extramural programs, or reorganized, in order to maintain internal initiatives. These changes do not necessarily serve the greater interests of Arctic research, especially in terms of educating and training future researchers and managers to deal with the challenges facing the Arctic.

The Commission reminds agencies of the following clause in public law: "All Federal agencies shall consult with the Commission before undertaking major Federal actions relating to Arctic research" (*Arctic Research and Policy Act*, SEC. 105. (c)). USARC will redouble efforts to work closely with agencies to encourage greater balance between extramural and intramural Arctic research. USARC commits to working with IARPC to ensure that this aspect of the law is followed, calling for an open budget process and a comprehensive and balanced approach.

SUSTAINABLE RESEARCH PROGRAMS BUILD HUMAN CAPACITY

It's all about people. A nation's most valuable resource is the vitality of its scientific workforce. Research requires scientists and technology experts. Despite broad and continued support for the President Bush's 2006 American Competitiveness Initiative, and Congress's America COMPETES Act to promote excellence in technology, education, and science, there has been, until 2009, a major, overall decline in the level of federal funding for peer-reviewed, investigator-driven, extramural Arctic research in Earth and ocean observations and marine ecosystem dynamics at a time when ocean policy, climate change adaptation, and sustainable fisheries management all require more.

This trend has been especially troubling because many educators and resource managers are approaching retirement and sufficient new scientists are not being taught and trained. Only a vibrant research and educational enterprise with consistent funding will attract a new generation of scientists to Arctic research that is critical to dealing with change already occurring in the Arctic. USARC asserts that Arctic research is essential in order for the United States to

LEFT. Mark Twickler, University of New Hampshire, working on chemical samples in the science trench at GISP2. (Photo credit: R. Alley) ABOVE. Viewing sea ice from a USCG Hercules C-130. (Photo credit: J. Farrell)

adapt to change while simultaneously achieving its national competitiveness goals. Priority needs to be given to funding projects that help build the human capacity to conduct scientific research.

FUNDING AMERICA'S ARCTIC SCIENCE

Generally, as national science funding expands across the board, greater resources are available for the Arctic Research Program. In 2009, President Obama and Congress worked to expand financial support for scientific research, including that associated with the Arctic. The FY09 operating budget, and the President's FY10 budget both included significant increases in scientific research budgets, and the American Recovery and Reinvestment Act of 2009 (ARRA) also provided a significant boost for research. In particular, NSF's first ARRA-identified expenditure was funding for the Alaska Regional Research Vessel, recently named the R/V *Sikuliaq* [pronounced [see-KOO-lee-auk], an Inupiaq word meaning "young sea ice," an initiative that the Commission has long supported. Will this recent support endure? A recent history of appropriations provides appropriate, longer-term context for consideration.

The omnibus FY08 appropriations bill was passed by Congress and signed by the President in December 2007. For the fourth year in a row, federal investment in research declined in real dollars. Of particular concern in the development of this budget was that going into the House-Senate joint conference, increases of approximately 10% were requested for many of the various federal research agencies. The negotiations, however, resulted in only a 1.1% increase for one of the nation's key science support agencies, NSF. Given an expected inflation rate of 2.4%, there was a loss of 1.3% within this agency in real dollars. Similar decreases occurred at NIH and other agencies that sponsor extramural research.

These cuts were particularly troublesome during the first IPY since 1958, with the potential to mark a new milestone in Arctic research. Many IPY aspirations for new US research activities were not met, and these research needs continue.

The United States must fully address the research funding goals that President Obama presented in *The Audacity of Hope,* and that the previous president and the Congress endorsed in the American Competitiveness Initiative and the America COMPETES Act. USARC joins the American Association for the Advancement of Science in drawing attention to this serious condition. We encourage the President and Congress to continue their recent turn around in support, and to make it enduring.

Recommendation

President Obama's recent commitment (April 27, 2009 speech at the National Academy of Sciences Annual Meeting) to invest more than 3% of the gross domestic product in research and innovation is most promising, and the Commission strongly encourages Congress to help him achieve this goal.

