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US Arctic Research Policy

BY KATHRYN MORAN AND JOHN W. FARRELL

The Arctic is “hot” and not only because it’s physically warming, but also because the world is looking north at climate change, resource exploration, undersea territorial claims, tourism, conservation and ecological impacts, and the promise of marine shipping opportunities. The United States, which became an Arctic nation almost 150 years ago by purchasing Alaska from Russia, has economic (primarily natural resources), security, and environmental interests in the North. These interests are encapsulated in two US national policies, one for the Arctic region in general and another specifically oriented toward Arctic research. In addition, “changing conditions in the Arctic Ocean” emerged as one of nine priorities developed by the National Ocean Council as it moves forward with implementing the President’s new ocean policy (see <http://www.whitehouse.gov/oceans/policy>). Research serves our nation by providing information for policy decisions, and, in turn, policy choices influence the type of research supported by the nation. This article provides an overview of Arctic policy positions and outcomes, with an emphasis on current research policy.

THE CHANGING ARCTIC ENVIRONMENT AS A POLICY DRIVER

Average surface temperature changes in the Arctic are twice that of the global average. This Arctic amplification (the ratio of the Arctic to global temperature trends), a significant research topic in itself that is linked to the dramatic decrease in Arctic sea ice cover (Figure 1; see Overland, 2011, in this issue), is directly affecting the region’s inhabitants, their infrastructure and livelihoods, and the region’s ecosystems. Furthermore,

through global teleconnections, changes in the Arctic’s climate, sea ice volume, and ocean circulation patterns are also affecting the rest of the planet (e.g., Beszczynska-Möller et al., 2011; Münchow et al., 2011; Perovich, 2011, all in this issue). Scientists and Arctic inhabitants are documenting a wide range of often dramatic changes, such as in weather and climate patterns, the food web, marine mammal hybridization, ocean currents and chemistry, wildfires, invasive species, thawing permafrost, and greenhouse gas emissions from a

variety of sources (e.g., Fienup-Riordan and Carmack, 2011; Rainville et al., 2011; Wassmann and Reigstad, 2001, all in this issue).

The many linked ocean-atmosphere-ice-land processes involve multiple feedbacks, only some of which are well understood. Melting of sea ice allows the sun to warm dark Arctic waters previously protected by reflective ice (Figure 2), and this ocean warming leads to further warming. As the volume (thickness and extent) of the Arctic sea ice pack diminishes, the previously remote ocean offers opportunities for tourism, trade, and natural resource extraction, particularly in energy, minerals, and fisheries.

Ironically, as the Arctic Ocean becomes increasingly accessible, Arctic lands become less so. Warmer winters translate into shorter seasons for Arctic ice roads, critical means for transportation. Thawing permafrost, some of which was formed during the last Ice Age, wreaks havoc on existing infrastructure, such as roads, buildings, and pipelines, and further increases the challenges of new construction in the Arctic.

