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Department of the Interior

The Department of the Interior performs biological, physical, engineering, and social science research; conducts mapping, monitoring, and assessment programs throughout Alaska and its offshore regions; and manages department lands in Alaska. These activities are performed by services or bureaus, each with administrative and technical offices located in Alaska.

The North Slope Science Initiative

Alaska's North Slope encompasses 233,500 square kilometers of diverse and unique ecosystems rich in natural resources. The North Slope Science Initiative (NSSI) is intended to enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and make this information available to decision-makers, governmental agencies, industry, and the public.

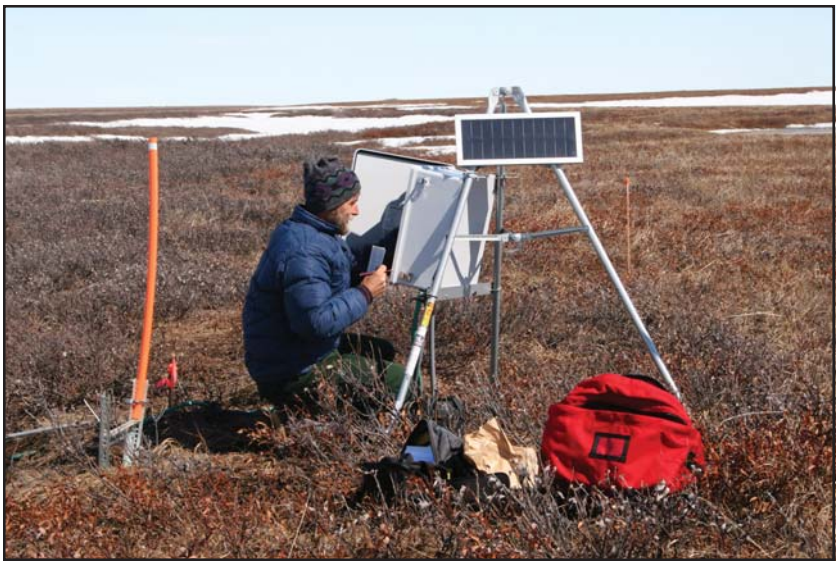
Established by Congress in the Energy Policy Act of 2005, the NSSI will focus on prioritization of pressing natural resource management and ecosystem information needs, coordination and cooperation among agencies and organizations, competitive selection of approved projects, enhanced information availability, and public involvement.

The Alaska leadership of ten local, state, and Federal land and resource agencies, including the Arctic Slope Regional Corporation as the largest private landowner on the North Slope, signed a charter establishing the Oversight Group for the NSSI, consisting of the following:

- The Mayor of the North Slope Borough;
- The President of the Arctic Slope Regional Corporation;
- The Commissioner of the Alaska Department of Fish and Game;
- The Commissioner of the Alaska Department of Natural Resources;
- The Regional Director of the U.S. Geological Survey;
- The Regional Director of the U.S. Fish and Wildlife Service;
- The Regional Director of the Minerals Management Service;
- The Regional Director of the National Marine Fisheries Service;
- The Regional Director of the National Park Service; and
- The State Director of the Bureau of Land Management.

The U.S. Arctic Research Commission and the Department of Energy serve as advisors to the Oversight Group.

Resource management agencies administering the resources of the North Slope of Alaska, include those at the local, state, and Federal level.



Hydrology study. BLM and USGS are cooperating to establish additional hydrologic gauging stations on the North Slope.

Objectives incorporated in the NSSI charter include to:

- Identify and prioritize information needs for inventory, monitoring, and research activities to address the individual and cumulative effects of past, ongoing, and anticipated development activities and environmental change on the North Slope;
- Develop an understanding of information needs for regulatory and land management agencies, local governments, and the public;
- Focus on prioritization of pressing natural resource management and ecosystem information needs, coordination, and cooperation among agencies and organizations;
- Coordinate ongoing and future inventory, monitoring, and research activities to minimize duplication of effort, share financial resources and expertise, and assure the collection of quality information;
- Identify priority needs not addressed by agency science programs currently in effect and develop a funding strategy to meet those needs;
- Provide a consistent approach to high-caliber science, including inventory, monitoring, and research;
- Maintain and improve public and agency access to accumulated and ongoing research and contemporary and traditional local knowledge; and
- Ensure through appropriate peer review that the science conducted by participating agencies and organizations is of the highest technical quality.

Budget

While the Energy Policy Act authorized to be appropriated such sums as are necessary to carry out this initiative, no appropriations have yet passed Congress. Contributions from the member agencies have been pooled to fund the position of Executive Director and some high-priority field studies. A dedicated long-term funding source that meets the objectives of the NSSI is currently being pursued.

2005 Activities

The Oversight Group met several times in 2005 to receive briefings on current North Slope inventory, monitoring, and research activities being conducted by each member agency, as well as the oil and gas industry, related organizations, and the various institutes within the University of Alaska. A database of all activities, now being compiled, will provide access for all project leaders to determine potential opportunities for collaboration and increased communication.

The charter for the Science Technical Group (STG) was drafted by the Oversight Group and approved by the Secretary of the Interior. As required by the Energy Policy Act, the STG will consist of a representative group of not more than 15 scientists and technical experts from diverse professions and interests, including the oil and gas industry, subsistence users, Native Alaskan entities, conservation organizations, wildlife management organizations, and academia. Members of the STG will provide advice on proposed inventory, monitoring, and research functions. The Secretary of the Interior appointed the STG members in January 2006.

Nesting goose on the North Slope. Researching the potential disturbance effects from aircraft, vehicles, pedestrians, and facility noise on populations of molting geese is critical prior to development in areas of high-density waterfowl populations.

Young caribou. Determining the effects of North Slope development on caribou populations and harvests is a priority for NSSI.

Priorities for the Future

The NSSI has developed an understanding of the scientific information needed by researchers and land managers. A 2004 assessment identified a need to develop infrastructure and communication pathways to support the continued exchange of information relevant to the North Slope. These include identifying and incorporating major endeavors, such as National Science Foundation programs for global climate monitoring and research and interfacing with initiatives such as North Pacific Research Board. The 2004 assessment also identified several areas where improvement is needed to afford a more complete understanding and analysis of Arctic environments. The assessment indicated incomplete baseline data for the North Slope at both spatial and temporal scales, insufficiently organized data management, and a lack of coordination to maximize and leverage data use. The NSSI Science Strategy, developed in concert with member agencies, provides a broad strategy for identifying priorities and addressing development issues. An Implementation Plan will be developed this year that incorporates a monitoring plan to more efficiently assess the impacts of oil and gas exploration and development on various surface resources of the National Petroleum Reserve–Alaska (NPRA) and to determine the effectiveness of current mitigation measures and management policies. The following areas within the biological, physical, and social systems sensitive to development on the North Slope have been identified as priorities for the NSSI:

- Regional long-term hydrologic gauging stations in areas of potential development;
- Caribou populations and harvest (the effects of ice roads and facilities on habitat use and migration; disturbance effects from vehicle and aircraft traffic, seismic exploration, and drilling activities; and potential displacement from areas of high forage quality, possibly affecting rates of reproduction and survival);
- Molting geese (the disturbance effects of aircraft, vehicles, pedestrians, and facility noise, potentially affecting survival);
- Potential impacts to fish caused by changes in hydrology from infrastructure and roadways (including ice roads), and changes in water quality caused by water withdrawals or sedimentation and scouring during spring floods;
- Change in access to subsistence resources (altered distribution or abundance of subsistence resources and physical or perceptual barriers to subsistence users);
- Alteration of predator/prey relationships (increased predator populations resulting from human developments and activities, and any resulting adverse impacts on prey species);
- Impacts to local cultural systems (any changes to the sharing network that may result from altered subsistence activities);

Seal hunters. Access to subsistence resources, including altered distribution or abundance of wildlife and physical or perpetual barriers to subsistence users, must be addressed as development expands into new areas of the North Slope.

- Populations of cliff-nesting raptor species (effects of disturbance and habitat loss);
- Effects on migrating bowhead whales in autumn (deflection of migrations from noise associated with barging, seismic exploration, and drilling in marine waters);
- Populations of threatened eider species (effects of collision and oil spill related mortality, increased predator density, habitat loss, and disturbance); and
- Environmental contaminants (oil or hazardous chemical spills, water effluent, and air emissions, resulting in contaminants in water, sediments, invertebrates, plants, fish, birds, and mammals).

The oil and gas industry has also recognized a need for continued technological improvements. To protect the integrity of the unique environment on the North Slope, oil and gas development in this area is subject to the most stringent laws and regulations in the U.S. The industry has conducted inventory, monitoring, and research to understand the effects of oil and gas exploration, development, and production while continuously developing technology that reduces the development footprint. The NSSI will help to integrate and coordinate an approach to making science-based resource decisions that consider the findings of agencies, researchers, and industry. Further development of the NSSI depends on continued support and interest from the U.S. Federal government and relies on participation from Federal, state, and local stakeholders, research institutes, and the oil and gas industry.

While the NSSI has already begun to address some of the priorities listed above, such as dedicating additional funding to establish four long-term hydrologic gauging stations in the NPRA and appropriating additional funding to ongoing research of the Central Arctic caribou herd, a constant funding source is needed to address priority information needs not met by current inventory, monitoring, or research efforts. Once a constant funding source is obtained, the STG will address additional priorities, review proposals to address those priorities, and provide recommendations to the Oversight Group for approval and implementation.

Minerals Management Service

The Minerals Management Service (MMS) has the statutory responsibilities to manage the mineral resources located on the U.S. Outer Continental Shelf (OCS) in an environmentally sound and safe manner and to collect, verify, and distribute mineral revenues from Federal and Indian lands. In addition, MMS is the lead agency for Federal offshore renewable energy and alternate use of America's offshore public lands.

In support of these responsibilities, MMS conducts two major programs of research that are relevant to activities in the Arctic. One, the Technology Assessment and Research (TA&R) program, focuses on engineering and technology issues. The other, the Environmental Studies Program (ESP), focuses on issues related to assessing and predicting potential environment and socioeconomic impacts. MMS utilizes the capabilities of universities, private firms, and state and Federal government laboratories to carry out most of its research.

Technology Assessment and Research Program

The MMS supports an active research program to understand the engineering constraints for offshore operations, especially as they relate to the structural integrity of structures and pipelines, the prevention of pollution, and the technologies necessary to clean up an oil spill, should one occur. In essence, the program provides an independent assessment of the status of OCS technologies and, where deemed necessary, investigates technology gaps and provides leadership in reaching solutions. The program also facilitates a dialogue among engineers in the industry, the research community, and MMS in dealing with the many complex issues associated with offshore oil and gas operations.

The TA&R Program supports research associated with operational safety and pollution prevention, as well as oil-spill response and cleanup capabilities. It was established in the 1970s to ensure that industry operations on the OCS incorporated the use of the Best Available and Safest Technologies (BAST). The program has two functional research activities: Operational Safety and Engineering Research (OSER) and Oil Spill Research (OSR).

	Funding (thousands)	
	FY 04	FY 05
Technology Assessment & Research	434	689
Environmental Studies Program*	5,915	5,054
Total	6,349	5,743

*Includes research conducted in Cook Inlet, Alaska

The MMS TA&R Program operates Ohmsett, The National Oil Spill Response Test Facility, in Leonardo, New Jersey. This facility provides testing and research capabilities to MMS, other government agencies, and the private sector on topics associated with the prevention and clean-up of oil spills. Ohmsett is the only facility in North America where full-scale response equipment and techniques (such as containment booms, skimmers, chemical dispersants, and remote sensing equipment) can be tested in a controlled environment using real oil.

Past technology developments, economic constraints within the industry, and a continuing need to ensure that offshore oil and gas operations can be conducted in a safe manner without harm to the environment has provided new goals and directions for offshore oil and gas research initiatives.

With a sound appreciation for the current state of offshore technology, the TA&R Program will continue to focus its research efforts in the following areas:

- Frontier areas of operations (both deep water and the Arctic), including safety issues as well as the integrity of structures and pipelines;
- Human and organization factors and how they can be addressed to mitigate accidents;
- The aging offshore infrastructure, including platforms and pipelines;
- The impacts of hurricanes Ivan, Rita, and Katrina; and
- Oil spill mitigation measures, should a spill occur (including remote sensing and surveillance, containment and cleanup technologies, chemical treating agents and dispersants, in situ burning, and sorbents).

Operational Safety and Engineering Research

Arctic offshore operations have been hampered more by the lack of commercially economic discoveries than by technology. The industry has tended to develop onshore resources in the Arctic, with just minimal exploration and development offshore. However, recently there has been increased interest by the oil and gas industry in Arctic offshore resources.

Sea ice is still the most severe environmental hazard to future offshore development in the Arctic. Such hazards include forces that moving sea ice may exert against offshore structures, icing of structures resulting from freezing spray, gouging of the sea floor by sea ice (which could interfere with buried pipelines), and interference with locating or cleaning up a potential oil spill. Engineering data for these hazards will become increasingly important as operations move from an exploration mode to a production mode and as structures are considered for deeper water, especially within the shear zone or pack ice.

Phase I of a study of interstitially insulated pipe found that the use of a low-thermal-conductivity, high-strength wire screen mesh between a pipe and its interior liner creates superior passive thermal insulation for cold-water (i.e. Arctic and deep water) flow lines and risers. The screen mesh creates an "air gap" or thermal resistance between the pipe and liner, thus reducing heat transfer. Further reductions were gained by adding a layer of Mylar film. Experiments with coupons of pipe/mesh/liner materials found that the thermal conductivity was reduced by up to 50 times over pipe material alone. Now under Phase II, laboratory experiments on a small-scale prototype are being conducted to validate the concept with regard to a pipe's geometry and to demonstrate its performance under steady and transient flow conditions. A model to estimate the thermal performance of the system under realistic conditions will be developed and calibrated with experimental data. The interstitially insulated pipe's insulation system is expected to be comparable with other insulation systems presently used for subsea applications, and it could prove to be less expensive, easier to install, and more robust than present insulation technologies.

Another project is identifying and assessing the current state of the practice for the construction and maintenance of ice islands. It will evaluate ice island technology to identify areas where further research and development would decrease the effort required to construct and maintain ice islands.

To better understand the challenges, impacts, and possible solutions that the oil and gas industry faces in the Arctic, MMS contracted with Det Norske Veritas to conduct a two-day workshop in May 2004 on the fundamentals, technical issues, and remediation of vortex-induced vibration of free-spanning pipelines in Cook Inlet, strudel scour in the Beaufort Sea, and wind-induced vibrations for elevated pipelines on the North Slope.

Oil Spill Response Research

The MMS is the principal U.S. government agency funding offshore oil spill response research. Through funding provided by MMS, scientists and engineers from the public and private sectors worldwide are working to address outstanding gaps in information and technology concerning the cleanup of oil spills. Credible scientific research and technological innovation are considered key elements for improving oil spill response and protecting our coasts and ocean waters against the damage that could be caused by spills. Information derived from the Oil Spill Response Research program is directly integrated into MMS's offshore operations and is used in making regulatory decisions pertaining to permit and plan approvals, safety and pollution inspections, enforcement actions, and training requirements. The OSRR program has funded a variety of projects to develop and improve Arctic oil spill response. MMS research currently underway focuses on four types of response technologies: remote sensing and surveillance, mechanical response, chemical treating agents including dispersants, and in situ burning.

Chemical Treating Agents and Dispersants. Dispersants are an important tool in spill response when it is critical to prevent oil from reaching a sensitive resource. Even though their use is pre-approved in various Area Contingency Plans, so much controversy surrounds dispersant use in the U.S. that they are seldom used. Analyses of tradeoffs between dispersant use and conventional mechanical recovery demonstrate that, in many incidents, dispersant use, either in combination with or instead of mechanical recovery, could significantly enhance protection of human health and the environment. The potential impacts and benefits of developing this technology are high. Development areas include increasing dispersant effectiveness, reducing the environmental impacts of the chemicals themselves, developing vessel and aircraft application methodologies and equipment, conducting a program of meso-scale and field-testing to refine application techniques and procedures, and researching the effects and effectiveness of this technology. Specific focus will be on dispersant use on cold water spills in the Arctic and Subarctic environments. The results of this research will facilitate the acceptance and use of dispersants throughout the U.S and North America.

An international joint research project gathering data to support decision makers in the process of determining whether dispersants should be

Radar team from Boise State University towing one of the two radar systems used at the U.S. Army Cold Regions Research and Engineering Laboratory to map oil under the ice in 2004.

used in low-energy environments. This information will be useful for dispersant decision making in ice cover (an ice field reduces wave motion) or other calm conditions. Questions to be addressed are:

- Will the dispersant stay with the oil until there is enough energy to disperse the slick?
- How much energy is needed to disperse the slick after dispersants are applied?
- If energy is provided to facilitate dispersion, will the droplets stay in the water column after mixing or will they resurface?

The researchers are working on laboratory-scale dispersant effectiveness tests in which four commercial dispersants have been applied to four oils (a naphthenic oil, an asphaltenic oil, waxy oil, and a paraffinic oil). Additional tasks for this project include developing a numerical model to predict the energy needed to shear dispersed oil droplets from a slick and energy needed to keep a dispersed oil droplet in the water column and validating the numerical model using test tanks. This project currently has nine partners representing the oil industry and agencies from Texas and Canada.

Remote Sensing and Surveillance. The present inability to reliably detect and map oil trapped in, under, on, or among ice is a critical deficiency, affecting all aspects of response to oil spills in ice. Although there is still no practical operational system to remotely detect or map oil in ice, there are several technology areas where further research into ground-based remote sensing could yield major benefits. Examples include ground-penetrating radar, optical beams for river spills, and vapor detection (for example, gas-sniffer systems) for oil trapped in and under ice.

A project that is developing new and innovative equipment and technologies for the remote sensing and surveillance of oil in and under ice is now in Phase 2. This project represents follow-on work to develop technologies to detect oil located in or under ice. In one task, detailed chemical analyses were completed to complement and further interpret results obtained from ethane flux measurements. Additionally, analyses were completed to enable efficient acquisition of data in the form necessary to properly measure and account for sea ice anisotropy and signal depolarization. In another task, field testing of several radar systems and antenna configurations over a variety of sea ice conditions was completed at Prudhoe Bay in 2005. A three-person team documented the ability of the systems to reliably measure sea ice up to 2 m thick and explored the potential to operate in rough ice areas commonly encountered as part of the land-fast ice. The Prudhoe Bay trials also provided an opportunity to further monitor the performance of the electronics at low temperatures.

Radar team at Prudhoe Bay in April 2005 during cold weather reliability trials and thick ice (up to 6.5 feet) profiling without oil.

In still another task, software is being developed and tested to provide for near-real-time data analysis, to determine and account for sea ice anisotropy and signal depolarization caused by surface irregularity, and to develop and test combined GPR attributes to minimize the potential for false positives. All analysis software was tested both with the data previously acquired in the test

basin at the U.S. Army Cold Regions Research and Engineering Laboratory and with new data collected on natural sea ice during April 2005 field tests. These data were used as input into a suite of model predictions showing the expected radar performance in a variety of oil-in-ice scenarios (varying thickness, oil pool depth, etc.).

The ultimate goal is to test a developed radar system incorporating improvements described above with crude oil spilled under actual sea ice over a large enough area to allow airborne measurements. Given the constraints on permitting such work in North America, the only realistic location for such work is Svalbard, Norway. Planning has been completed for a full-scale field experiment to evaluate the ability of ground penetrating radar to locate and map crude oil in and under sea ice in April 2006.