DEVELOP AND SUSTAIN ARCTIC RESEARCH INFRASTRUCTURE

The term "Arctic research infrastructure" covers a wide range of basic physical and organizational structures integral to the scientific research enterprise. Below, we address a variety of observing networks, vessels, satellites, laboratories, research centers, and emerging technologies, such as autonomous vehicles used under the sea, and in the air. A great challenge in scientific research is maintaining an appropriate balance in financial support for infrastructure, and the associated management and operations budgets, compared to budgets to conduct the scientific research with data collected from such infrastructure.

Arctic Observing Network (AON)

As described earlier, USARC supports implementation and further growth of AON, and recommends collaboration with other Arctic nations and the International Arctic Science Committee (IASC) to integrate AON into the international global observing and data management systems, up to, and including GEOSS. Key government decisions are necessary now to implement the AON vision of the Committee on Designing an Arctic Observing Network (NRC, 2006).

Polar Icebreakers

USARC has long supported a strong and viable national icebreaker fleet, and has been an ardent advocate of a timely and rational replacement program for the aging vessels *Polar Sea* and *Polar Star*. All of USARC's key points in this regard were communicated to the NRC Committee on the Assessment of US Coast Guard Polar Icebreaker Roles and Future Needs. USARC is pleased to see that these points were incorporated into the report published by the Council in 2007 (NRC, 2007a).

- The United States should continue to project an active and influential presence in the Arctic to support its interests. This presence requires a US government polar icebreaking capability to assure year-round access throughout the region.
- National interest in the polar regions require that the United States immediately program, budget, design, and construct two new polar icebreakers to be operated by the US Coast Guard.
- Polar icebreakers are essential instruments of US national policy in the changing polar regions. To assure adequate national icebreaking capability into the future, a presidential decision directive should be issued to clearly align agency responsibilities and budgetary authorities.

These recommendations are consistent with NSPD-66/HSPD-25, released in 2009. Further, in 2010, after additional cost-benefit studies are complete, USARC urges the President and the Congress to commit to building two new polar class icebreakers to meet US needs in the polar regions.

Earth Observing Satellites

In concert with the latest NRC study (NRC, 2007b) on what AAAS calls "the crisis in Earth observation from space," USARC also expresses grave concern that the network of satellites upon which the United States and the world have relied upon for global observations is at great risk. These observations are critical for anticipating the impacts of global change as well as being essential for weather forecasting; hurricane and storm warning; management of agriculture, forestry, and fisheries; and national security. Budget cuts and reallocations at NASA and NOAA will decrease satellite missions by 40% by the end of the decade. As noted in the NRC study, this trend toward a sharply diminished US capacity in Earth observations had also resulted from an explicit redirection of NASA's priorities away from Earth observations and toward missions to the Moon and Mars.

USARC supports recommendations of the NRC study for restoring US capabilities in Earth observations from space to acceptable levels, including:

- Reconstituting specific key observation capabilities that have recently been deleted from scheduled NOAA satellite series
- Accelerating NASA's current launch schedule to shrink the data gaps implied by current plans

- Committing to the 17 highest-priority new Earth-observation missions, out of more than 100 candidates evaluated for the 2010–2020 time period

The study concluded that its recommendations could be funded until 2020 by returning the Earth science budget at NASA to its FY1998–2000 level and stabilizing the budget of NOAA's National Environmental Satellite, Data, and Information Service at only slightly above the FY07 level, adjusted for inflation.

The February 2008 news release by the Office of Science and Technology Policy about the Bush Administration's plans to significantly enhance the nation's civil Earth observation capabilities was encouraging. Reinstating critical climate measurement capabilities (once part of the National Polar-Orbiting Operational Environmental Satellite System effort) and funding a new set of space research missions in NOAA and NASA to advance our understanding of changes in Earth's climate, ocean, and land surfaces is a welcomed development that USARC encourages Congress and this administration to support.

