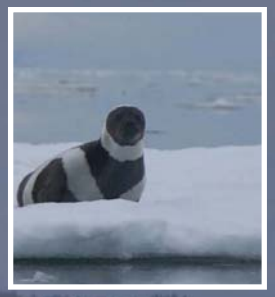
NOAA Action Plan for the Arctic



2010-2020

Pre-decisional - Draft

NOAA ACTION PLAN
for the
ARCTIC
2010-2020

National Oceanic & Atmospheric Administration
February 2009

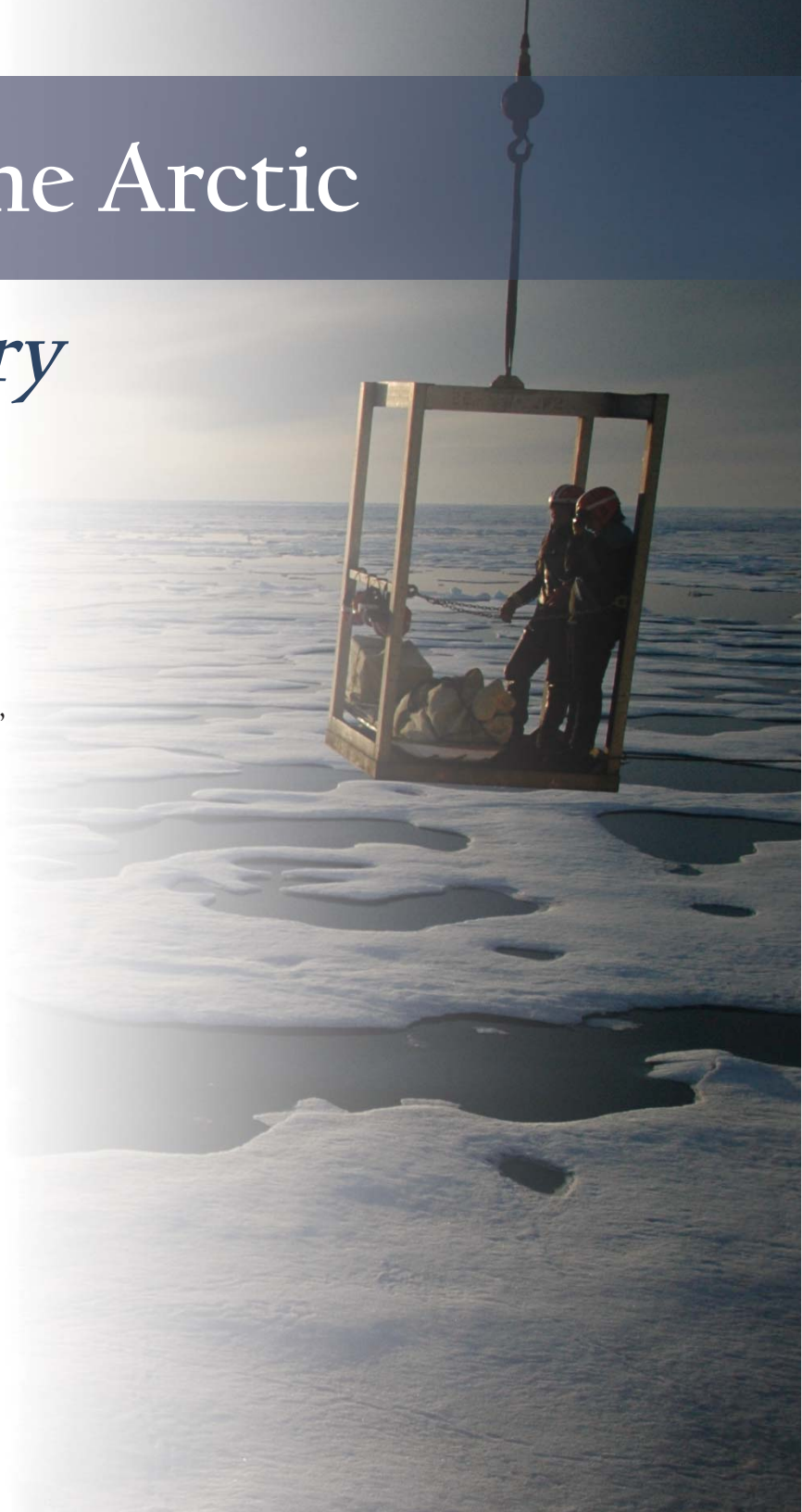
NOAA Action Plan for the Arctic

Executive Summary

Dramatic climate change in the polar regions is occurring, faster than anywhere else on the globe. In the Arctic, this bellwether change is affecting living resources and habitats, human lives and livelihoods:

- Alaskan coastal and inland communities face impacts to culture, health, and economic status.
- Infrastructure, especially in coastal areas, is threatened by stronger storms, increasing erosion, thawing ground, loss of protective sea ice, and changing sea levels.
- Living marine resources, including marine mammals and fishery species, are demonstrating shifts in distribution and abundance due to warmer ocean temperatures and loss of habitat.

As a result of climate change, critical environmental, economic and national security issues are emerging. For example, some economic sectors potentially stand to gain from continued loss of Arctic sea ice, such as shipping, tourism, fishing, and energy development. These activities may in turn compete with each other, or may conflict with existing uses such as indigenous subsistence livelihoods. They may also place additional stress on the environment and the nation's ability to protect its people and exercise United States sovereignty, sovereign rights and jurisdiction.



2010-2020

As the U.S. begins to confront these challenges, it becomes evident that despite some research to date, the Arctic environment itself – from ocean ecosystems to climate effects – remains a mystery. We lack significant and accurate information on Arctic climate change, its impacts on marine ecosystems, living marine resources, coastal communities, transportation and other activities, and the region's role overall in global climate change. But as human activity in the Arctic increases, these information gaps grow more urgent for understanding and managing the inherent conflicts between different uses. Management is made more complex because the U.S. must work with seven other Arctic nations to ensure national security, economic development, and environmental protections in this fragile region.

NOAA, because of its scientific, policy, regulatory and stewardship responsibilities, can play a key role in the implementation of a sustainable U.S. and international Arctic policy that governs access, balances risks, and understands the unique importance of the Arctic. Just as for any other part of the country, NOAA has national and global mandates extending to the U.S. Arctic, defined here as the Aleutian Islands north through the Bering to the Chukchi and Beaufort Seas. This Action Plan for the Arctic, intended to guide NOAA planning for Fiscal Year 2010 and beyond, assesses Requirements, Capabilities and Gaps, and presents Objectives with Strategies to accomplish them. The plan is built around the following theme areas:

- Climate Science and Services
- Coastal Community Resilience
- Weather and Water Services
- Marine Transportation
- Marine Ecosystems and Resource Management, and
- Homeland Security and Arctic Governance.

In conjunction with partners from federal to local levels, the NOAA Arctic Action Plan provides a comprehensive strategy to fulfill NOAA responsibilities and assist the nation in dealing with its Arctic challenges.

Map produced by the U.S. Central Intelligence Agency.

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NOAA's Arctic Role

NOAA's unique role is to protect life and property, conserve and sustainably manage natural resources, and enhance the economy. Through a coordinated and comprehensive Arctic strategy, NOAA will provide a reliable suite of climate, weather, marine ecosystem, living marine resource and geospatial information genuinely useful to the people and agencies making key decisions on environmental management, security and economic issues in Alaska and the Arctic.

NOAA MISSION

To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs

NOAA VISION

An informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions

Emerging Arctic Requirements

Setting the Stage...

Climate Change Drives Stakeholder Actions & Requirements

Global climate models predict a faster, greater warming for the Arctic than the rest of the world. The Arctic and Sub-arctic regions are already experiencing significant environmental and economic impacts from climate change. As reported by the Arctic Council (the intergovernmental forum for Arctic States) in its 2004 Arctic Climate Impact Assessment, observed data indicate that over the last 50 years, mean annual surface temperatures have increased 3-5˚F with some of the largest increases occurring along Alaska's North Slope. The extent of Arctic sea ice reached an all-time low in September 2007, shattering the 2005 record by 23 percent. Summer 2008 finished with the second-lowest minimum extent in the satellite record, 9 percent above the 2007 minimum and 34 percent below average. A more diffuse ice cover and a thinner pack nevertheless suggested a record-low ice volume at the end of summer 2008. (Intergovernmental Panel on Climate Change 2007; NOAA 2007 State of the Arctic; National Snow and Ice Data Center).

Pan-Arctic changes are visibly affecting Arctic and Alaskan weather, climate and ecosystems, with widespread melting of glaciers and sea ice and a shortening of the snow season. For example, Alaskan winter freeze-up and spring melt are now arriving more than three weeks later and earlier than usual. Critically important fishery and marine mammal resources are showing signs of shifts in distribution and migration patterns. Some coastal areas around Alaska are showing a rise in sea level. There is growing evidence of changes in storm frequency and intensity, as well as shifts in storm tracks and more frequent high amplitude weather episodes such as coastal sea ice breakouts. On land, an increased seasonal thaw depth of the active layer is causing accelerated permafrost thaw. The interior is also experiencing heavy precipitation and local flooding; low water events that impact river transportation and subsistence; episodic high wind events; and increasing periods of drought affecting forests, as resulted in the 2004 wildfire season record of 6.5 million burned acres.

These climate-change-induced realities pose significant threats and opportunities to our environmental, economic and national security that the U.S. must consider. Where the inaccessibility of these northern reaches once allowed passivity, now the nation must act quickly and strategically to manage for climate change, coastal hazards, surface and maritime commerce, national security, declining resources for subsistence living and environmental resource impacts in Alaska and the Arctic region. Working with its scientific and operational partners, NOAA has significant capabilities to contribute to a U.S. plan for action in the Arctic. It is fortunate that in addition to the numerous Federal agencies targeting research and observation efforts in the Arctic (see Appendix A and B), Alaska hosts a multitude of associations focused on common issues in the region, setting the stage for effective partnering and service delivery to a broad and diverse group of regional stakeholders and users. These associations include the:

- Regional Integrated Science and Assessment Program
- Alaska Center for Climate Assessment and Policy
- Alaska Climate Research Center
- Integrated Ocean Observing System Regional Association and Alaskan Regional Coastal and Ocean Observing System
- NOAA Cooperative Institute for Alaska Research
- Alaska Sea Grant/Land Grant at University of Alaska
- North Pacific Regional Management Council
- U.S. Arctic Research Commission.