Ohmsett–The National Oil Spill Response Test Facility. Ohmsett is a vital component of MMS's research program and plays a critical role in developing the most effective response technologies, as well as preparing responders with the most realistic training available before an actual spill. The facility directly supports the MMS goal of ensuring that the best and safest oil spill detection, containment, and removal technologies are available to protect the U.S. coastal and oceanic environments.

Ohmsett is not only vital to MMS's oil spill research program, it is a national asset where government agencies, private industry, and academia can conduct full-scale oil spill research and development programs. Ohmsett is also the premier training site for spill response personnel from government agencies such as the U.S. Coast Guard, U.S. Navy, National Oceanic and Atmospheric Administration, and Environmental Protection Agency.

To respond to the challenges of testing and evaluating the equipment required to respond to oil spills in ice infested waters MMS has upgraded the testing capabilities at Ohmsett to provide a controlled environment for cold water testing and training (with or without ice). The facility is now able to simulate realistic broken ice conditions. These upgrades enable the Ohmsett facility to remain open year-round, offering cold water testing and training during the winter months. Recent testing activities include evaluation of oil spill skimmers for collecting spilled oil in broken ice, cold water dispersant effectiveness tests, evaluations of viscous oil pumping equipment, basic research on the evaporation of oil and formation of emulsions, cold water oil spill response training, and evaluations of fast water oil spill response equipment. Additional information describing Ohmsett is available online at www.ohmsett.com.

Environmental Studies Program

Environmental studies have been conducted in Alaska under the auspices of the Department of the Interior's Outer Continental Shelf offshore oil and gas leasing program since 1974 to obtain information needed to make sound leasing decisions and to monitor the human, marine, and coastal environments. More than $285 million has been spent on studies in 15 OCS planning areas in the Arctic, Bering Sea, and Gulf of Alaska subregions. These studies cover a range of disciplines such as physical oceanography, endangered species, living resources, fate and effects, and socioeconomics. The information is used in MMS decision making and monitoring of proposed and existing offshore oil and gas development in Alaska.

A wide variety of interested stakeholders, environmental groups, oil and fishing industry workers, local and traditional knowledge sources, research contractors, scientists, and government personnel from Federal, state, and local agencies help the MMS identify environmental issues and information needs. Information Transfer Meetings and workshops are convened to bring together information from key sources. The pooling of shared knowledge results in a synthesis of information that identifies those studies most needed to meet the current focus on post-lease and monitoring information requirements.

Coastal Marine Institutes (CMI) were initiated by MMS to take advantage of highly qualified scientific expertise at local levels and to achieve cooperative research goals in key OCS regions. In 2005, the MMS renewed funding of the CMI at the University of Alaska Fairbanks (UAF) to benefit from its scope and depth of scientific expertise. This cooperative agreement commits up to $1 million per year for research if matching state or other non-Federal funds are available. The CMI conducts research focused on environmental, social, and economic studies relevant to both Federal and state offshore oil and gas and mineral resource management issues. The CMI, managed by the internationally renowned UAF School of Fisheries and Ocean Science, creates an opportunity for the MMS and the state to jointly accomplish research that could not otherwise be carried out. In addi-

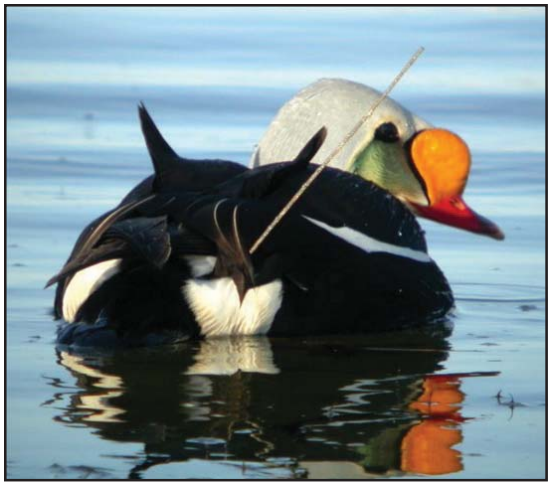
tion to 28 ongoing studies, several new studies are being evaluated for funding through the CMI in 2006.

Endangered and Protected Species

Marine mammals. The bowhead whale, an endangered species of high importance to Native cultures in the Arctic, migrates through areas of oil and gas exploration and development, including near the Northstar offshore production site. Efforts to monitor the fall migration of bowhead whales and related environmental factors continued through 2005 as the MMS conducted its Bowhead Whale Aerial Survey Project (BWASP). BWASP results indicate that fall bowhead whale sightings tend to be farther offshore in heavy ice years across the central Alaskan Beaufort Sea. While factors other than sea ice may have localized effects on site-specific distributions, broad-area distributions of bowhead whales in the central Alaskan Beaufort Sea apparently are related to overall sea ice severity.

A recently initiated effort to document the movements and migratory behavior of bowhead whales using satellite tagging began in 2004 as an MMS/UAF CMI project designed to study the feasibility of direct involvement of Native hunters in the deployment of the tags. In 2005, MMS funded the Alaska Department of Fish and Game to coordinate a five-year effort to tag bowheads, with extensive involvement of whale hunters from villages along the migratory route of the bowhead whale from Kaktovik to Savoonga, Alaska.

Ringed seals are the primary prey of polar bears and also a significant source of food for Natives living in the Arctic. A recently completed MMS/UAF CMI project focused on the timing and reinterpretation of ringed seal surveys as a follow-on to a previous study that developed correction factors for ringed seal surveys in northern Alaska. Sixty ringed seals had been monitored with radio-transmitters. The proportion of seals visible during aerial surveys was found to vary as a function of snow conditions on the surface of shorefast ice. A correction factor has been developed, and density estimates derived from previous surveys are now being reanalyzed.



Male king eider with an internal satellite transmitter.

Harbor seals are another important subsistence species that is abundant in the Gulf of Alaska region, including Cook Inlet. In 2003, the MMS funded two new studies of harbor seals conducted by the National Marine Fisheries Service, National Marine Mammal Laboratory. The first of these supported repeated, seasonal aircraft surveys of seals at haulouts to characterize the distribution and abundance of harbor seals in Cook Inlet, with an emphasis on the seasonal variability in relation to key life history events. The second study uses remote cameras to observe variations in haulout patterns at selected haulouts. This study will provide insight into sources of variation in observations by the aircraft surveys. In 2004, the MMS funded a related study, Movements and Habitat Use of Harbor Seals in Cook Inlet, that employs satellite tags to study individual harbor seals. This suite of studies is expected to provide comprehensive information for evaluating the potential effects of oil and gas development on the Cook Inlet population.

Another marine mammal study was funded by the MMS through an Interagency Agreement with the U.S. Fish and Wildlife Service. The study, Demography and Behavior of Polar Bears Feeding on Stranded Marine Mammal Carcasses, began in 2002 and focused on polar bear use of bowhead bone piles left by Native whale hunters near the village of Kaktovik (in the Arctic National Wildlife Refuge) and near a traditional subsistence whale hunting camp on Cross Island (near Prudhoe Bay). Increasing numbers of bears have aggregated and fed on whale remains at these locations. This study is yielding important new data on the patterns of use of these sites by individual bears and on other bear behaviors and will be useful for providing better estimates of bear mortality.

Seabirds. Eiders (a group of sea ducks) are harvested for subsistence by Alaska Natives, who have expressed concerns that the abundance of four species living in the Alaskan Arctic may be declining. From 2001 to 2003, the MMS funded

five research projects through the MMS/UAF CMI that study the population biology of eiders and the potential risk of effects from offshore oil and gas development. A new study of king eiders discovered that king eiders staged (the duration varied by sex) in the Beaufort Sea before migrating south-southwest to molt along the Chukotka and Kamchatka Peninsulas and Mechimegan, Karagin, and Anadyr Bays in Russia and in U.S. waters off St. Lawrence Island and the Alaska Peninsula. Marked king eiders with functioning transmitters

Scientist placing a temperature datalogger in a king eider nest at the Kuparuk oilfield.

wintered along the Chukotka and Kamchatka Peninsulas in Russia and in Kvichak and Togiak Bays and along the Alaska Peninsula in U.S. waters.

A multiyear study of the breeding biology and habitat use of king and common eiders on the coastal plain of northern Alaska examined and compared timing of nesting, clutch size, reproductive success, and habitat use between a relatively undisturbed site at Teshekpuk Lake (in the National Petroleum Reserve–Alaska) and an area with considerable activity in the Kuparuk oilfield (2002–2004). The number of monitored nests varied by year and area, with 37–44 and 31–42 nests monitored each year at Teshekpuk and Kuparuk, respectively. Apparent nest success each year ranged from about 18–33% and 26–43% at Teshekpuk and Kuparuk, respectively. Incubation constancy was high (95–98%) for female king eiders at both sites, though incubation behavior appeared to differ. Nest site selection apparently differed for females nesting at the two study sites.

Another study, King and Common Eider Migrations Past Point Barrow, repeated migration counts of king and common eiders during the spring and fall (2002 and 2003), similar to surveys conducted periodically for several decades. The results of previous surveys suggested that populations of king and common eiders had declined by about 50% between 1976 and 1996. Preliminary results of this study indicate differential peaks in migration chronology for king and common eiders, at least in the fall. In addition, there appeared to be variation in the timing of fall migration relative to sex and age for a given species. Estimates of passage for king eiders suggest that this population may no longer be declining and may have actually increased since 1996. In related research, stable isotopes were used to analyze marine versus freshwater "signatures" from feathers collected from eiders (largely from subsistence hunters at Barrow) during 2003 and 2004. During wing molt, there appeared to be sex-specific differences, with female diets coming from both marine and freshwater habitats, while male diets were largely derived from marine habitats. The third study, Population Structure of Common Eiders Nesting on Coastal Barrier Islands Adjacent to Oil Facilities in the Beaufort Sea, was designed to use molecular genetic markers to examine the level of population structuring among common eiders breeding on coastal barrier islands along the Beaufort Sea coastline. The results of this study indicate that common eiders breeding on the North Slope of Alaska are genetically distinct from other eider breeding groups. It appears that common eiders were historically subdivided into two refugia during the last Pleistocene glaciation and that North Slope common eiders may have been colonized from a different refugium than eiders elsewhere in North America and Scandinavia. In addition, because of the high fidelity of females and young to nesting areas, gene flow appears to be largely mediated by males.

A study of the foraging ecology of common ravens on Alaska's coastal plain was initiated during 2003. This study is expected to provide information on the predator–prey relationships between ravens and waterfowl breeding near the industrial areas of Arctic Alaska. Among the questions this study is addressing is whether industrial infrastructure is advantageous to ravens and the extent to which proximity to such infrastructure

Common raven nest at the Kuparuk oilfield.

increases raven depredation of eider nests and ducklings. During the spring and summer of 2004, 10 adult breeding ravens were captured and fitted with transmitters to document their home range size and movements in and around Kuparuk and Prudhoe Bay. In addition, 17 nests (7 at Kuparuk, 10 at Prudhoe Bay) were monitored to determine nest site selection, nest success, and number of young fledged; some fledglings were color-marked to document dispersal, movements, and fidelity. Pellets were collected in the vicinity of nest sites to determine diet. Additional data were also collected during the spring and summer of 2005, and these data are being analyzed.

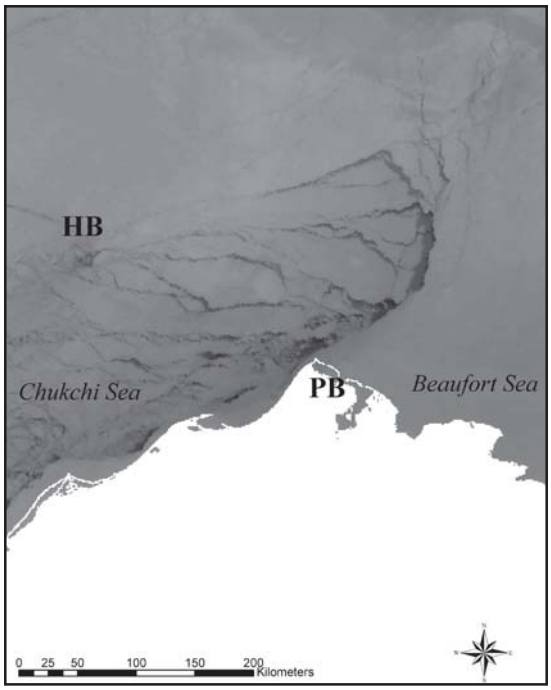
Physical Oceanography

The study entitled Synthesis and Collection of Meteorological Data in the Nearshore Beaufort Sea has collected over four and half years of meteorological data from five stations along the central Beaufort Sea coast. A project web site (www.resdat.com/mms) provides up-to-date project information, station locations, pictures, data downloads, and quarterly graphical data results. When completed, this study will provide a time series of wind data from January 2001 through September 2006. The wind data have been used to compare coastal and offshore winds along the central Beaufort Sea coast to surface current data collected from high-frequency Doppler radar and sub-surface current information collected with acoustic Doppler current profiler meters. MMS will continue to collect data from these stations through September 30, 2006.

During the summer of 2005, researchers from the Geophysical Institute at the University of Alaska Fairbanks stationed two high-frequency Doppler radars (CODAR) at BP Exploration, Alaska oil fields at Endicott and West Dock located along the Beaufort Sea coast for radar mapping of the surface circulation in Alaska coastal waters. Surface current measurements were transmitted in near real time to a central web site at the University of Alaska Fairbanks http://www.ims.uaf.edu/salmon/CIBS-MAP/index.htm. From June through the middle of October, two CODAR systems collected surface current speed and direction measurements over approximately 5000 square kilometers. The 12- and 25-MHz CODAR systems collected surface current data in open water and mixed ice conditions in front of the remnant landfast ice (June and July), in mixed ice conditions during breakup of the inner shelf ice (July and August), and out to 80 km during open water conditions (September and early October). Preliminary results indicate that the surface current measurements correlated well with wind measurements collected from the local MMS meteorological stations, although local changes in bathymetry and other variables may have also played a role in steering the surface currents offshore. These data are being analyzed. A second season along the Beaufort Sea coast is planned for the summer and fall of 2006. This project was undertaken as a collaborative effort with NOAA through the National Oceanographic Partnership Program.

Researchers from the Geophysical Institute at the University of Alaska Fairbanks processed and interpreted over 10 years of Radarsat synthetic aperture radar (SAR) and advanced very high resolution radiometer (AVHRR) data to map and document changes in the spatial and temporal distribution of recurring lead systems and landfast ice off the coast of northern Alaska in the Chukchi Sea between Wainwright and Barrow and the Beaufort Sea between Barrow and the Mackenzie River Delta. One conclusion was that major lead patterns and landfast ice extents were found to recur from year to year. These patterns are controlled to a large extent by a combination of topo-

MMS Cottle Island Meteorological Station, summer 2002.



Leads converging to grounded ice on Hanna Bank (HB) in the Chukchi Sea, Alaska, April 8, 1994. PB is Point Barrow, Alaska. The dark spot at Hanna Bank is open water or thin ice on the "downstream" side of the grounded ice.

graphic (bathymetric) constraints, atmospheric forcing, and large-scale ice dynamics.

Three MMS/UAF CMI oceanographic studies completed four of six years of planned effort, including the first successful winter-long measurements of currents directly under the ice at three locations from Camden Bay to Smith Bay in the nearshore Beaufort Sea. Three upward-looking acoustic Doppler current profilers were moored on the sea bottom to profile the entire water column. They have collected data on water and ice velocity, temperature, salinity, and water clarity (transmissivity) from August 1999 to August 2002 and from August 2004 to August 2005. Once landfast ice formed and blocked the wind, current speeds dropped drastically, with less than 1% of current speeds exceeding 20 cm/s. The most recent study, Beaufort Sea Nearshore Currents, will continue to deploy three similar moorings for two additional years.

A MMS/UAF CMI study entitled Sea-Ice-Ocean-Oil Spill Modeling System (SIOMS) for the Nearshore Beaufort and Chukchi Seas: Improvement and Parameterization continues the development of a new 3-D coupled ice-ocean model with links to a regional mesoscale atmospheric model. The resolution of the model is being increased to 1 km or less to resolve coastal barrier islands. This model will be used by the MMS to improve oil spill risk analysis.

Two other modeling efforts are proceeding in parallel to help advance the state of the art in ice modeling. The MMS/CRREL Simulation of Landfast Sea Ice along the Alaska Coast study focuses on seasonal development of the extensive landfast ice zone along the Beaufort Sea coast, including breakout events. A new study, Basin Scale Model of Sea Ice Dynamics, is developing a state-of-the-art ice model that will include deformation on discontinuities and anisotropic failure to better describe the behavior of pack ice. This is a collaborative project with NASA on oriented fracture patterns and frazil/pancake ice formation.

Another MMS/CMI effort to collect monthly in situ measurements of boundary conditions in lower Cook Inlet is ongoing. The results of this study, along with recently concluded in situ measurements to characterize hydrographic effects on salinity and temperatures and the effects of diurnal and semidiurnal tidal cycles, will improve the results of oceanographic modeling for Cook Inlet.

Fate and Effects

The MMS study Empirical Weathering Properties of Oil in Snow and Ice is examining the behavior in snow and ice of a range of Arctic Alaska crudes in small-scale and OHMSETT-scale experiments. Included are spreading over and under ice and snow, spreading through broken ice, migration through brine channels, and evaporation at very low temperatures, all for low- and high-pour-point crudes. The primary purposes are to improve our understanding of how specific crude properties affect oil behavior and weathering in Arctic conditions and to develop better Arctic algorithms for oil weathering models. The MMS is investigating oil spill occurrence estimators for Arctic conditions through a study called Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi OCS, Statistical Approach and a parallel series of fault-tree studies, most recently Alternative Oil Spill Estimators for the Beaufort and Chukchi Sea, and Updates to Fault Tree Approach to Oil Spill Occurrence Estimators for the Chukchi and Beaufort Sea Planning Areas. These studies address differences in potential spill causes in these Arctic areas compared to elsewhere in the U.S. OCS, primarily the Gulf of Mexico.

Marine Fish

Arctic cisco, a whitefish especially important for subsistence by Nuiqsut residents, are shared with other villages throughout the region. Recent low subsistence catches have raised concern about the possible causes of the variable catches. An ongoing study, begun after a 2003 workshop

of scientists and local elders, is collating and evaluating existing fisheries oceanography information to answer many of the questions raised and to suggest the most important information to collect in the future. The current study also emphasizes methods to integrate information through the joint efforts of local experts and scientists. This information will have increasing importance as oil and gas resources are developed in the Beaufort Sea.

Arctic cisco caught in a subsistence net that had been set under the ice in the Colville River, Alaska.

Very little documentation exists on the actual locations of overwintering habitat of Beaufort Sea anadromous fish. The potential of remote sensing applications, such as synthetic aperture radar, is being investigated as a means to locate and evaluate overwintering habitats. An effort to quantify inter-annual variation in winter abundances and to estimate which environmental factors contribute to observed variation will help minimize or avoid potential effects of offshore development on anadromous species.

Drift gillnetter in Cook Inlet, Alaska.

Socioeconomics

MMS environmental research in Alaska has included social and economic studies relating to the potential effects of offshore oil and gas development since the program's inception. Because of the distinctive nature of subsistence activities and socio-cultural attributes throughout rural villages and coastal communities in Alaska, MMS social research goes well beyond conventional economic considerations.