Other Emerging Technologies and Observatories

As noted in the above-mentioned NRC reports, Arctic scientific research objectives frequently depend on platforms such as observatories, ships, submarines, satellites, aircraft, and other technologies to detect natural phenomena and to collect data. The Arctic presents a wealth of opportunities to test and employ research platforms on land, in the sea, and in the air. Much of this infrastructure, however, lacks support and long-term commitment. The need is especially keen when international consensus and investments are involved. Coordination will reduce costs and increase effectiveness. Therefore, USARC recommends that IARPC help lead an international assessment of Arctic research infrastructure needs, and then work with public and private institutions to make appropriate investments in new platforms to support the nation's Arctic research program.

The Commission supports the following infrastructure opportunities as vital. Some of these elements have been addressed (NRC, 2006) as AON elements, and others have recently been funded, such as the Alaska Regional Research Vessel:

- Alaskan Permafrost Observatory
- Barrow and Bering Sea Cabled Observatories
- Barrow Arctic Research Center
- Hydrological Sensor Systems
- Technologies—Telemedicine, Communications, and Wireless Sensing Networks
- Unmanned Autonomous Aircraft and Underwater Systems
- Alaska Regional Research Vessel (ARRV)

ABOVE. IODP Arctic coring expedition. (Photo credit: M. Jakobsson)
RIGHT. Ice coring. (Photo credit: M. Dunn)

REINVIGORATE THE INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE (IARPC)

The primary objective of the 1984 Arctic Research and Policy Act was to produce and implement a comprehensive national policy and plan for Arctic scientific research. To this end, the Act created USARC, which develops and recommends to Congress and the President an integrated national Arctic research policy, and biennially publishes a *Report on Goals and Objectives*. IARPC responds to the report by formulating a five-year *US Arctic Research Program Plan* and by revising it biennially.

Growing interagency relationships are reinvigorating IARPC under the leadership of the NSF Director. In light of evolving national priorities, this interagency effort is transforming. Participants are becoming actively engaged, and IARPC is strengthening its internal partnerships. We encourage regular meetings of IARPC, and active involvement with USARC and representatives from the Executive Office of the President (specifically, the Office of Management and Budget, the Office of Science and Technology Policy, the Council for Environmental Quality, and the Natural Security Council). In its efforts, IARPC should engage the public and endeavor to improve its strategic planning and integration of Arctic research across federal agencies. We also encourage IARPC to work closely with the National Science and Technology Council that plans and oversees other interagency research initiatives.

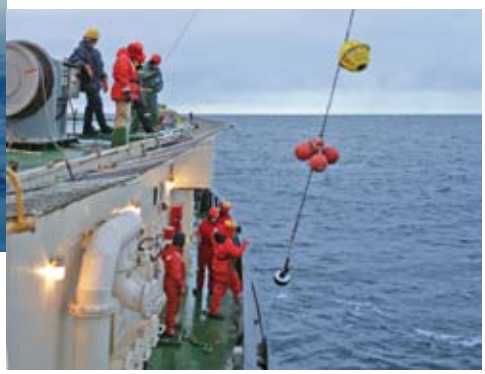
RECOMMENDATIONS

First, the Commission recommends that IARPC expand its membership and planning activities to include independent, federally created entities that can play a major role in Arctic research. The North Pacific Research Board, the North Slope Science Initiative, Alaska Ocean Observing System, and the Prince William Sound Oil Spill Recovery Institute—all created by Congress—are essential to making the goals of this report happen. The Denali Commission, also created by Congress, has the capability to support "pilot projects" that can advance research goals. Further, there is an increasing contribution to research by "community development quota" groups in western Alaska that exist as the result of federal fishing quota allocations.