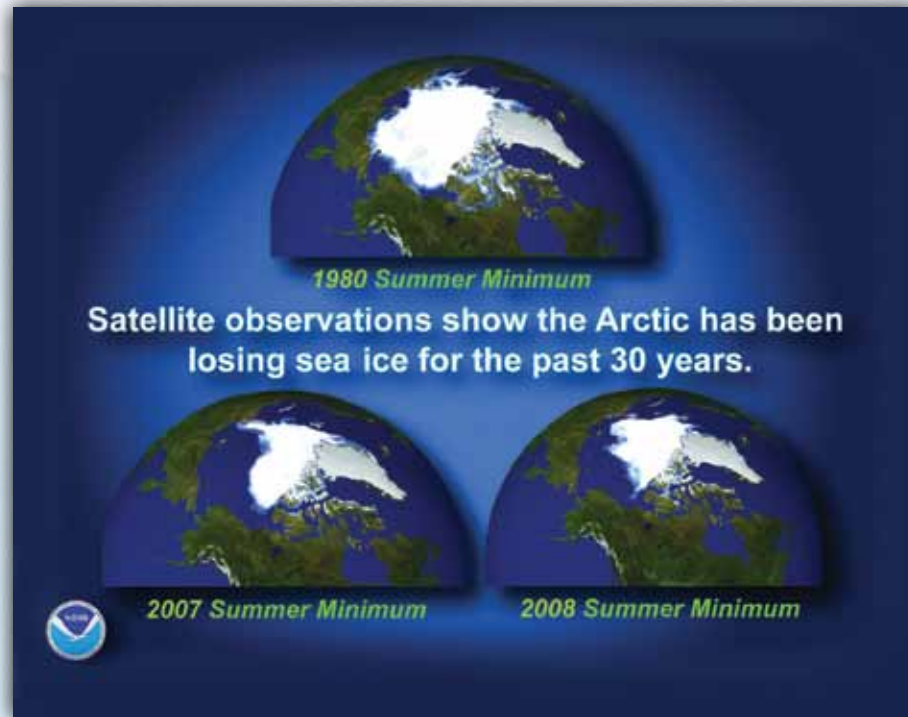


Figure 1. Satellite images show the recent loss of summer sea ice in the Arctic Ocean.

Melting of glaciers and ice sheets, such as in Greenland, is raising global sea level further (e.g., Pfeffer, 2011), compounding challenges at the land-sea interface, such as coastal erosion and flooding, affecting ports and harbors.

Taken together, these Arctic transformations are now major drivers of Arctic policy in the United States, in other Arctic states, and even in non-Arctic states, such as China, Korea, Japan, Germany, France, and the United Kingdom.

INCREASED ATTENTION ON THE ARCTIC REGION BY THE US GOVERNMENT

The US government is recognizing and responding to rapid changes in the Arctic. No US federal agency dedicates more resources to advancing progress in basic science in the Arctic than the National Science Foundation (NSF). Members of the basic science research

community first flagged the unusual environmental changes underway in the Arctic, and their concerns led to development of the interagency-sponsored Study of Environmental Arctic Change (SEARCH) effort, with NSF as lead agency (<http://www.arcus.org/search>). Various basic research activities occurring under the SEARCH umbrella were boosted during the International Polar Year, drawing considerable attention at the national and international levels to the magnitude and rapidity of Arctic change.

In May 2011, Secretary of State Hillary Clinton led a high-level delegation to Nuuk, Greenland, to participate in an Arctic Council Ministerial meeting. At the Ministerial—the first such meeting to receive such high-level participation by the United States—the eight Arctic Council states signed a historic and legally binding agreement on search and rescue in the Arctic, agreed to strengthen

the Council, agreed to rules for those nations requesting observer status, and began the process to establish a permanent secretariat in Tromsø, Norway (see <http://www.arctic-council.org>).

In response to growing national security concerns in the Arctic, the US Navy established a Task Force on Climate Change with special focus on Arctic policy, strategy, missions, and plans. In October 2009, that task force produced the *Navy Arctic Roadmap* (Task Force Climate Change/Oceanographer of the Navy, 2009) that, among other things,

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focuses on US strategic interests in the changing Arctic environment, potential climate-related increases in resource extraction and shipping, and fleet capabilities in the region.

The US Coast Guard (USCG) also recognizes the changing Arctic and its increasing responsibilities in the region. In April 2011, the Coast Guard Commandant issued an instruction outlining a strategic approach in the Arctic and the manner in which it will advance US national interests in the Arctic and continue to ensure maritime safety, security, and stewardship.

An outstanding issue is whether USCG will have the capability to perform its statutory missions in the demanding Arctic environment, given the harsh conditions, remote location, and technological challenges. For the past four years, USCG has been conducting seasonal Arctic operations to test assets and

procedures in recognition of the increase in maritime activity, working closely with Alaska Native and Native Tribal governments and communities.

USCG's ability to operate effectively in the Arctic is key to Arctic operations of the US Navy, such industries as petroleum and shipping, and tour operators. Importantly, and in light of the current budgetary climate, USCG is challenged to maintain or replace critical infrastructure, such as icebreakers. Two of the three Arctic icebreakers, *Polar Sea* and *Polar Star*, are currently out of service. *Polar Sea* will be decommissioned in 2011, and *Polar Star* is scheduled to return to service in 2013 after an overhaul that will extend its service life by another seven to 10 years.