MMS initiated a study in 2001 to describe the potential impacts of OCS activities on bowhead whale hunting and subsistence activities in the Beaufort Sea. The study, to be completed in 2006, focuses on Native perceptions of the acute and cumulative effects of oil industry operations on bowhead whale hunting. The study has collected information from residents of Nuiqsut, Kaktovik, Barrow, and Savoonga through survey instruments and considers both beneficial and detrimental potential effects.

Another socioeconomic project has developed and will implement a GIS mapping system to describe subsistence hunting and fishing activities for Nuiqsut, Kaktovik, and Barrow for bowhead whales, ringed seals, caribou, Arctic cisco, broad whitefish, Arctic char, and various waterfowl. The project focuses on describing contemporary subsistence patterns while accommodating the addition of past and future harvest data to enable the analysis of pattern changes over time. A sample of hunters in each community has been selected using systematic social networking methods. In addition, the project is documenting the location of harvest campsites and travel routes.

In Cook Inlet, the prospect of OCS oil and gas development has the potential for spatial conflict with local fishing operations, especially the commercial driftnet fishery. Drift gillnet fishermen often focus their efforts near turbulent rip tides because salmon are known to concentrate in these areas. The presence of an oil platform in favorable fishing areas could pose a navigational hazard, with potential consequences of diminished access, loss of harvest resulting from premature net release, or gear entanglement. A study completed in 2004 determined that:

- Navigational challenges and spatial conflicts may be avoided through strategic planning on the part of the oil and gas industry and its regulators.
- Many problems for the drift gillnet fleet potentially associated with prospective drilling on the OCS can be mitigated.

Stern section of the Selendang Ayu, *December 2005.*

- The salience of the issue of interaction between the fishery and the oil and gas industry is in reality overshadowed by a host of economic and social challenges confronting the drift fleet.

On Kodiak Island, a study began in 2003 to collect and analyze data on the socio-economic consequences of the *Exxon Valdez* oil spill litigation settlement for local residents. The project will investigate and document key secondary social and economic impacts from the litigation and settlement experiences that followed the primary impacts of the original spill event. It will also attempt to formulate general recommendations pertaining to the effective management of potential future oil spills and related litigation settlement procedures. The study was modified in 2005 to include a longitudinal analysis of the accidental grounding, spill, and potential litigation of the M/V *Selendang Ayu* along the Bering Sea coastline of Unalaska Island.

A study entitled "North Slope Economy, 1965 to 2005" is analyzing local government revenues and expenditures, including capital projects of coastal communities (both prior to and after the formation of the North Slope Borough), as well as property tax and other fiscal categories that merit analysis. The study:

- Classifies local government services by departments and other major categories;
- Describes how the revenues and expenditures have been a component and shaping force of the local economy;
- Describes the structure of the economy, including employment, income, and their fluctuations;
- Describes how quantifiable, non-cash economic factors for households have changed from 1965 to 2005 in relation to the greater availability of salaried jobs;
- Describes the role of the Arctic Slope Regional Corporation, the Ukpeagvik Inupiat Corporation, and other village for-profit corporations in the economy; and
- Describes how individual and household economies have responded to changes in the regional economy.

Some of the empirical measures include income and changes in quality of life such as housing and sewer and water facilities. The final report was published in April 2006.

In 2005, MMS began the process of working cooperatively through the Cooperative Ecosystem Studies Units (CESU) Network to initiate a new social research study to provide an empirical basis from which to quantify food sharing behaviors and to assess the plausibility of hypothetical associations between regional oil development

activities and changes in distribution or consumption of subsistence resources over time and geographic space. This is necessary because existing subsistence harvest data may be insufficient to assess the impact of potential disruptions.

Based on the extensive social research in Alaska and the substantial information accumulated over 30 years, MMS will soon publish a book that will enhance the accessibility of research products and summary findings for all interested parties. Currently under review for publication, the peer-reviewed book explains and synthesizes the results of more than 200 MMS-funded studies.

Environmental Research Monitoring

The Alaska OCS Region has collected baseline monitoring data in the vicinity of the Liberty Prospect and Northstar since 1999, as part of the ANIMIDA (Arctic Nearshore Impact Monitoring in the Development Area) study and its continuation, cANIMIDA. Designed to provide long-term continuity beyond what could be expected through industry-sponsored studies alone, ANIMIDA and cANIMIDA study:

- Partitioning of contaminants between dissolved and particulate water phases;
- Trace metals, hydrocarbons, and biomarkers in fish;
- Effects on kelp in the Boulder Patch (an area of Special Biological Concern); and
- Perceived effects on Native subsistence whaling.

BPXA put its plan for developing the Liberty Prospect on hold in January 2002; as of January 2006, it is pursuing options for development and production through directional drilling from onshore. Offshore development is still possible at this site or others in the central Beaufort Sea. Thus, the summer of 2007 will be the last field season for cANIMIDA until further developments occur.

An MMS/UAF CMI study recently examined and reported on the historical changes in trace metals and hydrocarbons in the inner shelf sediments of the Beaufort Sea. The study used a combination of dated sediment cores, freshly collected surface sediment, 30 years of prior analytical measurements by the investigator, and data from prior MMS Beaufort Sea monitoring projects. Of multiple metals, only vanadium and barium levels were possibly elevated in more recently collected and analyzed sediments. The levels of vanadium and barium found were still low, well below harmful levels. The hydrocarbon analyses primarily found natural compounds indicative of decayed marine plankton and peat from onshore. No petroleum signal was found. The study concluded that the near-shore Beaufort Sea has remained relatively clean as far as trace metals and hydrocarbons are concerned, despite the adjacent petroleum-related industrial activities over the past 30 years. A follow-up CMI study documents trace metals and hydrocarbons in sediments across the Beaufort Sea from Elson Lagoon near Barrow, to Prudhoe Bay, to Beaufort Lagoon in the eastern Alaska.

More information about the MMS Alaska OCS Region's ongoing environmental research monitoring projects can be obtained at http://www.mms.gov/envmonitoring/ResearchMonitoring.htm.

Information Management and Transfer

Studies within the Alaska program generally result in data and scientific peer-reviewed products derived from the analysis or summarization of data and expressed in reports published on paper or as electronic media. Most Environmental Studies Program (ESP) information is acquired by MMS through contracts, or other agreements, that support scientifically qualified entities to acquire, analyze, report, and archive relevant data. Organizations conducting oceanographic studies for MMS generally archive data at the National Oceanographic Data Center (NODC), in addition to any in-house systems they may have developed. MMS direct archival of some ESP-generated data is also accomplished within the MMS's centralized corporate database.

Reports and analyses resulting from studies supported by MMS are readily available from two sources. Copies of all MMS final reports by investigators are available at the Alaska Resources Library and Information Services (ARLIS). Another convenient source for hundreds of MMS final reports is the Environmental Studies Program Information System (ESPIS), which is easily accessed by the public through the ESP web site (http://www.gomr.mms.gov/homepg/espis/espisfront.asp). Additional information describing environmental studies in Alaska can be found at the MMS web site (http://www.mms.gov/alaska/ess/index.htm).

MMS Alaska OCS Region held its Tenth Information Transfer Meeting in Anchorage in March 2005. Principal investigators presented information on 43 ongoing studies in the Beaufort Sea, Chukchi Sea, and Cook Inlet regions. It was attended by a diverse audience drawn from local communities, industry, other Federal agencies, and state and local governments. Also, an Information

Update Meeting was convened by the MMS Alaska OCS Region in Barrow in March 2005. The MMS and officials of the North Slope Borough scheduled this meeting in Barrow so that residents would have better access to information on key MMS studies. Principal investigators presented information on 11 ongoing studies at the one-day event.

In 2004, the MMS Alaska OCS Region also sponsored an international workshop designed to produce recommendations regarding future Arctic Alaska hydrological modeling research needs. The MMS/UAF CMI workshop brought together international hydrological modelers and researchers to develop strategies to advance the state of the art in hydrological modeling.

Coordination and Cooperation

The Environmental Studies Program in Alaska carries out extensive coordination in the planning of research and conduct of ongoing studies. A major portion of the ESP in Alaska is conducted on a cooperative basis with the University of Alaska Fairbanks (UAF). In addition to funding CMI scientific research, a substantial portion of the MMS contribution supports education in Alaska by funding tuition and travel for UAF graduate-student research related to CMI projects.

The ESP in Alaska also coordinates with other U.S. and local research entities and has developed additional international linkages with other Arctic nations' research and regulatory entities. The U.S. and seven other Arctic nations voluntarily agreed to cooperate on an Arctic Environmental Protection Strategy (AEPS), which evolved into the formation of the Arctic Council in 1996. The ESP in Alaska maintains contacts and coordination with Arctic Council activities, such as the Arctic Monitoring and Assessment Program (AMAP), Conservation of Arctic Flora and Fauna (CAFF), Arctic Climate Impact Assessment (ACIA), and others. The ESP provides information to these working groups through review of reports and plans, and it helps to inform participants of available information sponsored by MMS. Further, specific studies that can coordinate and integrate with working group activities are identified and beneficial linkages facilitated.

The polar regions play a key role in our global environment. Many important broad and interlinked research challenges involving polar regions exist today. At its most fundamental level, the International Polar Year (IPY) 2007–2008 is a coordinated campaign of polar observations, research, and analysis that will be multi-disciplinary in scope and international in involvement. The IPY will use today's research tools to better understand the key roles of the polar regions in global processes. MMS has several proposed studies that are expected to dovetail with the IPY activities.

Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) conducts research in the Arctic to help accomplish its mission to conserve and manage migratory birds, threatened and endangered species, certain marine mammals, and anadromous fish, as well as all biota inhabiting nearly 77 million acres within 16 National Wildlife Refuges in Alaska.

	Funding (thousands)	
	FY 04	FY 05
Migratory Birds	3,550	3,490
Fisheries and Ecological Services	3,875	3,552
Marine Mammals	2,822	2,759
Refuges	8,761	8,494
Conserv. of Arctic Flora and Fauna	190	190
Total	19,198	18,485

Fisheries and Ecological Services

Fishery research in the Arctic by the FWS continues to focus on Yukon River salmon shared by the U.S. and Canada in support of the U.S.–Canada Yukon River Salmon Agreement. The FWS continues to implement enumeration techniques for Yukon River salmon to quantify abundance and to apply genetic stock identification techniques to assess genetic diversity and estimate the run timing of salmon stocks. These studies also generate data needed for in-season management of Yukon River salmon, including distinguishing those that are of Canadian origin. Research includes a mark–recapture study of fall chum salmon at Rapids/Rampart that uses video technology to determine the marked-to-unmarked ratio of these fish as well

as the catch-per-unit-effort for Chinook and fall chum salmon. To manage U.S. stocks of salmon, the FWS also uses resistance board weirs to enumerate summer chum and Chinook salmon on the Gisasa River and summer chum, Chinook, and coho salmon on the Andreafsky River. FWS also shares responsibility with an Alaskan Native nonprofit organization to operate a weir on Henshaw Creek to enumerate summer chum and Chinook salmon. Split-beam sonar is used to count fall chum salmon on the Chandalar River, and new imaging sonar is being tested to count Chinook in the same stream. The information from these monitoring studies is used to schedule fishery openings and ensure stock conservation on National Wildlife Refuges. Although salmon are extremely important to subsistence users and ecological productivity, the importance of other species is also becoming recognized.

Whitefish are used seasonally in areas with salmon fisheries and are used extensively in areas with no salmon runs. Studies indicate that whitefish in certain river systems are as abundant as salmon, and they may be critical to food webs and nutrient cycling. Radiotelemetry has identified important habitats and migration corridors of inconnu (sheefish), broad and humpback whitefish, and least cisco in several National Wildlife Refuges. Also, electron probe microchemistry has identified several anadromous stocks and indicates that these fish rival salmon in the distances traveled during their migration. These long-distance movements make these stocks vulnerable to fisheries as they travel to their spawning areas. In conjunction with physical movement studies, genetic work is being conducted to define the population structure of Alaskan whitefish, which will help to determine the geographical scale at which these species should be monitored and managed.

Fish stocks of Alaska's North Slope in the Arctic National Wildlife Refuge have also received attention recently. One study being conducted in the coastal lagoons near the village of Kaktovik is designed to determine the relative abundance of Arctic cisco and Dolly Varden. Catch-per-unit-effort, length frequencies, and length–weight relationships will be compared to baseline data collected on these species between 1988 and 1991. A second study is testing imaging sonar as a method for estimating the number of Dolly Varden that return to spawn in the Hulahula River. A third study is also testing the imaging sonar as a method for identifying unique habitats within the nearshore Beaufort Sea. These studies will provide valuable information to use for conserving these populations should the area be made available for oil and gas development.

Similar to whitefish, Dolly Varden is an important component of sport and subsistence fisheries and shows complex movement patterns between spawning and overwintering areas in fresh water and feeding areas in marine waters. Genetic data are being used to estimate the extent of reproductive isolation among Dolly Varden populations and to estimate the origin of Dolly Varden in overwintering areas. The data indicate that Dolly Varden return to natal streams to spawn; Dolly Varden overwintering in the Wulik River in Northwestern Alaska are a mixture of Dolly Varden originating from streams in Norton and Kotzebue sounds, but Dolly Varden overwintering in the Ivishak River, a tributary to the Sagavanirktok River on the North Slope, originate mainly from the Sagavanirktok River. These results show how Dolly Varden movement patterns vary across Arctic Alaska.

Environmental Contaminants

The FWS and its partners have actively pursued scientific studies and management solutions related to contaminants exposure in the Arctic for several decades. International research efforts such as the Arctic Monitoring and Assessment Program (AMAP) have shown that pollutants are both a circumpolar issue and a global issue. Highlights from FWS contaminants studies that were conducted or published during 2004–2005 are summarized below.

The Alaska breeding population of red-throated loons declined 53% from 1977 to 1993 and has since remained at a low level. Environmental contaminants specialists with the FWS served as co-investigators with the U.S. Geological Survey's Biological Resources Division (USGS-BRD) on an investigation to determine factors contributing to these declines in various parts of Alaska. Contaminant samples were obtained from eggs and whole blood from four Alaskan study areas: the Colville Delta on the North Slope; Cape Espenberg on the northern Seward Peninsula; the Yukon–Kuskokwim Delta; and the Copper River Delta. The study found that red-throated loons that nest in northern Alaska and winter in Asia have a different suite of contaminants, and greater body burdens, compared to other Alaska-nesting loons that winter along the Pacific coast of North America.

Although the direct toxic effects of large oil spills on sea ducks are relatively well understood,

the risk from low-level chronic oiling has received less attention. FWS biologists in the Environmental Contaminants Program served as co-investigators with the USGS-BRD on the effects of chronic oiling on sea ducks at Sand Point and Dutch Harbor, Alaska. Both Steller's eiders and harlequin ducks from industrialized areas such as Dutch Harbor show increased blood biomarker responses (indicating contaminant exposure) compared to other areas. Mussels and sediments from Dutch Harbor also exhibit greater contaminant concentrations than in other areas sampled. This project included collaboration with the FWS's Endangered Species program and the Alaska SeaLife Center (ASLC). Technical reports on the sea duck and red-throated loon studies will be completed in 2006.

Lead exposure from spent shot was identified as the primary contaminant concern for threatened eiders and other declining waterfowl species in Alaska by investigations completed by the FWS in 2004. In 2005, management actions to address this problem included a renewed focus on reducing lead shot input into Alaska's environment, primarily through outreach activities such as community and school presentations, partnerships with communities to develop their own lead shot outreach programs, incorporation of lead shot messages into other regional outreach products (including subsistence hunting regulations), and steel shot clinics and law enforcement activities. Because the use of lead shot to hunt waterfowl and other food items has the potential to result in unhealthy exposure to lead, particularly in children, the FWS has worked with human health professionals to explore links between human health, bird health, and lead shot. The FWS's partners in this effort include the USGS's Alaska Science Center, the ASLC, the Alaska Native Tribal Health Consortium, and the Centers for Disease Control.

Environmental contaminants specialists with the FWS are investigating the presence of mercury in northern pike, a locally important subsistence food item. Northern pike from Alaska contain mercury concentrations that often exceed the Environmental Protection Agency's critical value for human consumption and the Food and Drug Administration's action level for human consumption of fish tissue. For example, in 1987, eight of nine northern pike from Nowitna National Wildlife Refuge (NWR) and six of nine in 1991 had mercury concentrations in tissues exceeding the EPA critical value. More recently, eight of nine northern pike examined from the Andreafsky River, a tributary on the lower Yukon River, had mercury concentrations in muscle that exceeded the higher FDA action level. Overall, mean mercury concentrations in northern pike from Alaska and Arctic Canada equal or exceed those from the lower 48 U.S. states. Existing information on mercury con-

Pacific walruses.

Netting for live capture of sea otters.

centrations in northern pike from Alaska is numerically and spatially depauperate. To address this lack of data, which FWS managers need when making subsistence management decisions, FWS biologists are conducting a multi-year, systematic sampling for mercury and methyl-mercury in northern pike on several National Wildlife Refuges in western and interior Alaska: Yukon Delta, Selawik, Koyukuk, Nowitna, Yukon Flats, and the Northern Unit of Innoko. This study was initiated in FY 2005 and will be completed in FY 2008.

Marine Mammals

Pacific Walruses. Research on Pacific walruses continues to focus on developing and implementing a range-wide population survey for this subspecies, monitoring haulouts in Bristol Bay, and monitoring the spring Alaska Native subsistence harvest to collect information on the size and demographics of the harvest. In 2003, based on results from preliminary studies conducted in 2002, the FWS initiated a study of the application of airborne thermal scanner techniques to determine Pacific walrus population estimates. A survey was conducted in the area north and south of Saint Lawrence Island, encompassing a traditional walrus wintering, breeding, and calving area. Favorable results from this survey as well as discussions with Russian colleagues at the Polar Research Institute of Marine Fisheries and Oceanography, where similar research on ice seals is being conducted, resulted in the FWS and USGS efforts to mount a range-wide population survey of Pacific walruses scheduled for spring 2006. The survey will provide the FWS with information on the current population of Pacific walruses.

The FWS, with the Alaska Department of Fish and Game, also began an analysis of the age structure and productivity of Pacific walruses harvested in the Bering Strait region from 1952 through 2002. This study, utilizing biological samples collected from Alaska Native subsistence harvests, examines whether the age structure and productivity of harvested animals has changed over time. The analysis should be completed in 2006.

Northern Sea Otters. The FWS continued survey efforts for northern sea otters in southwest Alaska, including the Near and Fox Island groups in the Aleutian chain, several islands along the Alaska Peninsula, and the Kodiak archipelago. These surveys have documented continued sea otter declines in the eastern Aleutians (48%), on Pavlof and Shumagin Islands (33%), and along Sutwick Island (68%) since 2001. In the Kodiak

archipelago, population estimates declined significantly between 1989 and 2001. In 2004, the FWS estimated the population along the Kodiak archipelago to be 6,284 sea otters, a result that was slightly, but not significantly, higher than the previous survey in 2001. The reasons for differences in population trend in the southwest Alaska area remain unclear, and further investigation is warranted. The FWS also collaborated with USGS on capture studies to monitor the health and condition of sea otter stocks. Analyses on health and condition are still pending.