NOAA's Alaska Regional Collaboration Team also provides a cohesive mechanism for integration, collaboration and outreach. In partnership with these associations and others, NOAA can lead in addressing the panoply of interdependent Arctic needs with its own broad portfolio of climate, weather, water, ecosystem and transportation services.

Requirements Assessment

Climate Science & Services

A top priority requirement of virtually all stakeholders is a better understanding of what the future holds in terms of climate forecasts, sea ice and sea level projections. This information underpins decision-making in all sectors. Alaska's state government, for example, is at the forefront of calls to action on addressing and mitigating impacts of climate change, but to do that it asks such basic questions as:

- How fast will the climate warm?
- How warm will it get?
- What effects will the warming have?
- Is there anything [Alaska] can do to slow the increase or the extent of the warming?
- Realizing that [Alaska] can't stop the warming, how is the state to adapt? (*http://www.climatechange.alaska.gov/docs/govrpt_jul08.pdf*)

The State of Alaska, academia, Federal agencies with Alaskan and Arctic responsibilities (such as the Department of Interior, the U.S. Army Corps of Engineers and U.S. Coast Guard), industry, international partners and other users, have expressed concern that current NOAA and other available climate data are at too global a scale to guide Arctic management decisions. Higher resolution regional models are needed for guidance on climate change at scales important for planning, mitigating and adapting. Furthermore, the observed rate of warming and loss of sea ice over the past decade exceed all model projections, highlighting the need for improved global and regional models of climate change, sea ice loss and sea level rise.

NOAA has a long-standing mandate (based upon public law, executive orders, and international agreements) to provide climate observations, products, and services in support of policy decisions in government and the private sector. Such mandates include:

- The National Weather Service (NWS) Organic Act to ensure that there are atmospheric, oceanic, and terrestrial measurements suitable for establishing and recording U.S. climate conditions;
- The National Climate Program Act, which directs the Secretary of Commerce to lead in global data collection, monitoring, and analysis activities to provide reliable, useful and readily available information on a continuing basis, as well as increasing international cooperation in climate research, monitoring, analysis, and data dissemination; and
- The Global Change Research Act of 1990, created to ensure a commitment to the establishment and maintenance of worldwide observations, research into climate variability and predictability, and related data and information systems.

Many stakeholders look to NOAA for its climate science and official forecasts and projections to plan immediate response, adaptation, or mitigation actions across Alaska. However, there is no cohesive, coordinated clearinghouse or service available to them to access the relevant and reliable science information and tools needed. Expanding on existing relationships, NOAA can leverage its observing, monitoring and assessment activities with other U.S. and international agencies working in the region to provide the required authoritative climate data, information, and services. These relationships include the National Science Foundation, NASA, Departments of Energy and Defense, the Cooperative Institute for Research in Environmental Sciences, the National Snow and Ice Data Center, and the seven other Arctic nations.

Coastal Community Resilience

Alaska itself is trying to leverage opportunities by creating a Climate Change Sub-Cabinet in 2007 to develop a Climate Change Strategy. Advisory groups with local to Federal representation, including academia and the private sector, support the Sub-Cabinet with recommendations on adaptation and mitigation issues [see Appendix A]. NOAA sits on the Immediate Action Working Group, the Adaptation Advisory Group, and the Research Needs Working Group. Of great relevance to NOAA is a Sub-Cabinet Immediate Action Work Plan released in April 2008 calling for near-term mitigation of highest priority risks to six coastal communities imminently vulnerable to storm surge, erosion and flooding due to sea level change and loss of permafrost and protective shore ice, along with over 170 other communities facing differing degrees of risk. Projects include protecting or relocating threatened infrastructure, addressing the residual environmental cleanup of abandoned villages, tank farms and landfills, developing risk management and emergency evacuation plans, and addressing health threats. This call to action is echoed in the Intergovernmental Panel on Climate Change (IPCC) report stating that the adaptive capacity of coastal communities is the most important factor in reducing human vulnerability to the impacts of climate change. Ecosystems, too, are threatened by coastal hazards, both natural (tsunamis, hurricane-force storms, flooding and coastal erosion) and man-made (coastal development, oil/gas/mining activities, land-based pollution and oil/hazardous material spills). Alaska coastal managers are calling for science-based information to more effectively manage coastal resources and protect community and ecosystem health.

But managers need more robust tools than are available now to make effective coastal management decisions. In particular, accurate elevations, shoreline and nearshore mapping data, better flooding, storm surge and wave models, and sea level change predictions to protect coastal communities and ecosystems are a top priority. These tools will become increasingly important as the "ice-free" season in the Arctic lengthens.

NOAA already plays an important role as defined by the NWS Organic Act, which authorizes NOAA to assess how shifts in climate, development, and erosion patterns might make certain regions vulnerable to more continual or escalating flood damage;' the Hydrographic Services Improvement Act, authorizing NOAA to develop a geodetic framework supporting accurate positions and elevations for the entire nation; the Tsunami Warning and Education Act, authorizing NOAA with tsunami detection, forecast, and warning for the Arctic Ocean, and the Coastal Zone Management Act, which authorizes NOAA to:

- Conserve, protect and restore coastal habitat in the face of increasing loss and degradation;
- Mitigate and reduce impacts to communities from natural hazards, environmental degradation, and human health threats, exacerbated by long-term climate change and sea level rise; and
- Provide the best available science, tools, technologies, and training to Federal, regional, state and local authorities making decisions in and about the coastal zone.

Ultimately, stakeholders are looking to NOAA for coastal services and expert guidance as they build knowledge of the actual, foreseeable effects of climate change, and develop appropriate measures and policies to protect and prepare both coastal and inland communities for anticipated sea level rise impacts.

Weather & Water Services

NOAA also has specific authority for Arctic Observations under the NWS Organic Act in support of weather forecasting for commerce, safety and civil aviation. NOAA produces and delivers weather and water forecasts and information for routine planning and decision-making, in addition to urgent warning messages during hazardous events for the protection of life and property. However, these products and services do not meet customer and partner needs in terms of timeliness, accuracy, detail, and reliability.

While the population of Alaska is small compared to many other states, that population is primarily distributed along or is dependent on Alaska's coastal waterways and river systems. River communities depend on NOAA's hydrology, river, and ice forecasts to assess flood vulnerability and freeze/thaw impacts on rivers and permafrost-based ice roads, as these are the primary source of both transportation and sustenance. Alaska has 3000+ river systems, but over 90 percent of these are currently unmonitored. Yet nearly all of Alaska's communities are impacted by flooding or excessively low river stages. These river systems also provide critical habitats for species important to subsistence and commercial interests. Coastal freshwater discharge and upwelling play an extremely important role in the marine ecosystems surrounding Alaska, as they affect salmon returns, glacial retreat and ultimately sea level rise.

Severe ocean storm conditions in Bering Sea and Arctic waters pose a very complex weather and oceanographic hazard configuration that threatens ships and Alaskan communities onshore. Alaska's commercial fishermen have an annual fatality rate 26 times greater than the rate for all U.S. workers, making it the most dangerous profession in the nation (source: CDC). NOAA's marine weather forecast and warning capabilities are a "life line" for commercial fishermen, but they have changed very little in terms of accuracy, reliability, and availability over the last several years. For example, mariners still rely primarily on voice broadcasts over HF radio and facsimile weather charts for information. Frequent ocean storms over an ice-free Arctic will bring severe coastal erosion and flooding to Alaska's coastal areas due to the shallow continental shelf. This highlights the need for storm surge forecasts to protect coastal communities. The narrow Bering Strait is another area of major concern as it will be the busiest entrance/exit point for marine transport, mineral and fishery traffic.

Major stakeholders and public sector partners, including the U.S. Coast Guard and the State of Alaska Division of Homeland Security and Emergency Management, require more frequent and more accurate NOAA weather and water information for protection of life, property and the management of Alaska's coastal and living marine resources.

Marine Transportation

Alaska and the private sector are also responding to a number of new opportunities for which NOAA services in the region are necessary for safety and environmental protection. Until now too difficult to reach, retreating sea ice in the Bering, Chukchi and Beaufort Seas is opening up access to regional oil and gas development, commercial fisheries expansion northward, new port destinations and sea routes for commerce and tourism. Because the Arctic region could contain 25 percent of the world's remaining oil and gas reserves, oil companies are already making the investment in exploration with great expectations. With energy prices at historic highs in 2008, a record $2.6 billion was spent on Chukchi Sea Minerals Management leases, and increased drill and tanker ship operations are expected to follow. The mining industry is also exerting pressure in the region for access to mineral resources both on land and below the seabed; for example, Northern Alaska is home to the world's largest untapped coal reserves. These activities would likely increase vessel traffic, and the resulting potential for accidents and damage to the environment.

The private sector is anticipating a seasonal, if not permanent, oceanic trade route to open across the Arctic, which would cut existing transit between Western Europe and Eastern Asia by an estimated 4500 nautical miles. In 2007, the Northwest Passage opened completely over Canada, allowing small cruise ships and even yachts to make the trip across to the Beaufort Sea. For commercial interests, saving a week's time and 40 percent in freight shipping costs presents a compelling case for using such a route. NOAA, Navy and other scientists project that the Northwest Passage will be permanently ice-free during the summers sometime between 2013 and 2040. However, "ice-free" in the Arctic does not mean completely free of ice. Ships would still be limited by prudent speeds for the conditions and quality of marine weather and sea ice forecasts, as well as controlling navigable depths that may preclude very large vessels from utilizing the trans-Arctic route as an option.