The National Oceanic and Atmospheric Administration (NOAA) recently published *Arctic Vision and Strategy* that describes

six priority goals (NOAA, 2011). As Capt. John E. Lowell Jr., NOAA's Coast Survey Director, stated in his Congressional testimony on May 6, 2011, "By strengthening its Arctic science and stewardship, NOAA aims to better inform policy options and management responses to the unique challenges in this fragile region." Nonetheless, the status of NOAA's future polar-orbiting weather satellites, specifically the Joint Polar Satellite System (JPSS) that will provide the National Weather Service with primary data, is now uncertain. NOAA has not been allocated the \$1.06 billion requested in the President's Fiscal Year 2011 budget needed for instrument and spacecraft development to meet the planned 2016 launch date for JPSS. The delayed launch of JPSS will degrade weather forecasting for the nation because current weather satellites are scheduled to reach the ends of their design lives before JPSS begins.

The Department of Interior has several major efforts ongoing in the Arctic. First, the US Geological Survey (USGS) has recently completed a review of the Beaufort and Chukchi Seas that: (1) examines the effects of exploration activities on marine mammals, (2) describes research needs for an effective and reliable oil spill response in ice-covered regions, (3) evaluates what is known about the cumulative effects of energy extraction on ecosystems and other resources of interest, and (4) reviews how future changes in climate conditions may either mitigate or compound the impacts of Arctic energy development. Second, the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) is in the final stages of completing the next Outer

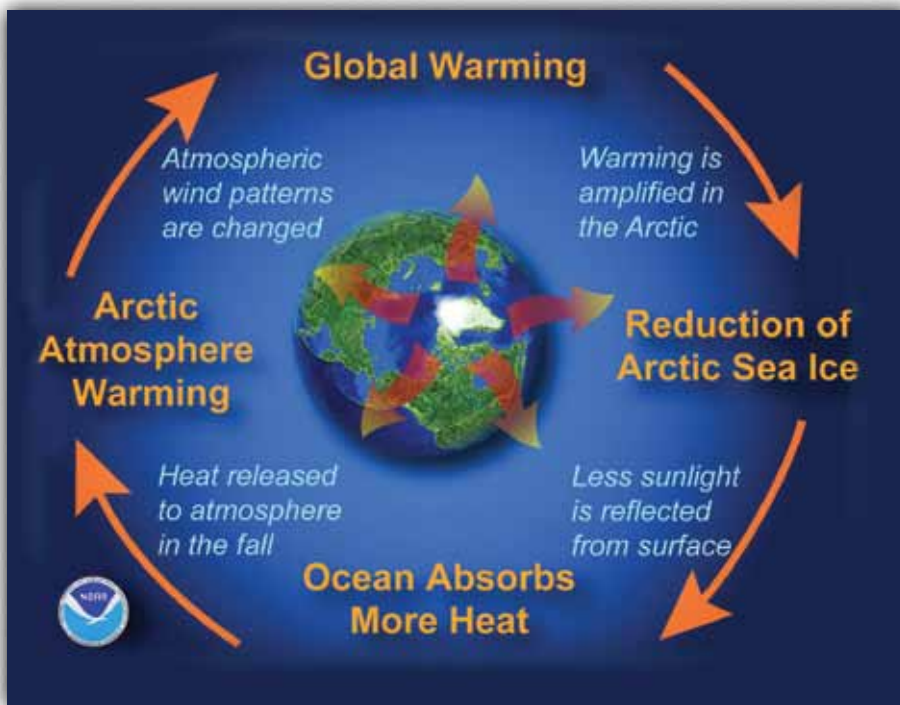


Figure 2. This diagram depicts the positive feedback loop that is contributing to an accelerated loss of Arctic sea ice.

Continental Shelf five-year oil and gas plan, including the Chukchi and Beaufort Seas, that will guide development from 2012 through 2017.

In addressing their various missions, other federal agencies, such as the Department of Energy, Department of State, Environmental Protection Agency, Department of Agriculture, Department of Health and Human Services (largely the National Institutes of Health), National Aeronautics and Space Administration, Department of Transportation, and the National Endowment for the Humanities and the Smithsonian Institution are also experiencing needs for greater attention to, and research on, the Arctic. This long list of agencies working in and focused on the Arctic demands policies with improved interagency collaboration and coordination.

