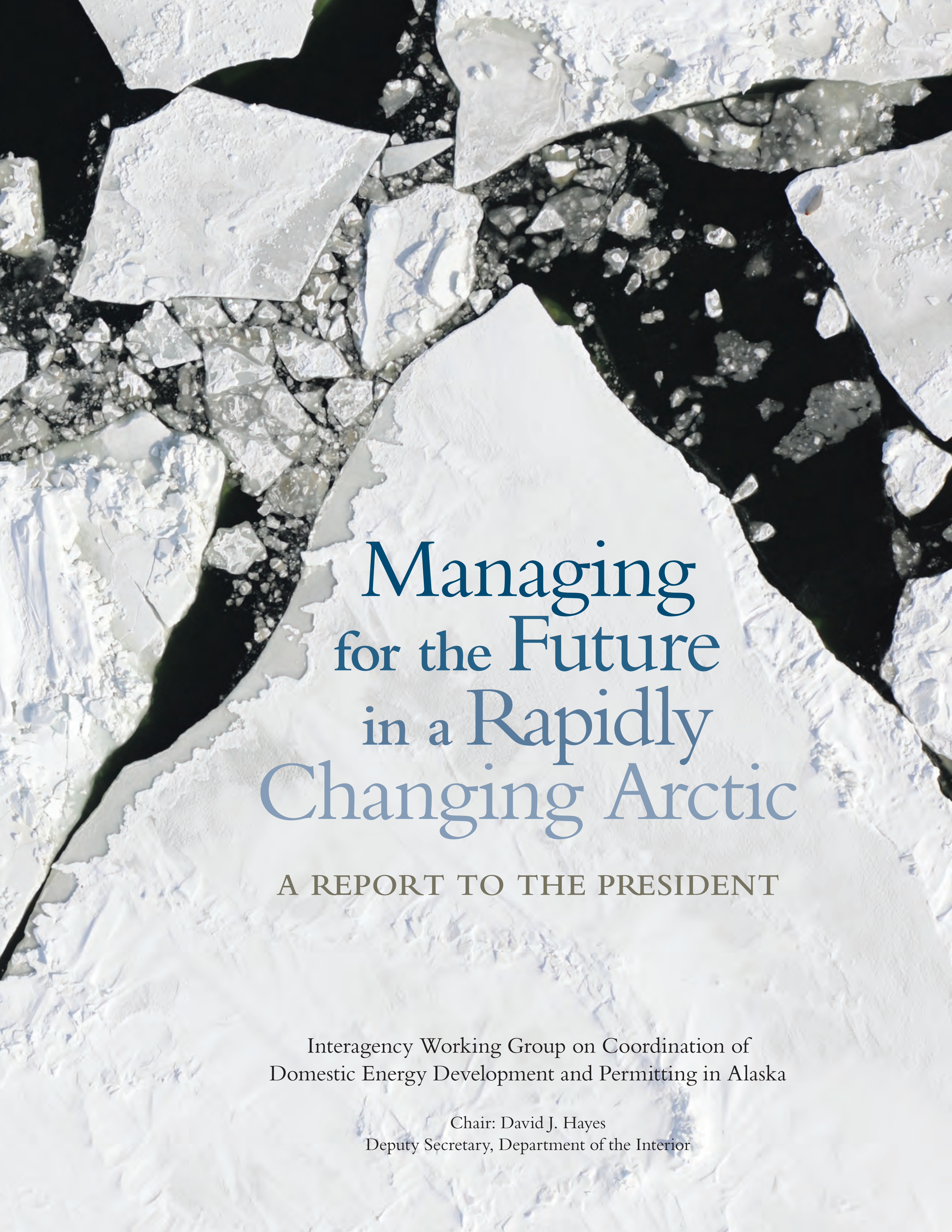

Managing for the Future in a Rapidly Changing Arctic

A REPORT TO THE PRESIDENT

Interagency Working Group on Coordination of
Domestic Energy Development and Permitting in Alaska

Chair: David J. Hayes
Deputy Secretary, Department of the Interior

Tundra landscape on the Seward Peninsula (credit: K. Hill, National Park Service)

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Deputy Secretary, Department of the Interior

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March 2013

This report has been prepared with the active consultation and assistance of:
Arctic Research Commission (Chair: Fran Ulmer) and
National Ocean Council (Co-Chairs: John Holdren and Nancy Sutley)
In addition, this report has been coordinated with the National Security Staff, the Domestic Policy Council, the Council on Environmental Quality, the Office of Science and Technology Policy, the National Economic Council, and representatives from relevant federal departments and agencies.

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

An Arctic Nation

The United States is an Arctic nation, one of only eight such nations worldwide that are responsible for the stewardship of a region undergoing dramatic environmental, social, and economic changes. The implications of these changes demand a fresh look at how the Federal Government and its partners address management challenges in the region. In consultation with the National Ocean Council, the National Security Staff, and the Arctic Research Commission, the Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska (Alaska Interagency Working Group) initiated this report to describe these challenges as they relate to the management of natural resources in the U.S. Arctic. The report presents recommendations for advancing a common management approach that provides coordinated, forward-thinking solutions.

Change and Uncertainty

The Arctic is warming faster than any other region on Earth, bringing dramatic reductions in sea ice extent, altered weather, and thawing permafrost. Implications of these changes include rapid coastal erosion threatening villages and facilities, loss of wildlife habitat, ecosystem instability, increased greenhouse-gas emissions from melting permafrost, and unpredictable impacts on subsistence activities and critical social needs.

In addition to elevating the already high level of uncertainty associated with resource management in the region, changes such as reduced sea ice are increasing interest in economic opportunities such as offshore oil and gas development and increased shipping through the region. The likelihood of increased human activity in this environmentally sensitive region has implications for managing a U.S. Arctic that currently lacks much of the costly infrastructure necessary to monitor and control the impacts of such activities.

Perspectives and Expectations

In the U.S. Arctic, more than 20 federal agencies have responsibilities that include resource management, scientific research, homeland security, emergency preparedness and response, maritime and aeronautical safety, and support to communities. Many partners in the region work closely with these agencies to achieve a wide range of management goals; these partners include state agencies, tribal governments and Alaska Native organizations, municipal governments, industrial and commercial stakeholders, and conservation organizations. While the perspectives of these partners vary on specific objectives for the region, particularly regarding the appropriate extent of development, there is broad interest in supporting stable economies, thriving cultures, and sustainable ecosystems in the U.S. Arctic. Among the stakeholder concerns are bureaucratic processes that require engagement at many levels and which can burden stakeholders and communities. Partners in the U.S. Arctic want a framework for more inclusive, efficient, and transparent engagement that does not add unnecessary layers of bureaucratic process.

Caribou on the Arctic coastal plain (credit: Dept. of the Interior)

Barriers and Opportunities

The U.S. Arctic is a vast area that is changing rapidly while economic and social expectations are growing. This combination of factors is adding stress to a largely balkanized management system already straining to address many competing issues and priorities. The sheer number of federal agencies alone presents challenges and underscores the need for a more coordinated approach. That said, however, there are many efforts at the local, regional, state, federal, and international levels that endeavor to improve coordination among the region's stakeholders. These promising approaches can provide a foundation for a more holistic, integrated approach to management in the region. In advocating for such an approach, stakeholders strongly urged that it emphasize the following principles:

- ***whole-of-government coordination to improve efficiency and operational certainty;***
- ***direct and meaningful partnership with stakeholders;***
- ***science-based decision-making focused on ensuring sustainable ecosystems;***
- ***adaptive approaches guided by ongoing research and monitoring;***
- ***a region-wide planning approach that looks across jurisdictional boundaries; and***
- ***improved understanding and consideration of the cumulative impacts of human activities in the region.***

Blanket toss (Nalukataq) festival at Wainwright (credit: J. London, National Marine Fisheries Service/NOAA)

Advancing an Integrated Approach

By incorporating those principles and considering multiple scales and jurisdictions in a more inclusive, transparent approach to management, an "Integrated Arctic Management" approach holds the promise of a broader-based consideration of economic, environmental, and cultural sensitivities and trends. The challenge is to improve the way that governments and stakeholders work together to implement such an approach without adding unnecessary layers of complexity or organizational overload in the U.S. Arctic. Building upon existing models, this report recommends that the U.S. Government:

1. ***Adopt an Integrated Arctic Management approach when making stewardship and development decisions affecting the U.S. Arctic:*** A commitment to apply the principles of Integrated Arctic Management will advance a common management approach that is resilient and adaptable to the changes taking place in the Arctic. *Integrated Arctic Management is a science-based, whole-of-government approach to stewardship and planning in the U.S. Arctic that integrates and balances environmental, economic, and cultural needs and objectives. It is an adaptive, stakeholder-informed means for looking holistically at impacts and sensitivities across the U.S. Arctic and generating sustainable solutions.*

2. ***Ensure ongoing high-level White House leadership on Arctic issues:*** A new National Strategy for the Arctic Region, to be established through the Presidential Policy Directive process, will identify strategic shared priorities for the U.S. Arctic region and will provide a framework for Executive Branch decision-making and high-level, government-wide leadership on the issues described in this report.

3. ***Strengthen key partnerships:*** The State of Alaska and Alaska Native tribal governments and organizations merit special partnership arrangements with the Federal Government.

4. ***Promote better stakeholder engagement:*** The Federal Government should conduct an assessment of existing means through which agencies, key partners, and other stakeholders interact on planning and management issues, with the goal of building upon best practices rather than creating new layers of engagement.

5. ***Coordinate and streamline federal actions:*** By the end of 2013, the Federal Government should conduct a review of the numerous interagency efforts related to the U.S. Arctic, with an eye toward identifying and addressing overlapping missions and reducing duplication of effort. In addition, there are several tools and processes already in use in the U.S. Arctic that, with increased coordination, can help to advance the Integrated Arctic Management approach to decision-making. These processes are described in additional recommendations related to linking science and management, environmental evaluations, important ecological and subsistence areas, scenario planning, and international coordination.

This report is a call to action on a pressing issue of national importance. The cultural, ecological, and economic costs of failing to adapt and strengthen management approaches in the face of rapid change are unacceptable. Our challenge is to apply the principles of Integrated Arctic Management to today's decisions and to those that lie ahead in our shared future as an Arctic nation.

Construction of subsea pipelines in the Beaufort Sea (credit: D. Hinnah, Dept. of Transportation)

Chapter 1:
Introduction

The U.S. Arctic is undergoing dramatic environmental, social, and economic changes. The implications of these changes demand a fresh look at how the Federal Government and its partners address management challenges in the region.

The United States is an Arctic nation, one of only eight such nations worldwide that are responsible for the stewardship of a circumpolar region experiencing rapid and transformative physical, ecological, economic, and cultural changes. Arctic sea ice and glaciers are rapidly diminishing; weather is changing; coastlines are eroding; oceans and seas are becoming more acidic; species are increasingly threatened; and ecosystems are changing faster than our ability to track such shifts. As multi-year sea ice recedes and Arctic marine areas become more readily accessible, the region has become increasingly attractive for resource extraction and maritime traffic. At the same time, critical cultural and social needs, such as food security, are at risk, and onshore infrastructure is deteriorating along with the permafrost upon which it sits.

The Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska *(the Alaska Interagency Working Group),* the Arctic Research Commission, and the National Ocean Council recognize that the management, safety, and security challenges posed by these changes are significant. Charged with facilitating safe, responsible, and efficient development of conventional and renewable energy resources in Alaska, the Alaska Interagency Working Group has been tasked with helping agencies make sound decisions that take into account economic development interests and needs, protection of human health and the environment, and the interests of indigenous populations.

The Alaska Interagency Working Group has had considerable success in facilitating more coordinated and better decision-making in the Arctic. More must be done, however, on a government-wide basis, to better integrate the development and conservation strategies that are pursued by a variety of federal, state, and local governments in this rapidly changing region. To adapt to these changes, the United States and its partners must develop a common management approach that can advance the shared goal of sound, forward-looking decision-making across all levels of government.

Improving coordination and integrating all of these values in a common management framework is no small task. Marine and terrestrial areas pose distinct and separate management challenges, and there are over 20 federal agencies with domestic Arctic-related missions that include promoting safety; permitting commercial activities and energy development; conserving fauna, flora, and ecosystems; assuring clean air and water; and protecting cultural resources and heritage. Increasing international interest in the Arctic draws the Departments of Defense and State into these otherwise largely domestic discussions as well. In addition to federal agencies, there are many state, tribal, borough (county), and municipal governments and agencies striving to achieve multiple economic, ecological, and cultural objectives.

Advancing a more coordinated, forward-thinking and inclusive management approach across all major sectors is challenged by the wide diversity of stakeholder interests and missions. In particular, those who live in the Arctic depend upon the services provided by the region's ecosystems. Alaska Natives, in particular, face uncertainty not only in terms of food and water security but also in maintaining thousands of years of cultural traditions. Given the many interdependencies between humans and the environment in the Arctic, new approaches must not only be precautionary and guided by the needs of the ecosystems upon which many Alaska residents depend, but must also acknowledge the role of economic development in helping to meet critical social needs.

Serpentine river near Shishmaref Inlet (credit: R.A. Winfree, National Park Service)

Common ground can be found, however, and existing models offer science-based approaches to balancing competing objectives. Some of these models and approaches are already being explored or applied in U.S. Arctic marine and terrestrial environments by agencies and groups with extensive responsibilities in the Arctic, such as the Department of the Interior and its Fish and Wildlife Service, National Park Service, Bureau of Land Management, U.S. Geological Survey, Bureau of Safety and Environmental Enforcement, and Bureau of Ocean Energy Management; the Department of Commerce and its National Oceanic and Atmospheric Administration; State of Alaska agencies; municipal and tribal governments; Alaska Native organizations; and interagency or international groups such as the National Ocean Council and the Arctic Council.

This report, which focuses on the portions of the Arctic that are within U.S. jurisdiction, seeks to build upon those efforts by exploring common management approaches to address this rapidly changing region. To lay a foundation for that discussion, Chapter 2 describes observed and predicted trends for the ecosystems, economies, and communities of the U.S. Arctic, with additional information on anticipated infrastructural needs in this transforming region. Chapter 3 explores and summarizes the goals and visions of the region's many stakeholders as expressed during the preparation of this report. Chapter 4 summarizes the challenges faced in managing competing objectives in a changing environment and provides guidance and principles for navigating those challenges. Chapter 4 closes by suggesting several steps that might be taken to develop a common management approach—which this report terms "Integrated Arctic Management"—that holds the promise of a broader-based and more consistent integration of development and conservation strategies, taking into account the values and interests of all key stakeholders in the Arctic.

1.1. | *Background of this Report*

President Barack Obama issued Executive Order 13580 on July 12, 2011, establishing the Alaska Interagency Working Group. The Executive Order acknowledged that federal agencies have many interdependent authorities and responsibilities related to energy development in Alaska. The Working Group was tasked with facilitating the coordination of relevant agency reviews, thereby enabling a more orderly, efficient, and informed approach to permitting and managing renewable and conventional energy projects in Alaska.

As the Alaska Interagency Working Group took on the task of coordinating project reviews and approvals in the energy sector—the primary commercial sector that is operating in the U.S. Arctic—two systemic challenges emerged. First, it became clear that scientific information and data relevant to U.S. Arctic decisions can be difficult to access, and it is not clear that the scientific agenda for the U.S. Arctic adequately serves the informational needs of decision-makers.

Second, as the Alaska Interagency Working Group reviewed permits for individual energy projects in the U.S. Arctic, it became apparent that the group could play a constructive role in advancing an overarching, Arctic-wide perspective on environmental and cultural issues, as well as a shared understanding of potential infrastructural needs. Such a perspective can help decision-makers exercise their authorities within a broader context that considers a range of environmental, social, and cultural needs—including the needs and aspirations of Alaska Natives, rural residents, and their local political leadership.

Other interagency groups support similar objectives. The National Ocean Council has identified many of the same issues for the marine portion of the U.S. Arctic, while the Arctic Research Commission and others have noted these issues for both marine and terrestrial areas. In March 2012, the Alaska

Polar bear on a barrier island near Kaktovik (credit: Fish and Wildlife Service)

Interagency Working Group teamed up with the National Ocean Council to jointly appoint Joel Clement of the Department of the Interior and Brendan Kelly of the White House's Office of Science and Technology Policy (representing the National Ocean Council) to begin developing an integrated approach to addressing and managing resources in the marine, terrestrial, and coastal areas of the U.S. Arctic.

In the summer of 2012, following interactions with the National Security Staff, the National Ocean Council, the Arctic Research Commission, and other relevant entities, the Alaska Interagency Working Group initiated the preparation of this Report to the President to address in more depth the two systemic issues noted above.

With regard to the first subject—improved access to scientific information on the Arctic—Fran Ulmer, Chair of the Arctic Research Commission, agreed to take the lead and, as stated in a memo from Interior Deputy Secretary David J. Hayes to White House officials on July 30, 2012, establish a partnership between the Commission and the Alaska Interagency Working Group to address these important scientific data needs. As an initial step, the Commission has developed a web portal that aggregates a broad array of links to other websites where Arctic information is publicly available. The site is designed to expand and improve over time with additional contributions of scientific information from the user community. Appendix I describes the Commission's efforts thus far.

With regard to the second subject—the need for a broader context within which to make management decisions about activities in the U.S. Arctic—the Alaska Interagency Working Group took the lead in preparing this Report to the President, working in collaboration with the National Ocean Council and several White House offices. This report provides a high-level review of key ecological processes and trends, cultural considerations, and long-term commercial needs and trends in the Arctic, with special emphasis on the following three areas:

- ***ecologically and culturally important areas, biota and processes, natural resources, and key drivers of environmental changes in the U.S. Arctic across agency jurisdictions and boundaries;***
- ***anthropogenic, environmental, and climatological trends that could affect these resources over time; and***
- ***commercial, societal, and governmental needs and trends that cut across agency jurisdictions, boundaries, and sectors such as energy, transportation, shipping, and tourism that could lead to future infrastructure-related needs in the U.S. Arctic.***

In undertaking this high-level review, this report underscores the importance of developing a broader understanding of alternatives for the future of the U.S. Arctic so that today's decisions support tomorrow's needs and aspirations for the region. In particular, this report begins to lay the foundation for developing and applying a common management approach to making important natural resource development decisions in the U.S. Arctic. The goal of such an approach is to promote ecological, cultural, and economic sustainability by bringing federal agency efforts into greater strategic alignment with each other, with the efforts of other key decision-makers, and with the needs of stakeholders in the region.

A wide variety of federal, state, tribal, municipal, industry, and non-governmental representatives provided substantial input to this report ***(Appendix II)***. The authors are aware that this report

Caribou calving grounds on the coastal plain of the Arctic National Wildlife Refuge (credit: D. Payer, Fish and Wildlife Service) only scratches the surface of the highly dynamic cross-currents of environmental, cultural, and economic trends in the U.S. Arctic, and that additional detail, context, and input are needed for follow-up actions. This report illustrates the complex issues confronting today's and tomorrow's decision-makers in the Arctic, and it offers important observations of how to continue to match decision-making processes to the special challenges presented by the Arctic.

1.2. | *Geographic Scope*

Although the U.S. Arctic region recognized by the U.S. Government (and defined in the Arctic Research and Policy Act of 1984 [ARPA]) encompasses an expansive marine and terrestrial zone, this report focuses solely on the northern portion of that area. For the Arctic marine environment, this report focuses on the area that extends north from the Bering Strait region into the Chukchi Sea and the Beaufort Sea ***(Figure 1.1)***. These northern seas are characterized by diminishing seasonal sea ice. The physical oceanography and ecosystems of the southern Bering Sea and Aleutian Islands differ markedly from those of the northern Bering Sea, and thus are not included in this report.

For the terrestrial environment, this report uses the ecoregional boundaries specified by the North Slope Science Initiative and the Arctic Landscape Conservation Cooperative. These initiatives have developed partnerships, science needs, and research strategies aligned with the management needs addressed in this report. This geographic scope also captures Alaska's unique terrestrial areas underlain by continuous permafrost and coincides with the boundaries used by the Arctic Council's Circumpolar Biodiversity Monitoring Program.

Figure 1.1. *The focus of the geographic area covered in this report is shaded in green. Ecological processes and environmental impacts often span zones crossing specific demarcation lines. Therefore, management efforts should consider how decisions may affect neighboring regions as well as what external factors may impact the region, such as species movements, transportation challenges, or social dimensions. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)*

Chapter 2:

Our Changing Arctic

The U.S. Arctic is experiencing rapid, sustained change, and those changes are expected to continue into the coming decades due to climate change, resource extraction, and increasing human activities. Terrestrial, freshwater, and marine ecosystems as well as broader environmental, cultural, and economic trends in the Arctic will be affected.

2.1. | *Environmental Trends*

The effects of continued climate change are seen throughout the U.S. Arctic. Scientific observations and traditional knowledge suggest that this region is moving toward conditions never before witnessed. Scientists and observers have documented significant changes in sea ice extent, ocean chemistry, coastal erosion, precipitation, hydrology, and ecology, as well as extensive thawing of terrestrial ice sheets and permafrost.[1] Climate change influences ecosystem structure and function in the short- and long-term, but because these environmental variables are so deeply interconnected, it is difficult to predict the status of future ecosystems.

Climate: The Arctic is among the fastest-warming regions on earth, and the U.S. Arctic has recorded general warming in all seasons over the last decade.[2, 3] This has brought reductions in sea ice and snow, rising sea levels, and rapid permafrost thawing. Additional challenges for coastal communities include erosion and flooding, ecological and cultural impacts of increased maritime access and development activities, and diminishing habitats for some of the ice-dependent species important for subsistence harvests, such as polar bears, several species of seals, and walrus.[1]

Although the average annual air temperature for all of Alaska increased by 3 degrees F (1.7 degrees C) during the past 60 years, the temperature across the Arctic areas covered by this report increased more rapidly.[4] For example, the mean annual temperature on Alaska's North Slope increased by 4.9 degrees F (2.7 degrees C) during the same 60-year period, with much of that change occurring recently ***(Figure 2.1)***. The U.S. Arctic's average annual air temperature is predicted to increase by an additional 4 degrees F (2.2 degrees C) over the next 30 years.[5] Decadal mean temperatures are expected to be consistently warmer than those of the late 20th Century, and by the end of the 21st Century the growing season in the U.S. Arctic is likely to lengthen by 20 to 25 days.

Snow and precipitation—Snow cover is important to Arctic terrestrial ecosystems for water storage and insulation, but snow cover also affects ground-surface temperatures, energy balance,

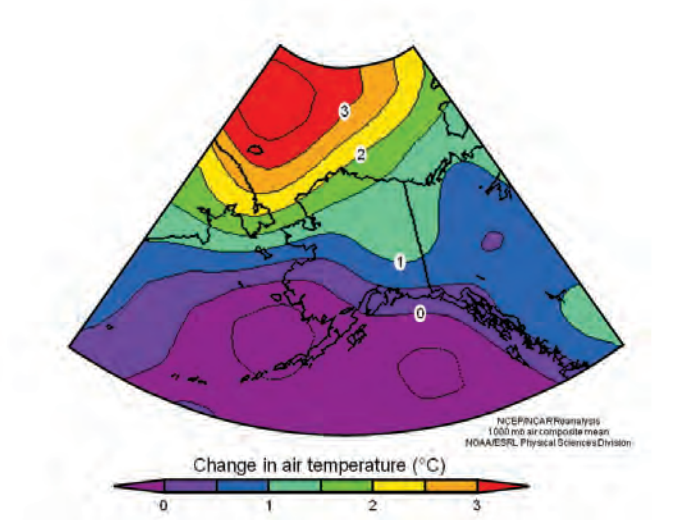


Figure 2.1. *Air temperatures have been rising over the U.S. Arctic, as seen by comparing the change in temperature between recent years (2006 to 2011) and average temperatures during the last 30 years of the 20th Century (1970 to 1999). Marine warming in the Arctic north of Bering Strait is separate from the changes in the southern Bering Sea, which has a stronger tie to the climate variability of the North Pacific Ocean. (image: NOAA/Earth Systems Research Laboratory)*

Tundra and hills on the Seward Peninsula (credit: J. London, National Marine Fisheries Service/NOAA)

> *Near Barrow, the date of spring snow melt has advanced by just over a week since the mid-1960s.[12] Scientific models predict that Alaska's North Slope will see a trend of increasing annual snowfall accompanied by a decrease in the duration of snow cover.*

hydrology, habitat quality, and permafrost thickness. Snow cover strongly influences the thickness and persistence of sea ice and provides important denning habitat for threatened polar bears and ringed seals. Northern Hemisphere snow cover extent in June, from 2010 to 2012, was well below average for the previous 42 years (1967 to 2009).[6] In Alaska, the snow-cover duration dropped by 15 days during the 30-year period of 1980 to 2009.