More likely and more near term is an increase in intra-Arctic transits. The Arctic Council's 2009 Arctic Marine Shipping Assessment (AMSA) forecasts continued growth in intra-Arctic vessel transits, for example from Asia to the Pacific, or from commercial fishing fleets moving north to follow the fish, and as a result of Arctic-based oil and gas extraction sites relying on marine transportation to reach markets. Commercial traffic through Unimak Pass, the primary connection between the Pacific Ocean and the Bering Sea to the Beaufort and Chukchi Seas, is already increasing. But ships operating in the Arctic environment must contend with difficult weather and sea states, and variable ice conditions that can impact stability and navigation, difficulties exacerbated by poor communications, poor navigation aids and poor nautical charts.

These commercial interests – the cruise industry, oil, gas and mining industries, commercial shipping and fishing – represent the primary economic drivers for NOAA navigation services in Alaskan and Arctic waters. At the 2008 Maritime Administrations Arctic Transportation Conference, a diverse panel of industry representatives and scientists agreed that commercial operations in the Arctic will require the critical services that NOAA provides for safe marine transportation and commerce under the Coast and Geodetic Survey Act of 1947, the Hydrographic Services Improvement Act of 2008, and the NWS Organic Act.

In 2008 the interagency Committee on the Marine Transportation System, on which NOAA sits as Commerce representative, made coordinated improvements to Arctic marine navigation a top priority in its strategic plan. Key concerns relate to Coast Guard aids to navigation, the age and quality of NOAA nautical chart data (with some data still shown from the 1800s), and the lack of designated and surveyed harbors of refuge along the main intra-Arctic routes. The draft AMSA report reiterates these same concerns, placing special emphasis on sea ice forecasts. As AMSA states, "operators need to know where the ice is and isn't; where it's going to be, how closely packed it is and how thick and strong it is; generally, how difficult it will be to go around or, when necessary, go through. These parameters [are] needed on a variety of space and time scales - from the hemispheric to the local, from months and weeks to daily or even hourly - to support tactical and strategic route planning for ships, scientific study and the development of policy and regulations to ensure safe marine practices."

NOAA has authority for: acquiring and disseminating hydrographic, tide and current, shoreline information, marine weather and ice nowcasts/forecasts to ensure safe navigation of commerce in all the Nation's waters, and for managing the National Spatial Reference System, which provides the fundamental geospatial control for transportation, mapping and charting, and any other activities requiring accurate latitude, longitude and elevation data. Although there are other agencies that acquire hydrographic data for other purposes such as the U.S. Army Corps and the Naval Oceanographic Office, NOAA is recognized internationally as the authority for hydrographic surveying and nautical charting in U.S. waters. Coast Guard chart carriage regulations require that NOAA charts, and tide and tidal current predictions are on board all large commercial vessels as essential tools for safe navigation.

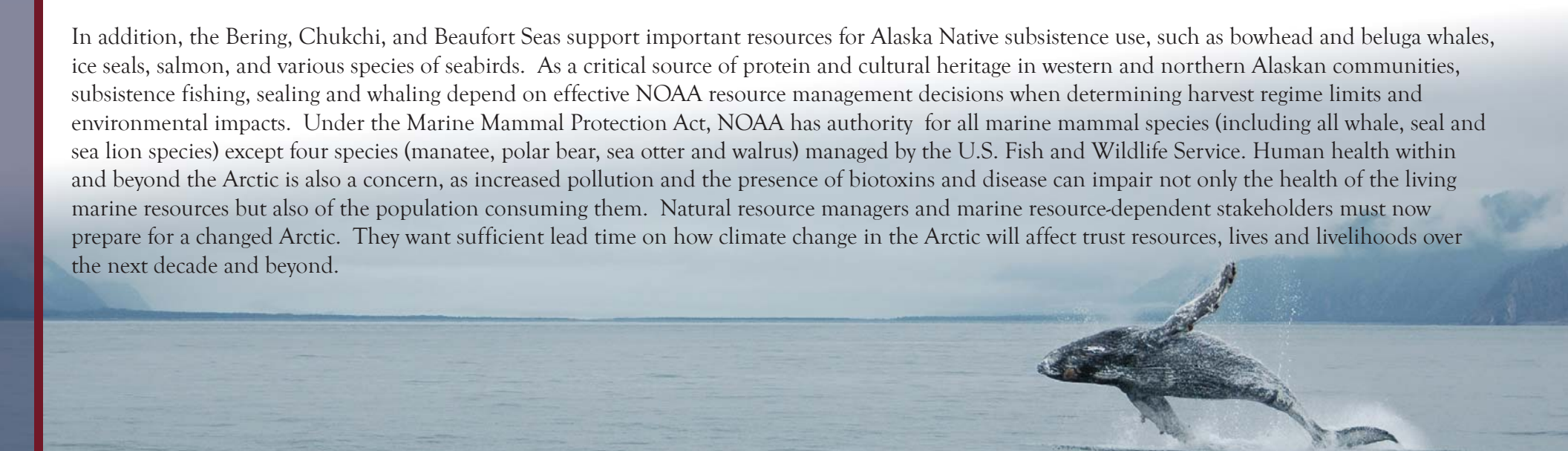
Marine Ecosystems & Resource Management

Loss of sea ice, increasing pH levels and other climate change impacts have put Arctic living marine resources in substantial flux, with the northward movements of many marine species including humpback, gray, beluga whales and other marine mammals as well as Alaskan pollock and other fished species. These changes in fisheries are economically important because Bering Sea commercial fisheries account for more than 40 percent of the U.S. catch. Overall Alaska's seafood industry produces a $5.8 billion economic impact in the state and accounts for 56,600 direct jobs and 22,000 indirect jobs within Alaska, more than the oil and gas and mining industries combined (Northern Economics. 2009. The seafood industry in Alaska's economy. *http://www.marineconservationalliance.org/docs/SIAE_Jan09.pdf*).

Fifteen marine fish species have moved significant distances northward in the Bering Sea between 1982 and 2006. In fact, a recent small-scale survey documented new species never before seen in the Beaufort Sea north of the Alaska coast, and new fisheries may develop on the North Slope. Additionally, it is likely that a warmer, seasonally ice-free Arctic will result in structurally different ecosystems emphasizing mid-water species production versus bottom-oriented ecosystems. Several species are likely to be negatively affected by the loss of sea ice and may become candidates for protection under the Endangered Species Act, including ringed, spotted and bearded seals.

Recognizing the heightened interest in and concern for Arctic fisheries, the North Pacific Fisheries Management Council has recently taken a precautionary approach with a prohibition on commercial fisheries until adequate scientific information on fish stocks and impacts both to and from the changing Arctic environment are available. There are also concerns over increased vessel traffic, such as increased risk of fuel spills and other pollutants, vessel groundings, marine debris and anthropogenic noise. In the future, invasive species and harmful algal blooms may play a more prominent role in Arctic ecosystems. NOAA has authority under the Magnuson-Stevens Reauthorization Act of 2007 (MSRA) for managing commercial and recreational fisheries, and must provide the scientific data to show that Arctic fisheries and living marine resources can be sustainably maintained and protected. Under MSRA, the Endangered Species Act and Marine Mammal Protection Act, NOAA's science and ecosystem management approach are critical to understanding the impacts of climate change on living marine resources and to achieving sustainability of the groundfish, crab, and salmon fisheries in Alaska.

In addition, the Bering, Chukchi, and Beaufort Seas support important resources for Alaska Native subsistence use, such as bowhead and beluga whales, ice seals, salmon, and various species of seabirds. As a critical source of protein and cultural heritage in western and northern Alaskan communities, subsistence fishing, sealing and whaling depend on effective NOAA resource management decisions when determining harvest regime limits and environmental impacts. Under the Marine Mammal Protection Act, NOAA has authority for all marine mammal species (including all whale, seal and sea lion species) except four species (manatee, polar bear, sea otter and walrus) managed by the U.S. Fish and Wildlife Service. Human health within and beyond the Arctic is also a concern, as increased pollution and the presence of biotoxins and disease can impair not only the health of the living marine resources but also of the population consuming them. Natural resource managers and marine resource-dependent stakeholders must now prepare for a changed Arctic. They want sufficient lead time on how climate change in the Arctic will affect trust resources, lives and livelihoods over the next decade and beyond.



Homeland Security & Arctic Governance

In 2007 the National Ice Center and U.S. Arctic Research Commission held a symposium on the 'Impacts of an Ice-Diminishing Arctic on Naval and Maritime Operations.' One conclusion was that little had changed in terms of services available to military and commercial navigation in the region, but that accelerating loss of sea ice was opening up a significantly larger area of U.S. territory in need of Federal services to support maritime security and threat and crisis response. Even as the region becomes seasonally ice-free, it will still be a dangerous place for ship traffic, as evidenced by the Selendang Ayu spill off Unalaska Island in 2004. More vessel traffic in the Arctic increases the likelihood of a marine incident with greater risk of oil spills, damage to the natural environment, and the need for search and rescue.

In response to this breaching of Arctic barriers, the U.S. Coast Guard and Navy are also increasing demand for NOAA services. They are expanding icebreaker patrols and military reconnaissance operations to improve Maritime Domain Awareness (MDA), and the Coast Guard is also exploring options for augmenting search and rescue capability out of a new seasonal base at Barrow, Alaska. Coast Guard cutter expeditions in 2007 and 2008 to prepare for this mission have highlighted the need for better weather and accurate and up-to-date nautical charts in the region, as well as the age of NOAA's existing data. The shortcomings of NOAA navigation products north of the Bering Strait were validated by a NOAA hydrographer aboard in summer 2008. Accurate shoreline is a key feature of the information needed for MDA and waterways management. It not only supports navigation from a charting standpoint, but it is also the basis for enforcement of maritime laws and regulation of domestic and foreign-flagged vessels. As recognized under customary international law – the United Nations Convention on Law of the Sea (UNCLOS) – every coastal State can establish certain offshore limits, such as the territorial sea and Exclusive Economic Zone (EEZ), measured from the low water line depicted on large scale nautical charts.