ARCTIC POLICY

What is Arctic Research Policy?

Research policy is the principle by which government encourages research and allocates resources in support of national interests in the public and private sectors; objectives may include advancing fundamental knowledge and higher education, promoting sustainable development and economic growth, and addressing national/homeland security interests, among others. US policy on Arctic research, primarily scientific in nature, is integrated into the overarching national policy on the Arctic region and is also described in federal law.

How are Arctic Research and Public Policy Linked?

Arctic research and public policy are linked in two fundamental ways. First,

Arctic research can inform policy. For example, research may document climate change that may lead a government to develop adaptation policies. Second, and in the opposite sense, policy can influence the type or nature of Arctic research. For example, a policy decision to implement the concept of coastal and marine spatial planning necessitates marine scientific research, for example, on the timing and patterns of marine mammal migration, in order to inform methods to de-conflict overlapping uses of the marine environment.

US Arctic Region Policy

A primary influence on US national policy in the Arctic region is the acceleration of human-induced climate change. Simply put, this change makes the Arctic Ocean increasingly accessible to human activity. Other important influences include sovereignty and territorial issues (such as delimiting national extended continental shelf areas under the United Nations Convention on the Law of the Sea), increasing demand for resources, global commerce, the eventuality of new trade routes through Arctic seaways, technological advances, and homeland and national security interests.

US Arctic policy has most recently been expressed in the National Security Presidential Directive 66/Homeland Security Presidential Directive 25 (NSPD66/HSPD25; issued by President Bush on January 9, 2009; <http://www.dodeaformda.navy.mil/ContentView.aspx?ID=672>). This policy supersedes the Arctic policy issued by President Clinton in 1994. In early 2009, the Obama Administration reaffirmed its support for NSPD66/HSPD25 and established an interagency policy committee,

chaired by National Security staff, to coordinate its implementation. The policy focuses on seven broad areas: (1) national and homeland security interests, (2) international governance, (3) extended continental shelf and boundary issues, (4) promoting international scientific cooperation, (5) maritime transportation, (6) economic issues, including energy, and (7) environmental protection and conservation of natural resources.

The policy directs the Secretaries of State, Defense, and Homeland Security to coordinate with heads of other relevant executive departments and agencies to: develop greater capabilities and capacity, as necessary, to protect United States air, land, and sea borders in the Arctic region; increase Arctic maritime domain awareness in order to protect maritime commerce, critical infrastructure, and key resources; preserve the global mobility of United States military and civilian vessels and aircraft throughout the Arctic region; project a sovereign United States maritime presence in the Arctic in support of essential United States interests; and encourage the peaceful resolution of disputes in the Arctic region.

The directive both states the interest of the United States in operating independently in the Arctic and highlights the need for international cooperation, specifically through the Arctic Council. The directive also requests that the Senate accede to the 1982 United Nations Convention on the Law of the Sea “to protect and advance US interests, including with respect to the Arctic.” The current Secretary of State has also confirmed that the Arctic is one area in which the Obama administration will

highlight international cooperation in its implementation of US foreign policy.

While scientific research, and specifically the promotion of international cooperation of such, is a specific area in the US Arctic region policy, the information provided by research is vital to promote nearly all national interests in the Arctic. For example, in the area of environmental protection and conservation of natural resources, it is US policy to “pursue marine ecosystem-based management in the Arctic region.” Such management is underpinned by the understanding of marine ecosystems provided by scientific investigators, including biological oceanographers, marine mammal and sea bird ecologists, fisheries experts, and physical and chemical oceanographers, among others. An excellent example of how such understanding is developed is the six-year (2007–2012) Bering Ecosystem Study-Bering Sea Integrated Ecosystem Research Program (BEST-BSIRP). This effort, supported primarily by the National Science Foundation and by the North Pacific Research Board, studies the Bering Sea ecosystem, from the seafloor to the atmosphere, and from plankton to human communities (see <http://bsierp.nprb.org>).