Future snow projections for Alaska generally include an increase in annual precipitation, primarily during winter, but by 2050 snowfall patterns are expected to shift to later dates of first snows, earlier snowmelt each year, and a decline in high snowfall days.[7, 8] Increasingly delayed sea ice freeze-up in the Arctic Ocean will lead to diminished accumulation of snow on sea ice, affecting both the seasonal dynamics of sea ice and the animals that depend upon that snow cover.[9]

Northern Hemisphere snow cover has declined by about 10 percent since the late 1960s, with stronger trends noted since the late 1980s.[10] Alaska has shown similar trends, with a significant decrease in snow cover extent in May. Generally, the disappearance of snow in the spring has occurred about 4 to 6 days earlier during the past three decades, which appears to have been driven by climate warming rather than a decrease in winter precipitation.[11, 12]

Marine ecosystems: Historically, high-latitude marine ecosystems are characterized by extreme light and temperature conditions, seasonal ice, relatively simple food webs, and complex adaptations to life in cold environments.[13] Much of the research

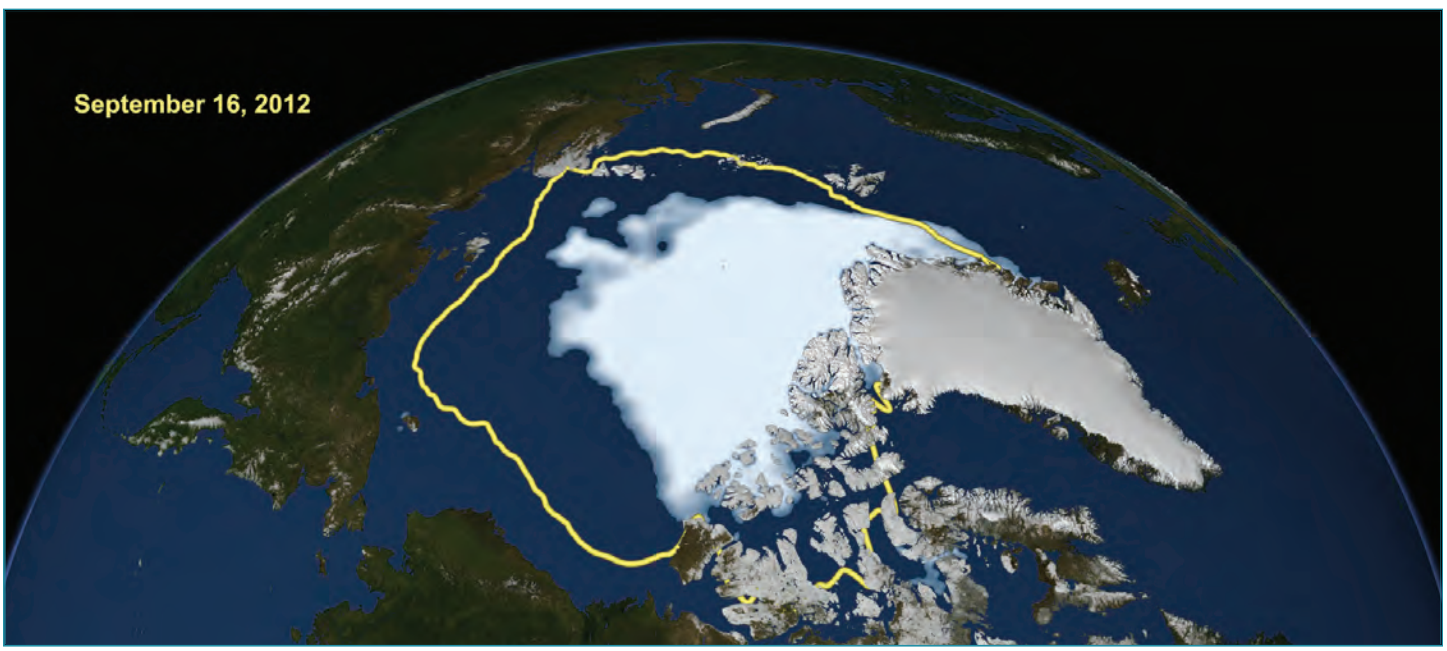


Figure 2.2. *This circumpolar view shows the coverage of Arctic sea ice (white area) on 16 September 2012, the day that the National Snow and Ice Data Center identified to be the minimum extent of sea ice coverage reached in 2012. Satellite data reveal how this new record low Arctic sea ice extent compares to the average minimum extent over the past 30 years (yellow line). (image: NASA/Goddard Scientific Visualization Studio)*

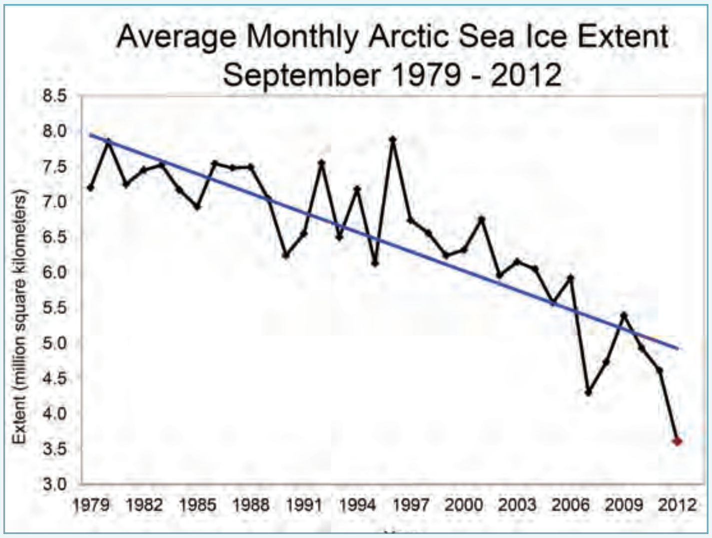


Figure 2.3. *The total extent of minimum annual sea coverage throughout the entire Arctic has been trending lower during the period for which satellite data have been available. Note that the minimum sea ice extent for each of the last 6 years has been lower than for any previous annual record. (image: National Snow and Ice Data Center)*

thus far has focused on species of special status (e.g., certain species of fish, seabirds, seals, walrus, whales, and polar bears); those which are important for subsistence harvests; or those which may be at risk from industrial activities, climate change, or pollutants. The scientific understanding of the many ecological linkages among freshwater, nearshore, and marine environments across this entire region is limited.

A combination of warmer surface water, loss of sea ice, and ocean acidification will adversely affect the development and productivity of some species, their food supplies, and their natural predators.[14, 15] Changes in Arctic sea ice are already affecting marine ecosystems and raising concerns for ice-dependent species, as reflected in recent listings of the polar bear, ringed seal, and bearded seal as threatened species under the Endangered Species Act.[16, 17, 18] Spring melt and break-up of sea ice strongly drive phytoplankton production near the ocean surface, and the associated energy and nutrient dynamics are already affecting Arctic food chains.[19] A 20 percent increase in primary productivity was reported throughout the Arctic Ocean from 1998 to 2009, including a 48 percent increase for the Chukchi Sea alone.[20]

Biological productivity, including algal growth under ice, form the base of marine food webs, which then support creatures higher up the food chain, including zooplankton, fish, birds, and mammals. Arctic cod, for example, are the most abundant forage fish, and they play a central role in the transfer of energy from plankton to higher-level consumers like ringed seals and polar bears. As warming alters sea ice conditions, northward shifts in the distribution of marine fishes are expected. Such food-web impacts would propagate through the ecosystem, from sea-floor organisms to their predators, and, ultimately, to the subsistence users whose livelihoods largely depend on having reliable access to marine mammals, fish, and other wildlife.

Shifts in marine biodiversity will, in part, depend on whether species are associated with the open ocean or with seasonal sea ice. Species like humpback whales and orcas may benefit from longer

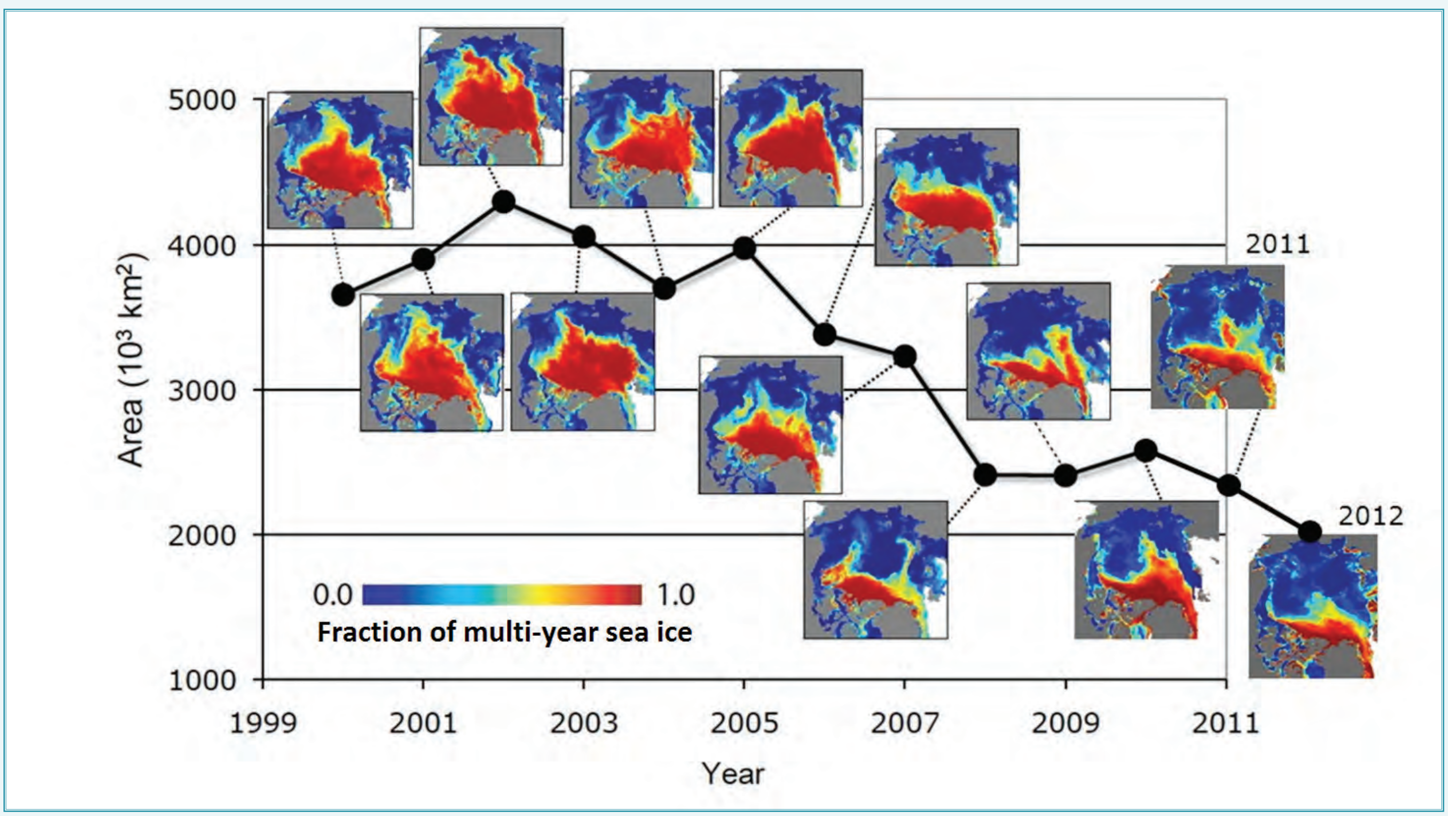


Figure 2.4. *Fifty percent of the old, thick sea ice in the Arctic Ocean disappeared during the past seven years, having been replaced by thin, first-year sea ice. The multi-year (and therefore, thick) sea ice added stability to the northern hemisphere's climate system and provided inertia to smooth out the influence of short-term atmospheric changes. The current, thinner fields of sea ice are more mobile and sensitive to climate change. (image: updated from Kwok and Untersteiner[33])*

Arctic Report Card 2012:
Tracking recent environmental changes
(http://www.arctic.noaa.gov/reportcard)

"The Arctic is changing in both predictable and unpredictable ways, so we must expect and prepare for surprises."

Jane Lubchenco
Administrator, National Oceanic and Atmospheric Administration

"Multiple observations provide strong evidence of widespread, sustained changes that are driving the Arctic environmental system into a new state."

Martin Jeffries
Arctic Science Advisor,
Office of Naval Research

ice-free periods, though anticipated changes in the food chain due to acidification may impact such species adversely.[21, 22] Ice-associated seals rely on sea ice for resting, pupping, and molting, and thus species like ringed seals may be especially vulnerable to predicted changes, as will the polar bears that prey upon them.[23, 24, 25]

Sea ice—Seasonal patterns of Arctic sea ice are important drivers of change for marine ecosystems and global climate.[26] The observed loss of summer sea ice has been more extreme than climate models had predicted, and this loss has been accompanied by decreases in both ice thickness and the presence of multi-year ice.[27] Observational data and models forecast a nearly ice-free Arctic Ocean before mid-century, and possibly before 2030.[27, 28, 29]

The summer ice-free region in the U.S. Arctic has increased from about 30 to 300 miles (48 to 482 km) away from shore, but satellite data do not account for the presence of small remnants of pack ice; in the summer of 2012, such ice delayed oil exploration in the Chukchi Sea. Sea ice extent is likely to fluctuate significantly from year to year, but an overall downward trend is consistently predicted by climate models. The implications of decreasing sea ice are serious and include altered global climate patterns, greater coastal erosion, increased ocean acidity, alterations in contaminant transport and cycling, inundation of coastal areas, and changes in marine ecosystem productivity.[26, 30, 31, 32]

"While the permafrost of the polar latitudes may seem distant and disconnected from the daily activities of most of us, its potential to alter the planet's habitability when destabilized is very real."

Marcia McNutt, Director
U.S. Geological Survey

For the entire circumpolar Arctic, summer sea ice only covers half the area that it did at the end of the 20th Century ***(Figure 2.2)***. In each of the last six years, Arctic sea ice extent in September was lower than in any other year since the start of the satellite record in 1979. In September 2012, Arctic sea ice extent was 49 percent below the average ***(Figure 2.3)***. Prior to 2005, most of the Arctic Ocean was covered by thick, multi-year ice (i.e., had survived one or more summers of melting). Multi-year ice stabilized the ice pack, but its 50 percent decline since 2005 has made the ice far more susceptible to melting ***(Figure 2.4)***.[33]

Open water absorbs most of the solar radiation reaching the ocean's surface, while ice reflects that energy. Thus, as sea ice cover diminishes, the Arctic Ocean warms further and melts still more ice. This "new normal" makes it highly unlikely that the U.S. Arctic climate will return to previous conditions in the coming decades.

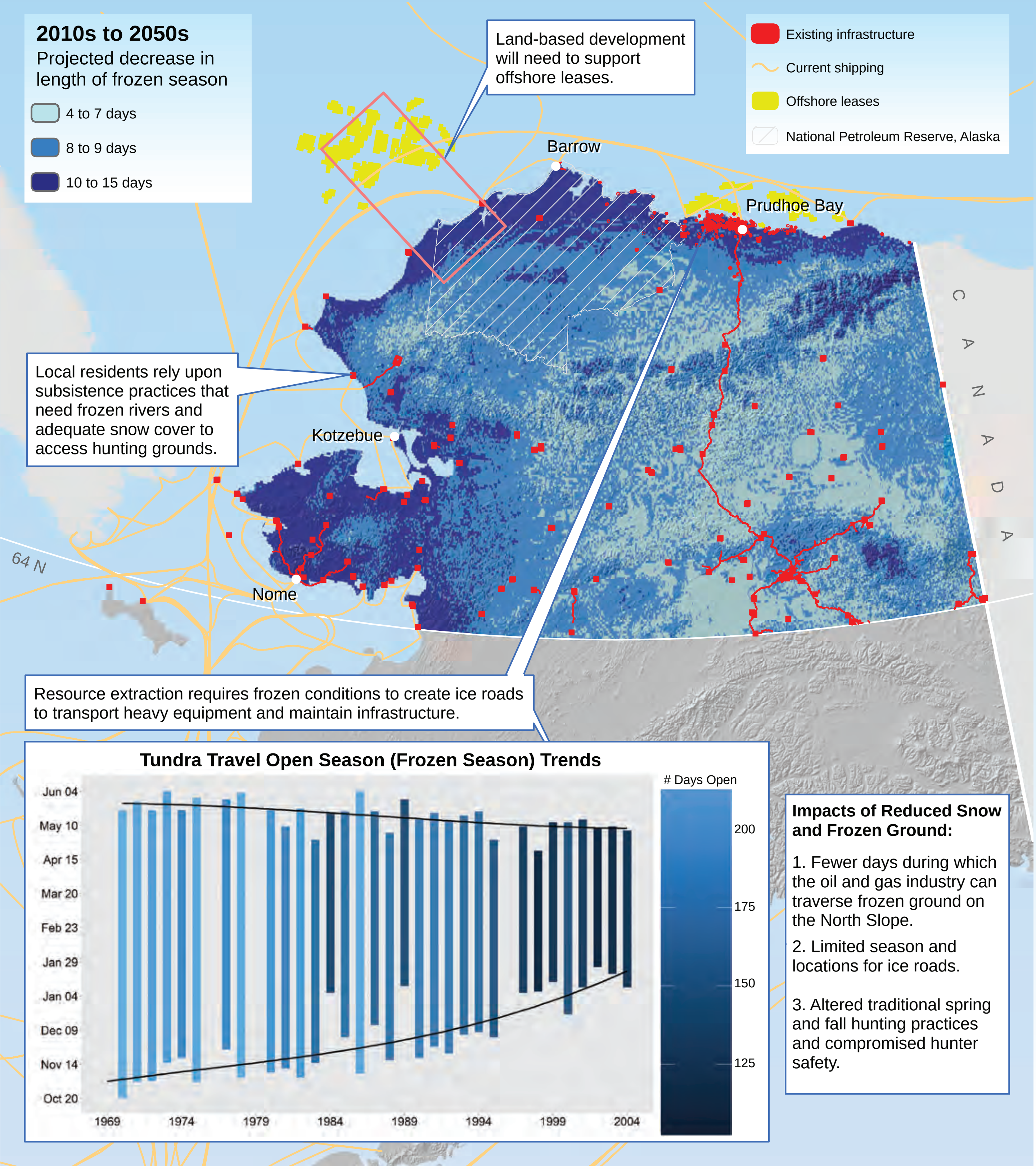
Ocean acidification—The Arctic Ocean is becoming more acidic as it absorbs the increasing amounts of carbon dioxide building up in the atmosphere. This acidification is especially rapid in the Arctic because: (1) cold seawater holds more carbon dioxide than warm water; and (2) a decrease in sea ice cover has increased the seawater exposure to atmospheric carbon dioxide.[34, 35]

Ocean acidification will have serious consequences for the entire Arctic marine ecosystem.[35] High acidity causes decreased shell production and impacts other basic biological processes, potentially causing a system-wide reorganization of the marine ecosystem.[34, 36] For example, ocean acidification is thought to have detrimental effects on the shell-producing prey of many fish species, which will impact subsistence communities and possible future commercial fisheries.[14] Shifts that benefit some species may severely harm others, and the precise nature of ecological change will be difficult to predict.

Permafrost exposed by coastal erosion along the Beaufort Sea (credit: K. Dunton, Univ. of Texas)

In the U.S. Arctic, a shorter frozen season presents **challenges** for land–based development.

Infrastructure in the fragile wetlands and tundra relies upon ice, snow and frozen ground.



Terrestrial and freshwater ecosystems: Changes in terrestrial and freshwater ecosystems are likely to alter both the size and distribution of plant and animal populations.[37, 38, 39] Fundamental shifts in biodiversity are expected due to such landscape changes as less lake ice, more permafrost thawing, warming of freshwater bodies, saltwater intrusion into freshwater areas, and increasing coastal erosion. For example, saltwater intrusion has already facilitated the sevenfold increase in the abundance of white-fronted geese since 1980, while at the same time shifting populations of molting black brant toward the Arctic coast.[37, 38, 39]

Warmer temperatures may also lead to increased rain-on-snow events during winter, creating a layer of ice that prohibits animals like caribou or muskoxen from grazing on the vegetation required for their winter survival. Such events have reportedly caused large die-offs of muskoxen in Canada and smaller die-offs of caribou in Alaska.[40, 41] Warmer temperatures may also allow intrusion of non-native species once blocked by the cold temperatures, some of which may cause environmental or economic harm.

Permafrost—In the U.S. Arctic, permafrost (perennially frozen subsoil) is becoming thinner and retreating as air temperatures increase.[8, 42] The frost-free season is projected to be one month longer than present by the end of the 21st Century, and longer thaw periods will hasten permafrost degradation at its southern extent.[8, 11] Permafrost thawing is already reshaping Arctic and near-Arctic landscapes and causing less stable ground in some areas.[8, 42] Such thawing may compromise containment of contaminants in landfills, sewage lagoons, drilling waste pits, and tailings ponds, allowing those pollutants to migrate to nearby water bodies.[43] Thawing permafrost and milder winters are also impacting winter road construction, thereby limiting access to isolated communities and industrial sites.[44]

Permafrost in the Arctic holds a massive amount of carbon, much of it in the form of frozen organic matter (four times the amount of carbon already released to the atmosphere by human activities). As the permafrost melts, large amounts of carbon dioxide and methane may be released, further accelerating atmospheric warming. The release of carbon gases from the Arctic by 2020 may well negate 42 to 88 percent of the planet's ability to store and sequester carbon in vegetation and soils.[45]

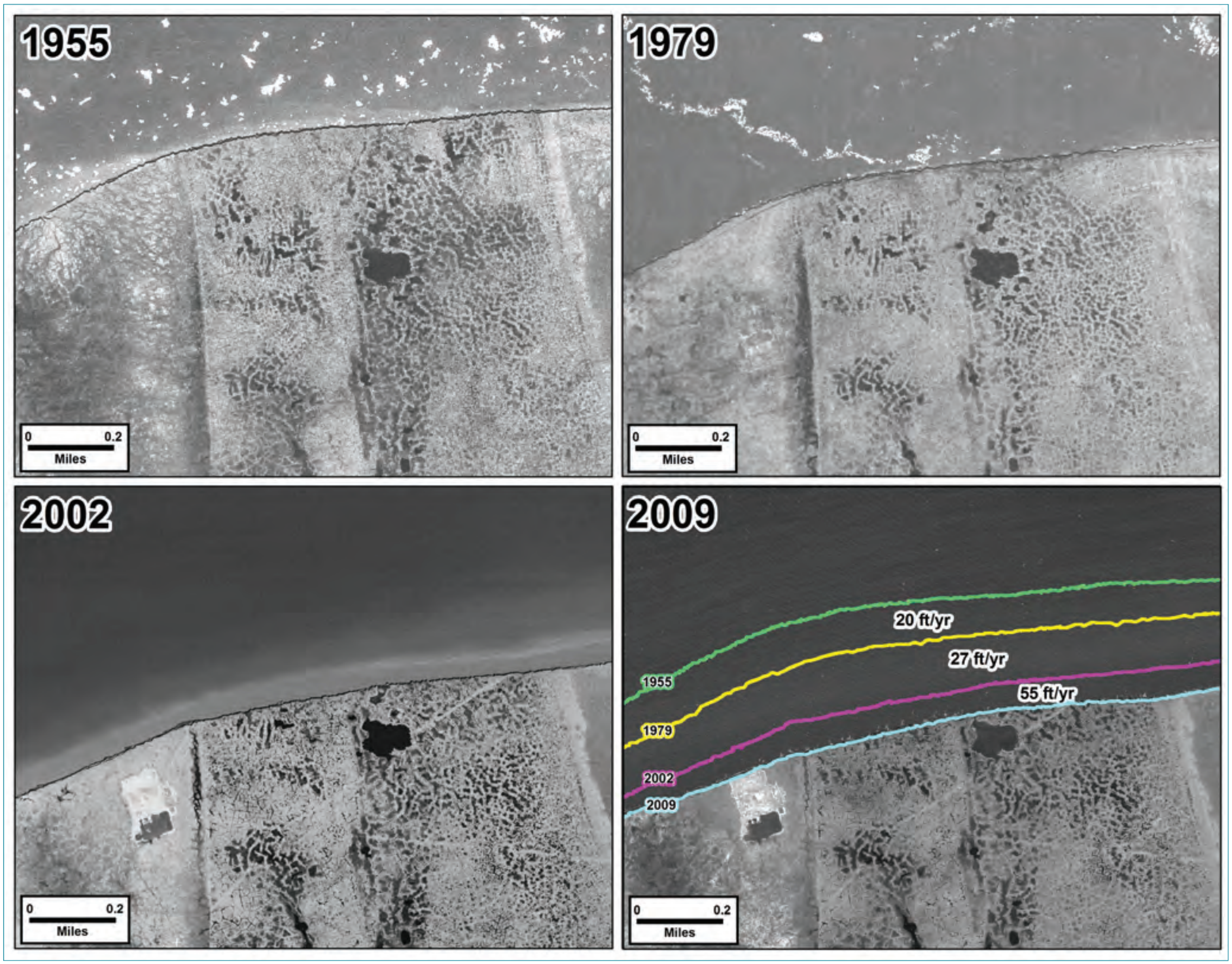


Figure 2.5. *Aerial imagery of tundra and ocean showing the impacts of coastal erosion near Drew Point, AK. Between 1955 and 2009, approximately 7,000 acres (2,833 hectares) of land were washed into the sea along a 40-mile (64 kilometer) stretch of Beaufort Sea coastline that included the portions shown here. The annual rates of coastline erosion were 20, 27, and 55 feet (6, 8, and 17 meters) per year, respectively, for the periods 1955 to 1979, 1979 to 2002, and 2002 to 2009. For year-to-year reference, note the large lake near the center of the photo. The colored lines in the 2009 image outline the location of the shoreline in the years indicated. (photo: Benjamin M. Jones, U.S. Geological Survey)*

Hydrology—Permafrost thawing will likely impact hydrology, surface water availability, and land surface in the U.S. Arctic. As shallow permafrost degrades, new pathways will open for surface water to drain from the landscape, reducing water availability for people and ecosystems. The precise nature of these changes is difficult to predict due to expected variability in snow depth, air temperatures, timing and amount of rain, and permafrost thawing rates.[8] Northern latitude lakes are already showing a trend toward increased duration of open water, earlier ice breakup, freezing delays, and reduced ice growth.[46, 47]

Erosion—Coastal erosion in the U.S. Arctic is increasing due to reduced sea ice, increased wave action, and permafrost degradation. Remarkably, the erosion rates of some coastal areas along the Beaufort Sea east of Point Barrow have doubled over the past half century, from 20 to 45 feet (6 to 14 meters) per year ***(Figure 2.5)***.[48, 49] The coastline is thus being reshaped, with several attendant impacts on residents. Coastal villages, property, infrastructure, and livelihoods are being adversely affected, and the continued viability of some coastal villages is in doubt.[48, 49, 50, 51] Erosion and other climate change impacts have the potential to increase the cost of maintaining infrastructure in Alaska by over $6 billion in coming decades.[52] Shoreline fuel storage and delivery systems like pipelines and tanks are also threatened.[53, 54] Government agencies are preparing inventories of coastal areas and facilities whose deterioration from erosion and inundation may threaten waters, fish, and wildlife.