Mortality studies, initiated in the winter of 2002 by the FWS in collaboration with the USGS, the ASLC, and Alaska Veterinary Pathology Services, are providing a baseline of, as well as an opportunity for, biomedical studies to establish the causes of mortality (other than hunting) for northern sea otters throughout Alaska. Prior to this effort there was little information available on mortality trends for northern sea otters. Since 2002 almost 100 otters have been studied by the program, most being prime-age adult males from the south-central population stock. Comprehensive necropsies, including histopathology and screening for protozoal, viral, and bacterial pathogens, provide information that can be compared to work being conducted in California with southern sea otters. Comparison of the cause of mortality in the northern and southern populations will allow sea otter researchers to better monitor patterns and changes in disease risks affecting these populations. The leading causes of death for Alaska sea otters are trauma and cardiac disease. The primary source of carcasses has been local volunteers who were trained by the FWS, NOAA Fisheries, and the ASLC to participate in a marine mammal stranding network in Alaska. The first training was held in Homer, Alaska, in 2004, and another is planned for Kodiak, Alaska, in 2005. Additional funding for this project came from the Oiled Wildlife Care Network and the Minnesota Zoo.

On February 11, 2004, the FWS proposed listing the southwest Alaska Distinct Population Segment (DPS) of the northern sea otter as threatened under the Endangered Species Act. This determination was based on range-wide population surveys that indicated dramatic declines throughout much of the population stock. A 120-day public comment period ended on June 10, 2004. The FWS reviewed the comments received, as well as other available information, and on August 9, 2005, made a decision to list this DPS of the northern sea otter as threatened pursuant to section 4 of the Endangered Species Act. The listing took effect on September 8, 2005, and the FWS is currently preparing a recovery outline.

Polar Bears. In 2000–2005, the FWS conducted weekly aerial surveys for polar bears along the coastline and barrier islands of the Beaufort Sea during the open water period (September and October). An increasing number of polar bears have been observed during the fall months along the Beaufort Sea coast of Alaska in recent years, particularly around human settlements. The purpose of the surveys is to monitor the distribution and abundance of polar bears along the coast to better understand the importance of coastal habitat to polar bears, as well as to assess the potential impacts of climate change and offshore oil exploration, development, and production activities on polar bears.

The number of observations varied considerably among years, with the greatest number of observations in the fall of 2004 (five surveys, 405 observations). Regression analysis of bear sightings indicates that there is a significant relationship between the number of bears on shore and the distance to pack ice. As the distance to the ice increased, the number of bears near the shore increased; conversely, as ice advanced near shore, the numbers of bears decreased. In other words, more bears used coastal habitat during years when the pack ice remained farther offshore for extended periods of time. Adult females with dependent young comprised the majority (49%) of bears observed in all years. The survey results for 2000–2005 also indicate that 71% (1,100 of 1,547) of all bears observed were within 30 km of the Native village of Kaktovik, on Barter Island.

In 2002–2004, the FWS, with support from the Minerals Management Service, the Alaska Nanuuq Commission, the North Slope Borough, and the villages of Kaktovik and Nuiqsut, conducted a ground-based study on polar bears at Barter and Cross Islands during the fall, open water period. These areas were selected because of the annual presence of hunter-harvested bowhead whale carcasses, which apparently attract relatively large numbers of bears. The objectives of the study were to determine the number, sex, age, and activity patterns of polar bears using Barter and Cross Islands during the fall, open water period.

A total of 1,230 hours of observations were conducted in 2002–2004. A range of 0–65 polar bears were observed each year at Barter Island, with a three-year mean of 33.1 bears. At Cross Island, a range of 0–13 bears were observed, with

a three-year mean of 6.1 bears. At the bowhead whale carcass feeding sites at Barter and Cross Islands, the three-year mean was 4.9 and 2.8, respectively. All age/sex classes used the feeding sites at both islands. The majority of bear use at Barter Island was by bears in family groups (47%); at Cross Island, it was by single adult bears (66%).

Polar bear.

Overall, polar bears were primarily inactive during day, with activity levels (particularly feeding) increasing with the onset of darkness. Frequently, all age/sex classes of polar bears were observed feeding simultaneously in close proximity to each other, with relatively little time spent in aggressive interactions. When aggressive interactions did occur, they tended to be initiated by mothers accompanied by dependent cubs. Interestingly, 8–12 brown bears also used the Barter Island carcass feeding site, often displacing polar bears that were already feeding there. The study was continued at Barter Island in 2005, with an added component of documenting bear–bear and bear–human interactions.

A study on the use of trained dogs to verify polar bear den occupancy was conducted in 2002. The purpose of the "dog verification study" was to determine whether trained, air-scenting dogs could verify the locations of known or suspected polar bear dens. Preliminary results from 2002 indicate that the use of dogs, particularly in combination with forward-looking infrared technology (FLIR), can be considered a viable technique to help minimize the impacts from oil and gas industry activities on denning polar bears. Since then, the FWS, in cooperation with Alaska Department of Fish and Game brown bear biologists, has continued to use trained dogs opportunistically to locate and verify dens in areas where oil and gas activities occur.

Threatened and Endangered Species

Spectacled and Steller's Eiders. Virtually the entire Pacific population of Steller's eider (both Russia-breeding population and the threatened Alaska-breeding population) molts and winters in the nearshore waters of southwestern Alaska. This population is estimated at roughly 100,000 individuals and, based on annual aerial surveys, appears to have been declining at 3.8% annually over the last 13 years. The Alaska-breeding population includes, at most, 2,500 individuals. In 2004 and 2005, the FWS continued to participate with the North Slope Borough in a long-term study of Steller's eiders nesting near Barrow. The study documents their abundance and distribution and the primary influences on their survival and reproduction. Nesting effort and success of Steller's eiders vary tremendously from year to year; 2005 was the first year since 2000 in which nesting was observed. Predation is considered to be the main cause of Steller's eider nest failure near Barrow. In 2005, this study included foot and aerial surveys, video monitoring of nests to identify avian predators responsible for egg loss, removal of arctic foxes from the study area, marking of females at hatch with VHS transmitters to measure brood success, and collaborative efforts with the ASLC to develop artificial incubation techniques. In preparation for potential re-introduction efforts, FWS and ASLC salvaged eggs to begin a captive flock of birds with a known geographic origin.

Spectacled eider populations on the Yukon Delta National Wildlife Refuge (YDNWR) declined more than 90% from the 1970s until they were listed as threatened in 1993. Probable reasons for the decline include subsistence harvest and lead poisoning due to the ingestion of spent lead shot. Education efforts on these issues have been intense over the past decade. An annual nest plot survey on YDNWR indicated that the nest population in 2005 was the highest in 17 years. A long-term study on productivity and annual survival continued on Kigigak Island, YDNWR; ongoing analyses will provide information on current sources of mortality.

Satellite telemetry has confirmed that Alaska-breeding individuals of both Steller's and spectacled eiders spend part of their annual cycle (molt or pre-molt staging) in northeast Russia. Recognizing that effective wildlife conservation efforts

must reach across the border, the FWS has sponsored several projects in northeast Russia. In 2004 and 2005, the FWS continued to support a nesting biology and survival study of spectacled eiders in the Chaun River Delta, Chukotka, initiated in 2003. The goal of this project, in concert with the study on YDNWR described above, is to compare the productivity and survival of spectacled eiders in Russia and Alaska. The FWS also continued to sponsor subsistence harvest surveys in villages in the Yakutia and Chukotka regions in 2004 and 2005. Results indicate that hunting pressure on eiders is variable among villages, but high in some areas, and that local knowledge of waterfowl conservation issues, such as the effects of lead shot, is very low.

In 2004 and 2005, the FWS continued to support eider research at the ASLC, including reproductive studies; nutrition, physiology and biomarker development studies; immunology and disease ecology studies; and contaminant, endocrine, and immune studies. FWS also supported a Steller's eider banding project to estimate annual survival, a project to monitor blood lead levels in both species, and satellite telemetry studies of Steller's eiders and glaucous gulls (potential predators of Steller's eider nests) to determine annual movement patterns.

Short-tailed albatrosses. Once numbering in the millions, the short-tailed albatross was driven to the brink of extinction by feather hunters. Today, about 2,000 individuals exist, and they nest on only two islands in the western Pacific. Japan's Torishima Island, home to 80% of the world population, is an active volcano, with the albatross colony located in the caldera's fluvial outwash plain. Japanese attempts to establish an additional albatross colony at a safer location on Torishima appear to be achieving success, after more than 10 years. In December 2005, there were 15 nests, each with an egg, at this artificial colony site.

The short-tailed albatross is listed as endangered throughout its range. Since 1990 there have been five documented takes of this endangered seabird in Alaska's longline fisheries. Recently the FWS has undertaken, funded, and cooperated in a number of projects aimed at understanding the birds' movements and threats. As a joint conservation initiative, the FWS and Japanese Ministry of Environment began a satellite tracking study of post-breeding short-tailed albatrosses in 2001. Since 2001, tracks lasting between 50 and 140 days have been obtained from 17 albatrosses, for a total of over 6,000 at-sea locations. In an effort to further define where short-tailed albatrosses are foraging, the FWS undertook a study to track adult and sub-adult birds at sea. All of these data will be used in conjunction with oceanographic data (collected via satellite remote sensing) and fishing effort and bycatch data to identify important marine habitats for the short-tailed albatross and environmental factors that affect their potential interaction with longline fishing fleets.

Previous studies conducted by the Washington Sea Grant Program indicated that paired streamer lines, towed behind longline fishing vessels, are very effective at reducing seabird attacks on bait (thus reducing potential bird hookings and drownings). Current research will help determine whether proposed streamer line performance standards are appropriate for small vessels and on vessels using snap-on gear. Additionally the FWS is funding Washington Sea Grant to study whether integrated-weight groundlines, with their faster sink rates, are effective in reducing seabird bycatch by the longline fishery.

The draft short-tailed albatross recovery plan was recently released, and a final plan should be available in 2006. One of the primary criteria for recovery of the short-tailed albatross is the establishment of an additional breeding colony or colonies on "safe" (non-volcanic) island locations. Joint Japan–U.S. plans are underway to initiate a new breeding colony, through both passive attraction of breeding birds and active translocation of older chicks, at a location in the Bonin Islands, some 300 miles south of Torishima.

National Wildlife Refuges

The National Wildlife Refuge system in Alaska encompasses 16 refuges and approximately 77 million acres. The staff of each refuge conducts a variety of research, monitoring, and inventorying studies, ranging from long-term ecological monitoring to more narrowly focused intensive studies of specific plant, fish, and wildlife species. Research highlights are included for several refuges in Arctic Alaska.

Arctic National Wildlife Refuge

Muskoxen were extirpated from Alaska in the late 1800s. The species was re-introduced to its former range within the Arctic National Wildlife Refuge in 1969–1970. In April 2005, about 350 muskoxen were estimated to be present in the total population, with approximately 50 in the refuge; this is down from nearly 370 in 1986. Low calf

Bull muskox on the coastal plain of the Arctic National Wildlife Refuge.

recruitment, increased adult mortalities, and shifts in distribution have caused a decline of muskoxen in the refuge. Calf production and adult survival were likely affected by severe winter weather conditions that reduced the availability of winter forage and increased energetic costs. Predation may have also played a role. Since 1998, several incidents of grizzly bear predation have been documented. Predation events may cause abandonment of calves, fracturing of groups, and shifts in distribution. The NWS is currently monitoring radiocollared muskoxen. In addition, they are cooperating with the Alaska Department of Fish and Game to study predator–prey relationships. Researchers are using stable isotope analysis of hair and serum samples collected from grizzly bears over the last 30 years to examine whether bear diets have shifted. Four grizzly bears will be outfitted with satellite collars in late winter 2006. Their daily movements will be tracked to document predation events and other resource use.

Seismic exploration was conducted on the coastal plain of the Arctic National Wildlife Refuge during the winters of 1984 and 1985. The coastal plain has rolling to level topography, with tundra plant communities underlain by continuous permafrost. Exploration occurred along 2000 km of seismic line traversed by tracked vehicles with low ground pressure. At least 2000 km of additional trails were created adjacent to the seismic lines by D-7 Caterpillar tractors pulling ski-mounted trailers between camps. In the summer of 1984, the FWS initiated a long-term monitoring program to document the initial vegetation and soil disturbance and to track natural recovery. There was significant recovery over an 18-year period for deciduous shrubs, forbs, and lichens but not for mosses. The response to disturbance was more complex for evergreen shrubs, which recovered well in some vegetation types but not in others, and for graminoids, for which the response depended on the severity of the initial disturbance. The greatest disturbance persisted where vehicle traffic had broken the insulating vegetative mat, allowing warming of the soil. This caused the subsurface ice to melt and the trail to subside into a trough. At these sites the vegetation in the trough had more sedges and fewer shrubs than the surrounding tundra.

Selawik National Wildlife Refuge

The terrestrial and wetland ecosystems of Selawik NWR form a significant and diverse landscape where the boreal forest of interior Alaska meets the Arctic tundra. Vegetation ecologists from the FWS and the University of California at Davis carried out an ecosystem field survey of the refuge to establish a hierarchical classification of plant communities and gather location-specific baseline data for representative sites that are important correlates of biological productivity. This is the first quantitative vegetation study of the refuge that includes vascular plants as well as lichens and mosses. The specific objectives of this study are to:

- Record the floristic composition and structure of plant communities present in the variety of

Repeat photographs of a study plot on a winter seismic exploration trail on the coastal plain of the Arctic National Wildlife Refuge. Scuffing and crushing of vegetation and compression of soil were evident in 1984, the summer following disturbance (top). By 2002, a network of sedge-filled troughs had developed where melting ice wedges caused ground subsidence (bottom).

Hockley Hills, Selawik National Wildlife Refuge. The foreground shows an alpine tundra fellfield on a rounded mountain summit. White spruce woodlands occur on lower and middle mountain slopes; these grade into alder shrublands on upper slopes.

major vegetation types spanning elevational gradients from lowlands to alpine;

- Classify the plant communities into community types on an ecosystem basis;
- Record bryophyte, lichen, and vascular plant diversity within individual plant communities; and
- Document plant species distribution and correlate this with gradients in the environment, including landform, substrate type, elevation, soil chemistry, and permafrost depth.

One hundred fifty nine plots, of which 30% are permanent, were used to document the major vegetation types of the refuge. These types included alpine tundra, low-elevation tundra, upland forests and woodlands, lowland forests and woodlands, riparian forests and shrublands, and aquatic and semi-aquatic vegetation. Should the biota change through climatic modification or other circumstances, comparisons can be made through time to show the explicit biological consequences of this change.

The Selawik NWR and the Fairbanks Fish and Wildlife Field Office collaborated to identify seasonal migrations and important habitats of humpback and broad whitefish using radio-tagged fish in the Selawik River drainage. Whitefish are a key subsistence resource in the Kotzebue Sound region. Preliminary data from radio-tagged fish suggest that broad whitefish found in the Selawik River delta come from Kobuk River spawning stocks, and humpback whitefish appear to spawn in several locations within the Selawik River drainage. As in 2004, no radio-tagged fish were reported captured by Selawik or other Kotzebue region village residents in 2005. Since many people are fishing and thousands of fish are captured each season, these data suggest that there is an abundance of fish in the system. Refuge and fisheries office staff will continue to monitor the 2005 transmitters for two to three years, allowing an assessment of spawning frequency and long-term habitat fidelity.

Another study is establishing an abundance estimate of spawning inconnu (sheefish) in the Selawik River approximately 10 years after a similar study was conducted on the same population. A fall and winter mixed-stock fishery in Hotham Inlet and Selawik Lake impacts Kobuk and Selawik River inconnu. The fall and winter harvests totaling 20,000 inconnu from the Kotzebue area are substantial compared to annual spawning aggregates that were found in the Kobuk River (30,000 fish) and the Selawik River (less than 6,000 fish) in the mid-1990s. From early July through mid-August 2005, fishery biologists captured 627 inconnu and marked them with Floy anchor tags. During the subsequent recapture event, they captured 1,243 inconnu, including 16 tagged fish. The preliminary estimate of spawning inconnu in the Selawik River is 46,472 fish. This estimate is substantially higher than the previous estimates generated from similar mark–recapture statistical methods (5,190 fish in 1995, 5,157 fish in 1996, and a preliminary estimate of 23,480 fish in 2004). In a concurrent study, 31 radio transmitters were implanted in pre-spawning inconnu. These transmitters were intended to confirm spawning area locations and measure inconnu spawning periodicity. Also, a major proportion of the radio-marked inconnu migrated from the marking event area to the spawning area and provided preliminary validation that inconnu marked with Floy tags were meeting the conditions of the mark–recapture assumptions.

Biologist implanting sheefish with a radio transmitter.

Flagged bar-tailed godwit banded on Yukon Delta National Wildlife Refuge.

Yukon Delta National Wildlife Refuge

Each fall, tens of thousands of bar-tailed godwits migrate from the coast of western Alaska to Australia and New Zealand. This 11,000-km flight is apparently the longest non-stop bird migration in the world. Since 1999, refuge biologists have studied flocks of godwits staging along the coast of the Yukon–Kuskokwim Delta. The proportion of juveniles in the fall staging flocks has been consistently low, exceeding 3% only once in six years. A population model recently developed in collaboration with the USGS to assess the impact of chronically low productivity indicated a population declining at 9% per year. A joint FWS–USGS survey of the staging grounds in fall 2005 corroborated the model results. Only about 42,000 godwits were counted, down from 94,000 in 1997. In 2004, the refuge initiated a study of the godwit's breeding ecology to elucidate potential causes of the low productivity. Among 27 nests located in the main study area in 2004 and 2005, no eggs hatched. Future field work aims to determine if poor nesting success is a local or regional phenomenon.

The Kwethluk River was selected as one of the "observatory rivers" in a suite of many that circle the Pacific Rim as part of a ten-year project called the Salmon Rivers Observatory Network (SaRON). The Kwethluk annually averages returns of over 100,000 salmon. Food web dynamics are being evaluated in the context of this source of marine-derived carbon, nitrogen, and phosphorus subsidies to the various habitats that characterize these alluvial river systems. Data on hydrological, physical, and other biotic factors are also being collected in a temporally and spatially explicit way to evaluate their effects on salmon productivity and diversity. Innovative remote sensing techniques such as GPS-fitted acoustic doppler current meters used to interpolate high-resolution satellite imagery allow for detailed mapping of stream depth, veloc-

Complexity of habitats on the Kwethluk River, Yukon Delta National Wildlife Refuge.

ity, and temperature over large areas and at different stage heights. This allows researchers to model nutrient flux, thermal regimes, stream velocities, groundwater flow, and availability of habitats in three dimensions and through time in this complex ecosystem. Preliminary results indicate that springbrooks (isolated relic side channels) show the highest productivity and diversity for all salmon species studied. Springbrooks are recharged by groundwater, resulting in a more stable thermal regime, staying cooler in the summer and warmer in the winter. Turbidity is also significantly less and the percentage of canopy closure greater than in the main stem and side channels. Springbrooks also represent transitional zones between the aquatic and terrestrial ecosystems, sharing food web elements from both.

Although there is plentiful moose habitat in the lower Kuskowim River drainage, moose have been struggling to colonize this region for years, and population numbers remain low. The Lower Kuskokwim River Moose Project is designed to investigate how patterns of landscape factors and variables hinder or foster movement, habitat use, and colonization patterns. In April 2005, 25 moose were fitted with VHF and GPS transmitters. Resource selection models based on landcover maps and other datasets are being developed to help understand habitat use and movements. Population dynamics are being investigated by monitoring the reproduction and survival of collared moose, as well as by using standardized censuses. In 2006 the FWS will fit an additional 20–30 moose with radiotelemetry collars.

Moose captured at Yukon Delta National Wildlife Refuge in 2005.