The Coast Guard is also assisted by NOAA in emergency response and scientific support as authorized by the Oil Pollution Act of 1990, the 2007 U.S. National Search and Rescue Plan, the 2008 National Response Framework, which lays out a role for NOAA to bring its scientific expertise to bear in oil spill response and other incidents, and the National Oil and Hazardous Substances Pollution Contingency Plan, which tasks NOAA to provide scientific support to the Federal On-Scene Coordinator at spill and emergency incidents. But as Coast Guard District 17 Commander Rear Admiral Gene Brooks acknowledged, "We are not prepared for a major oil spill in the Arctic environment. The Coast Guard has no offshore response capability in Northern or Western Alaska and we only dimly understand the science of recovering oil in broken ice." His comments extend to NOAA as the Coast Guard's provider for scientific support.

The Oil Pollution Act of 1990 also requires NOAA to conduct assessments of ecological harm and losses to communities, and to plan and implement appropriate restoration actions after oil spills in conjunction with other natural resource trustee agencies and responsible parties. NOAA's natural resource damage assessments are integrated into oil spill response through the incident command system. With the increase in vessel traffic in the Arctic, the possibility of increased oil exploration, and the potential for melting permafrost to destabilize and break oil pipelines, spills are increasingly likely, and natural resource damage assessment will be a vital component of response to spills to ensure that the environment recovers.

Another driver for increased action in the Arctic stems from UNCLOS's recognition that a coastal nation's sovereign rights over its continental shelf may extend beyond the 200 nautical mile EEZ limit. It sets forth a process for international recognition of the outer limits of a coastal nation's continental shelf and the sovereign rights over the associated seabed resources therein. Russia, Canada, Denmark and Finland are actively pursuing submissions to the Commission on th e Limits of the Continental Shelf. According to the U.S. Arctic Research Commission, if the U.S. were to become a party to UNCLOS, it s submission could include an area in the Arctic of about 450,000 square kilometers – approximately the size of California. Although almost no information exists pertaining to potential resources in this area, it is anticipated that petroleum, gas hydrate, and other mineral resources will be discovered, as well as new habitats attracting communities of fish, deep coral, and other organisms. Establishing a foundation of information on the nature of the potential extended continental shelf and its resources through mapping and exploration is a critical first step for:

- determining how they might be appropriately conserved and managed; and
- forming a baseline for understanding how the region is changing in response to climate change.

Although the U.S. has yet to ratify UNCLOS, Congress has recognized the importance of delineating the U.S. Extended Continental Shelf. NOAA, the Department of State and the U.S. Geological Survey have been recognized as primary U.S. agencies with the capabilities to execute the required activities and to ensure a successful submission. A major challenge is ensuring international and interagency coordination in developing the required evidence for a potential U.S.submission. In 2008 the U.S. and Canada conducted a precedent setting joint expedition to collect seismic and bathymetric data in the Arctic Ocean, which leveraged resources from both countries.

The 2009 U.S. Arctic Policy and Homeland Security Presidential Decision Directive (NSPD66/HSPD-25) articulates six principal objectives in the Arctic region:

- Meet national security and homeland security needs relevant to the Arctic region;
- Protect the Arctic environment and conserve its biological resources;
- Ensure that natural resource management and economic development in the region are environmentally sustainable;
- Strengthen institutions for cooperation among the eight Arctic nations (the United States, Canada, Denmark, Finland, Iceland, Norway, the Russian Federation, and Sweden);
- Involve Arctic indigenous communities in decisions that affect them; and
- Enhance scientific monitoring and research into local, regional, and global environmental issues.

The Department of Commerce and NOAA's scientific and resource management capabilities are key to implementing this policy and to the development and success of additional domestic or international policies that may evolve to meet the growing threats and opportunities in the Arctic region.

Current Capabilities & Gaps

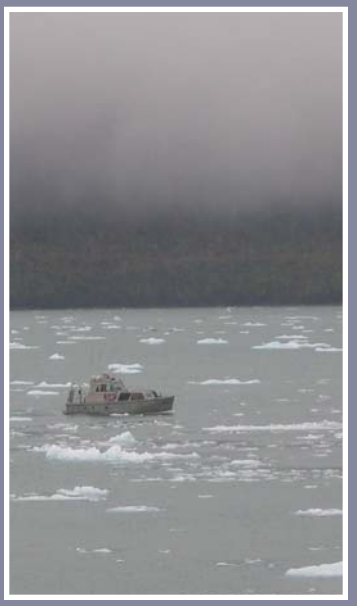
Climate Services & Science

NOAA is an essential partner in climate-related research and monitoring of the Arctic. In fact NOAA was a principal sponsor of the Arctic Climate Impact Assessment that alerted the world to the rapid change in Arctic climate, its implications, and need for monitoring. To this end, NOAA observes the Arctic atmosphere and cryosphere from manned Atmospheric Baseline Observatories at Barrow, Alaska, and Summit, Greenland with the National Science Foundation. With its international partners, NOAA also has operations at Alert and Eureka, Canada, Ny Alesund, Spitzbergen, and at Cheriskiy and Tiksi, Russia. NOAA performs periodic sampling at many locations to monitor global and high latitude carbon dioxide, methane, nitrous oxide and other greenhouse gases, as well as special campaigns to describe and understand the roles of clouds, aerosol and radiation in controlling the Arctic climate and its impact on other geographic areas.

Understanding the rate of Arctic loss of ice and its impacts on Arctic ecosystems and global climate cycles is a critical nexus for NOAA's current and required science investments to provide policy makers with realistic predictions for the Arctic and beyond. Sea levels globally will rise as Arctic glaciers and the Greenland Ice Sheet melt, but the rate at which they are melting is poorly understood. The observed acceleration of the rate implies a global sea level rise earlier than current predictions. These melt waters may also affect the global ocean circulation, possibly slowing the transport of heat from the tropics to the polar regions. As noted in Climate Change Science Project Synthesis Report 1.2, Past Climate Variability and Change in the Arctic and at High Latitudes, it is also important to understand the role of sea and glacial ice in Arctic amplification of global-scale climate changes, along with the ocean, the atmosphere, and the land surface. Additionally, the region contains vast quantites of methane trapped in terrestrial and subsea permafrost and in methane hydrates. Should warming lead to a release of large quantities of this potent greenhouse gas, the rate and extent of global warming would surge beyond any model projection. Because there is already evidence of increased methane release from thawing permafrost in the Siberian region of Russia, the detection and modeling of climate feedbacks associated with greenhouse gas release grows increasingly important.

Scientists can forecast that climate change in the Arctic will affect much of the northern hemisphere through changes in weather and storm patterns and associated changes in precipitation. However, uncertainties in these areas are large, and require continued monitoring and research to fully understand their implications. Current observing deficiencies include insufficient atmospheric vertical soundings, buoy coverage, carbon dioxide and methane measurements, climate reference network stations and sea ice measurements. To refine the models, NOAA and its partners must increase polar region observations of clouds, sea ice, snow, atmospheric temperature and humidity, winds, storms, precipitation, land cover and other parameters necessary to adequately monitor, assess, and predict changing Arctic conditions. The ability to address modeling gaps also hinges on high performance computing capacity and the unknown factors in the discrepancies between observed conditions and current model predictions and projections. Improving global and regional models of warming, sea ice loss and sea level rise depend critically on a strengthened climate research program in NOAA and other agencies.

Turning from NOAA's capabilities and gaps for climate science to climate services, it is worth noting that the demand for relevant and reliable Alaska climate information and services continues to grow as government, industry, academia, and other sectors seek to plan response, adaptation, and mitigation actions across the state. But NOAA and its IPCC partners in climate science do not presently provide a convenient, easy, integrated, accessible means of retrieving that climate change information. Moreover, existing products are at scales not useful for local or regional decision-making and products such as a Seasonal to Inter-annual to Decadal Sea Ice forecast do not exist. There is no forum for users to identify desired climate products and services, no basic suite of services appropriate for Alaskan and Arctic users, and no public inventory of current research, monitoring and data collection efforts that users might mine for information. The absence of a coordinated approach to Alaskan climate services is an opportunity for NOAA to play a leadership role in delivering climate services in the region and nationally. Developing and implementing an Alaska/Arctic Climate Services Partnership would enable NOAA and its partners to deliver science-based research and operational climate products more relevant to Alaska and the Arctic region than is available today.



Coastal Community Resilience

In general, NOAA has strong, broad capabilities in:

- Providing Science: Conducting mission-oriented research and technology development; and coastal monitoring, observations, and mapping;
- Building Capacity: Enabling state and local managers to make full use of NOAA services through training, technological tools, and technical assistance, as well as education and public awareness programs
- Managing: Creating and implementing best management practices and conserving and restoring critical habitat; and
- Promoting Collaboration: Expanding the impact of coastal investments by leveraging partner capabilities and resources essential to management of coastal resources.

However, NOAA is limited in its ability to meet mission goals in coastal Alaska due to insufficient resources, historical datasets and integrated frameworks for the physical, chemical, biological and socio-economic parameters that support coastal management needs. Specific to storm surge and sea level change projections to aid local decision-making on impacts and adaptations, what is true for the mid-Atlantic is also true for Alaska. As per the January 2009 Climate Change Science Project Synthesis Report 4.1, NOAA lacks crucial pieces of information at the right resolution and detail to deliver a comprehensive understanding of how coastal landforms will respond to sea level rise.

To model the impacts of sea level change on coastal communities and ecosystems, NOAA must address observing deficiencies in the Arctic region, including the need for:

- Accurate elevations based on new and updated gravity data
- A geodetic framework tied to present-day water levels
- Long-term sea level records from tide gauges
- Altimeter mission coverage, and
- High-resolution topography and nearshore bathymetry

The Alaska Climate Impact Assessment Commission also recommended that NOAA collect gravity data to derive accurate elevations in the coastal zone for better flood and coastal erosion rate models. There is significant partnership potential for this gravity data collection with interested agencies such as the Navy and the state of Alaska. Other partnership opportunities exist for shoreline and nearshore mapping data, including collaborating with the U.S. Army Corps and U.S. Geological Survey on their projects to map Alaskan coastal areas with airborne Lidar for sediment transport, shoreline movement and change detection. Such coordination would address the gaps in age, quality and coverage of NOAA's Alaska shoreline data, much of which was mapped pre-1964 earthquake and pre-digital technology. Finally, the vast and remote expanses of much of Alaska's coast will require novel and integrated approaches to most effectively and efficiently address these gaps.