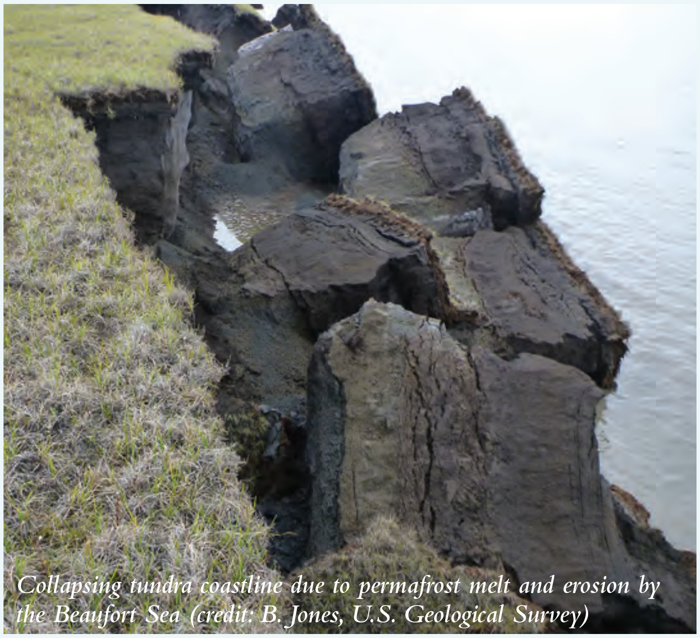
Fires—Tundra fires have been rare historically, but they are expected to increase under projected climate scenarios.[55, 56, 57] While models suggest that Arctic precipitation will increase, evapotranspiration and water drainage predictions indicate a drier tundra that will be susceptible to more numerous and intense tundra fires, releasing carbon and contaminants like mercury into the atmosphere.[8, 58, 59]

2.2. | *Cultural and Social Trends*

Traditional ways of life in much of the U.S. Arctic are at risk. Alaska Natives face a number of cultural and social challenges stemming from climate change as well as from economic and industrial development in rural areas.[60] Physical impacts to villages from erosion, subsidence, floods, and storm surges often require emergency responses, infrastructure investments, and in some cases even full-scale community relocation.

The subsistence way of life of many Alaska Natives and other rural residents relies upon natural resources for food, shelter, clothing, transportation, and the maintenance of cultural traditions. While industrial development, new technologies, and changing climate all affect locally based practices, reliance on natural resources remains high. Deep-seated cultural values of family, sharing, traditions, and supportive social networks are important to maintain amidst the changing circumstances.

Basic infrastructure is rudimentary or lacking in many U.S. Arctic communities. Low population densities over a vast geography, high engineering and construction costs, and/or lack of financial resources have led to absent or outdated water and sewer systems, a lack of passable roads between communities, and locally produced electricity that is expensive and lacks a centralized energy grid.



Collapsing tundra coastline due to permafrost melt and erosion by the Beaufort Sea (credit: B. Jones, U.S. Geological Survey)

Subsistence way of life: Reliance on subsistence approaches—hunting, fishing, and gathering of plants—is widespread in the U.S. Arctic. Subsistence harvesting is not simply about calories and nutrition; it is culturally significant for Alaska Natives and other rural residents. Although economic development and climate change have challenged some subsistence practices, local reliance on natural resources and traditional ways remains high.

For example, Alaska Natives in the U.S. Arctic make use of land and marine mammals, birds, fish, and plants. Migratory birds like white-fronted geese and northern pintail ducks continue to be harvested for subsistence. In the North Slope area, total annual bird harvests in this region were about 44,000, 45,000, and 20,000 in 2007, 2008, and 2009, respectively. The western Arctic caribou herd is hunted for subsistence at a rate of about 15,000 to 20,000 animals per year. Fish, including whitefish, Arctic char, Arctic cisco, and Arctic cod, are among many species taken by Alaska Natives. Bowhead whales, beluga whales, bearded seals, ringed seals, spotted seals, walrus, and polar bears have been critically important components of the Alaska Native subsistence diet and culture for thousands of years. During the last decade, an average of 40 bowhead whales was landed annually, and between 2008 and 2012 Alaska Native subsistence hunters annually harvested thousands of seals and walrus and dozens of polar bears.

Traditional knowledge has proven essential for subsistence harvesting and for sustainable management of natural resources. In conjunction with scientific investigations, traditional knowledge will continue to provide valuable evidence, assessment, and insight into fish, wildlife, and wildlife habitat as subsistence hunters adapt to changing environmental and social circumstances.

> **Traditional Knowledge**
>
> *Traditional knowledge (TK) refers to a body of evolving practical knowledge based on observations and personal experience of local residents over an extensive, multi-generational time period. TK typically finds expression in a specific environmental context, as technical mastery or expertise that promotes survival and well-being in that location and is shared primarily through kinship or household networks.*
>
> *By definition, TK is local rather than global in scope; it favors a dynamic rather than rigid approach to understanding; it is based on experience rather than innate qualities; and it is unevenly accumulated among residents. Some residents are more knowledgeable than others on specific topics of interest, and such expertise usually enjoys wide recognition within each community. Equally evident, TK involves much more than a mere collection of factual observation — it also yields an understanding of the landscape and one's place in it that inspires others and anchors community values. Fundamentally more profound than other popular expressions of "citizen science," TK retains a distinctive quality by emphasizing a fundamental sense of unity between humans and nature. For this reason, decision-making must distinguish clearly among three types of knowledge: facts (based on observation), inferences (based on hypotheses), and values (based on longstanding norms and preferences).*
>
> Excerpt from BOEM Ocean Science, Vol. 9, Issue 2, May/April/June 2012, page 4.

Historic and archeological resources: Alaska holds many nationally and globally significant archeological sites, historic structures, and traditional cultural properties. This legacy bears witness to a record of remarkable achievement: the arrival of humans in the western hemisphere over 14,000 years ago; the development and spread of Eskimo, Aleut, Athabaskan-Eyak-Tlingit, and other cultures; and human ingenuity and tenacity in a forbidding environment.

Traditional and historically significant places are essential to the practices that transmit culture from one generation to the next. These sites, which document a long record of human adaptation to environmental change, include camps of pioneering hunters from the Ice Age, remains of sod houses, long-abandoned camps of prospectors in search of gold, and the graves of pilots from World War II. These unique cultural resources derive much of their significance from "place." When conditions change, these sites cannot be relocated and still retain the same degree of cultural significance. Environmental consequences of climate change and modern development are affecting many of these sensitive sites, and that trend is likely to accelerate.

2.3. | *Economic Trends*

The U.S. Arctic remains a frontier economy; many of the products and much of the value of commercial activities derive from natural resources and are intended for out-of-state markets. Economic activities in the U.S. Arctic are technically challenging and expensive due to the harsh environment and limited transportation routes. Despite the challenges, the industrial sector operating in the U.S. Arctic has a major impact statewide in Alaska, generating, directly and indirectly, thousands of jobs, millions of dollars in personal income, billions of dollars in revenue (for federal, state, and local governments), and substantial industry profits.[61] Revenue, employment, and personal income from these industrial activities can improve the quality of life for local residents and support the ability of state and local governments to provide public services to communities.

U.S. Arctic industrial investments continue to increase and drive infrastructure expansion and modernization. Alaska's tourism and fishing industries also are based on natural resources, and their long-term profitability depends on the sustainability of ecosystem services. Projected increases in permafrost thawing will further restrict land-based resource development, such as onshore oil and gas exploration and development, which affects fragile tundra landscapes but also depends upon the frozen ground for stability.[51]

> *"What we now call subsistence is not a relic from the past—a holdover from previous times that will inevitably disappear as market conditions take over—it continues to be the foundation of Alaska Native society and culture."*
>
> Julie Kitka, President
> Alaska Federation of Natives

Trans Alaska pipeline in winter (credit: Dept. of the Interior)

Oil and gas: The U.S. Arctic holds large oil, gas, and mineral deposits, and these resources are dominant in the regional and state economies. Oil accounts for 98 percent of all natural resource revenues collected by the State of Alaska, and about half of all jobs in the state are directly or indirectly related to North Slope oil production and associated spending.[62] Oil production has steadily declined since 1988, however, raising concerns about the economic sustainability of the Trans-Alaska Pipeline System if daily oil throughput continues to fall.

Onshore resources—Recent assessments indicate that significant amounts of oil and gas accumulations still exist on land, especially in areas like the central North Slope. While extraction on state lands in the central North Slope continues, oil reserve estimates in the National Petroleum Reserve in Alaska have been substantially reduced in recent years. Additional oil and gas resources may be accessible from shale formations and with increased use of advanced recovery technologies. Over the last 30 years, exploration activities have been limited by a 50 percent reduction in the number of days the ground was frozen and suitable for travel.[63]

Offshore resources—Over 23 billion barrels of technically recoverable oil and 108 trillion cubic feet of technically recoverable gas are estimated to lie in the Outer Continental Shelf (OCS) of the Beaufort and Chukchi Seas. That represents over 89 percent of all oil and 82 percent of all natural gas estimated for all of Alaska's OCS.[64]

Shell Oil Company conducted limited preparatory activities for exploratory drilling in the Beaufort and Chukchi Seas in 2012, although ice encroachment and the failure to obtain certification of a required spill containment vessel precluded drilling into hydrocarbon zones. Shell Oil Company has elected not to continue exploration activities in the 2013 season. If Shell Oil Company is able to provide federal authorities with assurances that required safety and environmental safeguards are in place and functional, the company hopes to continue exploration activities in 2014 and beyond. ConocoPhillips and Statoil also hold leases in the Chukchi Sea; ConocoPhillips intends to begin exploratory drilling as soon as 2014. Several other companies also hold offshore leases in the region and seek permission to conduct seismic testing. The 2012 to 2017 Outer Continental Shelf Oil and Gas Leasing Program anticipates that additional lease sales could occur in 2016 in the Chukchi Sea and in 2017 in the Beaufort Sea.

Renewable energy: Renewable energy development and distribution in the U.S. Arctic is currently limited. Communities rely heavily on diesel or natural gas for heat, electricity, and transportation, even though heating fuel costs $4 to $10 per gallon.[65, 66] Statewide, average heating fuel prices have increased by 64 percent since 2005, leading local governments to subsidize residential heating fuel costs and incentivize small-scale renewable energy integration.[67, 68]

Wind energy is currently the most feasible renewable energy source for the Arctic, due to strong winds in coastal and mountainous areas. Alaska's goal is to generate half of the state's electricity from renewable resources by 2025; the Northwest Arctic Borough has a goal of 75 percent reliance on local fuel sources, both renewable and nonrenewable, by 2030.[66] Kotzebue and Nome are leading the way in the Arctic with wind turbines that have capacities of 2.28 megawatts and can fully power up to 360 homes in each community.[66, 69] Several federal, state, and local entities are encouraging rural energy generation via wind turbines and solar panels. In addition, the NANA Regional Corporation, an Alaska Native association of 11 villages, is planning to expand the Kotzebue wind farm and study the potential for wind energy in other Northwest Arctic Borough communities. More recently, the Department of the Interior initiated a project with the National Renewable Energy Laboratory and several leading energy companies to explore potential development of a standardized and reliable small-scale wind-diesel renewable energy system for potential siting in small, off-grid U.S. Arctic villages.

Concrete Island Drilling System (CIDS) surrounded by sea ice (credit: Dept. of the Interior)

Mining: The U.S. Arctic hosts a variety of important mineral deposits. Seven large mines currently operate statewide in Alaska, and six more are in the exploration or permitting phases, along with thousands of smaller operations.[70] The Red Dog Mine, located within the report area and the largest in Alaska in terms of production and reserves, is processing zinc, lead, and silver ore from one of the largest zinc deposits in the world. It accounted for 49 percent of Alaska's total non-fuel mineral production in 2010 and it has produced ore worth over $1.5 billion.[71] Further production of copper and zinc may develop from mineral deposits in the southern portion of the U.S. Arctic. High gold prices have brought increased exploration activity for placer gold in Alaska's northern region in recent years, and gold production in 2010 totaled a reported 2,595 ounces (80,714 grams).[71] The U.S. Arctic holds considerable coal resources, with North Slope basins containing as much known coal as the rest of the United States combined.[72, 73, 74] Over 330 billion short tons (299 metric tons) of bituminous coal lie within the Colville River basin, which constitutes a major part of the National Petroleum Reserve in Alaska.[75]

Arctic mining is both challenging and expensive due to the region's remote and harsh environment, lack of roads, and potentially frozen shipping lanes. Nevertheless, exploration and development investment has increased in the last few years, driven in part by high commodity prices.[76]

Commercial shipping: Current shipping activity in the U.S. Arctic is mostly regional and centered on the export of resources and the resupply of communities and facilities extracting natural resources. Most shipping is done with tugs and barges due to the absence of deep-water ports in the U.S. Arctic. Oil and gas exploration and development continue to be the primary drivers for commercial maritime traffic in the region. Successful offshore oil and gas exploration and extraction ventures will depend heavily on safe marine transportation.

Diminishing Arctic sea ice is likely to encourage growth of commercial shipping via international trans-Arctic routes, though the time horizon for such an expansion is unclear. These routes may reduce transit distances between Europe and Asia by as much as 5,200 miles (8,369 km).[77] The Marine Exchange of Alaska reports that commercial traffic through the U.S. Arctic increased by 30 percent from 2008 to 2010, though total number of transits remains small relative to

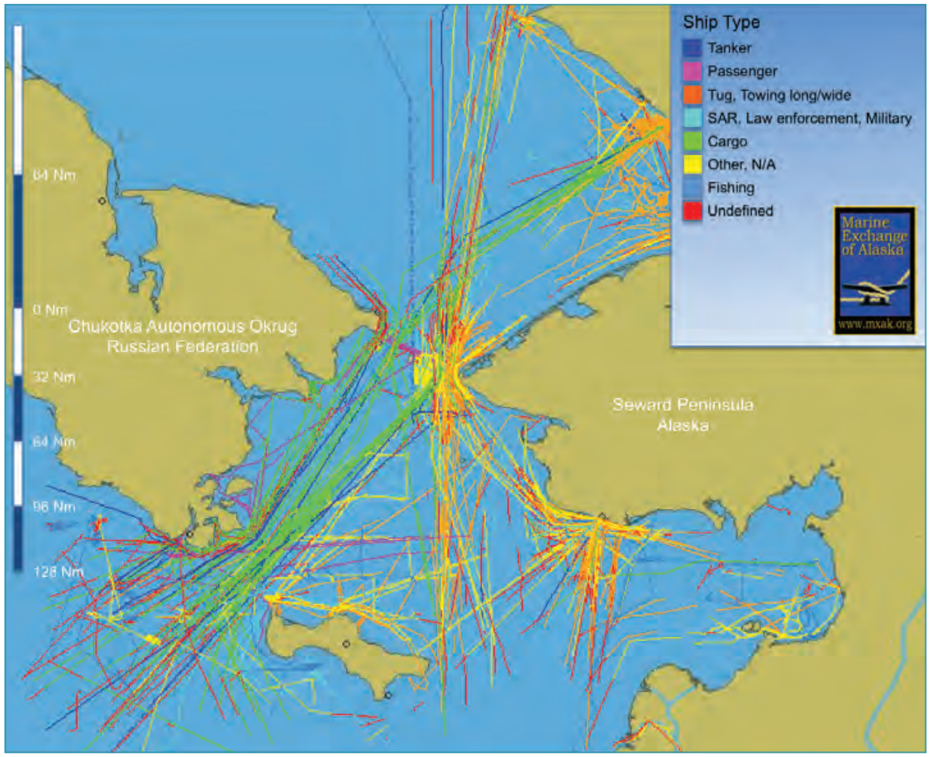


Figure 2.6. *Tracks of ship traffic passing through Bering Strait and nearby areas during 2011. (image: Marine Exchange of Alaska)*

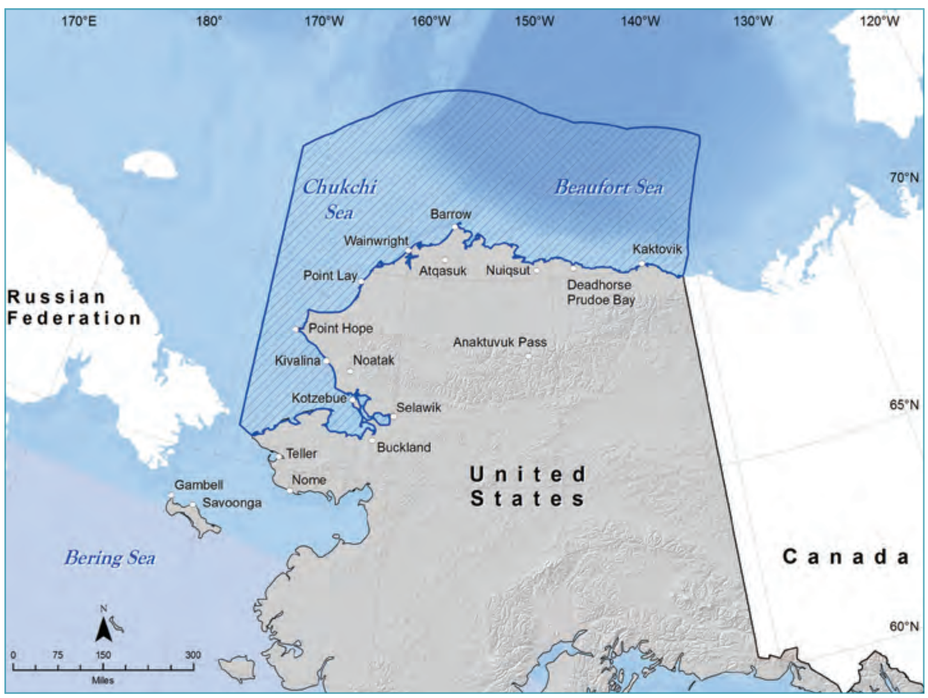


Figure 2.7. *The U.S. Arctic Fishery Management Plan Area is defined as all marine waters in the U.S. Exclusive Economic Zone of the Chukchi and Beaufort Seas, from 3 nautical miles off the coast of Alaska or its baseline to 200 nautical miles (370 kilometers) offshore, north of Bering Strait, westward to the 1990 U.S./Russia maritime boundary line, and eastward to the U.S./Canada maritime boundary. The hatched area shown in the figure is provided for illustrative purposes only, and does not include State of Alaska waters within 3 nautical miles (5.6 kilometers) of the coast. The Arctic Fishery Management Plan Area (federal waters) is currently closed to commercial fisheries. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)*

other routes.* Transits through the Bering Strait also increased 25 percent during the same 2-year period. As recorded by the Exchange's Automatic Identification System, there were 300 and 333 commercial-vessel transits of the Bering Strait in U.S. Arctic waters in 2011 and 2012, respectively, with many other vessels transiting west of the maritime boundary with Russia (***Figure 2.6*** shows transits for 2011). Increased traffic in the Arctic is leading to a growing use of the Bering Strait and U.S. Arctic waters, along with a dependency on the currently limited U.S. Arctic support infrastructure.

Commercial fisheries: Until recently, year-round sea ice coverage beyond the U.S. Exclusive Economic Zone made commercial fishing infeasible in the Arctic Ocean. Although there is not yet a concentration of fish species of commercial interest in the Arctic Ocean, salmon and other fish may move northward as the Arctic warms. Diminishing sea ice may lead to the loss of ice-dependent species—such as Arctic cod—from large portions of their range in the next few decades, but it will lead to a reduction in the level of plankton on the ocean floor, favoring pelagic species of fish over bottom-feeders.[78] Some salmon species (e.g., pink, chum) and cold-tolerant snow crab may increase in abundance in U.S. Arctic waters.[79]

Local fishers report occasional catches of other salmon species (chinook, sockeye, and coho), but colonization will depend on their ability to successfully reproduce in the perennial small spring habitats found in the rivers and streams that drain from the Brooks Range and the ability of juvenile fish to survive cold marine waters. No northward migration of the current groundfish fishery in the Bering Sea is expected in the next few decades, as seasonal ice cover and cold (<36 degrees F [2 degrees C]) bottom waters on the Bering Sea shelf still form a barrier to a northerly migration by pollock and cod.[80]

In anticipation of conditions that could lead to commercial fishery development in the U.S. Arctic, the North Pacific Fishery Management Council recommended, and the National Oceanic and Atmospheric Administration (NOAA) implemented, the Fishery Management Plan for Fish Resources of the Arctic Management Area, effectively preventing commercial fisheries from developing in federal waters until more information is available to support sustainable fisheries there ***(Figure 2.7)***.[81] These regulations were made prior to the rise of commercial interest in such fisheries to preclude the emergence of unregulated or inadequately regulated commercial fishing, which could adversely affect ecosystems as well as Arctic residents' subsistence way of life.

Tourism: Tourism in Alaska's far north has a long history, but the total activity remains low compared to tourist visits elsewhere in Alaska. Data for 2011 provide an overview: the Arctic accounted for 2 percent of Alaska tourist destinations, down from 3 percent in 2006, while overnight stays in the region dropped from 2 to 1 percent of statewide totals. In 2009, direct employment in the visitor industry of Arctic Alaska was 200 jobs.[82, 83]

Land-based tourism in the U.S. Arctic has grown since the 1980s, and the opening of the Dalton Highway to Deadhorse in 1995 contributed to an increase of overland visitors.[84] While guided Arctic cultural and wildlife tours remain popular, independent travel entering Alaska on the Alaska Highway has dropped significantly in the past decade.[83] Visitation to National Parks, Preserves, and Monuments (Gates of the Arctic, Noatak, Kobuk Valley, Bering Land Bridge, Cape Krusenstern) as well as in the Arctic National Wildlife Refuge have remained stable.[85, 86] Marine tourism in the U.S. Arctic has been almost nonexistent in the past, and currently only one or two small (about 200 passengers) cruise ships enter Alaska's Arctic waters each year.[87, 88] It is unknown if diminishing sea ice cover and longer, warmer summer seasons will be sufficient to drive an increase in Arctic marine tourism in the future.[53, 89, 90]

2.4. | *Infrastructure Trends*

Warming conditions in the Arctic strongly affect existing infrastructure as well as the needs and designs of future infrastructure. Permafrost thaw can undermine existing roads and buildings and, when combined with increased wave action due to reduced sea ice, accelerates coastal erosion, destroying or threatening shoreline infrastructure. Over time, the cost to mitigate damage and to protect, maintain, repair, or replace affected structures potentially could be in the billions of dollars.[52]

The changing climate presents new challenges, both to existing and to new infrastructure in the U.S. Arctic. In an unstable or changing Arctic, design and construction of new infrastructure will require much higher engineering investments. Potential future climate change impacts from thawing permafrost, increased flooding, and increased coastal erosion have been estimated to add 10 to 20 percent to future costs of public infrastructure statewide.[51] Where the thawed, unstable ground layers above permafrost increase in thickness, the consequences for industrial and village infrastructure will increase as the frozen foundations of those facilities become less stable.[51]

Oil and gas: Alaska's North Slope oil and gas infrastructure includes more than 3,400 wells and approximately 90 drilling pads, 260 reserve pits, 13 production centers, 14 support facilities, 6 docks and causeways, 5 air strips, 370 miles (595 km) of roads, and over 430 miles (692 km) of trunk pipelines linking up to the 800-mile-long (1,287 km) Trans-Alaska Pipeline System that stretches from Prudhoe Bay to Valdez, Alaska.[91] Although not yet developed, oil and gas production in the Chukchi Sea would have significant infrastructure needs, requiring either extensive pipeline construction across over 200 miles (322 km) of the North Slope or dramatic increases in maritime tanker traffic in the region and through the Bering Strait. As the challenges associated with Arctic offshore drilling and production in environmentally sensitive areas grow increasingly complex, government and industry must provide new technological solutions to address these complexities and enhance spill prevention measures.