Alaska Maritime National Wildlife Refuge

One of the establishing purposes of the Alaska Maritime NWR is to conserve marine bird populations, which requires the ability to detect large changes in abundance. Monitoring populations of auklets and other crevice-nesting seabirds has proven problematic, even though numerous methods have been attempted since the mid 1960s. Quantifying changes in the geographical size of auklet colonies may be useful as an alternative to attempts to directly measure population size. Anecdotal evidence suggests that several large colonies have decreased recently in both extent and abundance, simultaneously with vegetation encroachment and succession. The FWS recently developed a new standardized method for mapping colonies using a randomized systematic grid survey, which they employed in July 2005 on Hall and St. Matthew Islands in the Bering Sea. The survey had two components: a simple presence/absence survey and an auklet sign density survey. Quantitatively mapping all large auklet colonies using this method could provide an important, and logistically feasible, baseline for monitoring the status of auklet colonies through time.

Migratory Bird Management

The Migratory Bird Management Program is responsible for conducting research, monitoring, and surveys of migratory bird populations throughout Alaska in support of the management of migratory birds. In Arctic Alaska, efforts are concentrated on shorebirds, sea ducks, and other waterfowl that inhabit areas undergoing exploration and development by the oil and gas industry.

Waterfowl Population Surveys, Banding, and Research on the North Slope of Alaska

Since 1986 the FWS has conducted systematic aerial waterbird breeding pair surveys on the North Slope of Alaska. Together these surveys have shown that the breeding populations of most species are stable, although declines in long-tailed ducks and increases in Arctic terns, king eiders, red-breasted mergansers, tundra swans, and sandhill cranes have been detected. The FWS has also conducted annual surveys of molting geese in the Teshekpuk Lake Special Area (TLSA) since 1982. This survey brought important recognition of the TLSA, which attracts up to 30% of all black brant and growing numbers of mid-continent greater white-fronted geese during the July molting period. In addition to trend and abundance surveys, the

FWS renewed annual goose-banding efforts on the North Slope, which provide data necessary to calculate annual survival and harvest distribution throughout Alaska, the Central and Mississippi Flyways, and Mexico. Finally, increased interest in the status of yellow-billed loons led to collaborative efforts between the FWS and USGS to develop a habitat selection model, currently on schedule to be completed in 2006.

Program for Regional and International Shorebird Monitoring

The goals of PRISM are to:

- Estimate the size of breeding populations of 74 shorebird taxa in North America;
- Describe the distribution, abundance, and habitat relationships for each of these taxa;
- Monitor trends in shorebird population size;
- Monitor shorebird numbers at stopover locations; and
- Assist local managers in meeting their shorebird conservation goals.

PRISM has four main components: Arctic and boreal breeding surveys, temperate breeding surveys, temperate non-breeding surveys, and neotropical surveys. Arctic PRISM has three components:

- An extensive survey of the entire Arctic region of North America, using random sampling and methods that permit estimates of abundance;
- Annual or semi-annual surveys at 10–20 non-randomly selected permanent shorebird sites using either index or density methods; and
- Collection of checklist data, using a standard protocol, at as many sites and as often as possible.

Taken together, these components will provide essentially unbiased estimates of the actual population size and thus of the change in size since the last major survey. During the past eight years, most of the focus has been placed on developing and testing methods to accomplish the first component. The extensive surveys use a combination of GIS methods to select plots and double sampling to collect the bird information. Stratified sampling is used to separate the good and less good habitat so that sampling effort can be concentrated in the higher-quality areas. Such surveys have been conducted across most of the Arctic Slope of Alaska, providing the first detailed information on shorebird species distribution. Full implementation of the program awaits additional funding.

Beginning in 2003, the breeding biology of shorebirds has been studied at Barrow, Alaska, with the goal of accomplishing the second component, that is, annual surveys at non-random, permanent shorebird sites. Data collected include site and mate fidelity, adult survival, natal philopatry, and hatching success of a variety of upland and wetland species. In addition, information on lemming abundance, climate, and predator numbers is being collected to relate to the breeding parameters. Recently, researchers have begun to investigate the effects of a new landfill and climate change on shorebirds.

In addition to the breeding biology studies, an extensive study on post-breeding shorebirds was begun in 2004. Starting in Barrow, this study expanded to Peard Bay, the Colville River Delta, the Sagavanirktok River Delta, and the Okpilak River Delta in 2005. The principal goals of this study are to:

- Document shorebird diversity, abundance, and tenure times at each coastal staging area;
- Document movements between breeding and post-breeding areas and among post-breeding areas; and
- Determine how physiological measurements (fat metabolism and stress) from captured birds can be used to predict site quality.

International Activities

Arctic Monitoring and Assessment Program

Polar bears are a primary indicator species within the Arctic Council's Arctic Monitoring and Assessment Program (AMAP) because of their position at the top of the Arctic foodweb. Two technical reports summarizing the concentrations of trace elements and organochlorine compounds (OCs) in adult male polar bears from Alaska were completed by the FWS in 2004. Mercury, cadmium, and selenium were significantly higher in liver and kidney tissues from bears harvested in the southern Beaufort Sea compared to polar bears from the Chukchi and Bering Seas. Mercury concentrations were about half those found in polar bears in the western Canadian Arctic and are similar to values reported for Svalbard, Norway. Concentrations of polychlorinated biphenyls (PCBs) and chlordanes were significantly higher in adipose tissue in polar bears in the southern Beaufort Sea than in polar bears from the Chukchi and Bering Seas. Except for hexachlorocyclohexane isomers (HCHs), OCs including the sum of the major PCB congeners, chlordane-related compounds, and DDT-related compounds were relatively low in polar bears from Alaska compared to other Arctic populations.

The FWS also collaborated with scientists from Canada, Norway, Greenland, Denmark, and academic institutions in the U.S. in publishing several papers over the past two years. These papers primarily examined OCs, perfluorinated compounds such as perfluorooctane sulfonate (PFOS), and polybrominated diphenyl ethers (PBDEs). The latter two classes of compounds have received less study than the OC compounds until recently. Concentrations of PFOS were greater than other organic compounds in polar bears from the Chukchi Sea region, including chlordanes, PCBs, HCHs, and DDTs. In contrast, concentrations of chlordanes and PCBs were greater or equal to PFOS levels in polar bears from the Beaufort Sea region. Compared to polar bears from other Arctic regions, polar bears from Alaska were characterized by higher proportions of relatively volatile compounds such as HCHs, pentachlorobenzenes, and less-chlorinated PCBs. Concentrations of PBDEs (sum of all congeners) were lower in polar bears from Alaska and Canada than from East Greenland and Svalbard. Concentrations of PFOS in South Hudson Bay, East Greenland, and Svalbard were significantly higher than in western locations such as the Chukchi Sea.

The FWS also contributed polar bear tissue samples to the Alaska Marine Mammal Tissue Archival Project (AMMTAP). These samples have been archived so they can be analyzed in the future for environmental contaminants. Such retrospective studies are important when emerging issues arise.

Conservation of Arctic Flora and Fauna

The FWS is the designated Federal agency for participation in the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) program. Between 2002 and 2004, FWS employees chaired CAFF as well as its Flora Group and the Circumpolar Seabird Working Group. Shorebird biologists within the circumpolar Arctic recently formed the Committee for Holarctic Shorebird Monitoring (CHASM), an organization formed as the essential first step for guiding the implementation of an effective circumpolar program for monitoring Arctic-nesting shorebirds. CHASM is a "project" within the International Wader Study Group and is one of seven networks within the Circumpolar Flora and Fauna's Circumpolar Biodiversity Monitoring Program.

National Park Service

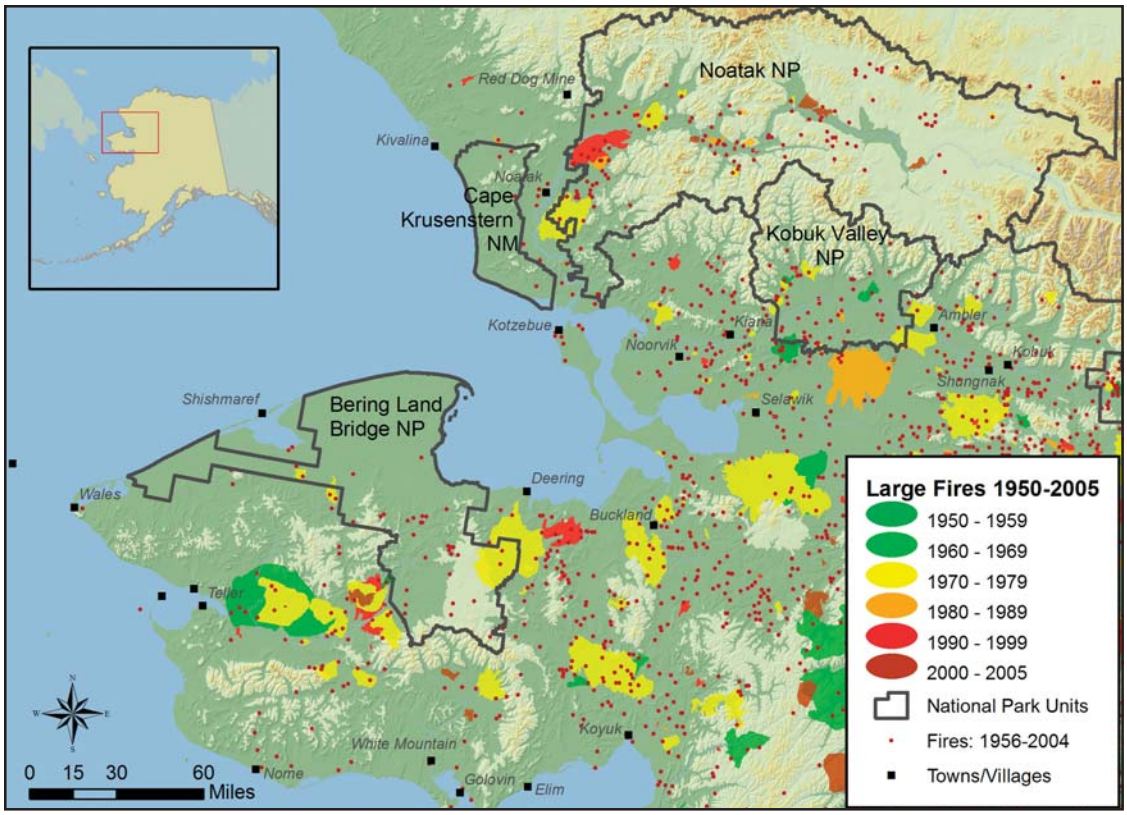
	Funding (thousands)	
	FY 04	FY 05
Cultural Resources	552	579
Natural Ecology	697	694
Inventory & Monitoring	263	1,392
Total	1,512	2,666

The National Park Service (NPS) preserves unimpaired the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of present and future generations. The NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout the U.S. and the world.

Specific objectives for NPS research in the Arctic are generated within each of the Arctic park units' enabling legislation, which includes the directives to maintain the environmental integrity of the natural features, to protect and interpret cultural resources, and to protect habitat for, and populations of, wildlife. Established in 1980, the Arctic park units include Bering Land Bridge National Preserve, Cape Krusenstern National Monument, Gates of the Arctic National Park and Preserve, Kobuk Valley National Park, and Noatak National Preserve. Cultural and natural resource research provides necessary data and information to managers, while it also benefits the public. Work is accomplished through partnerships with educational institutions and intergovernmental organizations at all levels. In addition, the National Park Service is increasingly enlisting the skills and talents of research partners to develop the scientific information needed to make effective management decisions.

Fire in the Western Arctic Parklands

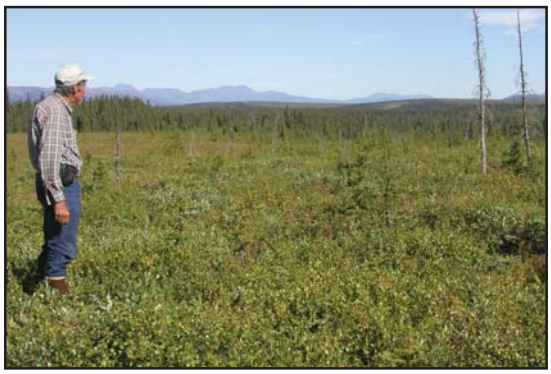
Climate, terrain, and vegetation strongly influence the occurrence and extent of fires within the western Arctic parklands: Noatak National Preserve, Bering Land Bridge National Preserve,



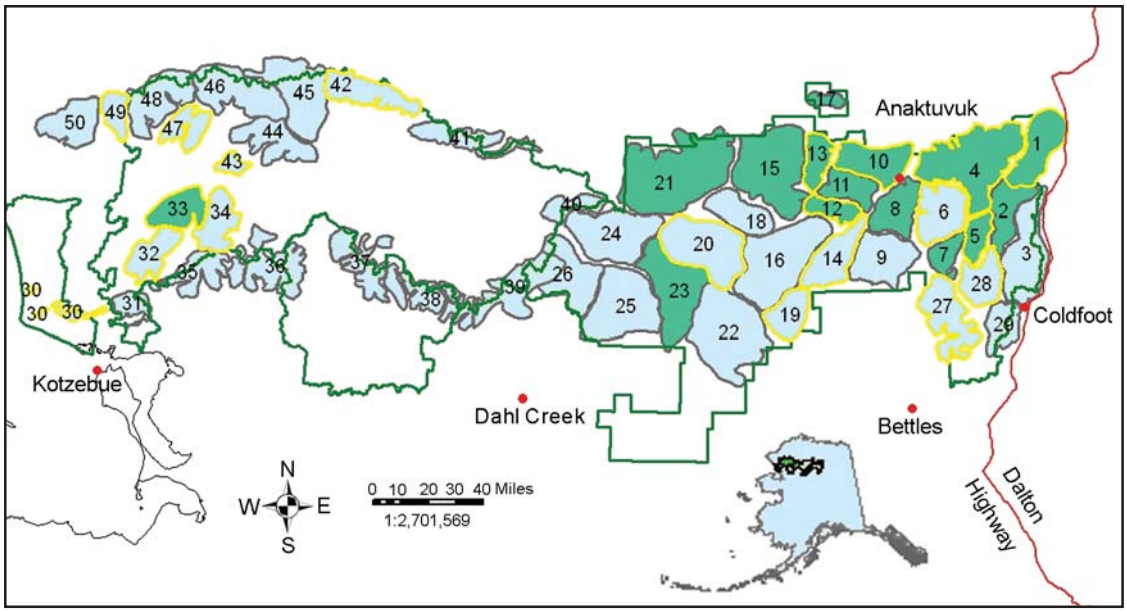
Fire history of northwest Alaska. The points show fire starts from 1956 to 2004. Historical wildland fire perimeters are shown for fires generally larger than 1000 acres prior to 1988 and larger than 100 acres after 1988.

Kobuk Valley National Park, and Cape Krusenstern National Monument. The subarctic boreal forests and low Arctic tundra biomes are subject to periodic, sometimes large fires. Over the last 50 years, more than 280,000 hectares have burned within the western Arctic park units; 96% of the fires are caused by lightening. The frequency and extent of the fires are variable within the park units, governed by vegetative, geographic, and climatic factors. During 2005, 16 fires occurred in Noatak NP, with a total of 7,300 hectares burned, and 2 fires were detected in Bering Land Bridge NP. Fires can exert landscape-scale controls on vegetation structure and composition, permafrost dynamics, nutrient cycling, carbon loss and gain, primary productivity for herbivores, and biodiversity.

The natural fire regime (fire frequency, extent, and severity) and resulting fire effects are likely to respond to local and global climate changes. Very few studies have looked at the effects of fire in tundra ecosystems. During 1981 and 1982, eight tundra fire plot sites were established in Noatak National Preserve in burned areas of varying ages (1972, 1977, and 1982 fires). None of these plots had been re-measured since their initial establishment. As part of the Arctic Network Inventory and Monitoring Program, a Cooperative Agreement was established with the original investigator to re-locate, re-measure, analyze, and report on these



Fire effects plots in the Noatak National Preserve. The left picture shows the plots in 1982, 10 years after the fire. The right picture shows the same site in 2005, 33 years after the fire. There was an increase in dwarf birch and a decrease in grasses and willow.



Sheep survey units in the Arctic Network. The survey units are based on Singer's work from 1983 and 1984 and were classified as high-density sheep areas (more than 1.3 sheep per square mile; dark green) or low-density sheep areas (less than 1.3 sheep per square mile; light green) based on Singer's original data. Units surveyed during June and July 2005 are outlined in yellow.

fire effects plots. During 2005, the researchers relocated and re-measured eight fire plot transects. The objectives of the project are to assess the changes in vascular and non-vascular plant composition and structure, depth of active layer, and thermokarst development, and to initially assess the potential of shrub and tree-line expansion in relation to fire and climate. Preliminary results indicate an increase in shrub cover and a decrease in graminoids and forbs. In addition, six fire effects plots were established immediately after the 2004 Uvgoon Creek fire in Noatak NP by NPS personnel. During 2005, these plots were re-measured by NPS fire staff. The objectives of these plots are to understand plant succession under varying burn severities.

Western Brooks Range Dall's Sheep Survey

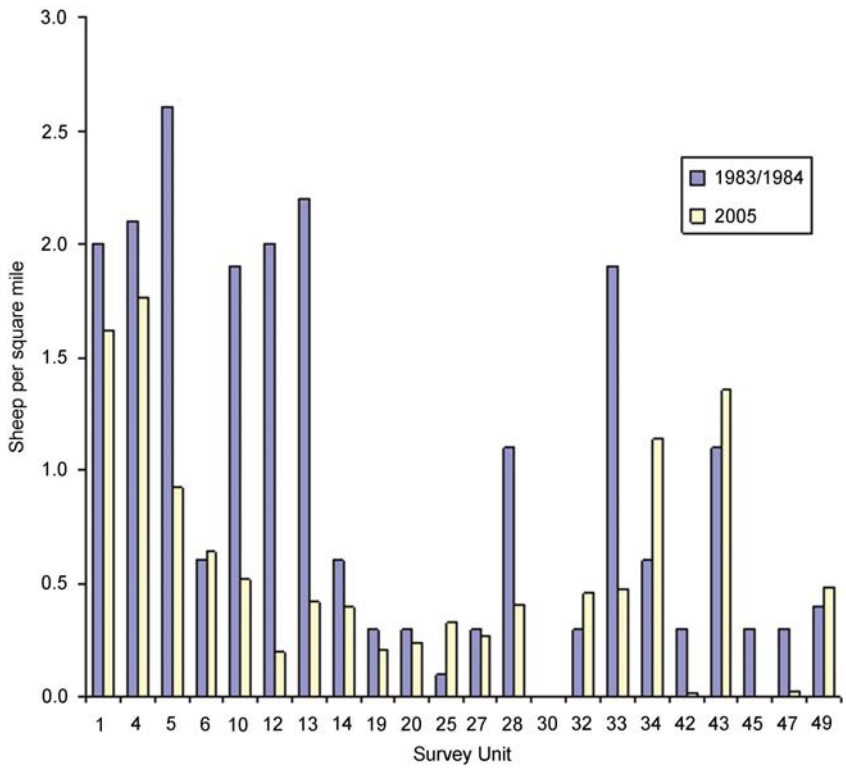
The Brooks Range is the northernmost limit of Dall's sheep range, and little is known regarding their population health and distribution. For the majority of the western Brooks Range, the last comprehensive survey was in the early 1980s. Dall's sheep are of interest because they are a resident alpine and Arctic species that is sensitive to environmental variation. In addition, a widespread decline in Dall's sheep occurred throughout the Brooks Range in late 1980s and early 1990s, but the extent of the decline and the degree of recovery since the decline are unknown.