Weather & Water Services

NOAA supports Alaska with three Weather Forecast Offices, an Aviation Weather Unit, a River Forecast Center, a Tsunami Warning Center, and several remote field offices for data collection. These offices, in addition to a Regional Headquarters Office, execute the weather mission to protect life and property and enhance the regional and national economy. NOAA's river and weather forecast offices provide weather forecasts and warnings to promote public safety, economic benefit and hazard resilient communities. NOAA also operates an ice forecast desk at the Anchorage Weather Forecast Office, which produces graphical analyses of sea surface temperatures and sea ice as well as a seasonal five-day sea ice projection. The National Centers for Environmental Prediction, including the Ocean Prediction Center, and the National Ice Center contribute to NOAA's weather mission with offshore and high-seas forecasts and ice products for the Arctic and sub Arctic regions. Observations and data are gathered via satellite, radar, airborne, floating and ground instrumentation. Research laboratories and testbeds develop state of the art science and technology upon which these weather and water resource services depend. NOAA's capabilities deliver information, forecasts and warnings for surface, marine and aviation weather, as well as high-impact events such as extra-tropical storms, droughts, floods, volcanic ash, coastal hazards such as erosion and tsunamis, and wildland fires.

In terms of gaps, NOAA must improve its observing, modeling, and forecasting capabilities to meet evolving customer needs in the Arctic with particular emphasis on marine weather and sea ice conditions and hydrology services for the rivers and coasts. This includes:

- Deploying automated stream gauges and acoustic sensor gauges to enable adequate hydrologic monitoring and improvements in river and flood forecasts;
- Implementing new observing technologies to help fill gaps in meteorological and oceanographic observation fields
- Improving the reliability of forecasts of extreme weather and water events by reducing uncertainty and extending lead time
- Expanding to a new offshore marine weather forecast and warning zone for the U.S. Exclusive Economic Zone north and west of Alaska in the Arctic Ocean, and
- Improving operational sea ice and iceberg mapping, tracking, and forecasting.

Particular to marine weather for the Arctic Ocean are necessary enhancements to observational capabilities such as extending the NOAA buoy network coverage into the Arctic Ocean for wave observations and continued access to Synthetic Aperture Radar data for ice advisory and search and rescue needs, oil spill monitoring, and for coastal wind observations. Improving marine weather forecasts also requires expansion of the operational NOAA Wave Watch 3 (NWW3) Model domain from 75°N all the way to the North Pole to cover the Arctic Ocean. The program is heavily dependent on NASA's QuikSCAT to aid in determining the appropriate wind warning category for extratropical weather systems so critical to commercial shipping, and for ice detection. The impending loss of QuikSCAT in the next few years requires action if NOAA is to maintain these forecasting capabilities. Addressing these gaps would enable NOAA to issue operational offshore forecasts and warnings two times daily, in addition to the current Coastal Waters Forecasts, to mariners in the expanded Arctic marine service area, along with storm surge warnings and forecasts for Alaska coastal communities.

NOAA's five-day regional sea ice projections are critical for tactical level marine transportation support, but NOAA should also develop seasonal sea ice outlooks for useful lead times to provide planning guidance for shipping and other industries. NOAA should also improve the ability to provide real-time weather support for Coast Guard search and rescue and marine incident response. Currently the National Weather Service issues general outlooks for sea ice and sea surface temperature three days a week, but as vessel traffic increases and communities are increasingly imperiled by storm surge and sea level rise, leveraging this capability into daily advisories and forecasts is critical to meet Coast Guard requirements for daily ice forecasts, sea ice analyses, and sea surface temperature forecasts for the Bering Strait and Arctic.

Marine Transportation

In addition to weather and sea ice forecasts, NOAA has long been responsible for providing the nation with nautical charts and oceanographic information for marine transportation, and accurate positioning infrastructure, models and tools that actually benefit all modes of transportation. Where NOAA falls short is not so much in its ability to deliver marine-transportation related services, but in the resource capacity to deliver them comprehensively and nationwide.

As noted earlier, Alaska and the Arctic in particular lack the fundamental geospatial infrastructure that NOAA provides the rest of the nation. Alaska is the only state without digital shoreline imagery and elevation maps meeting nationally accepted standards. Moreover, the State's reference system has neither the density of control points to support sub-meter level accuracies for surveying and positioning activities, nor vertical datum coverage for the western half of the state to support accurate determination of elevation heights. These shortfalls translate into widespread gaps in sounding and shoreline data on nautical charts of the region and 2-meter level errors in the state geodetic positioning framework. Sporadic coverage by the NOAA managed Continuously Operating GPS Reference Station (CORS) network also makes access to the State's ailing reference system difficult. The CORS Network in Alaska only provides coverage to approximately 50 percent of Alaska compared to almost 100 percent for the rest of the nation.

There are also large gaps in tidal datum and tidal current prediction coverage, primarily due to lack of physical support infrastructure. NOAA has only 26 NOAA National Water Level Observation Network stations in Alaska, with most sited south of the Aleutian Chain There are 29 identified gaps, most north of the Aleutian Chain, which have been prioritized by the Alaska Immediate Action Working Group and the NOAA Arctic Regional Team, along with a plan to address these gaps where physically possible. Tidal current predictions are also almost non-existent north of the Aleutian Chain. The deficiencies in shoreline and hydrographic data have also been noted but are reiterated here. NOAA's ability to meet survey and mapping requirements is heavily impacted by the health of its fleet and aircraft assets. In order to enable the range of services required, NOAA needs to:

- Establish accurate elevations and a new vertical reference frame (or datum) to provide the fundamental geospatial infrastructure required to support Arctic navigation and many other uses;
- Establish adequate tides and currents information; and
- Pursue an integrated mapping plan across NOAA and externally for Alaskan shoreline and Arctic waters to update the nautical charts and other uses now relying on pre-1940 hydrographic and shoreline data.

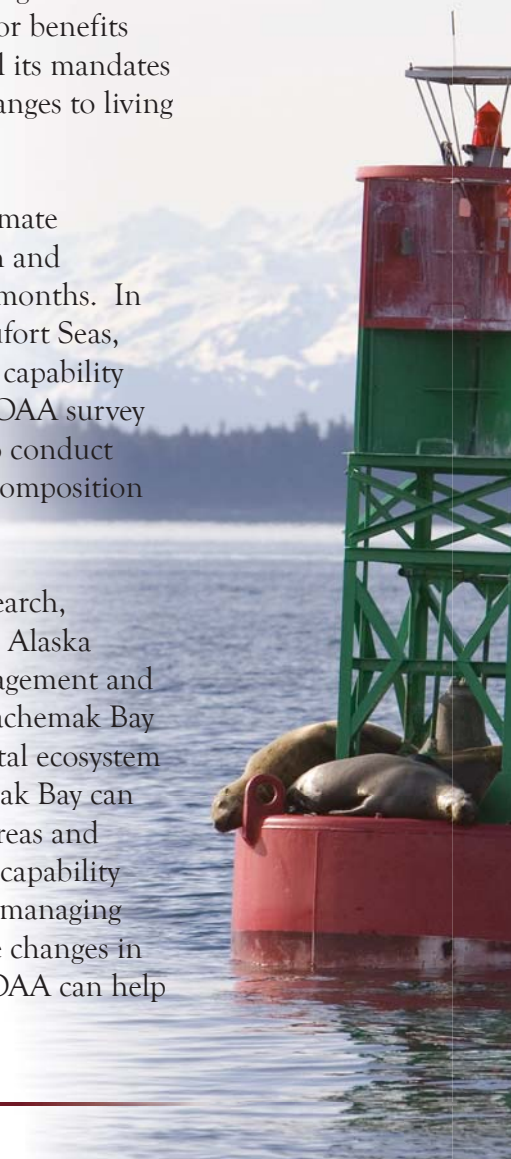
Many other non-transportation activities such as Homeland Security, emergency response, long term sea level trends, storm surge/tsunami modeling and warnings, floodplain mapping, coastal zone management and climate services also rely on these same valuable NOAA capabilities, but they do not have adequate access to them north of the Bering Strait. For example, NOAA's Fisheries, Research and Ocean Services depend heavily on bathymetric, water level, tidal currents and shoreline data to establish baselines for climate studies, sea ice retreat, coastal erosion and sea level rise monitoring and predictions, and to integrate with marine habitat mapping and fish survey data.

Marine Ecosystems & Resource Management

NOAA conducts population assessments and ecological process studies to meet its living marine resource management and protection mandates. However, its data in the Arctic are insufficient to make adequate assessments of some commercial fish, cetaceans and shellfish stocks in the Bering, Beaufort and Chukchi Seas. These stocks are inadequately assessed because some species have shifted outside of areas NOAA presently monitors. It is currently beyond the scope of existing ecosystem models to provide reliable indications of how loss of sea ice and increasing ocean temperatures will impact key species such as pollock, cod, salmon and crab, as well as ice seal species and Arctic cetaceans (e.g., bowhead, gray, humpback and beluga whales). NOAA must monitor trends in marine species abundance as commercial and subsistence usage continue, and also to implement better data collection, analyses and models to provide reliable predictions of the changes coming to the Bering, Chukchi, and Beaufort Seas Large Marine Ecosystems. NOAA will also need to provide ecological characterizations and better understand the ecosystem services, or benefits provided by the ecosystem, to meet management needs and protect living marine resources at risk. NOAA cannot fulfill its mandates without baseline information about Arctic ecosystems and accurate documentation of ecosystem changes, including changes to living marine resources.

At present the biggest limiting factors in providing managers with the information they need regarding the impact of climate change on Arctic living marine resources off Alaska are insufficient oceanographic moorings, insufficient fish, shellfish and marine mammal surveys, and insufficient access to appropriate research vessels and aircraft during the ice free summer months. In particular, very few surveys have been conducted to assess the status of living marine resources in the Chukchi and Beaufort Seas, and the spatial and temporal coverage of what surveys have been made is extremely limited. Additional Arctic surveying capability is proposed in NOAA's Fleet and Aircraft Recapitalization plans, which include state-of-the-art replacements of aging NOAA survey vessels and planes. Additional charters are required to meet the overall capacity shortfalls. Also, resources are needed to conduct ecological process studies on how loss of sea ice and sea surface temperature warming will change the productivity and composition of Arctic marine resources in waters off Alaska.