* *"Commercial vessels" consist of landing craft, oil support vessels, drill ships, tugs, cargo ships, cruise ships, government vessels, and tugs. The Exchange does not count vessels making round trips to the Prudhoe Bay area supporting drilling operations, private boats, small oil spill response vessels, personnel launches operating near shore in support of oil development operations, or other commercial vessels.*

Roads: The Dalton Highway, terminating at Deadhorse, Alaska, is the only road connecting Alaska's North Slope to southern Alaska and the rest of the North American road network. Permanent road construction in the U.S. Arctic is controversial, for both environmental and cultural reasons, as well as expensive. Temporary ice roads provide an important transportation option during winter months, though the period during which ice roads are passable has shortened due to warming.

Marine shipping and support: Shippers, insurers, and government agencies remain concerned that the existing U.S. Arctic Marine Transportation System is inadequate to support increased marine traffic and projected development activities.★ Because the coastal waters of northern Alaska are shallow, there are limited refuges for ships in distress or deep-draft port facilities to handle increases in shipping in the region.

There are no deep-water ports north of Adak and Unalaska in the Aleutian Islands, and few navigational aids exist from Kotzebue Sound to the Canadian border. The nearest permanent U.S. Coast Guard (USCG) facilities and vessels for U.S. Arctic emergency response and search and rescue are located in Anchorage, Kodiak, and Dutch Harbor; these are 730, 920, and 1,150 miles (1,175; 1,480; 1,850 km), respectively, from Barrow, Alaska. Such great distances obviously delay responses for search and rescue and response to potential oil spills, although oil production operators are required to maintain response equipment in the region during drilling operations. Basic logistics and support for such functions are inadequate, and state and federal agencies are now exploring solutions to these problems.

Aviation infrastructure and services: The four major public airstrips in the U.S. Arctic that support commercial jet aircraft are in Deadhorse, Barrow, Kotzebue, and Nome. All other communities in this report's study area are served by gravel runways. The Deadhorse airport has supported oil development in the Prudhoe Bay since 1970, and it continues to see a demand for additional apron space and lease-lot development. The Kotzebue airport has planned development to include runway safety area improvements and apron development. While the Barrow airport currently is meeting the needs related to oil exploration, it may be inadequate to support the transportation needs associated with oil production.

Federal Aviation Administration systems for aeronautical communications, navigation, and surveillance in Alaska are based on a combination of ground and satellite technology. The Alaskan Satellite Telecommunications Infrastructure is the primary carrier for data/traffic for communications, weather information, surveillance, and environmental and navigational aids enabling air traffic services up to 72 degrees north latitude. The Automatic Dependent Surveillance-Broadcast system, which supports air traffic control and aeronautical operations, should be operational for the North Slope of Alaska by March 2014, increasing the surveillance coverage for air traffic control.

Weather and sea ice forecasts: Rapid loss of sea ice during the summer will continue to be a major driver of changes throughout the Arctic. The loss of sea ice and extreme variability in freeze-up and melt dates affect marine access, regional weather, global climate, marine and terrestrial ecosystems, and coastal communities. Furthermore, severe ocean storm conditions due to the lack of sea ice, coupled with complex weather and oceanographic hazards, threaten mariner safety in the Bering, Chukchi, and Beaufort Seas and the well-being of coastal Alaska communities. The rapid freeze-up in the Chukchi Sea in the fall of 2012 and the major storm that caused the grounding of the drillship *Kulluk* near Kodiak Island in the Gulf of Alaska on New Year's Eve 2012, illustrate such dangers.

Deadhorse Airport at Prudhoe Bay
(credit: A. Brower, National Marine Fisheries Service/NOAA)

★ The U.S. Committee on the Marine Transportation System is coordinating the establishment of domestic transportation policy to ensure safe and secure maritime shipping in the Arctic. On the international front, the Arctic Maritime and Aviation Transportation Infrastructure Initiative builds on the work of the Arctic Council's Arctic Marine Shipping Assessment, which focused on three themes: (1) enhancing Arctic marine safety; (2) protecting Arctic people and the environment; and (3) building Arctic marine infrastructure.[87]

Weather, ocean and wave, and sea ice forecasting continue to be challenges in the Arctic. Despite the availability of accurate information and analyses on current sea ice from the National Ice Center (jointly operated by NOAA, the Navy, and the Coast Guard), better sea ice forecasts are needed. Numerical weather prediction models, which also drive short-term sea ice forecasts, perform significantly worse in the Arctic region compared to the rest of the United States. In fact, the U.S. Arctic region has the second-worst global weather verification statistics. The scarcity of surface observations in the Arctic exacerbates the forecast challenges. To best address these issues, NOAA has engaged federal, foreign, and industry partners to enhance its polar-observing satellite and in-situ capabilities with additional satellite imagery and surface observations, as well as to develop future ocean, atmosphere, and sea-ice-coupled modeling capabilities.

Space weather forecasts: "Space weather events" manifest as solar flares and coronal mass ejections. These events can cause significant degradation of high-frequency communications and positioning errors with Global Positioning Systems. The Arctic is especially vulnerable to space weather events due to its proximity to the geomagnetic pole, and impacts are generally stronger and longer-lasting than those occurring at lower latitudes. Access to accurate forecasts can help reduce risk to most activities in the Arctic that depend on precise geolocation and communications, such as offshore energy exploration and development activities, transpolar flights, search and rescue, marine transportation, and recreation. NOAA's current GOES and POES satellites carry instruments that are critical tools for NOAA's Space Weather Prediction Center. Future space weather monitoring will rely heavily upon instruments aboard the GOES-R and DSCOVR spacecraft once they are launched.

Mapping: Accurate mapping is essential to the responsible development of the Arctic, preservation of human life and safety, and the advancement of scientific discovery. Accurate positions (both horizontal and vertical) of water depths, critical hazards, navigation aids, shorelines, water levels, and other features are essential for safe navigation. Due to its historical inaccessibility, the U.S. Arctic lacks the geodetic and tidal control infrastructure currently available to the rest of the Nation.

Less than one percent of navigationally significant U.S. Arctic waters have been surveyed with modern technology for depths and navigation hazards.[92] Some U.S. Arctic waters were first surveyed by Captain James Cook in 1778, and they have not been surveyed since.[93] The key to safe maritime transportation in an ice-free Arctic will be accurate hydrographic and shoreline charting to support safe harbors, navigation, and emergency response to disasters, whether natural or manmade. To improve Arctic marine navigation, NOAA has begun taking steps to survey and update nautical charts for the highest priority areas in the Arctic.

Alaska's terrestrial elevation (or topographic) map is over 50 years old, has never met National Map Accuracy Standards, and is widely considered grossly inaccurate. To begin addressing this infrastructure need, the Department of the Interior and the State of Alaska have been working together on the Alaska Mapping Initiative to bring Alaska's terrestrial map into the 21st century. Many federal agencies are cooperating in the effort; the Alaska

U.S. Coast Guard icebreaker Healy *in the Chukchi Sea (credit: E.C. Siddon, Univ. of Alaska/NOAA)*

Mapping Executive Committee hopes to finish topographic mapping of the entire state, including the U.S. Arctic, by 2018. A network of seven long-term water-level monitoring stations in the U.S. Arctic provides important data for navigation, shoreline boundary purposes, and mapping activities.

Coastal erosion and rural communities: Coastal erosion rates in the Arctic over the past half century have been among the highest in the world.[50] This is particularly noteworthy because marine waters which have typically remained frozen for 9 months of the year are now rapidly trending toward longer open-water periods, leading to increased wave action and still faster rates of erosion.[94] In some locations, erosion rates have already doubled since the early 2000s ***(Figure 2.5)***.[48, 49]

A recent U.S. Government Accountability Office report found that 86 percent of Alaska's 213 predominantly Native villages, historically situated along rivers and coasts, are now affected regularly by floods or erosion, and these impacts are expected to be greatly exacerbated by climate change.[95] Several Arctic communities in northwest and western Alaska, including Shishmaref, Kivalina, and Newtok, have suffered substantial erosion; houses and buildings are falling into the sea, and landfills, archeological sites, and other infrastructure are being lost ***(Figure 2.8)***.

Sustaining imperiled communities will entail significant financial and social costs. For example, while the least socially disruptive alternative proposed for Shishmaref is to move the entire community off of its barrier island (Sarichef Island) to the mainland, other alternatives include dispersing households from the community to "hub" communities such as Nome or Kotzebue or remaining on Sarichef Island and continuing to fight the erosion.

Emergency preparedness and response: The vast geography and limited communications infrastructure in the U.S. Arctic significantly lengthen search and rescue and oil spill response times and create substantial challenges for federal agencies and other responders. Under current law, the oil industry is legally required to provide the capability to respond to any spills that may be associated with its operations. Alaska Clean Seas, an industry spill-response cooperative, responds to selected areas of the Outer Continental Shelf, adjacent shorelines, and the Trans-Alaska Pipeline System. Oil industry response is overseen by limited state and federal assets.

The Alaska Regional Response Team (ARRT), one of thirteen Regional Response Teams around the Nation, was established by the Oil Pollution Act of 1990. It operates under the authority of the National Oil and Hazardous Substances Pollution Contingency Plan to prepare for, and respond to, oil discharges and hazardous materials releases for all of Alaska. The ARRT is co-chaired by the Coast Guard and Environmental Protection Agency and provides federal and state governmental agencies, tribal entities, and other stakeholders with a forum to participate in pollution preparedness planning as well as a means to support coordination during pollution incidents. The ARRT developed a Unified Area Contingency Plan for response to oil and hazardous substance discharges or releases in Alaska; ten Subarea Contingency Plans were developed statewide, including three that cover the geographic boundaries in this report.

In 2011, the eight member-nations of the Arctic Council signed the Agreement on Cooperation on Aeronautical and Marine Search and Rescue in the Arctic. In May 2013, these nations intend to sign the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic. Both agreements represent necessary steps to facilitate international cooperation in the event of a search and rescue event or marine oil spill incident in the Arctic. Successful implementation of these agreements will require appropriate response capabilities stationed strategically in the U.S. Arctic. There also is a need for more cooperative oil spill response research, development, and testing for conditions unique to Arctic environments.

Arctic access: The United States assets that provide physical access to the Arctic to conduct domestic federal missions include aircraft and ships capable of operating in the cold, harsh environment. The Coast Guard relies upon mobile assets, such as major cutters and seasonal air and communications facilities, to meet mission requirements.

Icebreakers—Currently, one medium icebreaker (the USCG Cutter *Healy*) is operating seasonally in the Arctic. The Coast Guard is reactivating one of its two heavy icebreakers (the USCG Cutter *Polar Star*) in late 2013. Other vessels available to the Coast Guard in the Arctic region have limited icebreaking capability and capacity. In 2014, the National Science Foundation will launch its new ice-capable research vessel, the R/V *Sikuliaq*. Planning is underway for acquisition of a new Coast Guard icebreaker with the initial resources proposed in the 2013 President's Budget. The USCG Cutter *Healy's* unanticipated support role in the emergency refueling mission to Nome in the winter of 2011 to 2012 raised awareness of the challenges that Arctic communities face, and the need to develop contingencies to meet critical needs.

Aviation— The Coast Guard does not have a permanent air station in the Arctic region. The closest Coast Guard Air Station is at Kodiak, which is 920 miles (1,480 km) from Barrow via air. During summer 2012, as part of the Coast Guard's "Arctic Shield 2012," the Coast Guard had cutters equipped with helicopters patrolling the Chukchi and Beaufort Seas and leased a hangar in Barrow to create a temporary "Forward Operating Location." Two Coast Guard helicopters were deployed to Barrow from Coast Guard Air Station Kodiak and flew 289 hours in support of search and rescue, ice reconnaissance, Arctic maritime domain awareness, and other missions.

Communications: Securing reliable communication is becoming increasingly important in the U.S. Arctic; poor communications infrastructure affects day-to-day operations and emergency responses. Communications companies are considering installation of new submarine fiber optic cables through the region despite the harsh conditions.[96] Stakeholders have also identified a need for improved vessel-to-vessel and ship-to-shore communication capabilities to include satellite communications.

Figure 2.8. *Coastal erosion undermines a building at Shishmaref, Alaska, in 2007. (photo: R.A. Winfree, National Park Service)*

Chapter 3:

Visions and Goals for the U.S. Arctic

The U.S. Arctic faces many challenges in the coming decades, and the many federal and state agencies, native groups, and other stakeholders in the region are determined to successfully address these challenges. While the groups do not always share the same needs and goals, they often do have many common aspirations. A summary of those perspectives is provided here. This summary does not purport to be a comprehensive assessment of the vision and goals of all stakeholders, but it provides a high-level overview of some of the driving forces that are likely to influence the future of the U.S. Arctic over the next 20 to 30 years.

3.1. | Industrial and Commercial Stakeholders

Oil and gas: During the coming decades, the oil and gas industry expects to develop onshore and offshore oil and gas resources in the U.S. Arctic. The industry maintains that the degree to which this happens will depend on the regulatory conditions, type and amount of resources discovered, economic factors, and infrastructure developed. The insurance industry will also play a key role by determining the availability of insurance packages to address unique Arctic conditions. The industry seeks a future that includes:

- ***improved coordination by regulatory agencies, and clear and consistent application of standards, regulations, and statutes;***
- ***creation and maintenance of infrastructure to move oil and gas to markets, including a potential natural gas pipeline from the North Slope, subsea pipelines from the Chukchi or Beaufort Seas, shore-based facilities to support offshore operations, pumping stations, a 250-mile pipeline across the National Petroleum Reserve, and continued operation of the Trans-Alaska Pipeline System;***[97, 98, 99]
- ***management plans that consider environmental protection and cultural needs alongside resource extraction activities;***[100] ***and***
- ***a balance of industrial operations with local subsistence harvest needs.***[100]

Several large, international oil companies have major, long-term investments in the U.S. Arctic. In recent years, there has been additional heavy investment in potential offshore oil development activities in the Chukchi and Beaufort Seas. For example, the 2008 Chukchi Sea offshore lease sale garnered approximately $2.7 billion in high bids from the oil and gas industry.[101] Recently, Shell Oil Company has been leading the way in investing in offshore exploration activities in the U.S. Arctic.[102]

Renewable energy: The State of Alaska and regional governments are setting goals for significantly increasing the number of renewable energy projects statewide. The state has accompanied its goal-setting with significant investments in renewable energy projects through the Alaska Energy Authority. Although Kotzebue and Nome utilize wind power, the largest investments, and highest-profile Alaska renewable energy success stories, have taken place outside the Arctic *(e.g., wind energy deployment in Kodiak)*. Expansion of this industry in the U.S. Arctic is hindered by a lack of infrastructure, seasonal climatic variations, and—as in other areas in rural Alaska—uncertainties regarding funding, regulatory processes, electrical grid access, and maintenance in remote locations. The Department of the Interior has been working with the State of Alaska, tribal entities, local governments, and nongovernmental organizations to coordinate the federal renewable energy effort in Alaska.

Mining: According to the Alaska Miners Association, industry representatives have indicated an interest in expanding operations in the U.S. Arctic over the next 20 to 30 years with legal, regulatory, infrastructural, and environmental conditions that include:[103]


Researcher scanning sea ice (credit: J. London, National Marine Fisheries Service/NOAA)

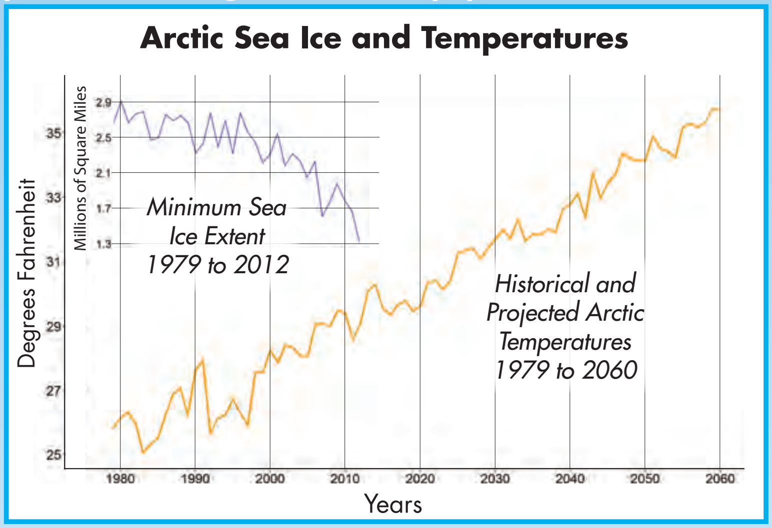
- *litigation reform to provide more accountability to the appeals and litigation processes for community and resource-development projects;*
- *financial assurance requirements for environmental compliance managed exclusively by the State of Alaska, with taxes that are equitable and stable;*
- *wetlands and water-quality management with state-led managing authority, based on place-based and scientifically supportable standards, and fewer federal impediments to development;*
- *prohibition on establishing international parks or nature reserves in Alaska;*
- *minimal, but science-based, endangered species listings;*
- *adequate road infrastructure to remote areas;*
- *regional electrical connections to rural communities; and*
- *lifted restrictions on bulk shipping to allow movement of nonpetroleum bulk natural resources.*

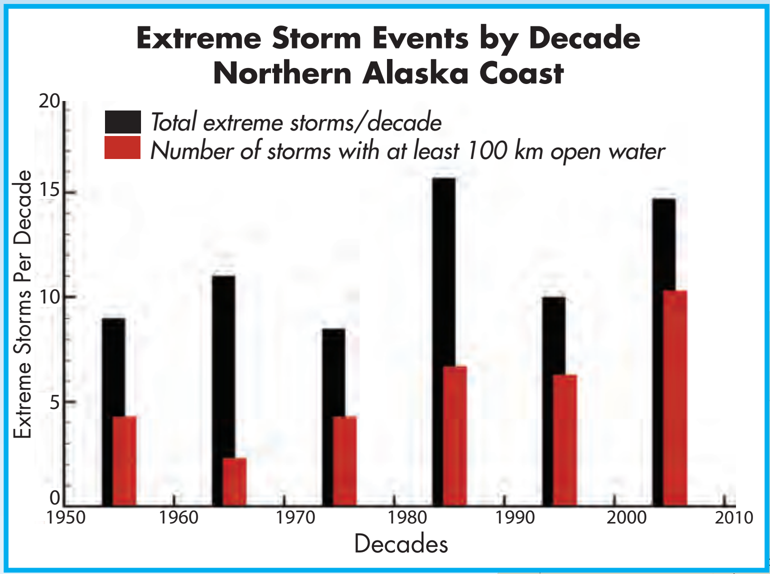
Shipping: According to marine shipping experts, supporting a significant expansion of shipping in the U.S. portion of the Arctic would require the following developments:

- *deep-water ports for ship refueling, cargo transfers, materials storage, and visitor disembarkment;*
- *site response plans for offshore anchoring, cargo loss, discharge from ships, as well as oil spills and other hazardous material discharges;*
- *creation of trust funds, financial pools, or other private insurance schemes, for liability and compensation purposes, should accidents occur;[87]*
- *updated and new navigational charts;*
- *international harmonization of U.S. regulations and statutes, as with the Marine Mammal Protection Act;*
- *effective ballast water control and management to prevent the introduction and spread of invasive species;[87] and*
- *improvements in weather- and iceberg-monitoring data-sharing protocols.*


Oil field support facility at Prudhoe Bay (credit: M. Lindeberg, National Marine Fisheries Service/NOAA)

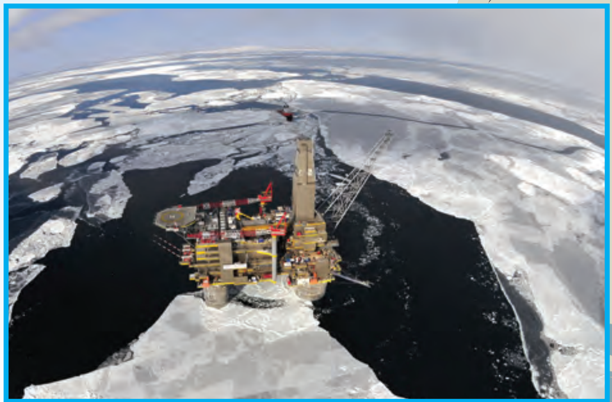
The Arctic is **changing rapidly**, providing new opportunities and challenges.



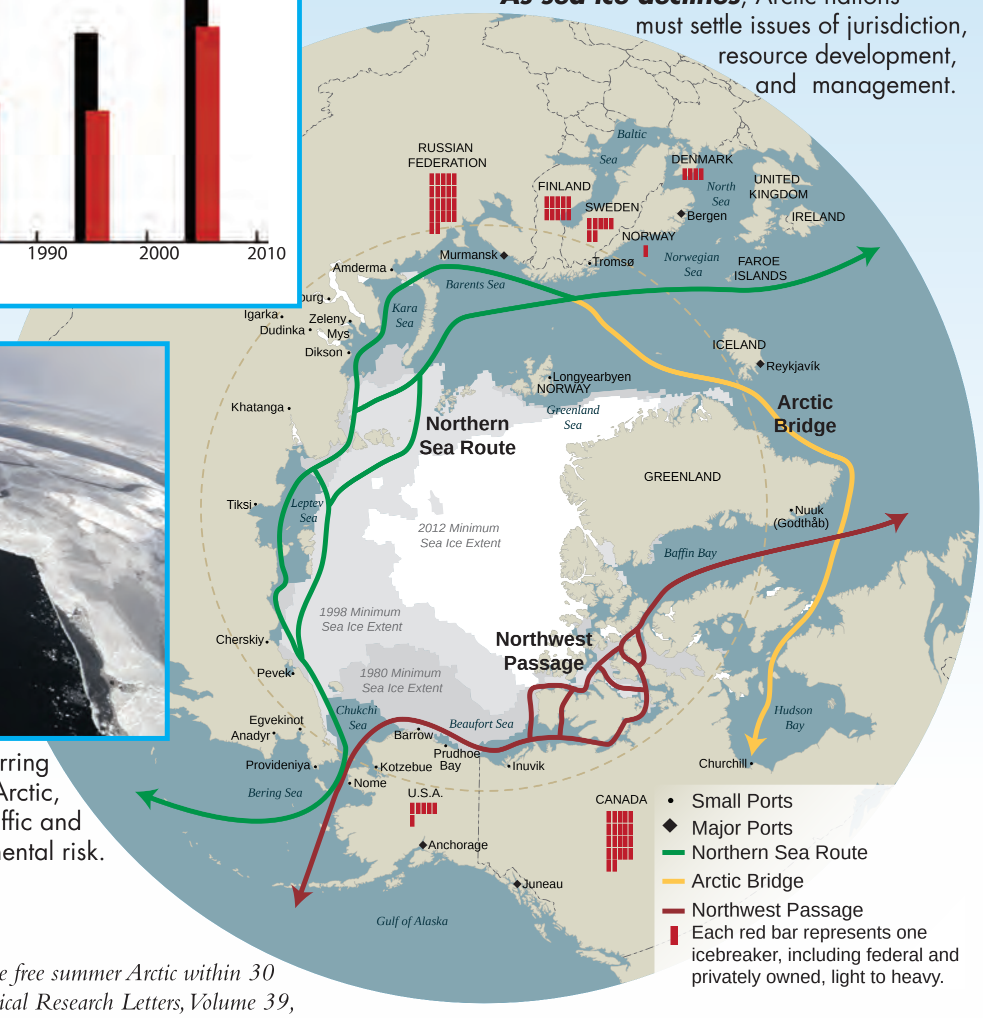


Summer sea ice extent and overall ice thickness have been declining for at least 30 years, since satellite monitoring of sea-ice extent began. Recent projections for sea ice minimums indicate that a nearly ice-free Arctic Ocean will occur by mid-century, and perhaps before 2030.* An ice-diminished Arctic is creating growth potential for commercial shipping on international trans-Arctic routes, which reduces existing transit distances between Europe and Asia by 5,200 miles (8,369 km).

The intensity of summertime storms north of Alaska is also projected to increase. Ice distance from shore is expected to increase 10 fold (from 30 to 300 miles [48 to 482 km]) contributing to greater fetch, stronger winds, and less shoreline protection. These changes will make coastal areas susceptible to severe erosion, creating potentially hazardous marine transportation and operating conditions, and increasing the need for new operations and weather forecasting capability. Severe storms have impacted large research vessels (September 2010) and Arctic communities (2012). Hurricane-force winds of 70 mph (113 km per hour) occurred in the Arctic Ocean in August 2012.



Offshore development is occurring and set to increase throughout the Arctic, further spurring increases in marine traffic and environmental risk.



As sea ice declines, Arctic nations must settle issues of jurisdiction, resource development, and management.