Second, the Commission recommends that IARPC, under NSF's leadership, meet its statutory obligations and "provide the necessary coordination, data, and assistance for the preparation of a single integrated, coherent, and multi-agency budget request for Arctic research" as per Section 108 (a) 5 of the Arctic Research and Policy Act. This budget will be produced annually, in conjunction with the release of the President's budget. As per Section 105(c), IARPC agencies "shall consult with the commission before undertaking major Federal actions relating to Arctic research." The Commission supports bringing both IARPC and the Interagency Coordinating Committee on Oil Pollution Research under the umbrella of the White House NSTC.

Third, consistent with the two prior recommendations, the Commission asks that the White House Office of Science and Technology Policy and the Office of Management and Budget actively participate in integrating Arctic research plans and budgeting and budget reporting as explicitly called for in the Arctic Research and Policy Act of 1984.

LEFT. Nuclear icebreaker in the fog.
(Photo credit: J. Farrell)
BELOW. Launching a mooring.
(Photo credit: M. Dunn)



REVIEW AND REVISE US ARCTIC POLICY AND INTERNATIONAL COMMITMENTS

President Bush released a new Arctic Region Policy in January 2009 following a comprehensive two-year review and assessment that was recommended in USARC's 2007 goals report. This policy, designated National Security Presidential Directive 66 and Homeland Security Presidential Directive 25, builds upon the previous review, completed in 1994 (Presidential Decision Directive 26) during the Clinton administration. At that time, circumpolar cooperation was just getting started. The Arctic Council was established in 1996 as a high-level intergovernmental forum to foster and promote cooperation, coordination, and interaction among the Arctic States, including the United States, with the involvement of Arctic indigenous communities and other Arctic inhabitants on common Arctic issues.

We commend the Obama Administration for the initiatives it has taken to implement this policy. Some examples: The Ocean Policy Task Force has paid close attention to the imperatives of an increasingly accessible Arctic Ocean and the need to establish a baseline integrated ecosystem science program that can bring together and build upon significant work done to date. The US Navy completed an "Arctic Roadmap" that will provide a basis for Arctic research and operational investments in the decade to come. USCG has conducted a "High Latitude Study" and continues to advance its operations in the Arctic region. DOS has commenced negotiations on search and rescue cooperation in the Arctic and has announced an initiative with EPA to address black carbon and other short-term forcers of Arctic climate change.

We now know that climate change in the Arctic will impact research, civil infrastructure, energy supplies, indigenous cultures, fisheries, national security, and global transportation—to name a few. The policy in place mandates an integrated US strategy that will allow us to better adapt our goals and international commitments in the areas of research, safety, search and rescue, environmental protection, economic development, health and ecological risks, biodiversity, offshore oil and gas development, shipping activities, marine pollution, and cultural tourism.

ENGAGE THE NEXT GENERATION OF ARCTIC RESEARCHERS AND RESIDENTS

Many Arctic residents, and particularly indigenous peoples, contribute significantly to the success of scientific research efforts. Highly successful co-management agreements, such the Alaska Sea Otter and Sea Lion Commission, the Alaska Nanuuq (polar bear) Commission, and the Eskimo Walrus Commission, have been established with USFWS. These entities biosample subsistence-harvested marine mammals, thus providing researchers with valuable materials and data on animal populations and behaviors. Other forms of traditional and TEK provided by Alaska Natives have also been critical to success. Likewise, NOAA has a cooperative agreement with the Alaska Eskimo Whaling Commission to co-manage the subsistence harvest of bowhead whales. Similarly, this agreement provides researchers with valuable samples and data. Despite the importance of these research relationships, funding for co-management agreements, like extramural research funding, are often cut off when agency budgets tighten.

Communication and collaborative efforts need to be improved between researchers unfamiliar with Arctic people and local communities of indigenous Alaskans. Constructive and culturally sensitive engagement with the communities that provide logistical and other research support are critically needed, and will go a long way toward better communication and collaboration in future scientific research and policy efforts. Higher priority must be placed on incorporating and translating local traditional knowledge into scientific research issues that impact Arctic residents. Scientific progress is not a one-way street, from the Arctic outward. Instead, research results from studies of Arctic climate change, ecosystems, oceanography, human health, resource assessment, polar technology, and infrastructure must be communicated and disseminated back to Arctic residents in manners that best serve their needs.