Given the need for decisions to be based on sound scientific and socioeconomic information, Arctic environmental research, monitoring, and vulnerability assessments are top priorities. NOAA's Alaska Fisheries Science Center and the Fisheries Alaska Region are essential components to meeting NOAA's statutory responsibilities for living marine resource research, management and conservation as sea ice recedes and human activities increase in the Arctic. NOAA's Kasitsna Bay Laboratory and the Kachemak Bay National Estuarine Research Reserve also serve as focal points for research, outreach and education on marine and coastal ecosystem science to improve coastal habitat health and to inform management and use of coastal resources. In addition, Kachemak Bay can serve as a sentinel site for measuring climate change and ecological changes over time to help predict changes in other areas and address the causes. If resourced sufficiently, these assets will help to address NOAA's gap in coastal ecosystem forecast capability in Alaska. The collection and integration of biological, physical, and chemical information at these sites is essential for managing existing and emerging fisheries, developing models to assess risk of action or inaction, and detecting ongoing and future changes in this delicate and complex Arctic ecosystem. Through conservation, research and response to environmental threats, NOAA can help the region develop risk-averse strategies to prevent damage to critical marine resources.



Homeland Security & Arctic Governance

The *Selendang Ayu* spill highlighted the gaps in scientific knowledge necessary to evaluate the impacts of oil spills on Arctic resources and restoration opportunities that NOAA is able to provide effectively in other regions of the U.S. However, in Alaska and Arctic waters NOAA is hindered by the lack of any offshore response capability and assessment capabilities including lack of baseline data in Northern and Western Alaska and lack of predictive capabilities for fate and effects of oil in cold, ice-laden waters. Many standard approaches to oil spill cleanup and restoration in temperate regions are inapplicable in the Arctic. NOAA thus lacks both capability and capacity to respond to the maritime oil and chemical spills that grow more probable as trans- and intra-Arctic vessel traffic increases.

In order for NOAA to effectively meet its mandate for scientific support to first responders and to conserve and restore ecosystems, it must better understand how oil released in Arctic waters weathers, how it lingers, and how these processes ultimately result in biological and ecological injury to the fragile Arctic environment. This effort requires significant coordination among NOAA programs to effectively utilize environmental data and deliver products to mitigate the inevitable impact of increased shipping and resource exploration in this fragile environment. It will also require continued collaboration between NOAA components and other agencies to improve preparedness and responder capability. The training and educational services that NOAA provides in other parts of the country need to be developed for Arctic responders; for example, training in how to assess and respond to oil in broken sea ice. NOAA has also developed a new high resolution environmental information system to aid responders that can access both static data (like biological sensitivities and shoreline characteristics) as well as real-time data from monitoring stations (like weather and currents). This system could be expanded to Alaska quickly with additional resources.

NOAA also lacks the capabilities to predict where a spill in sea ice may go and what effects it may have. To remedy this shortfall and better support first responder readiness with scientific expertise for oil spills and other catastrophic events, NOAA will work with the Oil Spill Recovery Institute in Cordova, Alaska, the University of Alaska Fairbanks, Norwegian Researchers and the University of Rhode Island to improve

predictive capabilities of oil-in-ice scenarios. Currently, NOAA, through the Coastal Response Research Center, is working with the international community to improve predictive capabilities of oil-in-ice scenarios. In addition, outreach and education concerning Satellite Search and Rescue emergency beacon registrations is essential to facilitating rapid search and rescue response in this harsh environment.

With respect to ECS delineation, NOAA, in conjunction with State Department, U.S. Geological Survey, Coast Guard and other partners, contributes its mapping expertise via NOAA Ocean Exploration and the NOAA Joint Hydrographic Center at the University of New Hampshire to collect bathymetry and acoustic backscatter data to support an ECS submission. The U.S. Task Force also charged NOAA's National Geophysical Data Center with managing the data integration and archive for these data supporting the U.S. ECS. In addition, NOAA and the Task Force are challenged to ensure a coordinated approach and dedicated funding for planning, executing and delivering the required products for a claim. NOAA in particular must leverage ECS activities to better understand the resource base contained in the ECS for informed decisions on potential economic value and potential necessary protections. In support of both ECS and other international negotiations, NOAA enjoys exceptional legal and scientific support, but its capacity to address the increasing number of Arctic issues is growing thin.

Strategies to Fill Gaps & Meet Objectives

Objectives:

In response to the needs and demands noted above, NOAA has identified a number of priority objectives it seeks to achieve over 2010-2020 in order to provide reliable, relevant and authoritative science, information and management services to the Arctic region.

Objective I: Design and deliver decision-support tools and information on climate change, supported by authoritative NOAA climate science, that are meaningful and useful to Arctic/ Alaska climate data users.

Objective II: Provide Alaska managers with the geospatial models, tools, and assessments needed to make scientifically-based decisions on coastal/ecosystem resource management, development and climate mitigation/adaptation planning.

Objective III: Deliver weather and water forecasts, warnings, and information that are more responsive to dynamic Arctic/Alaskan conditions for commerce, resource management and safety of life and property.

Objective IV: Deliver the same level of NOAA geospatial services to Alaska and the Arctic as for the rest of the nation by overhauling the region's positioning, tides, currents, shoreline, and hydrograph ic infrastructure) for safe and efficient maritime commerce and security.

Objective V: Deliver informed scientific assessments of ecosystems and living marine resources for Alaska and the Bering, Chukchi and Beaufort Seas with adequate spatial and temporal survey coverage for commercial and subsistence harvest regimes, protected species and other needs.

Objective VI: Support U.S. Homeland Security/ Maritime Domain Awareness efforts in the Arctic and assist the U.S. with the science needed for Extended Continental Shelf delimitation and sustainable use and management of Arctic resources.

To begin to meet its objectives and improve service delivery to Alaska and the Arctic region, NOAA should look first to the potential for integration and coordination of Arctic activities across the agency. Though integrating efforts may not fill every gap described here, there are certainly efficiencies to be found within and external to NOAA in accomplishing mission mandates. The plan below builds upon current cross-NOAA activities, and expands capabilities with agency and international partners toward achieving these actionable objectives. As specific projects and programs within NOAA's control develop from these strategies, NOAA will conduct environmental review pursuant the National Environmental Policy Act of 1969 and other regulations to analyze and consider alternatives to avoid, reduce or mitigate impacts to the environment.

Develop an Alaska/Arctic Climate Services Partnership that provides decision-makers with information for climate change adaptation and mitigation actions (*Objective I, II*)

- Alaska/Arctic Regional Climate Services Center
- Inventory and catalog existing NOAA Alaska regional products and services
- Provide common portal for access to NOAA Alaskan activities, products, and services
- Expand collaboration with academia and the research community as well as other governmental agencies regarding climate change
- Utilize the NOAA Alaska Regional Collaboration Team to increase dialogue with stakeholders and customers regarding climate impacts and climate service requirements
- Conduct user-focused research assessments
- Develop user-focused tools, including data management activities and support for Alaska Regional Integrated Science and Assessments

Close critical oceanic and atmospheric observational gaps to provide an unbiased baseline climate record and improve monitoring and climate change projections for rapidly changing Arctic processes and systems (*Objective I*)

- Complete inventory of non-NOAA observing systems in Alaska and the pan-Arctic; leverage existing inventory work being done by entities such as the Alaska Ocean Observing System, part of the U.S. Integrated Ocean Observing System (IOOS ®) and the Interagency Arctic Research Policy Committee.
- Continue partnership efforts with NSF and AOOS to inventory current research, monitoring, and data collection projects in the Arctic
- Expand NOAA buoy-mooring network coverage in the Arctic Ocean for wave, sea ice, ocean and ecosystem observations
- Expand cooperative atmospheric, river discharge, permafrost, and sea ice monitoring with Russia and Canada to encompass 75% of the Arctic coastline. This has exceptional potential for leverage as there are well established institutions with highly educated staff spread all along the Russian Arctic coast
- Make progress toward completing and sustaining Arctic observations as part of the U.S. contribution to international and interagency efforts on the Arctic Observing Network and the associated Global Ocean Observing System (GOOS) for climate observations - (significant opportunity for leveraging may be possible with continuing program funding from other US and international partners) to include:
  - o Heat transport to, from, and within the Arctic
  - o Sea level observations
  - o Freshwater input from glacier melt and precipitation and its impact on ocean chemistry and circulation
  - o Status of the ocean carbon system, including ocean acidification and methane release for thawing of subsea permafrost
  - o Ecological response to physical change in the Arctic Ocean and peripheral seas.
  - o Monitoring of high-latitude climate gases (CarbonTracker and MethaneTracker)
  - o Ocean moorings and ice buoys/stations
  - o Ship, UAS and biological transects
  - o Climate Reference Network stations
  - o Solar/IR radiation baseline networks
  - o Air quality and aerosol observations

Improve global climate model accuracy and work toward higher resolution regional physical/ecological models to provide guidance on climate change at scales important for planning and adaptation (*Objectives I, II*)

- Improve representativeness of the Arctic climate processes in global climate models and regional physical-ecological models
- Continue support for the Arctic System Reanalysis product

Focus specific attention on Sea Ice observations, dynamics, analysis and projections to benefit climate predictions and other important uses such as marine transportation, fisheries and ice-dependent species management, coastal community resilience, and resource extraction (*Objectives I-VI*)

- Near term invest in Synthetic Aperture Radar (SAR) sea ice and ocean imagery data buys to support sea ice analyzes and tracking of ice movement, coastal wind measurements, and oil spill analyses; longer term commit to NOAA/U.S. partnerships in future SAR operational satellite constellations with Canada, Europe, and Japan
- More direct measurements of sea ice thickness (by buoys or airborne remote sensing) for continual calibration and validation of satellite ice thickness products
- Process studies focused on increasing our understanding of sea ice changes and climate change feedbacks Sea Ice Model Prediction Assessment and Performance improvements, including joint research between GFDL, NRL, NIC and ESRL on physical understanding of the Arctic climate system Deliver an official Seasonal sea ice projection with quantified uncertainties