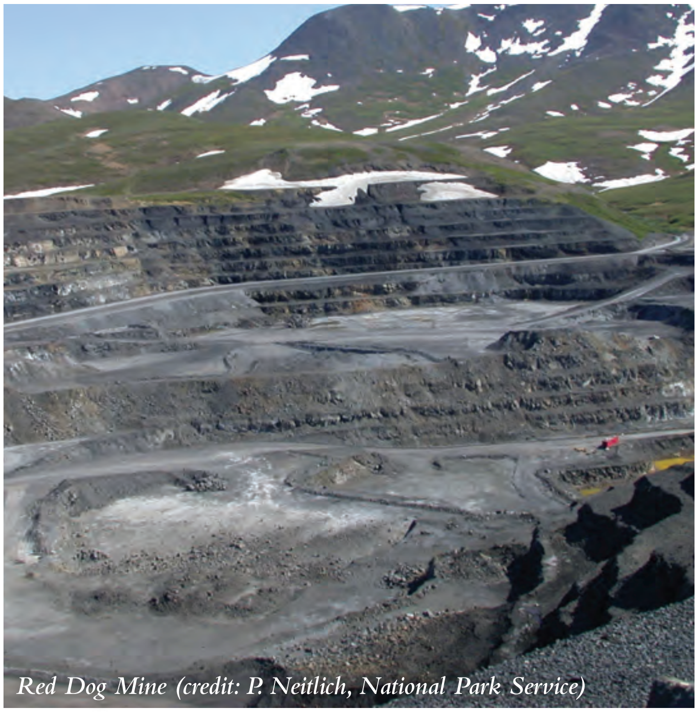
* *Wang, M., and J. E. Overland. 2012. A sea ice free summer Arctic within 30 years: An update from CMIP5 models. Geophysical Research Letters, Volume 39, L18501, 6 p., doi:10.1029/2012GL052868.*

Commercial fisheries: Through discussions with representatives of the U.S. commercial fisheries industry, it is apparent that if and when interest grows for developing commercial fisheries in the Arctic, the industry would support sustainable practices, effective regulatory procedures, and science-based management. Additional goals would likely include:

- ***continued Coast Guard presence to limit illegal fishing and provide emergency response capabilities, including search and rescue;***
- ***continued scientific research in Arctic waters to improve understanding of the important ecological relationships that coastal communities, seabirds, and marine mammals depend upon;***
- ***adoption of international agreements to facilitate legal protection of U.S. interests in the face of competition from other Arctic nations (one such agreement, currently being proposed by the United States, would forestall the advent of commercial fishing in the high seas portion of the central Arctic Ocean until an international mechanism is in place to properly manage such fishing);***
- ***onshore processing facilities and ports to increase efficiency and provide product storage;***
- ***careful consultation with coastal communities to protect subsistence harvests and lifestyles; and***
- ***reestablishment of the State of Alaska Coastal Zone Management Program to protect fish and wildlife habitat and facilitate communication between federal, state, and local governments when making decisions for both onshore and offshore development.***[104]

Tourism: Longer, warmer seasons and loss of sea ice may stimulate an Arctic tourism industry in and around Alaska. Despite increased interest in Arctic travel, the market for a major Arctic cruise industry is uncertain. A few small, adventure-tourism cruise ships have been traversing the Arctic, but the large vessels from major cruise lines would bring many hundreds of passengers and require onshore facilities to process waste and to meet food and fuel needs. Increased cruise line and shore-based tourism would require:

- ***modern ports to allow ships to dock, refuel, and replenish supplies, and to let passengers disembark and visit coastal towns (a major, deep-water port in Nome, Barrow, or elsewhere would be needed to allow access to onshore facilities; such infrastructure currently does not exist, and its development would face substantial logistical hurdles and high costs);***
- ***regional capacity for search and rescue capable of addressing the needs of very large vessels with hundreds of passengers; and***
- ***expanded tourism infrastructure onshore, such as hotels and transportation services.***



Red Dog Mine (credit: P. Neitlich, National Park Service)

3.2. | *State of Alaska*

The Alaska Statehood Act of 1958 granted the state approximately 104 million acres (42 million hectares) of land, ownership of the submerged lands of navigable waterways and submerged lands up to 3 miles (4.8 km) offshore under the Submerged Lands Act, and primary authority to manage fish and wildlife unless covered by federal law. State officials are dedicated to their constitutional duty to responsibly develop and utilize the state's natural resources for the benefit of citizens and to safeguard the state's fish, wildlife, and natural environment.

The challenges in the U.S. Arctic that state officials decribed in their comments for this report included: (1) high unemployment rates and high fuel and food prices in remote communities; (2) lack of affordable energy, modern sanitation, and advanced communication technology in rural areas; (3) burdensome federal regulations and permitting processes; (4) lack of infrastructure to maximize opportunities from increased shipping, tourism, research, and development activity; and (5) impacts of climate change, such as the erosion threatening coastal villages.

The Office of the Governor described a vision for the U.S. Arctic that includes the following characteristics:

- ***sustainable, healthy communities that incorporate traditional knowledge in decision-making and are supported by responsible economic development;***
- ***increased operational certainty to support economic activities, and revenue streams to help Alaska sustain its economy and healthy communities;***
- ***a federal-state partnership to manage the U.S. Arctic, with a seat at the table for all Alaskans, including rural Alaskans and Alaska Natives;***

- ***streamlined and coordinated permitting and regulatory processes that conserve the environment while allowing responsible resource development; and***
- ***increased domestic and international shipping, tourism activity, fishing, mining, and offshore oil and gas production made possible by reduced sea ice.***

State officials noted that they do not believe new layers of bureaucracy are necessary to accomplish this vision, but they indicated the following critical needs:

- ***a more effective and sophisticated collaborative relationship between the U.S. Government and the State of Alaska;***
- ***increased investments in infrastructure such as pipelines, oil and gas production facilities, deep-water ports, fisheries, search and rescue and shipping infrastructure, icebreakers, and oil spill response infrastructure;***
- ***increased attention to U.S. Arctic communities, particularly regarding human health, food security, and climate change issues such as coastal erosion, storm effects, sea ice retreat, and permafrost melt;***
- ***increased investments in scientific research, monitoring, and mapping;***
- ***cooperative agreements with Canada and Russia to leverage limited infrastructure; and***
- ***accession to the U.N. Convention on the Law of the Sea.***

The views of the Governor's Office are, to a large extent, shared by the Northern Waters Task Force—a body of Alaska state legislators, leaders of U.S. Arctic communities, and members of key state and federal agencies tasked with exploring opportunities for the U.S. Arctic. The findings of the Task Force's final report, issued in January 2012, included the need for a U.S. Arctic strategy and inclusive processes for decision-making; increased data sharing, monitoring, and research prioritization; research and improvements to support the prevention and containment of oil spills; support for cross-cutting maritime needs such as Arctic shipping routes, vessel tracking systems, icebreakers, deep-water ports, and hydrographic mapping; and greater international involvement through the Arctic Council.

In addition to the aspirations of state government officials, Alaska's U.S. senators have formally asked the Administration to develop a comprehensive federal strategy for the U.S. Arctic that describes future needs, priority areas, and specific implementation goals and objectives.

3.3. | *Tribal Governments and Alaska Native Organizations*

Tribal governments and Alaska Native organizations represent Alaska Native interests throughout the U.S. Arctic. Tribal governments operate both locally within individual communities as well as regionally. For example, the Inupiat Community of the Arctic Slope is the regional tribal government for all North Slope Borough villages. Additional groups that have been tribally authorized to represent their interests in the co-management of natural resources include the Alaska Eskimo Whaling Commission, Alaska Beluga Whale Committee, Ice Seal Committee, Eskimo Walrus Commission, and Alaska Nanuuq Commission. Alaska Native corporations, established under the Alaska Native Land Claims Act, also play important roles in the U.S. Arctic. Within the report area, there are 26 tribal governments, as well as 3 regional native corporations and 22 village native corporations. When discussing the next 20 to 30 years in the U.S. Arctic with some of these groups, the following important thematic goals emerged.

Alaska Native bowhead whale hunter (credit: Dept. of the Interior)

Subsistence way of life: Subsistence foods have sustained Alaska Natives for many thousands of years, and future generations must continue to rely on these foods for nutritional, economic, social, and cultural purposes. Maintaining the strength of the subsistence way of life is vitally important to Alaska Natives, both from food security and cultural touchstone perspectives. In the future, Alaska Natives seek to remain engaged in subsistence activities, both on land and at sea.

Tribal consultation: Alaska Natives want to be represented and provide input when important decisions are being considered that impact their land, their resources, and their way of life. Tribes have valuable information to contribute to the decision-making process, and they have a strong desire to participate in such decision-making. They noted that the Federal Government and tribal governments need to improve the system for effective and meaningful consultation on issues of mutual concern. Such a process should: (1) respect and take into account local and traditional knowledge; (2) provide a predictable and consistent framework for consultation; and (3) streamline consultations to minimize the workload burden on Alaska Native groups.

Traditional knowledge: Local and traditional knowledge is considered by many to be an essential part of science-based environmental policy-making. Traditional knowledge is particularly valuable as it represents observations made repeatedly over many generations. During the current period of rapid change, the wealth of knowledge held by Alaska Natives can make key contributions to resource management and to collaborative research projects.

Ecosystem-based management: The ecosystem-based management approach to managing natural resources incorporates and considers the role and needs of the human component of the environment. In the U.S. Arctic that means that this approach must include the needs and perspectives of Alaska Natives. Ecosystem-based management, as promoted by the National Ocean Council and implemented by working groups of the Arctic Council, should be implemented to support well-informed decisions that take a long-term perspective to balance environmental, economic, and cultural priorities. This approach recognizes that people depend upon ecosystems and that policy and management decisions that consider ecosystem needs will provide long-lasting benefits.

Economic development: Making progress on economic development, environmental protection, and ensuring the sustainability of the subsistence way of life are vitally important objectives for Alaska Natives. Because industrial development can result both in economic benefits to communities as well as environmental and social impacts, development decisions must be carefully considered in a balanced manner with a long-term perspective. When industrial development does occur in the U.S. Arctic, local communities need to receive real economic benefits, and the activities should not alter key features of ecosystems that are important to local communities.

Subsistence Way of Life

Food security, nutritional health, economic benefits, cultural values, spiritual connections, environmental stewardship

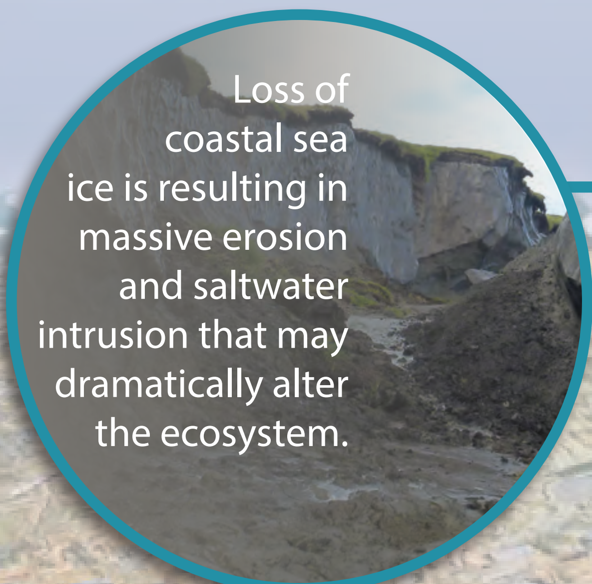
Reliance on a subsistence way of life is widespread in the U.S. Arctic. Although modernization and climate change are affecting subsistence practices, local reliance on natural resources remains high. Alaska's rural residents currently harvest about 22,000 tons (19,958 metric tons) of wild foods annually—a state-wide average of 375 pounds (170 kg) per person, 60% of which is fish. Maintaining the strength of the subsistence way of life is vitally important to Alaska Natives, both for food security and as a cultural touchstone. They seek to remain deeply engaged in subsistence activities, both on land and sea. The Alaska National Interest Lands Conservation Act mandated that subsistence uses of fish and wildlife by rural residents of Alaska be given a priority on federal lands. Subsistence hunting and fishing on federal lands and waters in Alaska—about 60 percent of the state—is managed through the Dept. of the Interior/Dept. of Agriculture Subsistence Management Program.

There are 10 Regional Advisory Councils to provide rural residents a direct opportunity to review proposed regulations, policies, and management plans; to have local public forums for subsistence issues; and to present recommendations and information to the interagency Subsistence Management Board, which sets seasons and bag/catch limits. Each Council consists of residents who are knowledgeable about subsistence and other uses of fish and wildlife resources in their region.

In addition, subsistence harvest of halibut is managed by the National Marine Fisheries Service (NMFS), while harvests of seals, sea lions, and certain whale species are co-managed by NMFS and Alaska Natives under the Marine Mammal Protection Act. Subsistence harvests of sea otters, polar bears, and walrus are co-managed by the U.S. Fish and Wildlife Service (FWS) and Alaska Natives, and the harvest of waterfowl and other migratory birds is co-managed by FWS and Alaska Natives under the Migratory Bird Treaty Act.

The rich ecology of **Teshekpuk Lake** is at risk from **climate change.**

The Teshekpuk Lake area provides crucial habitat for wildlife and subsistence activities, but is being impacted by a rapidly changing climate and is believed to hold recoverable petroleum resources. Balancing these pressures has proven challenging over the last twenty years.



Loss of coastal sea ice is resulting in massive erosion and saltwater intrusion that may dramatically alter the ecosystem.

Caribou utilize the windy coast to escape mosquitoes.

Caribou are a vital subsistence food source for Alaska Natives in the region.

Lakeside sedges provide essential food for caribou calves.

1977
1,734,000-acre (701,724-hectare) Teshekpuk Lake Special Area created

1978 to 1980
House versions of ANILCA propose turning the entirety of NPR-A into a national wildlife refuge

1983
Rep. John Dingell proposes establishing the Teshekpuk-Utukok National Wildlife Refuge

The Bureau of Land Management initiates an oil and gas leasing program, but with more than 200,000 acres (80,937 hectares) north of Teshekpuk Lake closed to protect molting geese

1998
The Bureau of Land Management designates the 857,859-acre (347,163-hectare) Teshekpuk Lake Surface Protection Area, of which 588,998 acres (238,359 hectares) are closed to oil and gas leasing to protect caribou, geese, and other resources

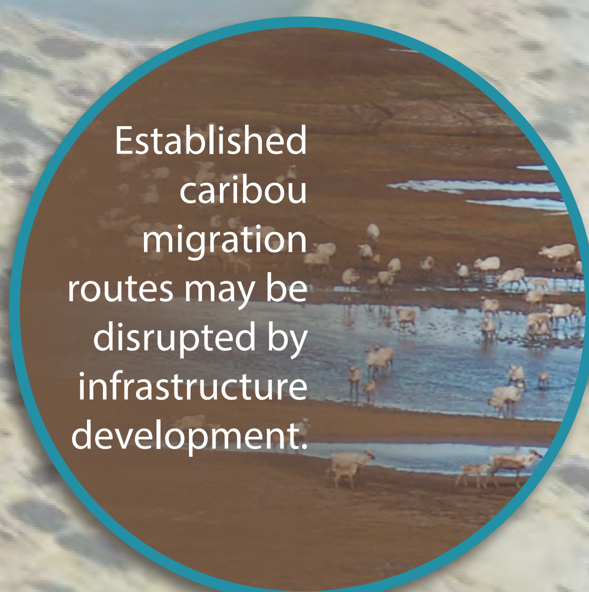
2006
The Department of the Interior approves drilling on about 500,000 acres (202,343 hectares) around Teshekpuk Lake

U.S. District Court for Alaska removes the wildlife habitat around Teshekpuk Lake from an oil and gas lease sale

2008
A revised Environmental Impact Statement defers any oil leasing in the area for 10 years

2013
A Record of Decision following a comprehensive National Petroleum Reserve-Alaska (NPR-A) Environmental Impact Statement/Integrated Activity Plan recognizes the importance of this area for wildlife and subsistence by making it unavailable for oil and gas leasing and off-limits to any new infrastructure unrelated to subsistence practices. This, coupled with oil and gas leasing outside the Teshekpuk Lake area, provides a balance for the greater NPR-A.

Teshekpuk Lake



Environmental protection: Tribal governments are concerned that pollution and cumulative impacts from shipping, industrial development, and other sources could make marine mammals less available to hunters and unsafe for human consumption. The U.N. Declaration on the Rights of Indigenous Peoples states that environmental degradation can violate the human rights of indigenous people and that it is the responsibility of governments to prevent environmental harm that threatens traditional food use.[105] As industrial activity increases throughout the Arctic, governments and industry must prevent, mitigate, and respond to accidents and spills that could have catastrophic impacts on the Arctic and the people who live there.

3.4. | *Municipal Governments*

The municipal governments of Alaska (i.e., cities, villages, and boroughs) comprise a strong and talented network of public servants dedicated to improving the lives of people across Alaska. Within Arctic Alaska, there are 3 borough governments, 20 municipal governments, and 26 village governments. When discussing the next 20 to 30 years with municipal government leaders during the preparation of this report, the following common thematic goals emerged.

Economic development: There is a strong desire to bring economic development to the communities of the U.S. Arctic. There is an equally strong desire to proceed with development in a way that respects and preserves local cultures. Communities are looking for ways to maximize local jobs and to ensure that local economies benefit from resource development and other industrial activities.

Emergency preparedness and response: Municipal governments have questioned the sufficiency of the capability and capacity to respond effectively to environmental emergencies such as offshore oil spills or ship accidents. Response plans rely heavily on industry's ability to respond quickly to environmental emergencies, such as offshore spills. Increasing levels of shipping and other industrial activities such as oil and gas development require accelerated efforts by industry and government to collaboratively enhance appropriate response infrastructure in the Chukchi and Beaufort Seas. In addition, with the environmental changes brought about by a changing climate, the Arctic is experiencing an increase in severe weather, flooding, and coastal erosion. Municipalities feel that improved search and rescue capability must be a key part of these preparations.

Shipping: The frequency, types, and seasonality of shipping through U.S. Arctic waters is anticipated to change dramatically. The growing diversity and presence of fuel barges, oil and gas support vessels, bulk carriers, research ships, cruise ships, fishing vessels, and marine freight vessels is already imposing new demands on the coastal communities in the U.S. Arctic.

Food security: Protecting the subsistence way of life and ensuring food security is a high priority in U.S. Arctic communities, where there are concerns about the impacts of noise pollution, chemical pollution, habitat loss, and other forms of disturbance on fish and wildlife populations and subsistence foods. Achieving food security is an important goal that must be sustained for many generations to come.

Community infrastructure: Many U.S. Arctic communities lack adequate housing, water, and sewer service, which pose dangerous health and safety issues to residents. A lack of roads and the high cost of energy pose additional challenges. Industrial development and population growth will dramatically amplify these problems if not carefully planned with current and future social needs in mind.

Partnerships: Local and regional governments are seeking better working relationships with federal and state agencies to deal with the magnitude of environmental and economic changes taking place across the U.S. Arctic. Communities want to foster true partnerships with government agencies throughout project planning and implementation. Recognizing that the staff resources of many communities are limited, there is a need to develop more efficient mechanisms for these interactions so that "initiative burnout" can be avoided.

Scientific research: Wise natural resource management decisions should be based on sound science and incorporate a precautionary approach that adopts a long-term perspective. Science-based decision-making should also include traditional knowledge, which can provide essential insights from the people living in the U.S. Arctic. The successful experiences of biologists and local hunters working together on research projects are great examples of how these two "ways of knowing" (i.e., scientific

Hiker pauses to search for wildlife, Arctic National Wildlife Refuge (credit: Fish and Wildlife Service) methods and traditional knowledge) can often complement each other to yield positive results.

3.5. | *Conservation Organizations*

Non-governmental conservation and environmental organizations have expressed deep concern about industrial expansion into the U.S. Arctic, with particular disquiet regarding offshore oil and gas development. These concerns were exacerbated by the 2010 Deepwater Horizon disaster in the Gulf of Mexico and by the lack of capacity and infrastructure to respond to such a disaster in the U.S. Arctic. In addition to their concerns about the threat of petroleum spills from oil and gas activities and shipping, conservation organizations are also concerned about disturbance of marine mammals from drilling, vessel traffic, and seismic surveying in Arctic waters as well as conflicts with subsistence harvest activities. Although some of these organizations urge prohibition of any development in the region, others urge deferral or a "time-out" for such activities until the capacity to respond to accidents or spills can be demonstrated and the areas of greatest ecological and subsistence value are described and mapped.

Conservation organizations providing input to this report noted that ecosystems and wildlife in the Arctic are already undergoing changes and stresses as a result of climate change—stresses that are increasing but poorly understood and that may be exacerbated by industrial activities. Regarding the combined or cumulative impact of these activities, conservation groups pointed to a recent U.S. Geological Survey report on science needs in the region: "Although studies and research have been done by many organizations on many factors in the Arctic, there has been relatively little specific focus on a holistic, integrated, comprehensive assessment of cumulative effects of industrial activities in the Arctic."[106]

Permanent protection of important onshore ecological and subsistence areas in the Arctic is a high priority for a number of conservation stakeholders. Terrestrial locations that conservation groups have cited as deserving permanent protection due to exceptional biological and subsistence value include Kasegaluk Lagoon, the Utukok River Uplands, the Teshekpuk Lake wetlands, and the coastal plain of the Arctic National Wildlife Refuge; marine areas deserving protection include Hanna Shoal, Barrow Canyon, Camden Bay, and Cross Island.

In providing input to this report, conservation organizations expressed a vision for the U.S. Arctic that includes:

- ***ongoing assessments of the food and health security necessary to support thriving indigenous communities;***
- ***comprehensive, integrated scientific information and traditional knowledge that guides decision-making regarding if, when, and where development should occur;***
- ***long-term monitoring of activities to measure the impacts of these activities and their interactions with climate change and other stressors;***

Emergency Preparedness and Response

Responding to emergencies like oil spills and hazardous waste accidents requires many resources: aircraft, maritime vessels, personnel, and other materials. These resources are necessary to plan effectively for response, prevention, and clean-up on both land and sea.

There are few airfields and no major roads (other than the Dalton Highway) in the U.S. Arctic. Alaska's North Slope has no refueling site for ships; the closest is over 1,000 miles (1,600 km) away in Dutch Harbor. The nearest Coast Guard air facility is in Kodiak, which is 920 miles (1,480 km) from Barrow. The State of Alaska has one response-equipment site in the U.S. Arctic (in Kotzebue) with an aerial dispersant-delivery system staged in Anchorage. There are two land-based oil spill response organizations that service the North Slope, but they lack open-ocean capability.

The U.S. Army Corps of Engineers and the Alaska Department of Transportation and Public Facilities have begun a 3-year deep-draft Arctic port evaluation study. The Alaska Federation of Natives is urging construction of docks and establishment of search and rescue capacity for every Arctic coastal village.

All federally permitted oil and gas activities require operators to have contingency plans approved and to maintain capabilities for emergency response. However, ensuring the capability for a rapid response in the event of a random event separate from such federally permitted activities, such as a spill from a passing ship, presents challenges. Several interagency federal efforts are underway, including those by the National Ocean Council, to better address preparedness for emergency response situations.

- *a consistent governance framework that incorporates consultation well in advance of management decisions and includes elders, hunters, and tribal leaders;*
- *identification and protection of important ecological areas with deferrals, exclusions, withdrawals, or time and/or place restrictions on certain activities or development;*
- *credible development scenarios that support the analysis of the cumulative effects of climate change, ocean acidification, development, and industrial stresses upon terrestrial and marine environments; and*
- *implementation of Arctic-specific safety and oil spill response standards and regulations.*

3.6. | *Federal Government*

More than 20 federal agencies play a role in resource management and scientific research in the U.S. Arctic. The Federal Government also serves the public through national and homeland security, emergency preparedness and response, maritime and aeronautical safety, and support to communities and Alaska Natives. There is a consensus among federal agencies concerning many of the goals that need to be accomplished to support wise management decisions in the U.S. Arctic over the next 20 to 30 years. Many of these goals are embodied in existing federal policy, including the U.S. Arctic Region Policy and Ocean Policy, as well as being advanced internationally in the Arctic Council.

Science-based decision-making:

Research and monitoring—An emphasis should be placed on scientific research and collecting baseline data to ensure that reliable information is available to inform management decisions. Shifts in Arctic climate variables, as well as terrestrial and marine ecosystems, should be monitored through rigorous, interdisciplinary research programs that collect and disseminate the best data and analyses to support environmental, economic, and cultural decision-making. Research should be designed to provide the information needed to facilitate well-informed decisions concerning environmental, economic, and cultural aspects of the U.S. Arctic.

Understanding and predicting change—Agencies involved in the U.S. Arctic should aim to better understand and improve forecasting of the effects of global environmental change in the Arctic as well as the potential impacts of economic development on communities and ecosystems.

Traditional knowledge—Centuries of careful observation and experience by Alaska Natives has produced a wealth of traditional knowledge about nature and ecosystems in the U.S. Arctic. Traditional knowledge can offer valuable, complementary perspectives to information gained through scientific research. Agencies and partners should continue to develop means for incorporating traditional knowledge into decision-making.

Researchers measure a young spotted seal (credit: M. Cameron, National Marine Fisheries Service/NOAA)

Data management and access—Information can only be used effectively if it is readily accessible to analysts and decision-makers. Data and data products must be carefully archived and made available (e.g., through web-based data portals) so that management decisions can benefit from the best available information.

Ecosystem-based management—Federal agencies expressed support for a more inclusive, science-based, holistic approach to research and management in the Arctic that is guided by the principles of ecosystem-based management. Decisions should be based on sound science and support healthy, productive, and resilient coastal communities and their associated marine, terrestrial, and freshwater ecosystems.

Adaptive management—Management should be based on the expectation that surprises will undoubtedly arise; therefore, emphasis should be placed on developing approaches and tools that are precautionary and adaptive. The precautionary, science-based approach being used for managing U.S. Arctic commercial fisheries is a possible model for other emerging uses; that is, to ensure adequate information is in hand before inadvertently causing irreversible damage to resources or ecosystems.