US Arctic Research Policy

Prior to both the 1994 and the 2009 Arctic region policy updates, US Arctic research policy was established in the Arctic Research and Policy Act of 1984 (ARPA; http://www.nsf.gov/od/opp/arctic/iarpc/arc_res_pol_act.jsp), signed into public law (98-373) by President Reagan and implemented through Executive Order 12501. Part of the motivation for ARPA was to advance

scientific knowledge of the Arctic to support vital national interests, including energy, security, and the environment. To advance this knowledge, the legislation created two entities: the US Arctic Research Commission (USARC) and the Interagency Arctic Research Policy Committee (IARPC).

US Arctic Research Commission

USARC is a small, independent federal agency that primarily serves in an advisory role. The Commission consists of seven presidentially appointed commissioners and, as an eighth, nonvoting *ex officio* member, the Director of the National Science Foundation. Staff members, located in offices in Arlington, VA, and in Anchorage, AK, support the commissioners in fulfilling the agency’s duties, among which is to develop and recommend an integrated national Arctic research policy and, in cooperation with IARPC, assist in establishing a national Arctic research program plan to implement Arctic research policy.

USARC’s Commissioners represent academic or research institutions, private industry, and indigenous residents of the Arctic. Major recommendations of the Commission on Arctic research policy, program priorities, and means of coordination are published in the Commission’s biennial *Report on Goals and Objectives for Arctic Research* and in a special report series. Recent reports have focused on the importance of oil spill research in ice-covered waters, on scaling studies in Arctic system science, on the US Navy’s submarine Arctic science program called Scientific Ice Expeditions (SCICEX), and on behavioral and mental health research in the Arctic (go to <http://arctic.gov> to download copies of these reports).

Interagency Arctic Research Policy Committee

IARPC includes representatives from 15 federal agencies or offices, and the NSF Director serves as its chair. IARPC’s broad charge includes helping to set future Arctic research priorities, preparing an integrated national Arctic research policy, developing a five-year implementation plan with biennial updates, coordinating preparation of multiagency budget documents for Arctic research, facilitating cooperation between the federal government and state and local governments as well as with other nations in Arctic research, promoting federal interagency coordination of Arctic research activities, and submitting a biennial report to Congress containing a statement of IARPC activities and accomplishments since its last report.

IARPC Moves Under the National Science and Technology Council

On July 22, 2010, President Obama signed a Presidential Memorandum in support of the growing national focus on the Arctic and on the importance of coordinating Arctic research. The Memorandum elevates the priority of IARPC, and of Arctic research in general, and further encourages increased collaboration and coordination of federal agencies under the auspices of the National Science and Technology Council (NSTC; <http://www.whitehouse.gov/administration/eop/ostp/nstc>). In short, the Memorandum brought IARPC under the NSTC umbrella and, thus, in closer contact with the White House.

The intent was to increase efficiency and avoid redundancy with regard to Arctic programs while ensuring that

agency Arctic programs evolve in alignment with Administration priorities. With the release of the Memorandum, IARPC became a designated interagency subcommittee under NSTC (Figure 3), with refocused duties that better reflect some of the Administration's priorities: coordinating Arctic research, technology, and observation programs; developing interagency plans for expansion of knowledge about the Arctic and its interactions with other components of the Earth system, including ocean, atmosphere, land, and living resources, and emphasizing the societal impacts of Arctic climate change; developing plans for predicting and forecasting Arctic climate change; and providing advice relating to ecosystem-based management and stewardship of Arctic resources.

National Science and Technology Council

NSTC, established by Executive Order in 1993, is a Cabinet-level council that coordinates science and technology policy across the research and development enterprise. Chaired by the President of the United States, NSTC membership includes the Vice President, the Director of the Office of Science and Technology Policy, Cabinet secretaries, agency heads with significant science and technology responsibilities, and other White House officials. A primary NSTC objective is to establish clear national goals for federal science and technology investments in a broad array of areas spanning virtually all the mission areas of the Executive Branch. The Council prepares research and development strategies that are coordinated across federal agencies to form investment packages aimed at



Figure 3. Diagram showing the structure of the President's National Science and Technology Council. Subcommittees of the Committee on Environment, Natural Resources, and Sustainability are shown, including the Interagency Arctic Research Policy Committee. Other NSTC subcommittees are not shown for simplicity.

accomplishing multiple national goals.