Deliver the Fundamental Geospatial Framework supporting marine transportation, coastal community resilience, climate monitoring and assessments, sea level rise and storm surge levels, and many other uses (*Objectives I-VI*)

- Establish an accurate vertical reference system for the region by collecting gravity data via airborne sensors for Alaska and the Arctic to efficiently allow Global Positioning System measurements to an accuracy of approximately 2cm
- Explore potential cost-saving alternatives with partners such as USGS, the Naval Research Laboratory, and the state of Alaska for either direct funding to defray some of the cost and/or providing flight hours, equipment, and other types of in-kind support.
    - o PM ~ % of Alaska with 2cm geoid accuracy
- Establish Continuously Operating GPS Reference Stations (CORS) in Alaska for cost-effective, efficient and easy access to precise positioning; and co-locate tide stations with CORS to enable measurement and monitoring of "true" sea level change
    - o PM - % of Alaska within 400km of a CORS
- Continue development of new technology and procedures to acquire long term measurements of water level data in remote regions currently not possible with existing capabilities;
- Site 29 new National Water Level Observation Network stations per implementation plan to address gaps in water level data
- Update tidal current predictions through tidal current surveys and short term observations

Improve marine weather/sea ice services and hydrology services for the rivers and coasts (*Objectives III, IV, VI*)

- Expand operational NWW3 Model domain from 75°N to the North Pole to cover the Arctic Ocean
- Increase Alaskan river/waterway/ precipitation observations to deliver better information about water quantity, timing, and quality for effective construction, transportation and resource management decisions.
- Complete Alaskan Precipitation Frequency Estimate update
- Leverage NOAA operational weather service infrastructure in the NWS Alaska Region to establish new offshore marine forecasts and warnings within the U.S. Exclusive Economic Zone north and west of Alaska in the Arctic Ocean
- Collaborate with Environment Canada under a new International agreement to support high seas marine weather warnings and forecasts for the Arctic Ocean
- Develop, test, and implement new observing technologies for ocean and meteorological parameters to improve numerical weather prediction and support operational decision-making

Collaborate with Federal/state partners to comprehensively map and monitor the Alaskan coast and Arctic waters for marine transportation safety, fisheries and living marine resource management, tsunami models and coastal hazard forecasts to mitigate erosion, storm surge and sea level change(*Objectives I-VI*)

- Utilize Integrated Ocean and Coastal Mapping partnerships to leverage NOAA and external mapping efforts to update the inadequate Alaskan and Arctic bathymetric, shoreline and habitat data for use by NOAA scientists and others
- Establish a committee for multi- purpose mapping standards and methods to develop a consistent set of techniques and equipment to facilitate integrated products
- Build the IOCM Planning tool to enable Principle Investigators to visually determine areas of mapping requirements overlap, existing data and opportunities for collaboration within NOAA
- Partner with the state of Alaska, the U.S. Army Corps and U.S. Geological Survey, among others, to comprehensively map Alaska's 44,000 miles of shoreline to NOAA's National Shoreline standard, supporting activities such as accurate Electronic Navigational Charts, coastal change analyses, erosion baselines, tsunami models and environmental sensitivity index areas for spill response and assessment
- Support both CMTS goals for improved Arctic marine transits and NOAA Fisheries Essential Fish Habitat mapping requirements by coordinating NOAA Survey vessel mapping projects (NSV, FAIRWEATHER, other Arctic-capable vessel)
- Collect hydrographic data on transits to and from NOAA EFH mapping sites ~ SNM Perf Metric

Study impacts of loss of sea ice on living marine resource to enable NOAA and its Federal, state, tribal, and international partners to monitor and effectively respond to changes in marine ecosystems and their services, and in marine mammal and fishery harvests (*Objective V*)

- Conduct abundance and distribution surveys of fish, cetaceans and pinnipeds
- Conduct process studies to understand these species' dependence on sea ice
  - o PM: % of living marine resources with adequate assessments for management
- Forecast, evaluate the socioeconomic impacts of loss of sea ice on commercial fisheries and subsistence harvests
- Expand monitoring of ice seal subsistence harvests through co-management with Alaska Natives
- Study how loss of sea ice, ocean warming, change in salinity, and altered ocean and atmospheric circulation will change productivity and composition of the food web and the fish and marine mammal species that rely on Alaskan/Arctic waters in order to inform decision-making
- Conduct status reviews of sea ice-dependent species to determine if they warrant protection under the Endangered Species Act.

Ensure adequate regional ecosystem assessment of the Chukchi and Beaufort Seas called for by the North Pacific Fishery Management Council's draft Arctic Fishery Management Plan; and protect and conserve the Arctic's living marine resources by increasing management actions and international cooperation (*Objectives V-VI*)

- Develop management actions, such as listing determinations, status reviews, and conservation and recovery plans for marine mammal and fishery resources to sustain stable or increasing population trends
  - o PM: # of Alaska/Arctic listed species with stable or increasing populations
- Monitor and mitigate potential impacts on marine mammals and other protected resources caused by increased industrial activities
- Enter into negotiations with Canada and Russia to develop a regional fishery management organization to conserve and manage the Arctic Large Marine Ecosystem and partner on joint fisheries research
- Develop international mechanisms for sharing access to research platforms and timely exchange of scientific samples, data, and analyses.

- Partner with Russia and Canada and other Arctic nations on fisheries and other joint scientific research, where possible.
- Seek to develop ways to address changing and expanding commercial fisheries in the Arctic, including through consideration of international agreements or organizations to govern future fisheries.
- Monitoring of status and trends of Arctic marine living resources and their habitats
- Issue Incidental Take Authorizations for Arctic oil and gas exploration activities that occur within listed species or marine mammal habitat.

Prepare for and respond to spills in the Arctic maritime domain (*Objective III, VI*)

- Research oil/ice interactions and mitigation strategies to assist Coast Guard and first responders in minimizing the effects of oil spills, other dangerous substances, and accidents in the Arctic
- Add capacity for spill preparedness, response and injury assessment for the Arctic/subarctic regions (currently, response assets would come from Anchorage and the lower 48 states taking days to weeks to arrive on-scene)
- Implement tools like the Environmental Response Management Application (ERMA) to the Arctic. Unimak Pass and the Chukchi/Beaufort Seas are high priority areas
- Update environmental sensitivity maps, improve baseline data for biological resources at risk and other planning tools for emergency responders, and develop pollutant fate and effects models for ice conditions
- Conduct critical research on Arctic response and restoration efforts including better understanding of behavior and effects of oil in cold water/ice conditions and the technologies for spill response in difficult environments.
- Develop natural resource damage assessment and restoration guidelines/protocols for the Arctic.
- Add capacity for effective Arctic spill preparedness and response
- Improve marine pollution trajectory predictions for oils and chemicals moving through cold environments;
- Implement GIS-based tools that integrate scientific support information in data layers compatible to current platforms
- Produce new and updated Environmental Sensitivity Index (ESI) maps for areas in the Arctic that were previously considered lower priority.
- Improve Arctic response agencies' (e.g. U.S. Coast Guard and EPA) familiarization with NOAA's scientific support capabilities.
- Through conferences and expositions for the Arctic marine transportation and aviation communities, provide outreach and education concerning the registration of Emergency Position-Indicating Radio Beacons (EPIRBs) and Personal Locator Beacons (PLBs).
- Work within existing frameworks such as the Arctic Council and International Maritime Organization to identify and address Security and Safety issues
- Promote voluntary cooperation and legal mechanisms necessary to address issues and changes in the Arctic Environment

Support Arctic governance issues (*Objective VI*)

- Support the collection and analysis of data in support of U.S. submission of the limit of its Extended Continental Shelf to the Commission on the Limits of the Continental Shelf
- Provide mapping expertise and support to the ECS Task Force via the Joint Hydrographic Center
- Support the U.S. ECS Task Force with baseline resource assessment to adequately assess the full resource potential of the ECS and for NOAA's evolving role in the Arctic
- Support International Cooperation to Address Issues of Use and Protection of Arctic Region and Resources
- Work with IHO to create a hydrographic commission in the Arctic

Appendix A: Federal Research Efforts

Agency	*Mandate*	*Activity*	*Assets*
Department of Agriculture	USDA Farm Bill	Supports and conducts research to improve the understanding, use, and management of natural resources at high latitudes.	The Alaska Native-Serving and Native Hawaiian- Serving Institutions Education Grants Program,the NRCS Alaska Snow, Water and Climate Services, and the Alaska MLRA Soil Survey Office
Department of Commerce		"Performs research in the high-latitude regions of the planet in connection with its environmental assessment, monitoring, and prediction responsibilities. Some of these activities co-shared with NSF (RUSALCA and T iksi Observatory). RUSALCA moorings are also coshared with the CRREL (DOD). The Barrow Observatory is also co-located with a DOE facility."	NOAA Arctic Research Program NOAA's Arctic Theme Page Laboratory Research at ESRL, PMEL, GFDL Barrow Baseline Observatories (Barrow, Tiksi, Alert, Eureka) National Ice Center National Snow and Ice Data Center Alaska Fisheries Science Center Advanced Satellite (Arctic) Products Branch
Department of Defense		Conducts military operations and maintains military facilities in the Arctic	The U. S. Army Cold Regions Research and Engineering Laboratory (CRREL) of the Corps of Engineers, Engineer Research and Development Center (ERDC)
		DOD Arctic research program seeks to enhance understanding of basic and applied phenomena that directly affect military activities and ops	The U. S. Army Cold Regions Research and Engineering Laboratory (CRREL) of the Corps of Engineers, Engineer Research and Development Center (ERDC) NOAA partners with CRREL to deploy network of Arctic sea ice mass balance buoys

Department of Energy		Provides for the long-term energy security of the United States.	"Arctic Energy Office, the funding profile increased from $1 million in FY 2001 to $7.0 million in FY 2005 NOAA partners with DOE Atmospheric Radiation Monitoring (ARM) Program facility at Barrow to study effects of clouds and aerosols on climate."
		Arctic and Subarctic activities support the DOE mission through studies of energy production, relevant atmospheric/ environmental measurements, and modeling.	
Department of Health and Human Services		Conducts Arctic health research through the National Institutes of Health and the Centers for Disease Control and Prevention.	Arctic Health web site at the University of Alaska has been supported with $65K annually
Department of Homeland Security		"Supports Arctic research through the U.S. Coast Guard, which operates polar icebreakers as national polar research assets for Arctic oceanographic expeditions of both government and nongovernment researchers."	"Operation of three polar icebreakers, USCGC Polar Sea, USCGC Polar Star, and the Healy. NOAA charters USCG icebreakers for ECS charting, climate research, ocean exploration."