During the early 1980s, Frank Singer, a biologist with the National Park Service (NPS), inventoried suitable Dall's sheep habitat within what is now the Arctic network of parks. Since that time, surveys have been performed consistently in only a few areas of the Arctic network; for the majority of the Arctic network the last survey conducted was Singer's. In June 2005, the first year of a two-year project was initiated to examine population levels and Dall's sheep distribution in the western Brooks Range.

Singer's original survey units were mapped using a GIS. Units were then randomly chosen for surveying. Units were surveyed using small, fixed-wing aircraft to arrive at a minimum sheep count. Sheep were classified as lambs, rams (legal and sublegal), ewe-like, and unclassified.

In the summer of 2005, surveys in 18 units (out of a targeted 25 units) were completed, and two more were mostly completed. The total number of units in the survey area is 50. Sheep densities were historically higher in the northeastern portion of the survey area than in the southern and western portions of the survey area, and this pattern was evident in 2005. In 13 out of 20 survey

Dall's sheep grazing.



Dall's sheep densities observed in survey units in the western Brooks Range during the summers of 1983–1984 and 2005.

units, the density of sheep observed in 2005 was lower than in 1983 and 1984, and these survey units were in the eastern portion of the survey area. Units in the western portion showed an increase in sheep density from the early 1980s to 2005. In units that were surveyed in their entirety, there were 33% fewer sheep observed in 2005 than in 1983 and 1984.

In the summer of 2006, surveys are planned for all units not surveyed in 2005. The final report from this project will evaluate changes in sheep densities in the entire survey area between 1983–1984 and 2005–2006 and will provide a population estimate of Dall's sheep in the western Brooks Range. Sex and age composition data from this survey will provide additional detail regarding changes in sheep density.

This information will be of great use to the NPS and other natural resource agencies as a baseline data set. It will also be of use for park managers evaluating the condition of the Dall's sheep population in the western Brooks Range and will help guide the management of this unique alpine and Arctic species.

Genetic Variation of Moose

An ongoing study assesses the baseline levels of genetic variation and connectivity among the moose populations of the Selawik, Noatak, and Gates of the Arctic regions of Alaska. In an interagency collaboration between NPS and the USGS Alaska Science Center's Molecular Ecology Laboratory, molecular genetics are used to analyze over 200 unique blood and tissue samples collected from moose in these areas. Nuclear-DNA microsatellite genotyping, the polymerase chain reaction, and mitochondrial-DNA sequencing are used to determine population levels of heterozygosity, allelic composition, inbreeding, and connectivity (gene flow) among these moose populations. Genetic characterization of these moose, together with radiotelemetry (demographics), will provide better information to monitor the "natural and healthy" status of these populations as mandated by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. Determination of a genetic baseline for these moose populations will both enable the detection of population change and assist in the development of long-term management plans to ensure population persistence. The results from this study will be summarized in an internal NPS report and submitted to a scientific journal for publication. The data will also contribute to the effort of USGS to assess genetic variation in moose populations statewide.

Nuclear and MtDNA analyses being used to reveal relationships among populations of wild moose in Arctic Alaska.

Inventory and Monitoring Program, Arctic Network

Fresh Waters in Gates of the Arctic National Park and Preserve

The Noatak River and its surrounding watershed is an internationally recognized UNESCO Biosphere Reserve, established for its unique contribution to the conservation of biological diversity and biological resources. The first step in conserving biological diversity is to conduct baseline surveys using an "ecosystem approach" to better understand the species present, the community composition, the species of concern, and the ecosystems that sustain them.

Understanding and forecasting the impacts of current and future change on biodiversity and ecosystem function in the Noatak Basin will depend on understanding the ecosystems of this unique and relatively undisturbed area. Except for a few isolated studies, little is known about the current geographic ranges of most aquatic species in the Arctic National Parklands. This includes freshwater and riparian vertebrates, nonvascular and vascular plants, invertebrates, and a multitude of microorganisms. Even less information is known about the ecosystems that sustain these organisms and how they are changing. For example, little is known about the effects of global climate change, Arctic haze, and airborne pollutants on species and ecosystems in the parks.

The primary purpose of this project was to extend the limited base of data and knowledge about freshwater resources of Gates of the Arctic. This initiative is part of NPS's Inventory and Monitoring program. The 2005 field initiative included landscape and freshwater ecosystem experts from the University of Vermont, University of Alaska Fairbanks, University of Alabama, Utah State University, Marine Biological Laboratory, and NPS. The study area for the 2005 effort focused on a portion of the Noatak River from 12-Mile Creek to Lake Matcharak in the western region of Gates of the Arctic. During the two-week field period, 20 stream tributaries and 12 lakes were assessed. All stream and lake sites were documented with digital photography and GPS.

The stream assessments included measurements of the physical characteristics of the streams (such as width, depth, substrate type and size, stability, and riparian cover). Dissolved oxygen, pH, temperature, conductivity, nitrates, total nitrogen, total phosphorus, base cations, and metals were measured. Benthic algal biomass was assessed in the field as extractable chlorophyll a and samples of benthic algae were identified. Representative specimens of key macroinvertebrates, riparian vegetation, and fish were collected and identified.

The lake assessments included detailed bathymetric surveys by GPS-linked sonar depth sounding. Light, temperature, and dissolved oxygen were measured in selected vertical profiles of each lake using an automated sonde. Zooplankton were collected by timed tows with a mesh net. Fish were collected by gill netting and by angling.

In general, the streams in this region were found to be naturally unproductive (oligotrophic), although the specific conductance (electrical conductivity) of the water was relatively high in all but one stream. The higher values are much higher than normally seen in Arctic tundra streams on the North Slope. High conductivity values are likely due to base cations dissolved from the carbonate geology that is prevalent in this area of the Noatak watershed. Algal and macroinvertebrate biomass was low and consistent with expectations for oligotrophic rivers. Tributary streams appeared to have few fish. Sculpin were found in several streams, with young-of-the-year salmonids (char or grayling) in some streams. The most productive and diverse stream site was at Kugrak Spring; juvenile char were observed at this site.

Lakes were more diverse than the streams. Lake types included glacial-kettle, oxbow, and thaw ponds, with maximum depths up to 35 m. Most of the surveyed lakes lacked stream inflows, and preliminary observations suggest that many of these lakes are primarily fed by groundwater inflows. Depth-specific conductivity gradients observed in some lakes suggest that the epilimnion and hypolimnion have different inflow sources. Also, chlorophyll concentrations were up to 14 times higher below the thermocline than in the epilimnion. Seven of the lakes contained fish, including populations of Arctic grayling, lake trout, northern pike, round whitefish, and nine-spine stickleback. The highest catch rates for young-of-year Arctic grayling occurred in a small pond with a maximum depth of 1 m that was dominated by bacterial mats. The highest diversity and catch rates for adult fish occurred in a spring-fed, high-mountain lake with relatively low conductivity. Northern pike were found in large thaw ponds and, when present, no other fish were observed.

Comparisons between lakes sampled in 1973 and 2005 indicate that the water clarity was 2.6 times higher during the 2005 survey. In 2005, fish

were caught in two lakes where fish were not observed during the 1974 survey (Lake Matcharak and Lake Omelaktivik). During the 1973 survey, Lake Matcharak also lacked a clearly defined outflow to the Noatak River; however, in 2005, there was a well-defined connection to the Noatak, and water clarity in the lake was six times higher than in 1973.

In general, the streams and lakes in this area of the Noatak River are oligotrophic and in good health. Spring streams, seepage lakes, and oxbow sloughs have higher productivity and diversity and should be considered areas of special ecological importance.

Arctic Network Coastal Erosion Study

In 2005, the Arctic Network initiated a study on coastal erosion in Cape Krusenstern National Monument and Bering Land Bridge National Preserve. Shoreline erosion is one of the most rapid and observable changes in Arctic environments. Protected by sea ice for much of the year, coastal ecosystems are sensitive to climate change and environmental stressors such as permafrost melting, sea-level rise, the frequency and intensity of storms, and the length of the summer ice-free season. With losses on the order of about 1–10 m/year (3–30 ft/year), coastal erosion threatens archeological sites and a variety of nearshore marine, terrestrial, and freshwater habitats.

Coastal ecosystems of Bering Land Bridge National Park, as viewed through the perspective, fly-through environment of www.EarthSLOT.org. The false-color Landsat satellite imagery shows the diversity of coastal landform types, including lagoons, spits, barrier islands, and low tundra bluffs.

In collaboration with researchers from the University of Colorado, this study will take advantage of GIS and high-resolution imagery. Orthophoto mosaics will be assembled with resolution as good as 0.5 m (1.6 ft) for the coastal environments of Bering Land Bridge National Preserve and Cape Krusenstern National Monument. Across this broad area, shorelines will be analyzed with "time slices" from approximately 1950, 1980, 1997, 2003, and possibly 2006. The aerial photography and satellite imagery will provide the basis to collect baseline data, determine long-term trends, and understand how landscape components interact and change over time. For more information, see http://www1.nature.nps.gov/im/units/arcn/index.cfm or http://instaar.colorado.edu/QGISL/ARCN.

Arctic Archeology

Archaeological Mentorship Program

The summer of 2005 was the second of three summer seasons for the Archeological Mentorship Program. Funded by an NPS Shared Beringian Heritage grant, the program provides training and archeological fieldwork opportunities for young people from villages in northwest Alaska. The program was envisioned as a way to bridge the gap between professional archeologists and young people in NPS-affiliated villages.

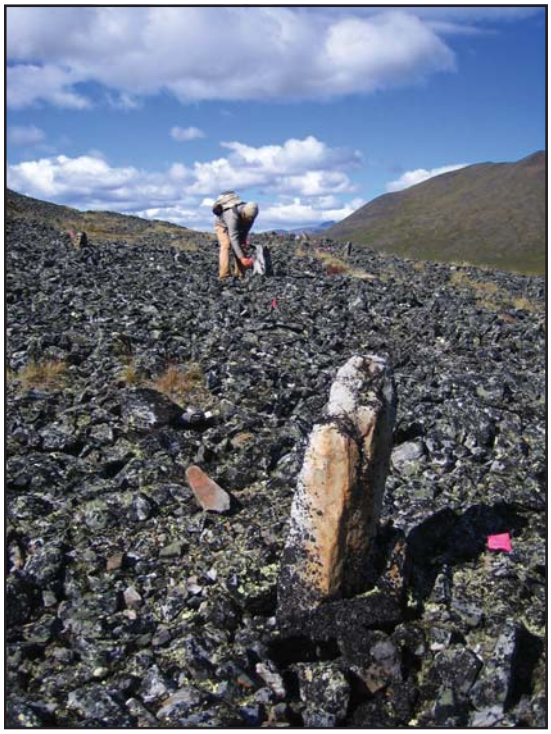
Archeologists from the Alaska Regional Office (ARO), Western Arctic National Parklands (WEAR), and Gates of the Arctic National Park and Preserve collaborated to provide training for five young people, aged 17–22, from the villages of Point Hope and Kiana in 2005. The mentorship lasted five weeks, from early July to mid-August. The five students, along with a community coordinator from Point Hope and one from Kiana, were all employed for the duration by the NPS as temporary summer hires. During the first week, they traveled to Kotzebue for training, delivered by ARO and WEAR archeologists and staff. The second week was spent back in their home villages working on specific projects they designed for their own communities. In Kiana, they mapped the old village site, now in ruins; in Point Hope, they planned and began construction of a traditional sod house. The final component of the mentorship was fieldwork. Two of the students traveled to Anchorage, and then to the Knik, to participate in an ongoing historic archeological project at the old townsite of Knik, while two students traveled to Bettles, and on to Agiak Lake in Gates of the Arctic National Park and Preserve to join an archeological crew mapping and testing an extensive landscape of ancient caribou-hunting sites.

Tent Ring Project

During the archaeological surveys in Gates of the Arctic in 2005, an undergraduate student in anthropology at the University of Alaska Fairbanks undertook a study of tent rings as part of an honors thesis project. These stone circles, once used to anchor skin tents, are a common but poorly understood part of the archaeological

Archaeologist recording a historic tent ring at the Iniqagliq site, which translates roughly to "they always camped here." The camp was last occupied by the Killikmiut band of Nunamiut in the 1930s and 1940s.

record in northern Alaska. The study sought to explore the age, function, design, and distribution of tent rings through an examination of newly discovered sites in combination with literature research. Preliminary results have been interesting and suggest that tent rings are much older than had been previously thought. Furthermore, distinct variation in the size and shape of tent rings suggest that methods of tent ring construction have changed over time and appear to differ from region to region, perhaps a reflection of cultural or linguistic boundaries. So far the work has documented more than 300 tent rings within and adjacent to the park and resulted in the discovery of 52 tent rings during 2005 field surveys.



Mapping a series of rock cairns that make up a caribou drive line at Agiak Lake. Several extensive drive lines were found at Agiak Lake and are composed of hundreds of such cairns. Caribou were likely steered into the lake, where they were speared by hunters from kayaks.

Agiak Lake Archaeological Survey and Mapping

In the summer of 2005, a Gates of the Arctic National Park and Preserve field crew documented archaeological features in the vicinity of Agiak Lake, about 30 miles west of the village of Anaktuvuk Pass. Agiak Lake was used in the past as a trap for migrating caribou, and it contains a dense and amazingly well preserved complex of hunting features, such as drift fences, blinds, storage pits, and camp locations. Archaeologists mapped more than 800 such features and produced a detailed map of the valley. One interesting site contained 41 tent rings—the largest single known concentration of prehistoric house remains in northern interior Alaska. Small-scale excavations at this site indicate that the tent remains are much older than previously thought, possibly as much as several thousand years old.

Killik–Nigu–Noatak Archaeological Inventory

Archaeologists conducted the first season of a three-year reconnaissance inventory of cultural resource sites in the Killik, Nigu, and Noatak River basins in Gates of the Arctic National Park and Preserve. This year crews focused on the Killik River. The work was undertaken by Gates of the Arctic park staff in cooperation with the University of Alaska Museum and involved graduate and undergraduate students from the University of Alaska Anchorage and University of Alaska Fairbanks.

Initial findings and achievements include:

- The discovery of 181 new sites, which brings the total number of known sites in the park to over 1200;
- Visits to 100 previously recorded sites to update location and condition information;
- The collection of radiocarbon samples from 20 sites, which will increase by 50% the total number of dated sites in the park;
- The discovery of rare preserved wood artifacts, including bow and arrow fragments, at two sites; and
- The discovery of unique high-altitude sites that consist of single historic- or prehistoric-age rock cairns perched on high mountain peaks; the function of these structures is unknown.

Killik River Nunamiut Ethnohistory and Archaeology

A component of the Killik–Nigu–Noatak River cultural resource inventory project was a series of site visits to historic Nunamiut camps on the Killik River with the participation of elders from Anaktuvuk Pass, who last occupied the sites in the 1940s. These camps are some of the most significant sites in the park. They figure prominently in Nunamiut cultural history as one of the areas where the Nunamiut first returned to an inland lifestyle after a time spent living on the Arctic coast, and they also document one of the last examples of a mobile hunting, fishing, and gathering lifestyle in North America. The work consisted of site visits, interviews, and archival research and was a cooperative effort between Gates of the Arctic and the North Slope Borough/Simon Paneak Museum. The elders were Justus and Ethel Mekiana, Rhoda Aghook, and Mollie Aghook. James and Anna Nageak translated between Inupiaq and English. Grant Spearman, the director of the Simon Paneak Museum, was instrumental in organizing the project, which built on decades of his careful research.

The highlights of the project include:

- Sharing by the elders of more than 20 hours of stories and knowledge that were captured with video and audio recordings;
- Documenting 50 place names and associated oral history and stories from the Killik and Nigu Rivers; and
- Relocating and recording detailed oral history and archaeological information from seven historic camp sites.

Elders examining an old wash bin at the Sulupaat camp on the Killik River. Sulupaat was the last Nunamiut camp on the Killik and was abandoned in 1949 when the Killik band walked to Anaktuvuk Pass.

Riparian Area Bird Inventory

Many migratory species face widespread alteration or loss of habitats at important sites along their migration routes. The impacts of habitat loss may be first detected through changes in the patterns of bird abundance and distribution on the breeding grounds. The riparian bird inventory was designed to document bird species distribution, diversity, density, and habitat within the major riparian corridors of Gates of the Arctic National Park and Preserve.

Bonapart's gull chicks on Kutuk Lake adjacent to the Alatna River. About 60 bird species were detected along the Alatna River in June 2005.

In 2005, the third year of this project, more than 150 points were sampled for landbirds along the Alatna and Itkillik Rivers, bringing the total number of survey points conducted in 2003–2005 to more than 800. The 2005 work completed surveys along all the major rivers in Gates of the Arctic, which also include the Noatak, North Fork of the Koyukuk, John, Kobuk, and Killik.

Before the riparian bird inventory and 2003's shorebird inventory, Gates of the Arctic was largely unsurveyed, leaving a gap in knowledge of the breeding distribution and habitat requirements of many migrant and resident bird species. Future field work will include the use of sound equipment to record songs and calls for 10-minute intervals throughout the day during the breeding season. The information will assist in determining daily and monthly timing of future monitoring efforts.

This bird inventory project was established through the Park Flight Program, which is a partnership between the NPS, National Park Foundation, National Fish and Wildlife Foundation/USAID, American Airlines, and the University of Arizona.

Bureau of Land Management

Mineral Assessments

In 2005, BLM's Branch of Solid Minerals initiated a mineral assessment of the southern portion of the National Petroleum Reserve–Alaska (NPRA). The mineral assessment objectives are to identify the nature, extent, and development potential of mineral resources; perform mining feasibility studies, using hypothetical mine models on mineral deposits that have economic potential; and fund geophysical investigations of areas having the potential to contain concealed mineral deposits. BLM work includes locating, sampling, mapping, and evaluating historic mines, prospects, and occurrences and investigating newly discovered mineralization. This assessment is part of BLM's mineral assessment program, authorized under the Alaska National Interest Lands Conservation Act (ANILCA), which has been ongoing since the early 1980s.

The NPRA contains many documented mineral occurrences, including deposits of lead, zinc, silver, barite, and phosphate. In addition, the reserve contains extensive resources of coal, sand, and gravel. The metallic minerals are concentrated in the southern portion of the reserve, while the coal is concentrated in the central and northern portions. An airborne geophysical survey was conducted over the southern portion to better map geologic formations and delineate anomalous mineral occurrences. Over ten thousand line-kilometers were flown, sampling magnetic field strength and electromagnetic conductivity at multiple frequencies. This work was accomplished through a cooperative agreement with the Alaska Division of Geological and Geophysical Surveys. Also, an interagency agreement was established with the U.S. Geological Survey to conduct detailed site investigations to gain a better understanding of the bedded barite deposits and the correlation between trace elements and silver-lead-zinc occurrences.

Airborne geophysical survey getting underway at the Ivotuk field camp in the southern National Petroleum Reserve–Alaska.