NSTC's work is organized under four primary committees: Science; Technology; Environment, Natural Resources, and Sustainability (CENRS); and Homeland and National Security. John Holdren, Director of the Office of Science and Technology Policy and a co-chair of NSTC, identified CENRS as the committee under which IARPC will conduct its work. As in the past, IARPC will be chaired by the NSF Director, currently Subra Suresh. And, it will continue to work with USARC to, among other things, establish an integrated national Arctic research policy; facilitate cooperation between the federal government and state and local governments in Arctic research; and coordinate and promote cooperative Arctic scientific research programs with other nations, subject to the foreign policy guidance of the Secretary of State.

The United States and International Arctic Policy

In 1996, an international agreement called the Ottawa Declaration established the Arctic Council. The Council is an intergovernmental forum designed to enable discussions that promote cooperation, coordination, and interaction among the Arctic States. Member States of the Arctic Council are Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States of America. Arctic indigenous communities are active participants in the Council. The Council is led and chaired on a two-year rotating schedule among the Member States. Currently, the Council is led by Sweden.

The scientific work of the Arctic Council is carried out in six expert working groups focusing on such issues as monitoring, assessing, and preventing pollution in the Arctic; climate change; biodiversity conservation and

BOX 1 | NATIONAL OCEAN POLICY OBJECTIVES

Ecosystem-Based Management: Adopt ecosystem-based management as a foundational principle for comprehensive management of the ocean, our coasts, and the Great Lakes.

Coastal and Marine Spatial Planning: Implement comprehensive, integrated, ecosystem based coastal and marine spatial planning and management in the United States.

Inform Decisions and Improve Understanding: Increase knowledge to continually inform and improve management and policy decisions and the capacity to respond to change and challenges. Better educate the public through formal and informal programs about the ocean, our coasts, and the Great Lakes.

Coordinate and Support: Better coordinate and support Federal, state, tribal, local, and regional management of the ocean, our coasts, and the Great Lakes. Improve coordination and integration across the Federal Government and, as appropriate, engage with the international community.

Resiliency and Adaptation to Climate Change and Ocean Acidification: Strengthen resiliency of coastal communities and marine and Great Lakes environments and their abilities to adapt to climate change impacts and ocean acidification.

Regional Ecosystem Protection and Restoration: Establish and implement an integrated ecosystem protection and restoration strategy that is science-based and aligns conservation and restoration goals at the Federal, state, tribal, local and regional levels.

Water Quality and Sustainable Practices on Land: Enhance water quality in the ocean, along our coasts, and in the Great Lakes by promoting and implementing sustainable practices on land.

Changing Conditions in the Arctic: Address environmental stewardship needs in the Arctic Ocean and adjacent coastal areas in the face of climate-induced and other environmental changes.

Ocean, Coastal, and Great Lakes Observations, Mapping, and Infrastructure: Strengthen and integrate Federal and non-Federal ocean observing systems, sensors, data collection platforms, data management, and mapping capabilities into a national system, and integrate that system into international observation efforts.

sustainable use; emergency preparedness and prevention, and the living conditions of Arctic residents. These groups bring together experts from the Member States who identify common research goals and priorities. The United States coordinates interagency input to the working groups through the Arctic Policy Group led by the Department of State.

The Arctic Council, as outlined in the Ottawa Declaration, combines environmental conservation elements with issues related to sustainable development. This task is challenging for policymakers and managers who will have to merge the goals of environmental protection with resource development drivers. The United States approach to this challenge is application of ecosystem-based management that has most recently been embedded in the new National Ocean Policy.

The National Ocean Policy

On July 19, 2010, three days before signing the Memorandum that moved IARPC under NSTC, President Obama signed an Executive Order that established a comprehensive, integrated national policy for the stewardship of the ocean, the coasts, and the Great Lakes. This policy is relevant to Arctic research because the Arctic features prominently in the ocean policy. The ocean policy is founded upon comprehensive planning for ocean preservation and sustainable use. The policy created the National Ocean Council to provide sustained, high-level, and coordinated attention to ocean, coastal, and Great Lakes issues and to focus on actions to advance this new National Ocean Policy.

The Executive Order adopts the final recommendations of the Interagency

Ocean Policy Task Force, established in 2009, and directs federal agencies to implement them under the guidance of the National Ocean Council. The implementation strategy identified nine priority objectives (see Box 1) to address some of the most pressing ocean challenges.