Synthesis and assessment—Periodic syntheses of available information are essential to understanding trends, likely future states, and potential consequences to people. Integrated, interdisciplinary assessments of Arctic information should be undertaken to coalesce information and make it available to related policy and management decision processes.

Develop natural resources in an environmentally and culturally sensitive manner:

Environmental protection—Development of natural resources and infrastructure must be undertaken in a safe and environmentally sound manner, taking into account future conditions and goals. Industrial development should not be allowed to harm vulnerable or sensitive plant and animal populations, habitats, or ecological processes.

Alaska Native culture and subsistence way of life—Decision-makers must ensure that development does not prevent the continuation of subsistence hunting, fishing, and gathering. Food security, as well as access to water and clean, affordable energy, must be assured for communities throughout the U.S. Arctic.

Archeological and historical resources—The significant archeological and historical resources in the U.S. Arctic must be protected from threats posed by climate change, industrial development, recreation and tourism, and shifting public-use patterns.

Wilderness experiences—The U.S. Arctic holds an inspiring and diverse array of natural beauty and life. Congress established wilderness areas in Alaska to ensure their protection and to enable visitors to experience such outstanding natural areas.

Support development of adequate infrastructure:

Oil and gas development—A key goal must be to ensure that offshore operations are accomplished safely. Sufficient personnel and logistical resources should be made available by the commercial entities extracting these resources to ensure that oil and gas resources are developed safely and in an environmentally responsible manner. The United States should be a leader in developing Arctic offshore regulations and standards.

Maritime awareness and presence—The Federal Government must maintain an appropriate presence in the U.S. Arctic to monitor, safeguard, and regulate maritime operations. Persistent awareness of all maritime activity in the Arctic will require greater collection and sharing of maritime data and analyses of real-time information. Acquiring an effective awareness will require all Arctic stakeholders to work together, which is critical for ensuring preparedness to respond to contingencies. This approach is also consistent with strategic priorities delineated in the National Strategy for Maritime Security and the National Plan to Achieve Maritime Domain Awareness.[107, 108]

Infrastructure needs—Infrastructure investments (e.g., airports, roads, communication systems, utilities, maritime transportation systems, navigation data and aids, aircraft and shipping traffic separation protocols, ports), regardless of the level of government involved, need to be tied to development and national security frameworks that promote protection and sustainability of natural ecosystems and subsistence resources. The unique and pressing infrastructure needs of U.S. Arctic communities also must be addressed by all levels of government, particularly proper housing and health care, clean water and sewer facilities, and affordable energy. Research programs will require the development and maintenance of technologies, research platforms, and observing systems that can withstand harsh Arctic conditions.

Emergency response—The United States, in conjunction with private sector operators, needs to maintain an appropriate presence in the U.S. Arctic to monitor, safeguard, and regulate activities, as well as to be ready to respond to threats and hazards. This includes being able to respond to emergencies and accidents, both from domestic natural resource development efforts and from increased international vessel traffic. Additional infrastructure and other resources to enhance U.S. operational emergency response capabilities in the Arctic would help fulfill U.S. commitments to international partners concerning spill or search and rescue events in the Arctic. Preparedness efforts should continue to include oil spill response science as well as baseline data-gathering to inform the Natural Resource Damage Assessment process.

Aeronautical safety—Systems that support air traffic control and aeronautical operations in the U.S. Arctic need to be upgraded and maintained. An example is the need to increase the coverage and availability of the Wide Area Augmentation System to improve aircraft navigation safety. Implementation of the Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic, which entered into force in January 2013, should continue.

Improve communications:

Interagency coordination—A fundamental goal for federal agencies is to improve interagency coordination on all aspects of science, management, stewardship, response, and permitting in the U.S. Arctic. "Whole-of-government" solutions should be pursued to eliminate redundancies and promote efficient operations.

Effective partnerships—Creating effective partnerships among federal agencies, the State of Alaska, Alaska Native groups, municipal governments, commercial industries, academia, and other stakeholders will facilitate sound science and provide opportunities for effective resource management. Early consultations, outreach, and input to governments and stakeholders in Alaska will promote more effective, holistic decision-making and advance the integration of cultural, ecological, and economic perspectives.

International engagement—The United States should continue to participate actively in international forums, such as the Arctic Council, to advance U.S. interests in transboundary issues such as fish, wildlife, and habitat conservation; best practices in energy development; international scientific collaboration; and safe shipping. Accession to the U.N. Convention on the Law of the Sea would also enable the United States to better protect its interests in the Arctic, including with respect to maximizing legal certainty and international recognition of the U.S. continental shelf.

Search and Rescue

One of the challenges of living or operating in the U.S. Arctic, compared to other areas, is the paucity of search and rescue resources. The scarcity of these resources is compounded by the risks of adverse weather conditions that may limit their use. Local weather forecasts and sea ice predictions in the U.S. Arctic are often only accurate for 2 to 3 days out, compared with 5- to 7-day predictive capabilities in much of the rest of the United States.

There are few airfields, no major roads, no deep-water ports, and relatively little coastal infrastructure and personnel to meet emergency search and rescue needs that may arise. During the 2012 summer season, the Coast Guard forward-deployed major assets (Coast Guard cutters, other surface assistance, and aviation support) in the waters off Alaska's North Slope for the duration of the exploratory oil drilling season. Assistance at other times, though, particularly in the Beaufort and Chukchi Seas, will likely be significantly delayed by the long distances to existing Coast Guard facilities.

On land, the North Slope Borough Search and Rescue Department provides critical-care air ambulance services (medevac) throughout the North Slope Region, as well as conducting search, rescue, and other emergency missions.

3.7. | *Comparing Future Visions and Goals*

The visions and goals expressed above reveal examples of both convergent and divergent views in the face of rapid environmental and economic change in the Arctic. All of the parties mentioned above acknowledge that the U.S. Arctic is changing at an accelerating pace. In general, many of the non-federal parties, including the State of Alaska, local governments, and many members of the Alaska Native community, call for increased scientific research, increased roles for Alaska Natives in decision-making, preservation of the subsistence way of life, and assurances that development will provide real economic benefits to nearby communities and be undertaken in an environmentally responsible manner.

Several of the stakeholders, including representatives of municipalities and Alaska Native groups, emphasized the importance of U.S. accession to the U.N. Convention on the Law of the Sea. The Convention sets forth key rules for managing and developing all living and non-living natural resources within an exclusive economic zone from the coast of each nation out to 200 nautical miles (370 km). The Convention also provides the surest means for a nation to obtain legal certainty and international recognition with respect to the full extent of its continental shelf, which, in the Arctic may extend hundreds of miles north of Alaska. The United States remains the only Arctic nation that has not yet acceded to the treaty. Until the United States becomes a member, it has a limited voice in decisions affecting the future of the oceans that are so important to the people of the Arctic and our Nation. If the United States accedes to the Convention, the extended continental shelf area that would come under U.S. jurisdiction would be about twice the size of the State of California. The Administration continues to strongly support Senate action to accede to the Convention without delay.

Goals and visions diverged on the issue of industrial development, particularly those that relate to additional oil, gas, and mining development. Whereas some Arctic residents and members of the conservation community seek to ensure that development will not take place until the capacity to respond to accidents or spills can be demonstrated and the areas of greatest ecological and subsistence value are better known and described, the State of Alaska, industrial corporations, and some other Arctic residents encourage expeditious exploration and development of these oil, gas, and mineral resources. Many Alaska Natives emphasized the need to seek a balance between ensuring that development provides economic benefits and ensuring that such development does not disrupt cultural values or adversely impact fish and wildlife resources, particularly those species needed for subsistence purposes.

It is clear that stakeholders are not interested in additional layers of process; existing processes already tax the capacity of many stakeholders without necessarily leaving them feeling fully informed or involved regarding federal decisions. A desire for more engagement and information may seem to contradict the desire for less process, but suggests that constituents and partners feel listened to but not heard. Partners in the U.S. Arctic want a framework for more inclusive, efficient, and transparent engagement that does not add layers of bureaucratic process.

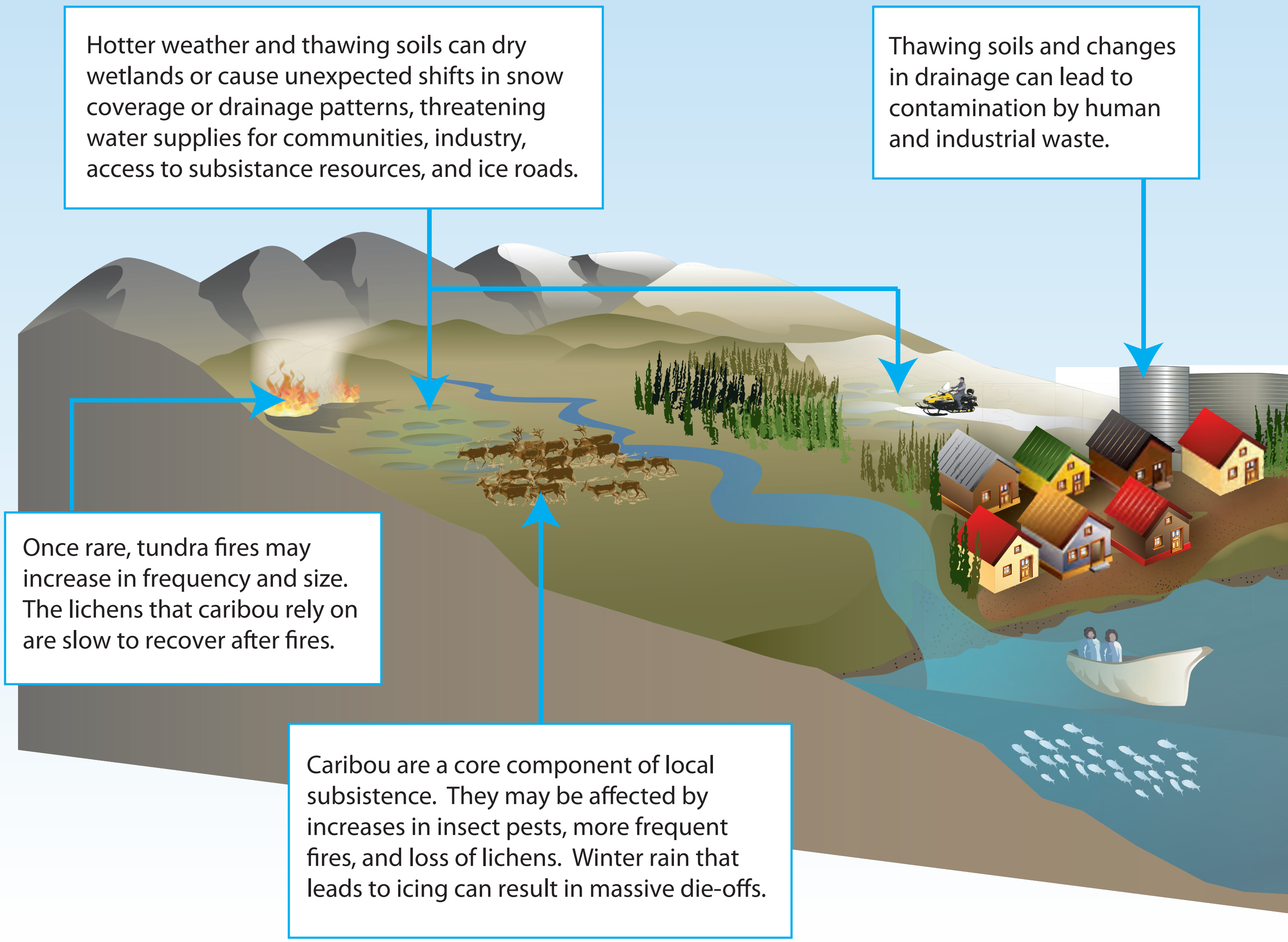
Many of the stakeholder goals described above explicitly described the need to better integrate federal decision-making on two levels: (1) across jurisdictions and boundaries; and (2) among economic, cultural, and ecological uses and values. The next chapter will discuss the barriers to such integration, some success stories, and suggestions for advancing a more integrated approach to managing U.S. Arctic resources.

Pipelines at Prudhoe Bay (credit: M. Lindeberg, National Marine Fisheries Service/NOAA)

The impacts of **climate change** in the U.S. Arctic are already being felt by local and Alaska Native communities and by industry.

The U.S. Arctic is expected to become much warmer in the middle and latter portion of this century, with a longer growing season, shorter less severe winters, and a deeper annual thaw layer in soils. Permafrost thaw may occur in limited areas, and wildland fires may increase. Changes to water flow and wetlands are likely, driven indirectly by permafrost thaw and vegetation change. The complex interrelationships between these factors are likely to significantly alter the way humans use this landscape.

Local communities are reliant on the traditional foods—including caribou, marine mammals, fish, and berries—supported by these ecosystems. It is likely that climate change will cause stress to most existing plant and animal species. Current tundra ecosystems may shift to spruce/aspen forest and intermixed grass and tundra. Extensive encroachment of trees and shrubs has already been recorded. These changes may increase food supplies for browsing species such as moose, while decreasing the grass and lichens needed by caribou.



The combination of thawing permafrost, greater evaporation, and more water taken up by vegetation suggest that the terrestrial landscape may become drier. Declining or shifting wetlands could affect migratory and resident bird species. Industrial development, which relies on ice roads, might be affected by a decreased supply of the water needed to create them. Changes in rivers, wetlands, and drainage might also impact community supplies of safe drinking water, and cause contamination from human waste or industrial waste.

Slow recovery of vegetation or vegetation shifts after fires can profoundly affect wildlife. Lichens—a crucial winter food for caribou—recover extremely slowly. Even small and relatively infrequent fires represent a new factor to be considered in the Arctic.

Many wildlife species are affected, either positively or negatively, by snow cover. Icing events might become more common. Changes in season length affect hunting seasons and safe food storage, and changes to the depth and duration of frozen soils impact winter travel, construction, and ice roads.

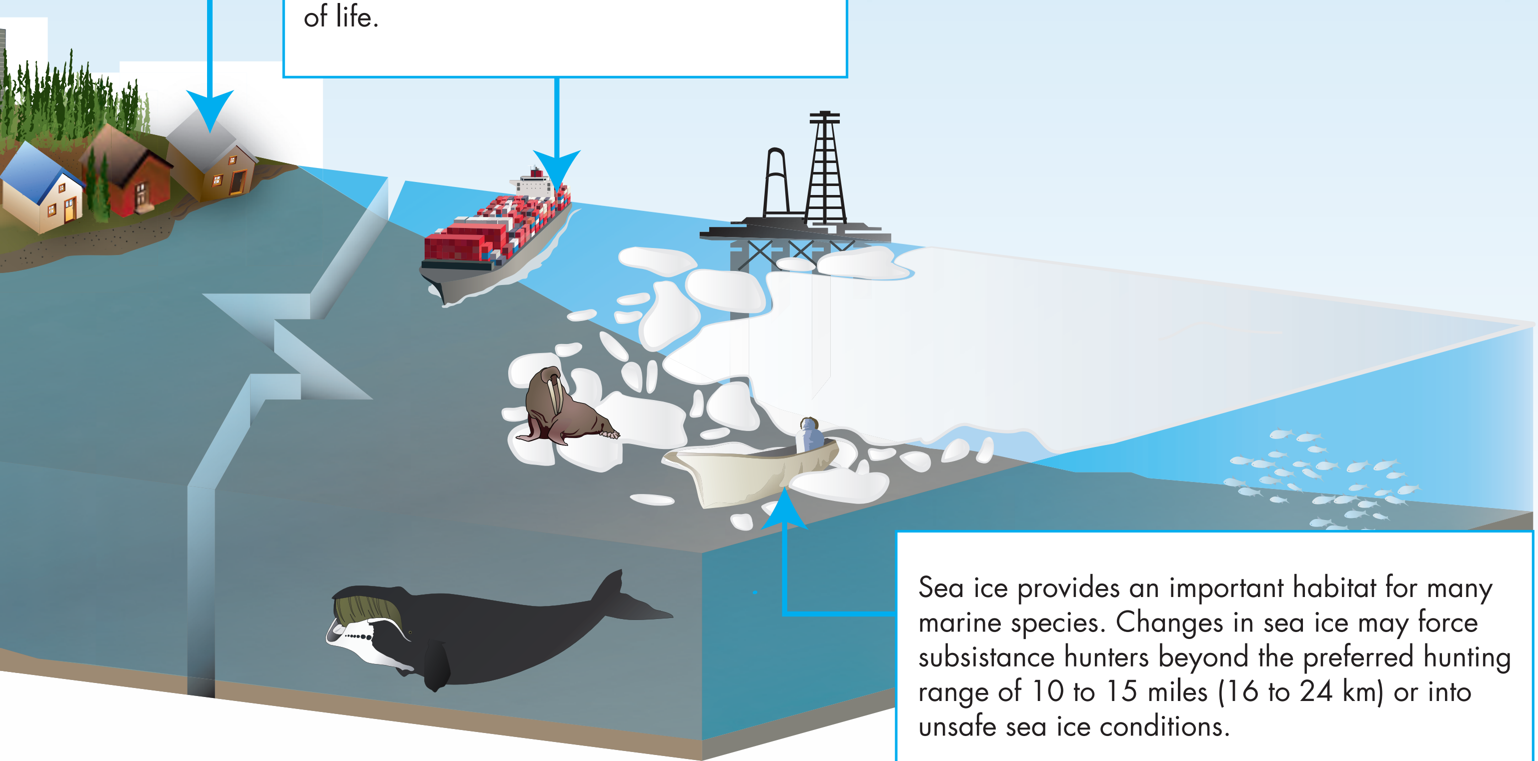
Loss of land-fast ice, thawing permafrost, and briefer seasonal freezing make coastal soils highly susceptible to storm erosion. Losses—including economic damage as well as wholesale community destruction—are already extreme in some locations, particularly on the western coast.

Major impacts to humans and their livelihoods include:

- *coastal erosion and loss of communities;*
- *reduced snow and ice season for transportation, hunting, and development;*
- *rain on snow events resulting in caribou starvation;*
- *thawing soils and altered flow in rivers and wetlands;*
- *new ice-free shipping routes;*
- *ecosystem shifts; and*
- *changes in fire cycles.*

Climate change is already forcing some coastal communities to relocate due to coastal erosion—at great economic and social cost.

New ice-free shipping routes may provide a local economic boom for port communities, but could also overwhelm infrastructure or threaten traditional ways of life.



Sea ice provides an important habitat for many marine species. Changes in sea ice may force subsistance hunters beyond the preferred hunting range of 10 to 15 miles (16 to 24 km) or into unsafe sea ice conditions.

Chapter 4:

Toward an Integrated, Science-Based Approach to Arctic Management

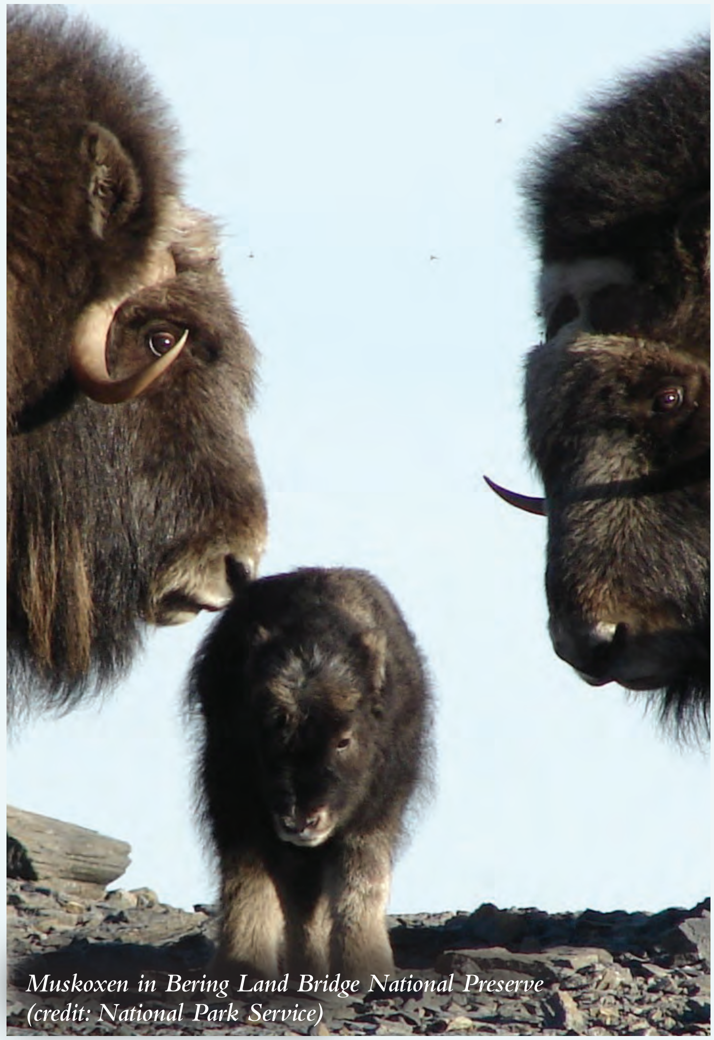
Integrated Arctic Management is a science-based, whole-of-government approach to stewardship and planning that integrates and balances environmental, economic, and cultural needs and objectives. It is an adaptive, stakeholder-informed means for looking holistically at impacts and sensitivities across the U.S. Arctic and generating sustainable solutions.

4.1. | *Institutional Challenges*

The U.S. Arctic is rapidly changing while economic, environmental, cultural, and social expectations are growing. This combination is adding stress to the largely balkanized management system for the Arctic that is already straining to address many competing issues across a vast area and many jurisdictions. An array of government institutions are engaged in trying to meet this challenge. More than 20 federal agencies and bureaus have domestic Arctic-related missions that include promoting safety, permitting commercial activities, conducting scientific research, assuring clean air and water, and conserving fauna, flora, and ecosystems. The responsibilities of each of those agencies are spelled out in U.S. law, but how they coordinate with each other can be unclear. State, municipal, and tribal governments also have authorities and responsibilities, further complicating the regulatory landscape.

Adding to management challenges in the U.S. Arctic are tensions inherent in the different missions of agencies working in the region. For example, some missions focus primarily on facilitating the extraction of minerals and energy resources, while others are charged primarily with understanding, moderating, and mitigating the potential impacts of human activities upon environmental or cultural values. Although there is considerable collaboration among agencies, different metrics of success in achieving agency mandates can hamper cooperation.

The vast area of the U.S. Arctic also impacts the level of coordination in the region—the total federal lands estate in Alaska is nearly the size of Texas and Wyoming combined. The Department of the Interior manages the majority of the land



Muskoxen in Bering Land Bridge National Preserve (credit: National Park Service)

Researchers navigate through sea ice (credit: J. London, National Marine Fisheries Service/NOAA)

within the report area *(Figure 4.1)*. This land includes the 22.8 million acre (9.2 million hectare) National Petroleum Reserve in Alaska (NPRA), the 19.3 million acre (7.8 million hectare) Arctic National Wildlife Refuge, the 8.5 million acre (3.4 million hectare) Gates of the Arctic National Park, and a number of other National Park Service, Fish and Wildlife Service, and Bureau of Land Management units. These are huge terrestrial areas, and most are larger than individual states (NPRA is the size of Indiana; the Arctic National Wildlife Refuge is the size of South Carolina). Each agency manages its areas under its own jurisdictions according to specific federal laws and regulations.

Like the terrestrial region, the Arctic maritime domain is also extensive and, once again, multiple federal agencies are involved. For example, in the Chukchi and Beaufort Seas, the Department of the Interior's Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) manage the exploration and development of offshore energy and mineral resources under the Outer Continental Shelf Lands Act, and they are charged with doing so subject to environmental safeguards. The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is responsible for the stewardship and use of species, ecosystems, and marine living resources in federal waters. The Coast Guard, operating within the Department of Homeland Security, is responsible for marine safety, security, and environmental stewardship in U.S. waters. The Environmental Protection Agency is responsible for enforcement of the Clean Water Act and the Clean Air Act as well as sharing responsibilities and authority with the Coast Guard under the National Oil and Hazardous Substances Pollution Contingency Plan. These agencies are all separate entities, most of them located in different Cabinet departments, and must work diligently to ensure that they have full access to the information, plans, and expertise of the others as they make decisions that potentially impact their responsibilities.