	Funding (thousands)	
	FY 04	FY 05
Natural Ecology	1,172	1,288
Minerals Research (Non-O&G)	2,030	3,868
Minerals Research (O&G, NPRA)	2,767	2,534
Cultural Resources	260	200
Pipeline Monitoring	0	0
Fire Control	339	317
Total	5,610	5,320

Other mineral assessment accomplishments include the following:

- In 2004, the final field season for the Delta River Mining District Study was completed. BLM collected and analyzed 446 rock chip, placer, pan concentrate, and stream sediment samples. A geologist from the Environmental Careers Organization served a summer field internship.
- The Aniak Mining District Study completed fieldwork in 2004 and 2005, collecting 932 rock chip, placer, pan concentrate, and stream sediment samples. Through a cooperative agreement with the Geologic Society of America, a student was able to spend the summer as an intern under the GeoCorps program.
- In 2005, two additional mining district studies were initiated in the Bristol Bay Mining District and the Admiralty Mining District.

Juneau–John Rishel Mineral Information Center

The Juneau–John Rishel Mineral Information Center (JRMIC) is home to a library with a collection of over 20,000 geologic and minerals publications focused on Alaska and available nowhere else in southeast Alaska. The Center's resources provide invaluable support to the mineral assessment program, and it is home to one of the mineral assessment teams. The JRMIC also maintains the Minerals Availability System files. These are the accumulations of Alaska-specific minerals data that, in many cases, can be found nowhere else in the world. In addition, JRMIC serves as a neutral intermediary for making private minerals industry data public. The JRMIC holds and disseminates many Alaska-specific mineral data sets. All current and past technical reports are available at the JRMIC website (http://www.blm.gov/ak/jrmic/).

GeoCorps intern measuring the strike and dip of exposed bedrock at Canyon Creek.

Through the JRMIC, the BLM provides public outreach and minerals education to the communities of southeast Alaska. In addition to responding to many request for presentations at area schools, the JRMIC staff also supports numerous annual events and programs, including Sea Week, evening classes, and Gold Rush Days.

Sea Week is an outdoor program held in April for fourth graders of the Juneau school district. Each year, a member of the JRMIC staff mans the geology/soils/glaciers station for part of the week. Over 400 students are served by this program, which focuses on Alaskan marine and coastal ecology.

Each year during fall and spring, JRMIC offers evening classes for adults and children. The classes focus on mineral uses, history, and field identification, with an emphasis on the physical properties of minerals and the mineral resources of Alaska.

At one of the many exhibition booths at Gold Rush Days, an annual Juneau event, JRMIC presents visitors with information about services and educational opportunities available at its BLM office in Juneau, as well as other resources managed by BLM throughout Alaska.

Weed Management in Alaska

BLM joined as a lead agency with 31 other agencies and organizations in 2000 to form the Alaska Committee for Noxious and Invasive Plants Management (CNIPM). In December 2001, CNIPM published the *Strategic Plan for Noxious and Invasive Plants Management in Alaska*. Much has been accomplished by CNIPM and the partner agencies and organizations. During 2004 and 2005, through a National Fish and Wildlife Foundation matching grant awarded to the Fairbanks District Office, BLM worked with grant partners to successfully develop and provide workshops for developing cooperative weed management areas and conducted additional inventory on public and private lands. Through the project, BLM also continued to build on the education awareness campaign begun through the previous grant and contributed to the building of an invasive species ranking system. A research needs assessment authored by University of Alaska and BLM scientists was published in the journal *Agroborealis*.

BLM continued to conduct invasive plant inventories on BLM-managed lands in 2004 and 2005, primarily within the Dalton Management Area (Fairbanks District Office) and Glennallen Field Office area. During 2005, BLM concentrated its inventory and control efforts within and adjacent to ten 2004 fires. Inventory data will be used to prioritize future control efforts in and around these burns. BLM began assessing weed inventory, control, and monitoring needs in and adjacent to the 2005 fires. The fire seasons of 2004 and 2005 resulted in the highest and third highest number of acres burned in Alaska, respectively, since records have been kept.

Biologists and other specialists in BLM Alaska continue to work actively with CNIPM and contribute to the education and outreach efforts, coordination with other agencies and groups in Alaska, identification of research needs and procurement funds, and development of management options and tools, such as a certified weed-free forage and mulch program.

BLM technician conducting surveys of invasive, non-native plants in the Dalton Management Area.

Neotropical Migratory Bird Surveys

The BLM Alaska wildlife biologists continued to participate in the Neotropical Migratory Bird (NTMB) conservation program during FY 2004 and 2005. The program is better known as Partners In Flight.

In an effort to monitor trends in North American bird populations, 11 breeding bird surveys (BBS) and 7 off-road breeding birds surveys (ORBBS) were conducted annually in northern and northwestern Alaska. Survey routes were initiated in 1992 and 1993. Many species detected on these routes are identified by Boreal Partners in Flight, the working group for Canada and Alaska, as species of conservation priority. These include the olive-sided flycatcher, Hammond's flycatcher, gray-cheeked thrush, varied thrush, Townsend's warbler, blackpoll warbler, and white-winged crossbill.

BBS routes were also conducted along the Unalakleet and Anvik Rivers in western Alaska, adapting standard protocols to a river setting, rather than a roadside. Sixty-seven species have been recorded on the Unalakleet route, and 66 on the Anvik survey, since the routes were established in 1996.

The surveys provide a source of standardized data on populations of breeding birds throughout the U.S. and Canada. Breeding habitats in Alaska are largely intact and provide an opportunity to clarify the importance of breeding habitat versus migration and wintering habitats for many species of long-distance migrants.

All BBS data are reported to the Biological Resources Division (BRD) of USGS. A trend analysis statistical procedure is used to estimate the population change for every species or trend each year.

Three bird banding stations were established to inventory breeding landbirds in 1998 and were continued to be run in FY 2004 and 2005. In June of each year, birds were banded at the Old Woman public use cabin on the Old Woman River, a tributary to the Unalakleet River that drains into Norton Sound. An ORBBS established in 1998 on Old Woman Mountain provides information to supplement the banding efforts. Bird banding stations were also established on the upper reaches of the Anvik and Bonasila Rivers, which drain into the Yukon River near the village of Anvik. The northern waterthrush was the primary species captured, followed by Swainson's thrush, Wilson's warbler, and myrtle warbler. Banded birds have returned to the stations in subsequent years. These recaptures provide information on breeding site fidelity and longevity.

A fall-migration bird banding station was established at the BLM's Campbell Tract in Anchorage in 1997 and continued to be run through FY 2004 and 2005. Migrant birds were captured with mist nets and banded and released annually from mid-August through September. In past years, 413 individuals were banded in 1997, 961 in 1998, 1010 in 1999, 1254 in 2000, 1343 in 2001, 924 in 2002, 1167 in 2003, 1228 in 2004, and 841 in 2005. The slate-colored junco was the primary species captured, followed by Wilson's warbler, orange-crowned warbler, and ruby-crowned kinglet. Band recoveries include yellow warbler, slate-colored junco, hermit thrush, fox sparrow, and black-capped chickadee banded since 1997.

BLM is working with USGS-BRD to determine the cause of a large number of black-capped chickadees found with deformed bills in south-central Alaska. Black-capped chickadees banded by BLM biologists in fall migration since 1997 with normal bills are being recaptured by USGS-BRD biologists, but with deformed, elongated bills. The banding data on these birds will give clues on the cause and age of onset of bill deformation in this species.

BLM partnered with state agencies and other organizations in 2004 to support a three-year research project on the Arctic warbler. The Alaska Bird Observatory (ABO) is conducting the study on BLM-managed and adjacent lands between the Tangle Lakes and Maclaren Summit. The study addresses the breeding ecology and habitat requirements of Arctic warblers. Little is known about this long-distance migratory bird, which is currently listed by the U.S. Fish and Wildlife Service as a Species of High Conservation Concern.

Arctic warbler just before being released.

After the second field season, ABO has assembled the largest database on Arctic warbler breeding ecology and habitat needs in North America. The results from the study will provide guidance to BLM and other agencies for future management plans and land use actions.

BLM biologists also participated in environmental outreach, presenting programs to students and the public on bird identification, biology, and conservation.

Mapping Arctic warbler breeding territories.

Fortymile Caribou Herd Monitoring

BLM and the Alaska Department of Fish and Game continue to cooperate in the monitoring and management of the Fortymile Caribou Herd (FCH), which ranges through the eastern interior of Alaska. Through this cooperative project, population and composition trends have been studied.

Important to subsistence hunters throughout the ages, the FCH once occupied 220,000 square kilometers of Alaska and Yukon and, based on estimates by the biologist Olas Murie in 1935, numbered about 568,000. As the FCH has recovered from 22,104 in 1994 to approximately 40,000 in 2005, the herd has begun to occupy more of the original range, including the highlands of the Steese National Conservation Area and east into former ranges in Yukon.

BLM joined state and Federal agencies, Yukon First Nations, Yukon and Canadian agencies, and concerned citizens in Alaska and Canada to plan for the recovery of the FCH, completing the FCH Management Plan in 1995. BLM and the Alaska Department of Fish and Game began implementing the plan in 1996 through 2001. BLM continues to monitor the FCH, managing for continued growth and expansion into former range.

A coalition of Alaska Fish and Game Advisory Committees and the local Subsistence Resource Advisory Council, in consultation with BLM, other Federal agencies, and partner agencies in Yukon and Canada and First Nations, began writing a harvest management plan in 2005. The plan will guide harvest for continued growth from 2006 to 2012. Data collected through cooperative projects contributed to the successful implementation of the 2001–2006 harvest plan and the development of the new plan.

Fire Ecology and Management Studies in Interior Alaska

Recent large wildfire events have captured the nation's attention and caused many communities, homeowners, and agencies to seek methods to reduce wildfire risks to homes and property at the urban interface. In 2004, the BLM Alaska Fire Service and Tanana Chiefs Conference, Inc. completed a four-year Fuels Treatment Demonstration project, with funding from the national interagency Joint Fire Science Program. This study was intended to compare degrees of fuel reduction by thinning with or without pruning in boreal black spruce forests, with the concomitant risk reduction, visual impact, environmental effects, and cost–benefit ratio.

The BLM Fairbanks District Office and Alaska Fire Service collaborated with the Army's Cold Regions Research and Engineering Laboratory to revisit tundra fire effects transects established 25 years ago. Permanent transects to monitor fire recovery on a tundra fire were established after severe fires in 1977 at Imuruk Basin, which is now within the Bering Land Bridge National Park. With assistance from the National Park Service,

BLM botanist conducting a tundra fire recovery study in a 25-year-old tundra burn scar on the Seward Peninsula. Note the abundant willow shrub.

Large mud flow into a stream channel caused by permafrost melting during the Hodzana River fire of 2004.

transects were re-located and re-sampled under the guidance of the original investigator. Vegetation and permafrost depths were compared to previous results from earlier stages of recovery, and the results were recently published. Notable findings included the slow recovery of lichens important for caribou forage and the new establishment of willow shrubs dating from the fire occurrence.

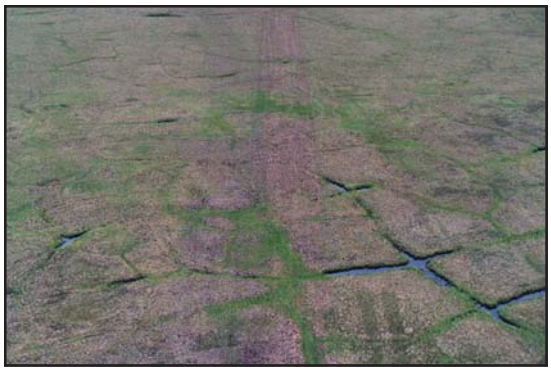
The 2004 and 2005 fire seasons in Alaska together burned over 11 million acres of boreal forest and tundra. These two years represent the largest and third largest annual areas burned, respectively, since record keeping began in 1950. Climate is changing rapidly in the Arctic, and fire seasons like 2004 and 2005 may become more common. Burn severity was uncharacteristically high, particularly in the central and upper Yukon regions, because of historic drought conditions. Erosion and permafrost degradation were striking in some burned areas.

Burn severity evaluation team on a large mud flow clogging a stream.

BLM and other Federal agencies mounted an extensive interagency effort to map burn severity over some of the large fire complexes using Burned Area Reflectance Changes (BARC) on pre- and post-burn satellite images. Field visits and aerial reconnaissance were used to tune the maps to reflect burn severity level on the ground surface. Federal land managers in Alaska feel that the rendering of BARC maps to preliminary burn severity maps will be a valuable legacy after the 2004 fires. Quantifying adverse or positive effects from the burns on managed resources such as wildlife habitat and subsistence users requires a landscape perspective and generally several years of data to determine ultimate effects. The burn severity maps covering entire fire complexes will be key data for determining effects as recovery proceeds and will yield important feedback to managers who need to revise and tune fire management plans to protect key resources.

NPRA Ice Roads

A study by the BLM of the effects on tundra vegetation of overlapping, multi-winter ice roads was begun in 2002 and continued until 2005. This study was intended as a pilot study, and the sample size (five) was limited by the availability of overlapping ice road paths in suitable vegetation cover types. The resulting power of the statistical tests was low. The four treatments in the study were a control, ice road paths from 2001 only, ice road paths from 2002 only, and overlapping ice road paths from both winters. The characteristics measured were the depth of thaw (the late summer distance between the tundra surface and the permafrost layer), the proportion of tussocks that were scuffed or crushed, and the percent cover of each of eight vegetation cover types. The third and final year of data collection on the ice road study occurred in 2004. Specialists returned in 2005 to take additional photos. As in previous years, there were no statistically significant differences in thaw depth among the treatments, but the trend toward greater thaw depths over time among all the treatments continued. Likewise, there were no differences in tussock damage among the three manipulated treatments, but evidence of recovery continued. Measurements of vegetation cover showed a significantly greater effect in the overlap treatment in only one of the three years when the data were analyzed separately by year, but this effect did not appear in an analysis of the data for



Ice road study site in 2002.

Ice road study site in 2005.

all three years combined. Thus, there is no evidence of additive impacts from building ice roads over the same path in two subsequent years. Given the fairly rapid recovery of the tundra, it is doubtful that any significant environmental benefit would be gained by requiring that all ice roads be completely offset from previous years' paths.

Human Impacts on Winter Movements of Wolves

The ecological effects of snowmobile activity on wildlife are increasingly a concern for resource managers and planners, yet little is understood about the implications for predators, particularly wolves, and the dynamic role that OSV (over-snow vehicle) trails can have on predator–prey interactions. As of 2003, there were more than 2.4 million snowmobiles registered in North America, 34,000 of which were in Alaska. The production of light-weight, fuel-efficient snowmobiles in the mid-1990s has expanded snowmobile activity into areas where little or no activity previously existed. OSVs and the alterations made to the landscape from their activity can have profound impacts on wolf–prey dynamics. The presence and noise from OSVs could displace and disrupt animal activity and movement patterns, while the creation of trails could allow energy-efficient travel for wolves (and increasing likelihood of encountering and successfully capturing prey). High hunting and trapping pressure could exacerbate these effects, particularly during critical periods such as late winter, when animals are most stressed and when anthropogenic activity is greatest.

Beginning in October 2004, the Alaska Department of Fish and Game and the University of Northern British Columbia, in cooperation with BLM, began addressing the ecological implications of OSV activity on predator–prey interactions in the Nelchina Basin (Game Management Unit 13) of south-central Alaska. With its dense network of trails and the increasing predator management program, the Basin presents a unique opportunity to quantitatively assess the spatial and temporal relationships of wolves, human activity, prey resources, and snow characteristics.

It is anticipated that this two-year research project will also begin to provide an essential component in unraveling the complexity of factors that affect ungulate survival, as well as providing a baseline for future investigations into the energetic implications associated with anthropogenic activity.

ADFG research biologist fitting a satellite collar on gray wolf. Transmitters on wolf collars report the animal's location at 15-minute intervals.

Shorebirds Staging on Alaska's North Slope

In 2005, the Arctic Field Office of BLM Alaska joined with many other agencies and private companies [University of Alaska's Coastal Marine Institute, Minerals Management Service, Barrow Arctic Science Consortium, North Slope Borough Department of Wildlife Management, U.S. Fish and Wildlife Service, Conoco Phillips Inc., BP Alaska (Exploration) Inc.] to participate in an effort to gain a better understanding of the abundance, distribution, phenology, movements, and physiology of post-breeding shorebirds during the staging period and to aid in assessing how future industrial and human activity across the North Slope may affect shorebird populations. A two-level approach was used, consisting of site-specific and broad-scale components:

- A site-specific, in-depth analysis of staging phenology, behavior, and physiology at five locations across the North Slope; and
- A broad-scale aerial survey and telemetry effort to investigate pre-migratory shorebird abundance, distribution, and movement patterns across the entire North Slope coastline.

BLM provided funding to conduct the first aerial survey specifically designed to count staging shorebirds along the entire North Slope coastline. The survey extended from the southern end of Kasegaluk Lagoon to the eastern border of the Arctic National Wildlife Refuge (2,468 km) and was conducted in August 2005. Approximately 16,850 individual shorebirds were counted during the survey; the majority of these were small calidrid sandpipers and phalaropes.

Radiotelemetry techniques being used to relocate radio-tagged shorebirds at Peard Bay, Alaska.

Red phalarope at Peard Bay, Alaska.

BLM also provided funding and staff for a field camp at Peard Bay. Personnel at each of the five field camps conducted regular surveys to examine shorebird abundance, distribution, species composition, and habitat use from late July to late August. Field camp crews also captured birds to collect blood samples for physiological analysis and to band or radio-equip individuals to determine tenure time at that site. Each camp maintained an automated telemetry station and conducted manual telemetry on a regular basis to examine the probability of birds dispersing between and among breeding and staging areas.

Cliffs along the Colville River, Alaska.

Raptor Surveys along the Colville River

Surveys for peregrine falcons were first conducted along the Colville River in 1952. Following that, efforts were sporadic until 1978, after which surveys have been conducted yearly. This valuable data set has documented the decline and subsequent recovery of the peregrine falcon population along the Colville River, with a low of 14 pairs

Attaching a satellite transmitter to a raven along the Colville River to gather distribution and productivity information.

detected in 1973 and a high of 62 pairs in 1998. Since 1981, the U.S. Fish and Wildlife Service and the BLM have been collaborating to provide funding and personnel to conduct surveys of the Colville River to document the occupancy and productivity of cliff-nesting raptors. Extensive data have been collected on gyrfalcons and rough-legged hawks in addition to peregrine falcons, and for many years an active banding program was conducted for peregrine falcons. Surveys were conducted in 2005 and are scheduled to be conducted every three years to maintain this long-term data set.

NPRA: Colville River Common Raven Project

In 2005 the Arctic Field Office of BLM Alaska funded a portion of a research project in collaboration with the University of Alaska Fairbanks and other government agencies and organizations [U.S. Fish and Wildlife Service, North Slope Borough Department of Wildlife, Phillips Alaska, Inc., BP Exploration (Alaska), Inc.] to collect data on foraging ecology and basic life history questions for common ravens in the NPRA. Funding from BLM paid for satellite transmitters and ARGOS satellite time for six transmitters to be deployed on ravens along the upper Colville River. The data from these transmitters will be combined with information that this study is collecting using ten other satellite transmitters in developed and undeveloped areas of the North Slope. This broader study will collect information on:

- The distribution of ravens on the North Slope prior to oil development in comparison to the current distribution;
- Foraging patterns and diet in developed areas (oil facilities and villages) in comparison to less developed areas (Long Range Radar Sites and undeveloped sites); and
- Nesting productivity of ravens in developed and undeveloped areas.

This study allows for data collection in undeveloped areas of NPRA and will allow informed management decisions regarding the effects of ravens as predators on nesting birds if and when industrial development moves into these areas.