One of the nine objectives, and the only one focused on a specific region in the country, is “Changing Conditions in the Arctic.” This objective was selected as a priority because of the importance of the region and because it is currently experiencing the greatest climate change impacts. Strategic action plans for each of the national priority objectives are currently in development and will be released in early 2012. Development of the Arctic strategic action plan is an interagency effort co-led by USARC and the Joint Chiefs of Staff. Information about the development of this plan is available at the National Ocean Council website (<http://www.whitehouse.gov/oceans>).


Coordination of US Arctic Policies

The expanding US interest in the Arctic has resulted in growth of policy instruments with an Arctic focus. Many of these policies overlap with each other; for example, the Arctic Region Policy and the National Ocean Policy both address sustainable natural resource development in the Arctic Ocean. Because this need to address Arctic issues is part of several policies, coordination among the groups is critical. The IARPC Presidential Memorandum represents the beginning of this coordination effort.

IARPC will serve as the central policy group for the United States on Arctic

research. In the future, IARPC will provide national research policy guidance to the Department of State’s Arctic Policy Group. This change will directly link the priorities set by IARPC with international Arctic Council initiatives supported by the United States.

In a similar manner, IARPC will provide the Arctic research priorities that support the goals of the Arctic Region Policy (NSPD66/HSPD25). Each of the six goals in this policy requires some level of research for their success. For example, to accomplish the development of greater capabilities and capacity to protect United States air, land, and sea borders will require improved understanding of the current and future climate change impacts in the Arctic region.

Finally, IARPC will review and provide final guidance to development of the strategic action plan for the National Ocean Policy Arctic objective to ensure its consistency with Arctic research policy priorities. 

REFERENCES

- Beszczynska-Möller, A., R.A. Woodgate, C. Lee, H. Melling, and M. Karcher. 2011. A synthesis of exchanges through the main oceanic gateways to the Arctic Ocean. *Oceanography* 24(3):82–99, <http://dx.doi.org/10.5670/oceanog.2011.59>.
- Fienup-Riordan, A., and E. Carmack. 2011. “The ocean is always changing”: Nearshore and farshore perspectives on Arctic coastal seas. *Oceanography* 24(3):266–279, <http://dx.doi.org/10.5670/oceanog.2011.78>.
- Münchow, A., K.K. Falkner, H. Melling, B. Rabe, and H.L. Johnson. 2011. Ocean warming of Nares Strait bottom waters off Northwest Greenland, 2003–2009. *Oceanography* 24(3):114–123, <http://dx.doi.org/10.5670/oceanog.2011.62>.
- NOAA (National Oceanic and Atmospheric Administration). 2011. *NOAA’s Arctic Vision and Strategy*. National Oceanic and Atmospheric Administration. 23 pp. Available online at: http://www.arctic.noaa.gov/docs/NOAAArctic_V_S_2011.pdf (accessed August 5, 2011).

- Overland, J.E. 2011. Potential Arctic change through climate amplification processes. *Oceanography* 24(3):176–185, <http://dx.doi.org/10.5670/oceanog.2011.70>.
- Perovich, D.K. 2011. The changing Arctic sea ice cover. *Oceanography* 24(3):162–173, <http://dx.doi.org/10.5670/oceanog.2011.68>.
- Pfeffer, W.T. 2011. Land ice and sea level rise: A thirty-year perspective. *Oceanography* 24(2):94–111, <http://dx.doi.org/10.5670/oceanog.2011.30>.
- Rainville, L., C.M. Lee, and R.A. Woodgate. 2011. Impact of wind-driven mixing in the Arctic Ocean. *Oceanography* 24(3):136–145, <http://dx.doi.org/10.5670/oceanog.2011.65>.
- Task Force Climate Change/Oceanographer of the Navy. 2009. *US Navy Arctic Road Map*. Department of the Navy, 33 pp. Available online at: http://www.navy.mil/navydata/documents/USN_arctic_roadmap.pdf (accessed August 5, 2011).
- Wassmann, P., and M. Reigstad. 2011. Future Arctic Ocean seasonal ice zones and implications for pelagic-benthic coupling. *Oceanography* 24(3):220–231, <http://dx.doi.org/10.5670/oceanog.2011.74>.