To address the challenges presented by the large number of federal agencies with major equities in the U.S. Arctic, the Federal Government has established many local, regional, and national interagency structures to enhance coordination and the sharing of information. Some of these bodies have added considerable value to government efforts in the region but, given the scope of issues and capacity limitations, some are perceived as adding to

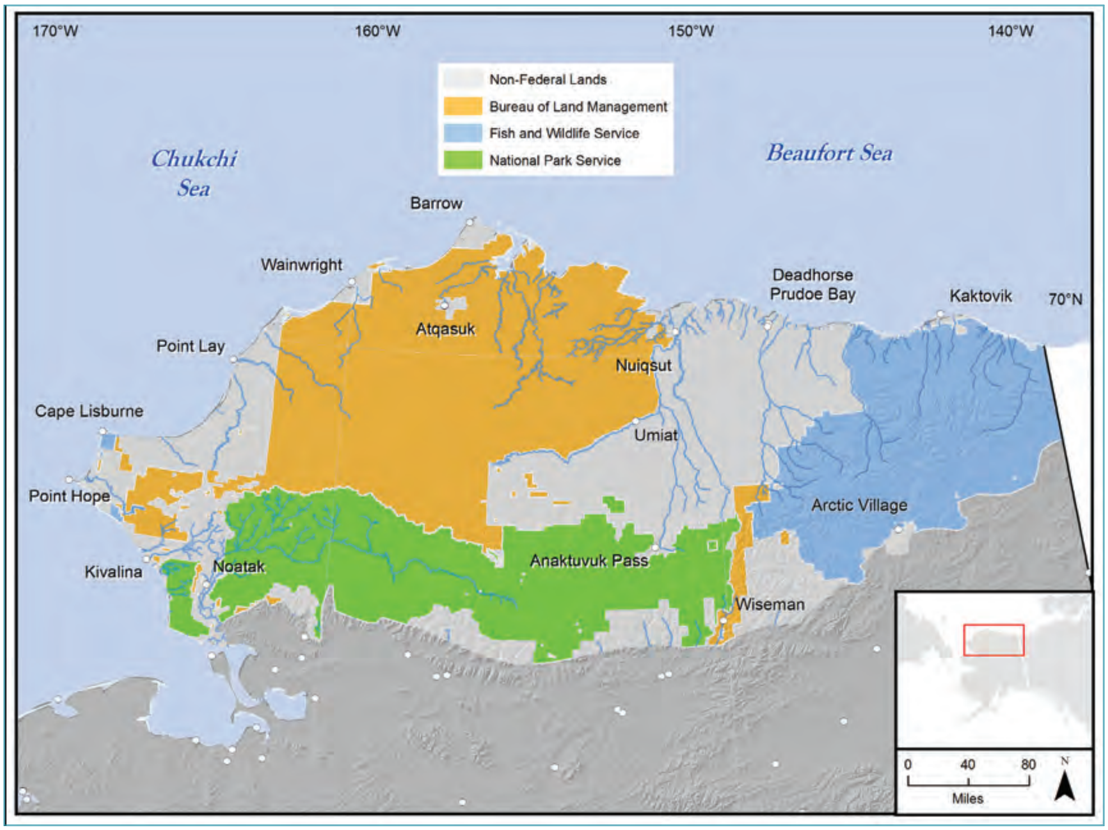


Figure 4.1. *Federal and non-federal land ownership within the Arctic area addressed in this report. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)*

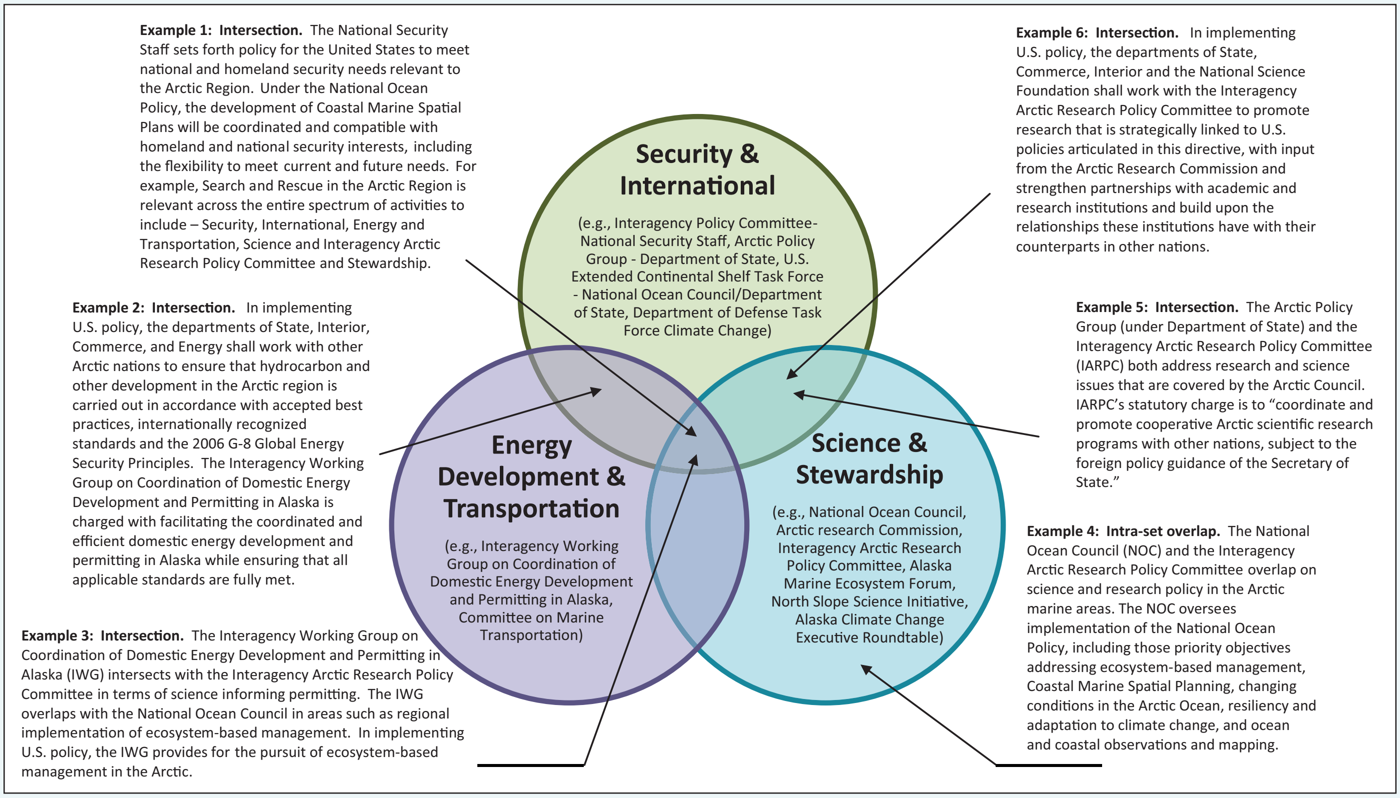


Figure 4.2. *Examples of the interrelationships among U.S. interagency Arctic activities. Areas of intersection or instances of intra-set overlap reflect U.S. policy and associated implementation guidance as articulated consistently across various authorities. The examples below are neither exhaustive nor intended to emphasize a particular policy consideration. They are presented for informational purposes only. Figure courtesy of the Interagency Arctic Research Policy Committee and the National Ocean Council.*

the complexity without adding value. There are some instances, however, where overlap can provide important advances in resource management, research, and other federal activities *(e.g., Figure 4.2)*.

An arena in which interagency coordination is particularly important is in the development of Environmental Assessments (EAs) and Environmental Impact Statements (EISs), as required by the National Environmental Policy Act (NEPA) and Council on Environmental Quality implementation guidance. NEPA requires that federal agencies evaluate the potential environmental impacts of major federal actions, such as permitting certain human activities, and evaluate reasonable alternatives. In addition to considering the relevant science, agencies are required to involve the public in the NEPA process and allow stakeholders to review and comment upon the EISs that present the lead agency's evaluation of potential impacts.

The NEPA process is one of the primary opportunities for potentially affected parties to participate in decision-making, and that participation strengthens the process considerably. There are often many such evaluations underway at any given time, however, making such participation more complicated *(Figure 4.3)*. In addition, the different and sometimes competing agency missions, as well as different jurisdictional boundaries, can frustrate efforts to fully address each agency's issues and values in a single NEPA document *(e.g., Figure 4.4)*. Federal decision-making in the U.S. Arctic relies heavily upon such NEPA processes; the challenges described above make it difficult for agencies to insure that decisions fully account for ecosystem sensitivities and potentially competing development scenarios.

The practical aspect of federal agency interactions with stakeholders in the Arctic is another issue that should be improved. For many of its proposed activities in the Arctic, the Federal Government is required to consult with and solicit comments from certain stakeholders. In some cases, there may be several different federal agencies taking separate actions in response to the same proposal. As a result, potentially affected groups and communities are sometimes inundated with government requests for input. These groups suffer from "meeting fatigue," and they struggle to muster adequate resources or time to respond to agencies. The Federal Government would be a more effective partner if agencies coordinated their consultations and public reviews so that input could be gathered while reducing demands on local communities.

Additional implications of compartmentalized management approaches include:

- ***best practices may not be applied evenly;***
- ***policies and practices can be inconsistent across agencies;***
- ***agencies may not have enough information or perspective to take into account long-term development and/or conservation trends or issues;***
- ***consultation efforts between tribal governments and federal agencies may be inconsistent and/or uncoordinated; and***
- ***scientific research priorities may not sufficiently address the management needs of decision-makers.***

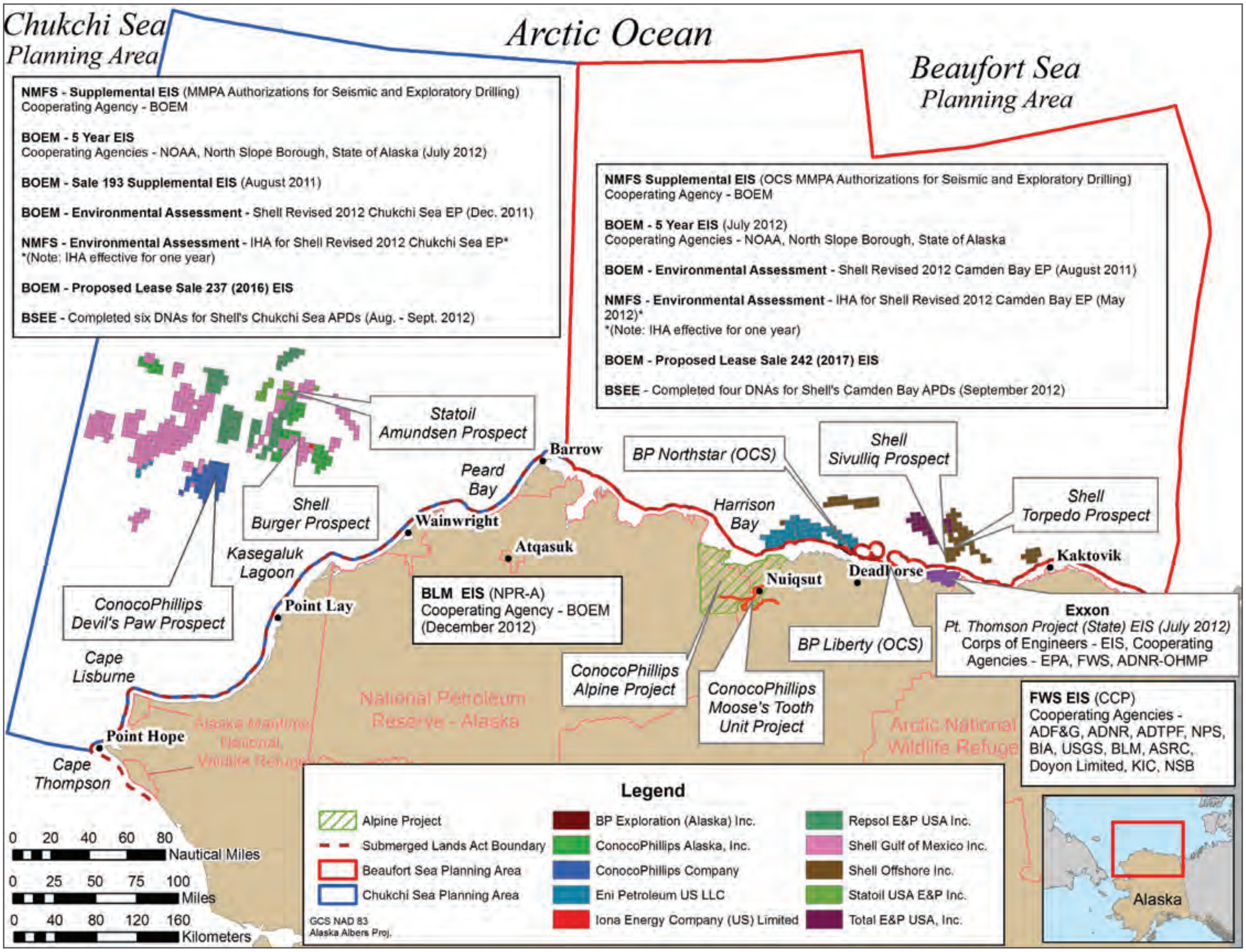


Figure 4.3. *Multiple environmental evaluations of proposed oil and gas activities in the Arctic are often underway simultaneously (BOEM—Bureau of Ocean Energy Management; BSEE—Bureau of Safety and Environmental Enforcement; NMFS—NOAA's National Marine Fisheries Service). (image: Bureau of Ocean Energy Management)*

These challenges underscore the complexity and possible variability of evaluating potential projects and plans in the Arctic with a proposal-by-proposal, area-by-area, piecemeal approach. In the rapidly changing Arctic, the current decision-making framework for managing natural resources may not be sufficiently flexible to adapt to future demands and emerging conflicts. In particular, individual agencies may not have the capability to develop an understanding of the broader development and/or conservation context in which their decisions may be nested. They also may not have a full understanding of the interests and needs of key stakeholders because of the limited resources available to stakeholders for responding to multiple actions. The concern, then, is that agencies may inadvertently make decisions that have unintended—and avoidable—consequences.

4.2. | *Promising Approaches*

Although the large number of agencies with Arctic responsibilities has created unique challenges for policy-makers and decision-makers, several good examples of local, regional, national, and international efforts to integrate the needs of ecosystems, economies, and cultures have emerged in recent years. These promising activities point the way toward common management approaches that can improve the knowledge base and decision-making capabilities in the Arctic for all levels of government.

Local and regional efforts: The Northwest Arctic Borough established the Subsistence Mapping Project to identify and map subsistence resources and provide information to support decisions about energy and infrastructure development. The project fosters cooperation with state and federal agencies and provides a foundation for integrating scientific information with local and traditional knowledge. Similarly, in the villages of Nuiqsut and Wainwright, the tribal governments, city governments, and the local Alaska Native corporations are collaborating to find structured ways to balance development and subsistence needs as they strive to prepare for the many changes that development may bring to the community.

The Open Water Season Conflict Avoidance Agreement between the Alaska Eskimo Whaling Commission (AEWC) and oil and gas companies is another example of integrating cultural, environmental, and economic needs. To avoid unnecessary litigation, expense, and potential adverse impacts upon subsistence whaling activities, the AEWC and representatives from oil and gas corporations that are actively engaged in exploration or development negotiate measures to minimize impacts to subsistence activities. In past years, the companies have agreed to cease operations in certain areas during whaling seasons in the spring and fall ***(Figures 4.4 and 4.5)***. A terrestrial example of such a partnership concerns the Red Dog mine near Kotzebue; to avoid disruptions to subsistence hunting, the mine operators agreed to build a holding facility and avoid trucking ore during caribou migrations.

> *"The goal of the Conflict Avoidance Agreement is to balance development with our subsistence so that our subsistence resources and livelihood are protected while our country and our communities receive the benefits of development."*
>
> Alaska Eskimo Whaling Commission
> February 2012

The Arctic Marine Mammal Coalition, a group of five tribally authorized Arctic Native organizations, has recently been formed to address similar issues for the Bering Strait. In a similar vein, several Alaska Native organizations are co-managing important subsistence species—including several marine mammal species—via formal co-management agreements with the National Marine Fisheries Service (NOAA) and the Fish and Wildlife Service (Dept. of the Interior).

Federal and state agency leaders in Alaska formed the Alaska Climate Change Executive Roundtable in 2007 as a mechanism for federal and state science agencies to share information about climate change activities and to facilitate cooperation among agencies. The North Slope Science Initiative (NSSI) was established by Congress as an intergovernmental forum of federal, state, local, and Alaska Native representatives to increase collaboration and address research and monitoring needs as they relate to development activities and environmental change on the North Slope of Alaska. NSSI has initiated a novel scenario-planning effort to gain a better understanding of the future and the kinds of activities and infrastructure it could support.

An innovative Arctic data-sharing agreement between NOAA and several oil and gas companies was signed in August 2011. The agreement provides a framework for industry to share information on meteorology, coastal and ocean currents, circulation and waves, sea ice, biological science, and hydrographic services and mapping with the Federal Government. This additional environmental information will enhance NOAA's ability to monitor climate change and to support effective management decisions in the Arctic.

The Arctic Landscape Conservation Cooperative (LCC) is a self-directed collection of agencies and stakeholders, established by the Department of the Interior, that is organized around the mission to identify and provide information needed to conserve natural and cultural resources in the face of landscape-scale stressors such as climate change. The USGS Alaska Climate Science Center provides scientific information, tools, and techniques that land, water, fish, wildlife, and cultural resource managers and other interested parties can use to anticipate, monitor, and adapt to climate- and ecology-driven responses. BOEM coordinates with both the Arctic LCC and the NSSI to provide funding opportunities for applied science for decision-making.

Bowhead whales in sea ice in the western Beaufort Sea (credit: A. Brower, National Marine Fisheries Service/NOAA)

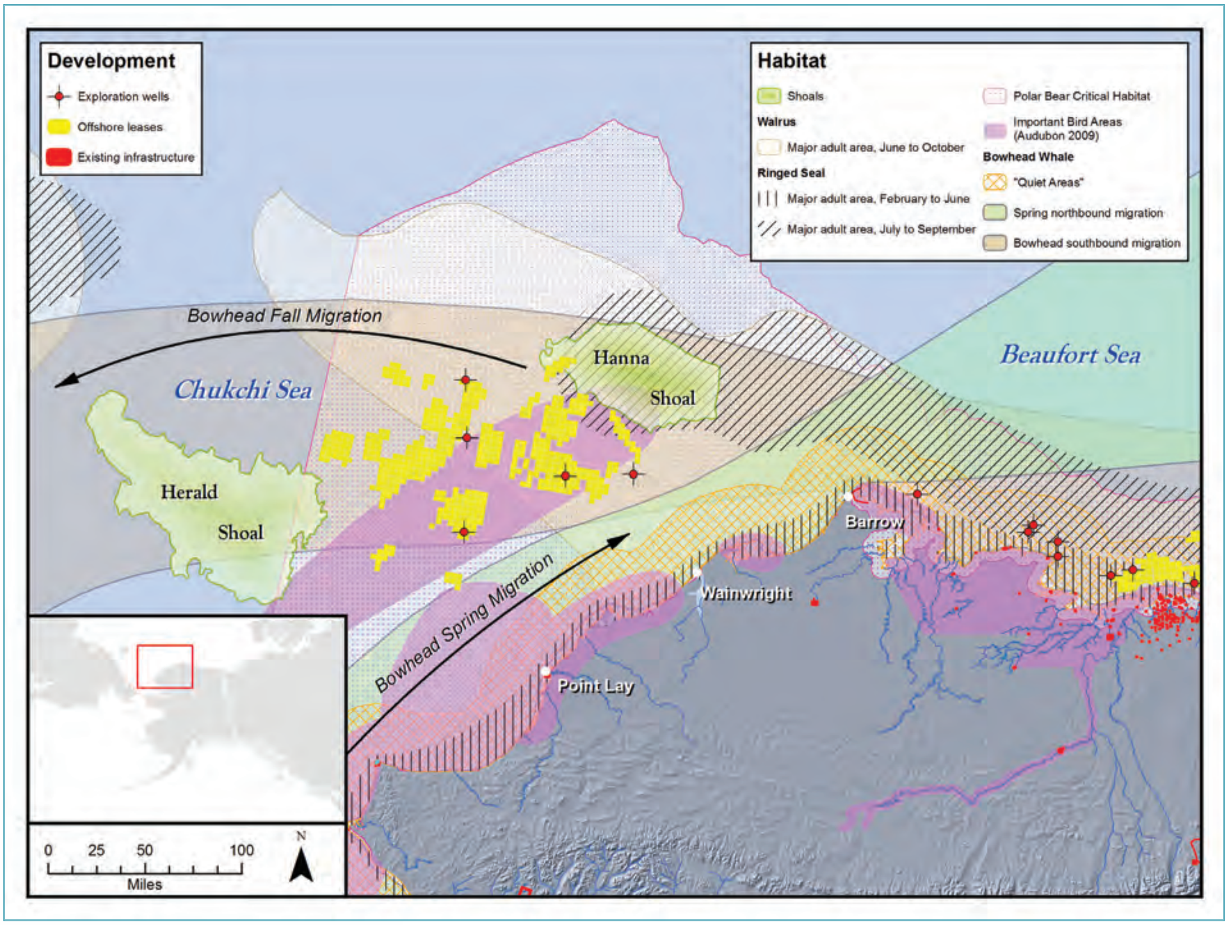


Figure 4.4. Sensitive ecological areas and zones of development in the marine areas off of Northwest Alaska. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)

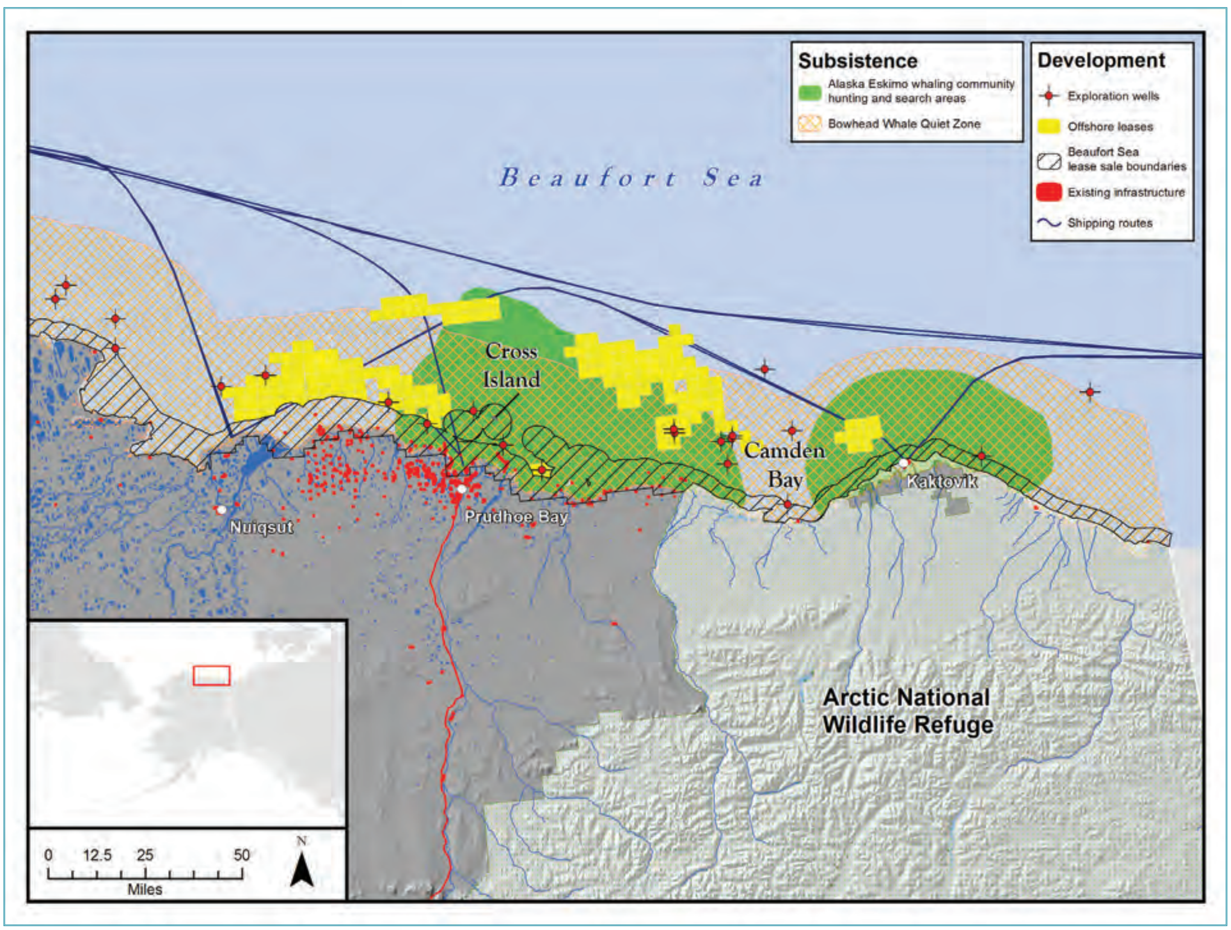


Figure 4.5. The spatial distribution of some examples of important areas for marine mammal subsistence hunting in relation to industrial development. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)

Alaska Native seal hunter (credit: Dept. of the Interior)

The State of Alaska has focused on the need to improve coordination, particularly regarding economic issues. By establishing the Office of Project Management and Permitting composed of "project coordinators" for each sector, the state seeks to have agencies speak through one point of contact and with one voice. Although focused on the economic sector only, the initiative may provide a good model for broader interagency cooperation in the region.

Federal efforts: The Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska was established on July 12, 2011 by Executive Order 13580 to coordinate federal permitting of energy development and "ensure the sharing and integrity of scientific and environmental information and cultural and traditional knowledge among agencies." The Executive Order also identified formal liaison roles to facilitate engagement and coordination with the State of Alaska and with local communities, governments, tribes, co-management organizations, and with other Alaska Native organizations. The Alaska Interagency Working Group brings relevant permitting agencies into regular and close coordination regarding all aspects of onshore and offshore oil and gas and renewable energy development in Alaska.