Department of the Interior	Established by Congress in the Energy Policy Act of 2005, the North Slope Science Initiative (NSSI) is intended to enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and make information available to decision-makers, governmental agencies, industry, and the public.	"Performs biological, physical, engineering, and social science research; conducts mapping, monitoring, and assessment programs throughout Alaska and its offshore regions; and manages department lands in Alaska. "	While the Energy Policy Act authorized to be appropriated such sums as are necessary to carry out this initiative, no appropriations have yet passed Congress.
	National Interest Lands Conservation Act (ANILCA),	Locates, samples, maps, and evaluates historic mines, prospects, and occurrences and investigating newly discovered mineralization. (BLM)	
		"Conducts research in the Arctic to help accomplish its mission to conserve and manage migratory birds, threatened and endangered species, certain marine mammals, and anadromous fish, as well as all biota within 16 National Wildlife Refuges in Alaska. (FWS)"	
Department of State		Chairs the Arctic Policy Group interagency working group comprising federal agencies with Arctic interests and programs to coordinate U.S. positions on international Arctic issues	The U.S. Senior Arctic Official, a Foreign Affairs Officer in the State Department's Office of Oceans Affairs/Bureau of Oceans, Environment and Science
		Leads U.S. participation on intergovernmental Arctic Council	NOAA contributes to Arctic Council activities on project-by-project basis.

Department of Transportation	"In 2005, a Memorandum of Understanding was signed between FHWA and NOAA to support surface transportation weather challenges and to work together to address this challenge."	Arctic and cold weather programs address transportation issues in the air, on land, and at sea	"No resources are devoted specifically to Arctic concerns under the FHWA Road Weather Management program"
Environmental Protection Agency		"Arctic-related work is designed to protect the health of Arctic residents and safeguard the Arctic environment"	
	"2005 Arctic Council Action Plan"	Focused on the source, transport, fate, and effects of contaminants in the environment; the risks and benefits of subsistence foods; global climate change; and UV-B radiation.	Alaska Office of the EPA, Alaska Department of Environmental Conservation's (DEC) Environmental Monitoring and Assessment Program
Minerals Management Service		Has the statutory responsibilities to manage the mineral resources located on the U.S. Outer Continental Shelf (OCS) in an environmentally sound and safe manner and to collect, verify, and distribute mineral revenues from Federal and Indian lands.	"Ohmsett–The National Oil Spill Response Test Facility. Ohmsett is also the premier training site for spill response personnel from agencies such as the U.S. Coast Guard, U.S. Navy, NOAA, and EPA."
		Lead agency for Federal offshore renewable energy and alternate use of America's offshore public lands.	
National Aeronautics and Space Administration		Supports research programs in the Arctic that emphasize space-based and airborne remote sensing studies to characterize, understand, and predict changes in the Arctic and to examine their interactions with the rest of the Earth System.	

National Science Foundation	The Arctic Research and Policy Act of 1984 (Public Law 98-373; amended as Public Law 101-609, November 16, 1990)	The ARPA establishes the Interagency Arctic Research Policy Committee (IARPC), chaired by NSF. The IARPC plans and reports to Congress on results of all US Arctic research. The NSF supports a formal Arctic research program within the Office of Polar Programs (OPP).	NSF received significant new funds to support the International Polar Year, and established an Arctic Observing Network (AON). The AON is considered an interagency effort under IARPC, and NOAA has joined NSF to co-lead development of the AON. NSF is using new resources targeted for Arctic logistics to enhance the U.S. leadership role in Arctic research and is being guided by the Arctic Research Commission's report on Logistics Recommendations for an Improved U.S. Arctic Research Capability at www.arcus.org.
Smithsonian Institution		Focused on studies of northern cultural heritage and environments and on the use of the institution's unique national collections for research, public outreach, and educational programs.	"1) Arctic Studies Center (ASC) of the Smithsonian National Museum of Natural History (NMNH) 2) Arctic research funding has remained fairly steady at an annual level of $0.5–0.6 million NOAA funded an Arctic exhibit at NMNH focused on climate change."

Appendix B: Federal Arctic Observing Activities: Today

	Federal Agency	*Current Observing Activities*
Atmosphere		
	NASA Satellite Constellation	Land- and space-based observations.
	NOAA/NWS	Weather forecasts; monitor atmospheric constituents that change radiative balance.
	NOAA/Marine Observational Programs	Monitor atmospheric variables near-shore and oceanic waterways.
	NOAA's Climate Reference Network	Measure climate variables and report data in real-time.
	NOAA, DOE & National Science Foundation (NSF)	Data analysis of cloud & radiative processes; trace gases and aerosols in Barrow, Alaska; as well as Eureka & Alert, Nunavut, Canada.
	NOAA & Federal Aviation Administration (FAA)	Land-based and marine weather observations~performed continuously to support weather forecasts updated every 6 hours, or as conditions warrant.
	U.S. Department of Energy (DOE)~ARM Climate Research Facility (ACRF)	Collects cloud, aerosols and radiation data continuously; reports data in near real-time for Barrow south to vicinity of Atqasuk, AK, and adjacent Arctic and ocean areas.
	NASA & NSF ~ Greenland Climate Network (CG-Net)	Support automatic weather stations to monitor conditions of the Greenland ice sheet.
	NSF	Core atmospheric measurements~Summit, Greenland; UV spectral irradiance monitoring~Barrow, AK & Summit, Greenland; high spectral resolution lidar~Eureka, Canada; surface & satellite measurements of clouds ~Arctic Basin; lidar studies of pan-Arctic circulation processes; chemistry.
	International Arctic System for Observing the Atmosphere~NOAA, NSF & NASA	International network of high quality data to validate satellite observations and model outputs.
	NOAA & NASA	Daily, near real-time plots of surface, cloud & radiative processes; temperature, humidity & polar winds;

	Federal Agency	*Current Observing Activities*
Atmosphere, cont.	Minerals Management Service (MMS)	Maintains meteorological stations on barrier island along the Beaufort Sea coast; collects & synthesizes wind time-series data from North Slop stations in Beaufort Sea, and a portion of the Chukchi Sea.
	U.S. National Park Service (NPS)	Monitors aerosols at Denali National Park; calculate & track visibility trends; evaluating water, snow, sediments, willow bark, fish & moose tissue for presence of metals from aerosols.
	Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), NPS, U.S. Fish & Wildlife Service (USFWS), and U.S. Forest Service (USFS)	Maintain Remote Automated Weather Station (RAWS) network for monitoring air quality, rating fire danger & research applications.
Ocean & Sea Ice	U.S. Coast Guard	Sea icebreaking operations; patrol shipping lanes; Maritime Domain Awareness
	NIC	Highest quality, timely, accurate, and relevant snow and ice products and services to meet the strategic, operations, and tactical requirements
	MMS	landfast ice & near shore measurements in Beaufort & Chukchi Seas;
	NASA	Satellite data of Arctic ocean conditions & sea ice data sets.
	NOAA	Buoys for ocean through flow from the Pacific to Arctic via Bering Straight; ecosystem monitoring Bering & Chuckchi Seas; NWLON National Water Level Observation Network~ realtime coastal oceanographic & meteorological data; marine forecasts & warnings;
	Alaska Ocean Observing System (AOOS)	Integrated ocean observing network~collects weather & surface currents, satellite imaging, and ecosystem data.

	Federal Agency	*Current Observing Activities*
Hydrology & Cryosphere	NOAA/NWS Alaska Pacific River Forecasting Center	monitors & forecasts river and ice conditions; flood & high water forecasting;
	DOD	monitors permafrost at Fox & Fairbanks, AK
	EPA	assesses condition of aquatic resources
	NASA	soil moisture & snow water equivalent; snow cover extent; surface albedo; glacier & ice velocity maps; ice topography
	NSF	hydrometeorological measurements at Kuparuk River watershed on North Slope; permafrost temperature deep boreholes; data sets of ice accumulation rate, surface elevation, ice thickness & velocity
	USDA	soil moisture & meteorological parameters
	USGS	benchmark glacier monitoring; soil moisture and vegetation change; permafrost
Terrestrial Ecosystems	NASA	baseline data sets of terrestrial ecosystems and their interactions
	NPS	Inventory and monitoring of freshwater ecosystems, mammals, fire extent and severity, permafrost & thermokarst, vegetation and soils, landscape patterns, aquatic assemblages
	USDA	Manages Alaska Soil Survey--scientific inventory of soil resources
	USFWS	Monitoring fish, bird and mammal species
	USGS	Monitoring of Arctic & Sub-Arctic landscape erosion and land cover mapping
Human Dimensions	NSF	Community based observing network focusing on marine species; marine mammal hunting; oil, gas and mineral development; tourism; and fisheries.
	NMFS	Field and laboratory research living marine resources; fishery db's; oceanography, marine mammal, and environmental
	USFWS	monitoring subsistence fisheries resources and management

	Federal Agency	*Current Observing Activities*
Human Dimensions, cont.	MMS	Environmental & socioeconomic studies
	Centers for Disease Control (CDC)	Network of hospital and public health laboratories throughout the Arctic~collection o& sharing of laboratory and epidemiologic data
Paleoenvironment	NSF	Greenland ice cores, and estuaries program; surface-based radar survey and depth/age scale modeling
	USGS	Sediment core recovery in the Chukchi Borderland region

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