USARC recommends renewed federal support for the Alaska Native Science Commission, which was established to bring together research and science in partnership with indigenous communities. The Commission recommends that IARPC agencies develop new mechanisms to create stronger collaboration with Arctic residents and the public at large. Too often federal agencies hold stakeholder meetings in Washington, DC, or other urban centers at times that conflict with local subsistence activities essential for Arctic communities. In addition, because travel from Arctic communities to Alaska urban hubs and beyond is costly, researchers and federal managers should seek out opportunities, such as the annual Alaska Federation of Natives meetings, to acquire input on research concerns of Arctic communities and user groups.

Communication among researchers, resource managers, and communities will lead to valuable collaborations that will assist in future research and in dealing with emergency situations. For example, in examining the response to the *Selendang Ayu* oil spill off Unalaska Island in the Aleutians, the key lessons learned were the need for more input from local organizations and individual community members, and better communication between the Unified Command and the local entities (Brewer, 2006).

REFERENCES

AMSA. 2009. *Arctic Marine Shipping Assessment 2009 Report*. Arctic Council, April 2009, second printing, 187 pp. Available online at: http://www.arctic.gov/publications/AMSA_2009_Report_2nd_print.pdf (accessed March 5, 2010).

Brewer, R., ed. 2006. The *Selendang Ayu* oil spill: Lessons learned. Conference Proceedings, August 16–19, 2005, Unalaska, AK. Alaska Sea Grant College Program, AK-SG-06-02, Fairbanks, AK, 130 pp.

BIAWG. 2006. *Climate Change and the Bering Sea Ecosystem: An Integrated, Interagency/Multi-institutional Approach*. Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, Seattle WA, 30 pp. Available online at: http://www.afsc.noaa.gov/Publications/ProcRpt/PR%202006-01.pdf (accessed March 5, 2010).

Dorman, C. 2009. *Arctic Research and Monitoring: Toward a Strategy for the Chukchi and Beaufort Se*as. A workshop report from the January 23, 2009 workshop sponsored by the Alaska Ocean Observing System and North Pacific Research Board, Anchorage, AK, 18 pp.

Gautier, D., K. Bird, R. Charpentier, A. Grantz, D. Houseknecht, T. Klett, T. Moore, J. Pitman, C. Schenk, J. Schuenemeyer, K. Sorensen, M. Tennyson, Z. Valin, and C. Wandrey. 2009. Assessment of undiscovered oil and has in the Arctic. *Science* 324:1,175–1,179.

Hild, C., M. Fair, and S. Smith, eds. 2000. *Arctic Telemedicine Project Final Report*. Presented to the Sustainable Development Working Group of the Arctic Council. University of Alaska Institute for Circumpolar Health, 97 pp. Available online at: http://www.ichs.uaa.alaska.edu/research/archives_telemedicine_arctic.htm (accessed March 5, 2010).

Hopcroft, R.R., B.A. Bluhm, R.R. Gradinger, T.E. Whitledge, T.J. Weingartner, B. Norcross, and A.M. Springer. 2006. *Arctic Ocean Synthesis: Analysis of Climate Change Impacts in the Chukchi and Beaufort Seas with Strategies for Future Research*. Prepared for the North Pacific Research Board, Anchorage, Alaska. Available online at: http://doc.nprb.org/web/05_prjs/503_pr_june06.pdf (accessed March 8, 2010).

Jeffries, M., F. Korsmo, J. Calder, and K. Crane, eds. 2007. *Arctic Observing Network: Toward a U.S. Contribution to Pan-Arctic Observing. Arctic Research of the United States*, vol. 21, 94 pp. Available online at: www.nsf.gov/pubs/2008/nsf0842/nsf0842_1.pdf (accessed March 5, 2010).