The Alaska Interagency Working Group has convened stakeholders from the region to discuss improving the linkages between science and decision-making. These discussions identified the following needs: (1) to improve the accessibility of scientific information and traditional knowledge, making it available for decision-making; (2) to develop a common approach for combining data to map ecologically sensitive areas in the Arctic ***(Figure 4.4)***; and (3) to gain a comprehensive understanding of potential infrastructure needs in the U.S. Arctic to anticipate development and conservation implications ***(Figure 4.5)***. The Chair of the U.S. Arctic Research Commission actively participated in these discussions, and the Commission initiative to provide easier public access to Arctic-related scientific information was a direct outgrowth of these cross-agency discussions *(*see ***Appendix I)***.

The Alaska Regional Response Team (ARRT), established to coordinate the federal response to releases of oil or hazardous substances, is a unique federal collaboration for which the State of Alaska is considered the de facto co-chair. The enormous area of responsibility necessitates collaboration among 10 geographically specific Subarea Committees and contingency plans—three of which cover the geographical areas in this report.[109]

A recent example of interagency progress in seeking ways to work together efficiently was the February 2012 workshop "Strengthening Partnerships: NOAA, BOEM, BSEE in the Arctic." That workshop sought to improve communication, avoid duplication, and ensure that relevant management issues are adequately addressed.[110] These agencies also signed a memorandum of understanding promoting cooperation on the development of Outer Continental Shelf energy resources and the conservation of living marine resources and marine ecosystems. In addition, multiple agencies and stakeholders participate in the annual "Open Water Meetings" in Anchorage, which address intersecting issues associated with oil and gas development and environmental protection.

The Interagency Arctic Research Policy Committee (IARPC), comprising representatives from 14 agencies, departments, and offices across the Federal Government, is charged with developing five-year plans to coordinate research in the Arctic. Under the 2013 to 2017 plan, IARPC is coordinating 140 research projects in seven broad areas that will especially benefit from interagency collaboration: (1) sea ice and marine ecosystems; (2) terrestrial ecosystems; (3) atmospheric studies of surface heat, energy, and mass balances; (4) observing systems; (5) regional climate models; (6) adaptation tools for sustaining communities; and (7) human health studies. Reflecting the broad scientific consensus that rapid changes in climate are altering ice and snow cover with consequences for Arctic ecosystems, indigenous societies, and global climate, these studies are being coordinated among federal agencies in partnership with the State of Alaska, industry, indigenous organizations, academic researchers, and international collaborators.

Executive Order 13547 established a comprehensive, integrated National Ocean Policy for the stewardship of the ocean, the coasts, and the Great Lakes. The Policy identifies changing conditions in the Arctic as a priority for federal agencies, in coordination with the State of Alaska, tribal governments, and Alaska Native communities. The National Ocean Policy also includes the adoption of ecosystem-based management as a foundational management principle. Ecosystem-based management is an adaptive, science-based management approach that accounts for economic and social benefits as well as environmental stewardship concerns; it is widely used by agencies nationwide.

International efforts: Under the leadership of the Department of State, the United States has played an active role in the Arctic Council since its establishment as a "high level forum" in 1996. In the Arctic Council, the United States works closely with the seven other nations with Arctic territory to discuss common challenges in the region and to seek joint solutions on the basis of consensus. The Council's working groups provide expert advice on a range of subject matters.

Norway's Arctic strategy has facilitated collaborative approaches to balancing development with ecosystem needs. Government agencies and stakeholders in the Barents Sea region worked together to develop an ecosystem-based management approach to balancing the needs of industrial development, the fishing industry, and the important or vulnerable ecosystems of the region. According to an industry representative, this ecosystem-based approach has led to significant cost savings, time savings, and a great deal more certainty for their operations in the region, and scientists are confident that the most sensitive areas will not be impacted. Canada has initiated a similar approach in all of its marine areas, and the Arctic Council has formed an expert group to recommend further activities related to ecosystem-based management in the circumpolar Arctic.

4.3. | *Integrating Arctic Management*

The promising approaches described above are encouraging signs that it is possible to overcome the institutional barriers that inhibit coordination among agencies and hinder the integration of important larger-scale, cross-cutting environmental, economic, and cultural factors into the decision-making process. Principles that should guide implementation of an "Integrated Arctic Management" approach to decision-making emerge from the activities outlined above as well as from stakeholder comments provided during the preparation of this report.

In particular, many stakeholders strongly advocated that:

(1) The Federal Government should continue to advance a "whole-of-government" approach to improve efficiency, ensure consideration of cumulative impacts, streamline decision-making, provide greater operational certainty for participants, and make the participatory requirements to stakeholders more efficient.

(2) Management decisions and forward-looking planning should include direct and meaningful partnerships among industry, non-governmental organizations, communities, Alaska Natives, the State of Alaska, and federal agencies, with transparent, respectful, and consistent consultation and engagement with tribal governments being integral to the process.

(3) Decisions should be science-based and focused on ensuring sustainable ecosystems and continuity of ecosystem functions and services by:

- ***identifying and protecting areas of significant ecological or cultural importance and/or sensitivity, along with the variables that define them;***
- ***using the best available science to understand ecological processes, to identify and measure indicators of change, and to make policy and management decisions;***
- ***utilizing and integrating traditional knowledge into decision-making;***
- ***investing in research that meets the needs of managers and stakeholders, and coordinating data collection and analysis across the U.S. Arctic; and***
- ***using precaution in decision-making, especially where the health, productivity, and resilience of ecosystems may be compromised.***

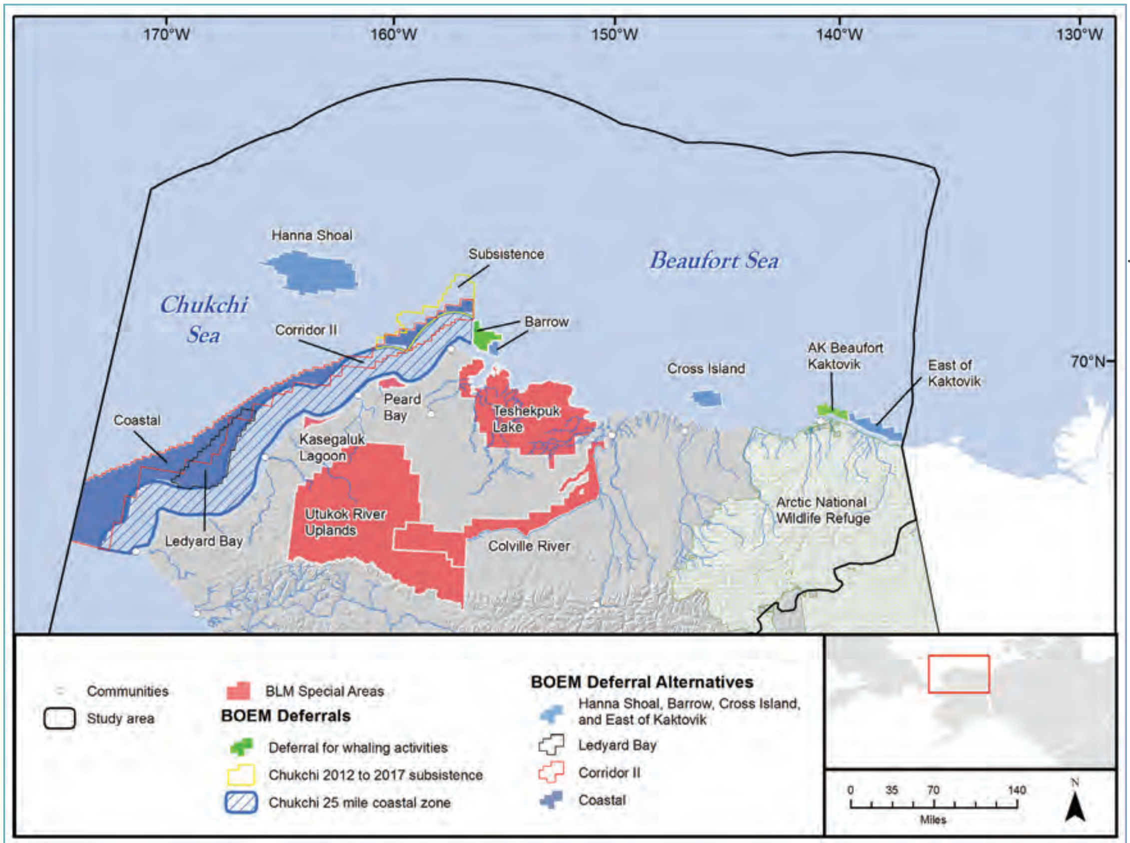


Figure 4.6. *Location of Bureau of Land Management special areas and Bureau of Ocean Energy Management deferral and alternate deferral areas within the area addressed by this report. (image: Scenarios Network for Alaska and Arctic Planning, Univ. of Alaska, Fairbanks)*

Stakeholders also identified additional principles of integrated decision-making, including the use of **adaptive management** approaches that allow decision-makers to manage through uncertainty by using baseline information and monitoring data to detect trends and make adjustments as new information becomes available; engaging in **region-wide planning** efforts that consider proposed activities across all U.S. Arctic jurisdictions to identify areas that are important to protect, those most vulnerable to change, and areas that can support development and infrastructure goals *(e.g., Figure 4.6)*; and finding better ways to assess **cumulative impacts**★ associated with development activities throughout the Arctic, enabling decision-makers to consider the broader context and potential additive consequences associated with individual project approvals.

4.4. | *Recommendations*

The principles outlined above form the basis of a common approach for Arctic management and planning, an approach that integrates environmental, cultural, and economic concerns. This "Integrated Arctic Management" approach holds the promise of a broader-based and more consistent consideration of both development and conservation sensitivities and trends in the Arctic. The approach considers a larger scale than can be appreciated at the project- or agency-specific level, and takes into account the values and interests of all key stakeholders in the U.S. Arctic.

Integrated Arctic Management should inform important planning and project decisions being made or influenced by federal, state, tribal, and local governments, as well as commercial interests, Alaska Native corporations, and non-governmental organizations. This is a management approach that already is taking hold in a meaningful way in the U.S. Arctic; the next step is to take additional, productive actions to facilitate the broader application of this approach without adding unnecessary layers of complexity or organizational overload. This report recommends that the U.S. Government:

1. ***Adopt an Integrated Arctic Management approach when making stewardship and development decisions affecting the U.S. Arctic:*** A commitment to apply the principles of Integrated Arctic Management will advance a common management approach that is resilient and adaptable to the changes taking place in the Arctic. *Integrated Arctic Management is a science-based, whole-of-government approach to stewardship and planning in the U.S. Arctic that integrates and balances environmental, economic, and cultural needs and objectives. It is an adaptive, stakeholder-informed means for looking holistically at impacts and sensitivities across the U.S. Arctic and generating sustainable solutions.*

2. ***Ensure ongoing high-level White House leadership on Arctic issues:*** Because of the importance of the Arctic to the United States, and recognizing the special challenges and opportunities that our Nation faces across a variety of sectors, the Administration is developing a National Strategy for the Arctic Region. This strategy, which will be established through the Presidential Policy Directive process, will identify strategic shared priorities for the U.S. Arctic region and will provide a framework for Executive Branch decision-making and high-level, government-wide leadership on the issues described in this report. The strategy, led by the National Security Staff, will help agencies coordinate and streamline the work of the Federal Government in the Arctic and amplify best practices and successful innovations. Integrated Arctic Management will play a key role in the stewardship, development, and infrastructure planning aspects of this broad strategy.

3. ***Strengthen key partnerships:*** The number of federal, state, local, and Alaska Native entities involved in Arctic decisions complicates efforts to build resilience and integrate the environmental, economic, and cultural interests and values of stakeholders in the region. Developing and maintaining strong, effective partnerships is integral to implementing an effective Arctic Strategy at the federal level. An important element of any strategy for the U.S. Arctic will be a clear delineation of state and federal roles implementing future Arctic programs. Two partners in the U.S. Arctic merit special attention from the Federal Government: the State of Alaska, and Alaska Native tribal governments and organizations.

   State of Alaska—The Federal Government should promptly initiate a high-level dialogue with representatives of the State of Alaska, with the aim of facilitating a clearer understanding of shared goals and the identification of promising joint initiatives with this important partner.

   Alaska Natives—High-level federal leadership should also promptly engage with Alaska Native leaders to reaffirm their special relationship with the Federal Government and to identify specific objectives for advancing Alaska Native roles and perspectives in the Arctic.

4. ***Promote better stakeholder engagement:*** The Federal Government should evaluate the existing ways through which federal agencies, key partners, and other stakeholders interact on management and planning issues in the U.S. Arctic. The goal of this assessment, to be conducted in 2013, should be to identify where stakeholder engagement is working well and to consider ways to build on good systems that are in place, rather than creating new layers of stakeholder involvement. To facilitate this exercise, it may be helpful to consider convening an "Arctic Partnership Roundtable" that would include representatives of federal, state, tribal, and municipal governments; Alaska Native corporations; commercial interests; and conservation organizations. This forum could be used to survey and evaluate the effectiveness of current approaches to stakeholder engagement, while also sharing perspectives, discussing future plans and expectations, identifying common goals, and promoting partnerships to achieve those goals.

★*The term "cumulative impacts" refers to the combined, incremental effects of human activity on a resource, ecosystem, or human community.*[111] *Impacts of an action may be relatively insignificant on their own, but as they accumulate over time and combine with the impacts from other sources, they can lead to significant overall degradation of resources.*

5. ***Coordinate and streamline federal actions:*** By the end of 2013, the Federal Government should conduct a review of the numerous interagency efforts related to the U.S. Arctic, with an eye toward identifying and addressing overlapping missions and reducing duplication of effort. In addition, there are several tools and processes already in use in the U.S. Arctic that, with increased coordination, can help to advance the Integrated Arctic Management approach to decision-making. With increased support from agency leadership, the following processes can be deployed in a coordinated, effective way to improve management decisions.

Linking science and management—Because sound management and planning decisions cannot be made without reliable information, it is vital that science and management efforts are linked together effectively. Integrated ecosystem research programs are a natural and essential partner to Integrated Arctic Management. The Federal Government should identify and implement specific actions that already are underway and/or that may be improved to: (1) strengthen the capacity of science programs to provide focused, ecosystem-based information needed by decision-makers for wise stewardship and development of natural resources; and (2) improve decision-makers' access to integrated scientific information and traditional knowledge relevant to management in the Arctic.

Environmental evaluations—Many agencies are preparing both project-specific and programmatic environmental analyses, as required by the National Environmental Policy Act (NEPA). While there is some cooperation across agencies in preparing these documents, different analysts often draw on different sources of scientific information and focus on different topics in these analyses. There is no common, up-to-date compendium, for example, that analysts can use to identify area-wide development trends, area-wide environmental sensitivities, or changing conditions. As appropriate, agencies involved in environmental evaluations should prepare broad-based, Arctic-wide information products that can be shared among agencies and be included as part of NEPA analyses for agency-specific actions. Having access to these types of shared analyses would promote the sustainability of key ecosystems and processes by enabling improvements in assessments of cumulative impacts of natural and anthropogenic change.

Important ecological and subsistence areas—There are a number of evaluations completed and underway that seek to identify sensitive or important environmental and subsistence areas in the Arctic and analyze the related impacts of climate change. These analyses should be assembled in 2013 to provide a more complete, region-wide picture of the areas of special environmental sensitivity, vulnerability, or importance. This evaluation should be kept current and made readily available to decision-makers and stakeholders alike to facilitate a broader consideration of environmental sensitivities in the Arctic.

Scenario planning—Planning in the face of uncertainty can be enhanced by recognizing a set of plausible futures, or "scenarios" for the systems under consideration. There are a variety of scenario-planning efforts underway in the Arctic that could provide the type of forward-looking information about development trends important to Integrated Arctic Management. When these efforts are complete, federal agencies should assemble and assess the results to guide priority-setting and share Arctic-wide information about future activities that might otherwise be overlooked.

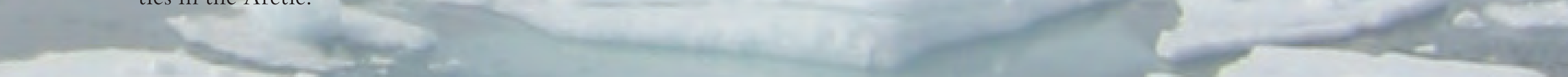
International coordination—The federal Arctic leadership team should facilitate international coordination by ensuring that the U.S. Senior Arctic Official is fully briefed on domestic efforts in the Arctic so that the Department of State can coordinate these efforts with those of the United States' bordering international partners and other Arctic nations through the Arctic Council. This coordination will be of particular importance before and during the U.S. chairmanship of the Arctic Council from 2015 to 2017.

4.5. | *Conclusion*

In preparing for this report, the authors engaged in dialogues with many agencies and stakeholders in the U.S. Arctic to determine how the U.S. Government might improve management processes and practices to adapt to the rapid changes taking place there. All parties agreed that management decisions in the U.S. Arctic should seek to foster healthy economies, promote thriving cultures, and ensure sustainable ecosystems—an encouraging consensus and good starting point for advancing a holistic, inclusive approach that integrates these goals.

Discussing this new approach has energized stakeholders and agencies, but its implementation will involve a very complex and challenging transition. In some instances this transition has already begun, and building momentum will require a thoughtful examination of opportunities and a much deeper engagement with partners and stakeholders.

This report is a call to action on a pressing issue of national importance. The cultural, ecological, and economic costs of failing to adapt and strengthen management approaches in the face of rapid change are unacceptable. Success will require innovative and coordinated approaches that build upon the vast knowledge and experience of the people that know this region well and are committed to finding sustainable solutions. Our challenge is to apply the principles of Integrated Arctic Management to today's decisions and to those that lie ahead in our shared future as an Arctic nation.



Sea ice in the Chukchi Sea (credit: J.L. Bengtson, National Marine Fisheries Service/NOAA)

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Polar bear swimming in the Chukchi Sea
(credit: S. Parker-Stetter, Univ. of Washington)

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Beluga whales in sea ice in the western Beaufort Sea (credit: V. Beaver, National Marine Fisheries Service/NOAA)

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Arctic cod swimming inside sea ice (credit: E.C. Siddon, Univ. of Alaska/NOAA)

Appendix I.
Arctic Science Portal

The U.S. Arctic Research Commission (USARC) created a web portal* to provide decision-makers with easier access to scientific information about the Arctic. This effort is consistent with the Commission's statutory responsibility to promote access to scientific information and to encourage greater coordination among research entities and government agencies. This document describes the project and the results to date.

*A web site that brings information together from diverse sources in a uniform way.

Purpose

A great deal of information and knowledge about the Arctic exists, though in many cases, it can be difficult to locate or access. At a time when the world is increasingly interested in the Arctic, and when many decisions are being made that will impact the region, it is essential that relevant research and information be readily available. The Arctic Science Portal, essentially a website guide to other websites, is designed to be a user-friendly interface that connects researchers, regulators, and the general public with information needed for decision-making, as well as for general information and education.

When publicly released, the Arctic Science Portal will be hosted on the U.S. Arctic Research Commission's website (**www.arctic.gov**). A draft version of the portal is currently available, for official use only, at **www.arctic.gov/portal**. The portal consists of an organized collection of links (URLs) to websites where Arctic information is publicly available. The portal directs users to appropriate websites based on topic and a short description (e.g., Arctic weather, sea ice conditions, fisheries, terrestrial ecosystems, oceanography, oil spill response research, etc.).

Importantly, the portal is not a tool whereby data from one or more sources can be combined, integrated, or analyzed. Nor will it be a site where data are archived. Instead, it is designed to direct users to readily available information. By categorizing this information and making it easily accessible from a single source, USARC's goal is to provide a product that adds value beyond existing capabilities.

Scope

The initial focus and emphasis of the portal is on the U.S. Arctic region, as defined by Arctic Research and Policy Act.* However, links to non-U.S. websites with relevant Arctic information are also included and will continue to be added as the portal grows.

Audience

The Arctic Science Portal is designed to be accessible by a broad audience, in addition to experts, such as students, reporters, elected officials, research scientists, subsistence users, regulators, and the general public. USARC attempted to design a tool that is user friendly and enables feedback that will enable us to improve the portal and make it even more useful to the user community.

Process

USARC solicited input from a broad community of entities that create Arctic information and knowledge. In response, USARC received suggestions from many federal agencies, the State of Alaska, non-governmental organizations, and from non-U.S. governments. Once the portal is publicly released, USARC will continue to solicit input. The portal is also designed to encourage users to send feedback and suggestions for improvement. USARC will regularly update the portal based on such feedback. It is USARC's hope to explore the possibility of a content management system during a second phase of the project, which would enable USARC to create an expanded, more searchable database that requires less day-to-day maintenance.

"Arctic" means all U.S. and foreign territory north of the Arctic Circle and all U.S. territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering and Chukchi Seas; and the Aleutian chain.

Appendix II.
Preparing This Report

This report was prepared with input from a broad group of agencies and stakeholders. One of the principal sources of that input came from listening sessions and discussions that were held with individuals and groups closely tied to the U.S. Arctic. Diverse perspectives were provided by representatives from federal, state, tribal, and municipal governments; Alaska Native organizations; commercial interests; and conservation and environmental organizations. The organizations listed below provided input to the development of this report. Their listing does not indicate that they support or endorse the report or its findings. The report is the sole responsibility of the U.S. Government. The listening sessions and discussions focused on the following topics:

1. ***Goals:*** The most important environmental, economic, and cultural or other goals for the U.S. Arctic over the next 20 to 30 years and beyond.
2. ***Opportunities:*** Effective strategies that have been used or could be used for decision-making in the Arctic.
3. ***Challenges:*** Removing obstacles to making sound, science-based decisions in the Arctic.
4. ***Federal Government:*** Steps through which the Federal Government can be a more effective partner in helping to achieve sustainability in the U.S. Arctic.

State of Alaska agencies providing input to this report

Alaska Department of Environmental Conservation
Alaska Department of Natural Resources
Governor's Office, State of Alaska

Tribal governments and Alaska Native organizations providing input to this report

Alaska Beluga Whale Committee
Alaska Eskimo Whaling Commission
Alaska Federation of Natives
Alaska Nanuuq Commission
Arctic Marine Mammal Coalition
Arctic Slope Regional Corporation
Bering Straits Native Corporation
Bristol Bay Native Association
Eskimo Walrus Commission
Ice Seal Committee
Indigenous People's Council for Marine Mammals
Inuit Circumpolar Council
Inupiat Community of the Arctic Slope
Kawerak, Inc.
Kuukpik Corporation
NANA Regional Corporation
Native Village of Anaktuvuk Pass
Native Village of Atqasuk
Native Village of Barrow
Native Village of Elim
Native Village of Gambell
Native Village of Kaktovik
Native Village of Kotzebue
Native Village of Nome
Native Village of Nuiqsut
Native Village of Point Hope
Native Village of Point Lay
Native Village of Shishmaref
Native Village of Teller
Native Village of Wainwright
Native Village of Wales
Olgoonik Corporation
Qayassiq Walrus Commission
Sitnasuak Native Corporation
Ukpeagvik Inupiat Corporation
Unalakleet Native Corporation

Boat frame at Gambell
(credit: R.A. Winfree, National Park Service)

Municipal governments providing input to this report

Trans Alaska pipeline in summer (credit: Dept. of the Interior)

Alaska Municipal League
City of Barrow
City of Kotzebue
City of Nome
City of Nuiqsut
City of Wainwright
North Slope Borough
Northwest Arctic Borough

Commercial and industrial stakeholders providing input to this report

Alaska Cruise Association
Alaska Oil and Gas Association
Alyeska Pipeline Service Company
Bering Sea Alliance LLC
ConocoPhillips Alaska
Resource Development Council
Shell Oil Company
United Fishermen of Alaska

Conservation and environmental organizations providing input to this report

Audubon Alaska
Defenders of Wildlife
Earth Justice
Natural Resources Defense Council
Oceana
Ocean Conservancy
Pew Environment Group
The Wilderness Society
World Wildlife Fund

Federal Government agencies providing input to this report

Arctic Research Commission
Army Corps of Engineers, Dept. of Defense
Bureau of Land Management, Dept. of the Interior
Bureau of Ocean Energy Management, Dept. of the Interior
Bureau of Safety and Environmental Enforcement, Dept. of the Interior
Coast Guard, Dept. of Homeland Security
Department of Agriculture
Department of State
Environmental Protection Agency
Federal Aviation Administration, Dept. of Transportation
Fish and Wildlife Service, Dept. of the Interior
Marine Mammal Commission
Maritime Administration, Dept. of Transportation
National Ocean Council, Executive Office of the President
National Oceanic and Atmospheric Administration, Dept. of Commerce
National Park Service, Dept. of the Interior
Navy, Dept. of Defense
Office of Science and Technology Policy, Executive Office of the President
Office of the Federal Coordinator for Alaska Natural Gas Transportation Projects
Office of the Secretary, Dept. of the Interior
Office of the Secretary, Dept. of Transportation
Pipeline and Hazardous Materials Safety Administration
U.S. Geological Survey, Dept. of the Interior

Tundra swan (credit: Dept. of the Interior)

Report production

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Grasses and wildflowers on the Seward Peninsula (credit: A. Andrew, National Park Service)

Drying fish at Savoonga (credit: R.A. Winfree, National Park Service)

Wainwright, on the coast of the Chukchi Sea (credit: M. Lindeberg, National Marine Fisheries Service/NOAA)

Cover: Aerial photograph looking down at seasonal sea ice (credit: National Marine Fisheries Service/NOAA)