Jones, A. 2007. An icy partnership. *Science* 317:1,469, doi: 10.1126/science.1149334.

Kruse, G.H., P. Livingston, J.E. Overland, G.S. Jamieson, S. McKinnell, and R.I. Perry, eds. 2006. *Report of the PICES/NPRB Workshop on the Integration of Ecological Indicators of the North Pacific with Emphasis on the Bering Sea*. PICES Scientific Report No. 33, North Pacific Marine Science Organization (PICES), Sidney, Canada, 109 pp. Available online at: http://www.pices.int/publications/scientific_reports/Report33/Rep_33_default.aspx (accessed March 5, 2010).

Levintova, M., W. Zapol, and N. Engmann, eds. 2010. *Behavioral and Mental Health Research in the Arctic: Strategy Setting Meeting*. A contribution to the International Polar Year. International Association of Circumpolar Health Publishers, Oulu, Finland, 64 pp. Available on line at: http: www.arctic.gov/publications/CHS%20(5)%20netti.pdf (accessed March 5, 2010).

Moore, S., and H. Huntington. 2008. Arctic marine mammals and climate change: Impacts and resilience. *Ecological Applications* 18(2):S157–S165.

National Science Board. 2006. *Science and Engineering Indicators 2006*. Volume 1, NSB06-01. National Science Foundation, Arlington, VA. Available online at: http://www.nsf.gov/statistics/seind06/pdfstart.htm (accessed April 27, 2010).

NRC. 2006. *Toward an Integrated Arctic Observing Network*. Committee on Designing an Arctic Observing Network, National Research Council, National Academies Press, Washington, DC, 115 pp. Available online at: http://www.nap.edu/catalog.php?record_id=11607 (accessed April 27, 2010).

NRC. 2007a. *Polar Icebreakers in a Changing World: An Assessment of US Needs*. Committee on the Assessment of US Coast Guard Polar Icebreaker Roles and Future Needs. National Research Council, National Academies Press, Washington, DC, 122 pp.

NRC. 2007b. *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future, National Research Council, National Academies Press, Washington, DC, 456 pp.

O'Rourke, R. 2009. *Coast Guard Polar Icebreaker Modernization: Background, Issues, and Options for Congress*. CRS Report for Congress, 7-5700, RL34391, 54 pp. Available online at: http://www.fas.org/sgp/crs/weapons/RL34391.pdf (accessed March 5, 2010).

Richter-Menge, J. Overland, M. Svoboda, J. Box, M.J.J.E. Loonen, A. Proshutinsky, V. Romanovsky, D. Russell, C.D. Sawatzky, M. Simpkins, and others. 2008. *Arctic Report Card 2008*. http://www.arctic.noaa.gov/report08 (accessed March 5, 2010).

Richter-Menge, J., and J.E. Overland, eds., 2009. *Arctic Report Card: Update for 2009*. http://www.arctic.noaa.gov/reportcard.

SEARCH SSC. 2001. *SEARCH: Study of Environmental Arctic Change, Science Plan*. Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle, WA, 91 pp. Available online at: http://www.arcus.org/SEARCH/resources/otherreportsandscienceplans.php (accessed March 5, 2010).

Wagner, P.J., P. Mongan, D. Hamrick, and L. Hendrick. 1995. Experience of abuse in primary care patients. *Archives of Family Medicine* 4:956–962.

Wexler, L.M. 2006. Inupiat youth suicide and culture loss: Changing community conversations for prevention. *Social Science & Medicine* 63:2,938–2,948.

Wigle, D., A. Gilman, K. McAllister, and T. Gibbons. 2005. *Analysis of Arctic Children and Youth Health Indicators*. Produced for the Arctic Council Sustainable Development Working Group. Future of Children and Youth of the Arctic Initiative, Report of the Health Programme, 111 pp.

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