Spectacled and Steller's Eider Surveys on the North Slope

In 2004 and 2005, the Arctic Field Office of BLM Alaska provided funding for two projects to conduct aerial surveys of the federally listed threatened spectacled and Steller's eiders on the North Slope of Alaska. The first survey was conducted along the entire North Slope and surveys for both Steller's and spectacled eiders. The Teshekpuk Lake region in the northeast area of the NPRA was surveyed at double the intensity of the remaining survey area in order to increase the precision of the estimates and the resolution of the distributional data in this area, which has high potential for oil and gas leasing and development as well as very high wildlife resource values. This survey had three main objectives:

- Determine the population trend for spectacled eiders in light of recovery and reclassification criteria, including power analysis;
- Estimate the abundance of spectacled eiders observable from the air; and
- Develop and implement a detectability study to correct for birds present but not detected in the sample area by observers.

In 1997, the Alaska breeding population of the Steller's eider was listed as threatened. Historical data suggest that Steller's eiders formerly nested widely across much of northern Alaska. Recent records suggest that the species' current range in northern Alaska has been greatly reduced, mostly to the vicinity of Barrow. Barrow is the only area in Alaska known to be used regularly by nesting Steller's eiders, with a few dozen pairs in most years. The spatial extent and the population size of the Barrow "cluster" is not known, because ground access is limited in this area. Thus, the second survey was designed to survey for Steller's eiders in the Barrow region. Aerial surveys

conducted annually are useful for describing the general distribution and relative abundance of Steller's eiders in the Barrow area and will be valuable for monitoring their population over time as required by the Steller's eider recovery plan.

Monitoring the Teshekpuk Caribou Herd in NPRA

In 2003, the BLM continued its cooperative effort with the Alaska Department of Fish and Game and the North Slope Borough's Department of Wildlife Management to monitor the population dynamics, movements, and range use of the Teshekpuk Caribou Herd, which calves in the northeastern NPRA. Both traditional satellite telemetry and GPS collars have been deployed to document large- and small-scale movement patterns. The importance of this information increases as plans progress for the first oil development in the northeastern NPRA. The project team continued to collect data in 2004 and 2005, and they now have a general picture of broad-scale annual movements and range use. There remains a need to collect detailed information to assess the impacts of specific developments within that range.

Critical Habitat for Subsistence Fish Species in NPRA

During 2004 and 2005, BLM became part of a cooperative effort to identify critical habitat for subsistence fish species utilized by villages within NPRA. The groups collaborating on this project include the North Slope Borough, Alaska Department of Natural Resources, MJM Research, and ABR, Inc. Much of the subsistence fish harvest for Barrow occurs in the complex network of interconnected streams and lakes that drain into Admiralty Bay and Smith Bay, including Teshekpuk Lake, the third largest lake in Alaska, and five major river systems, the Ikpikpuk/Chipp, Alaktak, Topagoruk, Meade, and Inaru. Broad whitefish and Arctic grayling are the most abundant subsistence fish species. High-value oil and gas interests in this area substantiate the need to identify high-use habitats for these species and examine stock structure; knowledge that is fairly limited at this time.

Fyke net sampling in targeted areas within the region of interest helped to identify some high-use summer habitat for broad whitefish and Arctic grayling. Stock structure was characterized in terms of fish length, age, and sex. Catch records and measurements were also maintained for other species, including least cisco, Bering cisco, humpback whitefish, burbot, northern pike, Arctic char, and lake trout. These species are utilized in the subsistence harvest as well, although to a much lesser extent. Broad whitefish and Arctic grayling over 300 mm were tagged with numbered Floy tags to document movements upon recapture. Over sixty radio transmitters were surgically implanted into broad whitefish, and these were tracked intermittently throughout the year in an attempt to identify migration patterns and summer feeding, fall spawning, and overwintering habitat. The developing data set from tracking efforts is beginning to fulfill project objectives. The project is scheduled to continue in 2006 and beyond.

Winter Water Withdrawals from Lakes in NPRA

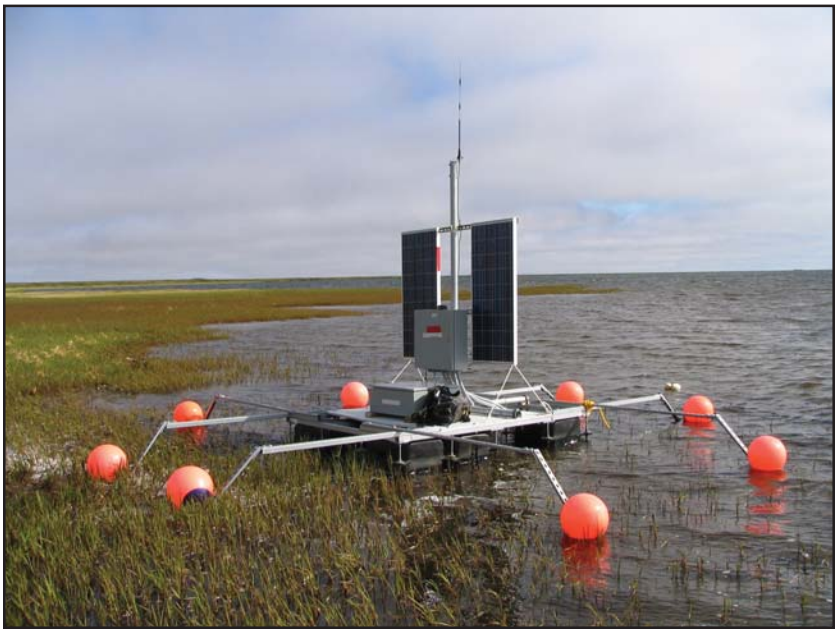
In the winter of 2004-2005, BLM began cooperating with the Water and Environmental Research Center at the University of Alaska Fairbanks and GW Scientific to assist in a study of the potential impacts from winter water withdrawals from lakes for the purpose of oil exploration. Water is removed from lakes in winter for building ice roads and drilling pads, and the amount of water permitted for removal is based on conservative guidelines designed to protect fish. The objectives of this project include examining lake recharge and chemistry parameters in pumped lakes to determine what impacts, if any, are occurring and whether or not different levels of water removal may be detrimental to fish. This project, largely supported by the Department of Energy and the oil industry, is scheduled for funding through 2008.

Flow Monitoring of NPRA Rivers

In 2005, BLM operated two gaging stations and provided funding to the USGS to operate four gaging stations in NPRA. They are distributed from the coastal plain to the Brooks Range foothills to enhance regional flood frequency equations with site-specific peak flow data.

Most rivers are affected by ice jamming, with snow and/or ice present on the bottom of the river during the peak flow. These effects raise the water surface elevations and can produce flooding at relatively low discharges. It is important that the range of these effects are known before planning

Transporting and setting up an instrumented raft for monitoring levels and chemistry of Arctic lakes.



Instrumented raft in summer, moved by the wind to the edge of the lake.

the construction of structures across rivers or the siting of facilities adjacent to rivers. Additional peak flow data will increase the design accuracy and safety for future stream crossing structures and will provide baseline streamflow data collection for researchers. Flows at all gaging sites begin during snowmelt in late May to early June and cease in November in most years. The Arctic coastal plain sites reach maximum flows during breakup, while the Brooks Range maximum flows occur primarily after intense summer rainfall events.

Winter ice roads for oil exploration may extend 80 miles and cross numerous rivers from their starting points. Ice bridges are constructed at stream crossings with enough strength to handle drilling rigs moving over them. These bridges must be mechanically removed before breakup to prevent water from being impounded and to allow upstream movement of fish. Scour and deposition of bottom sediments at these crossings can result from improperly breached ice bridges. The Ublutuoch River gaging station is near an annual ice bridge on this stream, and the real-time data transmissions from this site allow optimum timing of field visits to make discharge and velocity measurements in the vicinity of the ice bridge.

BLM assists the USGS in the operation of a gaging station on the Colville River at Umiat. This gage provides advance warning of peak flows for numerous data collection activities occurring downstream and within the Colville River delta. Many years of peak stage records have been collected in the Colville River delta and discharges estimated from them. Substantial errors in discharge estimates can occur when downstream ice jams and bottom ice affect stage values. The use of an ice-free upstream gage at Umiat is critical to evaluating discharge estimates made within the delta.

The Colville River ceases flow in February, allowing a saltwater wedge of water to move upstream from the ocean past Nuiqsut and as far as Ocean Point. The movement of this salt water upstream can affect the distribution of fish within the lower Colville River system and can halt water withdrawals from the Colville River for ice bridge construction. Flows measured at Umiat provide a reference from which to compare to downstream sites that are hampered by physical conditions preventing direct measurments of flow.

A long-term climate monitoring station was re-established at Umiat by BLM in 2004 after being discontinued in April 2001. This site has weather records extending back to 1949, with a total of 29 years of observations. Current climate records are available at http://www.colville-watershed.org/.

The BLM helped initiate a data collection network in NPRA in 2005, integrating scientific data collection objectives with agency resource management needs. This collaborative data network will provide weather, climate, and hydrology information. Management applications of the data

Rivers involved in BLM/USGS flow studies to increase the design accuracy and safety of stream crossing structures used in ice road construction.

include tundra travel and water use logistics. Scientific applications include climate change, Arctic hydrology, and active layer processes. The major partners in the collaborative network include USGS, University of Alaska Fairbanks (Water and Environmental Research Center), Department of Energy (Arctic Energy Office), and industry partners.

BLM–USGS Bering Glacier System Program

The BLM and the USGS have carried out complementary physical and biological inventory and research programs at Bering Glacier, Alaska. The synthesis of results from these studies, which range from glaciology to ecology, show that the Bering Glacier system is very dynamic, a system that is undergoing profound changes. To better address the short- and long-term management of the Bering Glacier region, BLM, in cooperation with USGS, has created a public/private partnership with Federal, state, local, academic, and nongovernmental organizations (NGOs), as well as commercial Bering Glacier stakeholders. The successful operation of the Bering research facility, populated by the stakeholders each summer conducting investigations in geology, glaciology, paleontology, plant biology, animal biology, oceanography/water quality, remote sensing, and GIS decision support, is testimony to the public/private partnership.

The Bering Glacier is the largest and longest glacier in continental North America, with an area of approximately 5175 square kilometers and a length of 190 km. It is also the largest surging glacier in America, having surged at least five times during the twentieth century. The last great surge occurred in 1993–1995. Bering Glacier alone covers more than 6% of the glacier-covered area of Alaska and may contain 15–20% of Alaska's total glacier ice. The entire glacier lies within 100 km of the Gulf of Alaska. The rapid ongoing retreat of the glacier and the expansion of Vitus Lake at the glacier terminus has provided opportunities for the establishment of new habitat and new flora and fauna. The post-surge retreat of Bering Glacier has created a dynamic landscape of reticulated and fluted surfaces with subtidal invertebrate fossils, lake sediments, and previously overrun forests.

The BLM/USGS's coordinated investigations of the Bering Glacier system have suggested that the site is biologically and environmentally significant. Paleontological research has documented a diverse assemblage of invertebrate species, preserved forests, and ancient peats, and preliminary botanical studies have identified more than 350 vascular and non-vascular species. The forelands are also known to support a highly diverse vertebrate community: fresh and anadromous fishes, three rare subspecies of geese, and a previously undocumented harbor seal haulout. The diversity of fauna and flora in the area around the margins of the Bering Glacier is likely due to the dynamic physical habitat. In contrast to the forelands of most retreating glaciers, in which distance from the glacier reflects both habitat age and climate, the pattern of surges and retreats has created a landscape where local climate and time since glacial cover have effectively decoupled. Within this relatively small region, the impact of habitat age, climate, and physical properties on community structure can be studied independently over a broad range of habitats. In the limited area around the glacier, habitats vary from newly exposed rocks at close to sea level to 10,000-year-old moraines at

elevations above 5,000 m, and from wet fens to relatively dry subalpine forests. Outcrops and corings reveal sediments that record the interactions of climate, sea level, and earthquake-induced land movements over the past few thousand years.

BLM personnel are currently developing a new land use plan for the Glennallen District, which includes the Bering Glacier region. This plan is referred to as the East Alaska Resource Management Plan. The current guiding document is the *Southcentral Management Framework Plan of 1980*. This plan is outdated, and the only reference to Bering Glacier is to "provide opportunities for development of coal reserves in the Bering planning block." A set of decisions will be made in the East Alaska Resource Management Plan relative to the Bering Glacier. These include vegetation resource management, special status species management, state role in fish and wildlife management, recreation use, off-highway vehicle use, land use planning, and oil, gas, coal, and mineral management.

In addition to the formidable task of creating a new land use plan for the Bering Glacier region, there are three scientific reasons for research on Bering Glacier. First, because the Bering Glacier landscape is being created by the dramatic and catastrophic disintegration of a piedmont ice lobe, it will likely be substantively changed as the glacier continues to retreat. Second, understanding the interactions between the physical habitat and the biological communities in this region will help scientists understand how glacial retreats (now occurring world-wide) are likely to impact local biotic communities. And third, because human activities at the site are increasing because of growing interest by commercial and recreational users, it is likely that there will be impacts on the fragile ecosystems in the area.

To address the Bering Glacier research and land use issues, the BLM, in cooperation with USGS, operates the Bering Glacier field camp each summer. The field program typically starts in early July and runs through the end of August. The camp is located on the edge of Vitus Lake on a former terminal moraine. The camp, complete with refueling airstrip, kitchen and mess tent, command center, and restrooms, can comfortably host 25 scientists at a time. The scientists and their staff sleep in tents or wooden-floor huts.

BLM-invited investigators, representing other Federal, state, academic, and non-government organizations, address a variety of scientific and observational issues, including:

- Bering Glacier observations (terminus, ice movement, ablation, thickness, berg calving rate, ice depth, and sub-glacial geology);
- Vegetation studies (mapping communities surrounding the glacier);
- Water properties of Vitus, Berg, and other Bering Glacier lakes (bathemetry, conductivity, temperature, density, O_2, pH, turbidity, oxidation– reduction potential, and total dissolved sediments);
- Paleontology and paleoseismology (fossil and plant analysis in estuarine, lake, and glacial outwash areas);
- Geology, geomorphology, and sea level studies (moraine deposits, thermokarst, and coastal and lake sediments);
- Seal population studies (count, behavior, and food source);
- Fish population (species, count, and size);
- Remote sensing (mapping) of the Bering Glacier area;
- Hazard modeling and mitigation; and
- Environmental monitoring.

These specific investigations all aid the BLM in managing this wilderness area. To support the ongoing Bering Glacier science and observational investigations, the BLM has incorporated the use of National Technical Means (NTM). NTM contributions, along with the use of civil and commercial satellite remote sensing data, are being used to specifically support hazard and risk mitigation issues at the glacier, as well as to support the environmental characterization and monitoring. NTM contributions are coordinated through the Civil Applications Committee. The lessons learned at the Bering Glacier are being used by BLM and other civil agencies at other sites such as the Alaskan North Slope. The BLM Bering field camp is a good example of leveraging resources. BLM provides logistical support to invited investigators, while salaries, equipment, analysis, and reporting are the responsibility of the participating investigators. To encourage and facilitate collaboration across the various science disciplines, the BLM has created a web-based portal (http://quickplace.erim.org/bering) as a repository for the field observations and reports. A part of the portal is a comprehensive geographic information system that includes the geological, glacier, oceanographic, and water properties, as well as the biological surveys. The BLM also conducts an annual Bering Glacier workshop, where previous findings are reported and planning for future field activities occurs.

U.S. Geological Survey

The U.S. Geological Survey (USGS) has conducted research in the Arctic since the late 1800s. Today the USGS addresses a complex array of earth science issues through its water science studies, specialized mapping and land cover efforts, geological programs, and expansive biological studies on DOI lands and of trust species. Most Arctic research is conducted from the Alaska Science Center (ASC) in Anchorage and the Cooperative Fish and Wildlife Research Unit at the University of Alaska Fairbanks. Additional specialists from USGS facilities across the U.S. provide unique research and technical expertise required to address the complex issues of Arctic lands and resources, particularly for energy and mineral assessments.

	Funding (thousands)	
	FY 04	FY 05
Water Resources	2,568	2,400
Geography Program	1,837	1,708
Minerals Program	3,543	2,915
Biological Sciences	7,115	6,938
Energy Resources	3,000	3,000
Hazards Program	1,558	1,107
Total	19,621	18,068

USGS streamgaging station surrounded by the annual overbank flooding during the spring breakup along the Kuparuk River.

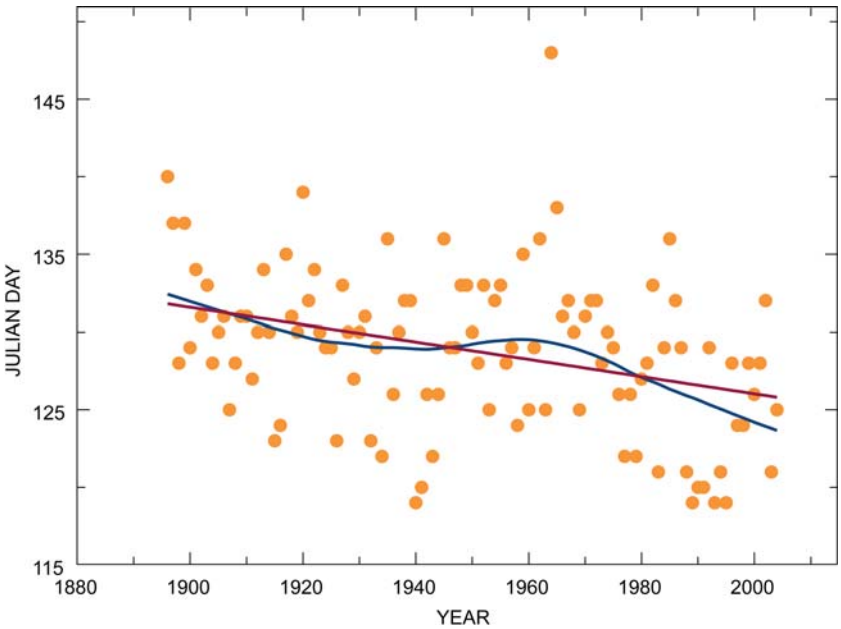
Water Research and Assessments

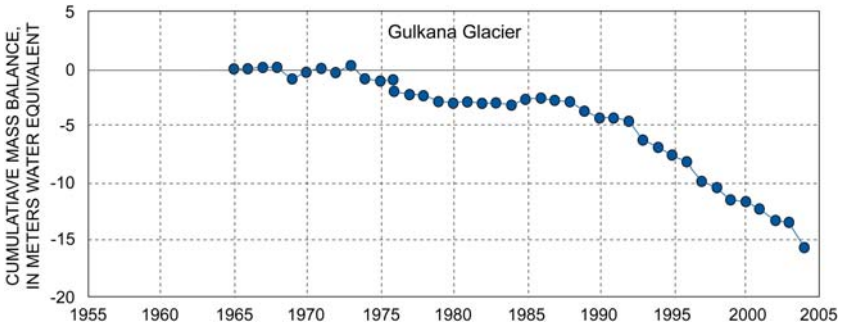
The USGS continued to conduct streamgaging, water quality, and glacier mass balance studies during FY 2004 and 2005. Some 120 stream gages were operated in Alaska, with approximately 90 providing real-time streamflow information; only a few of these were within Arctic Alaska, where the extreme Arctic climate and intense flow patterns after ice breakup and snowmelt make retention of gaging equipment difficult. However, the few streamgages operational in the Arctic, near the Trans Alaska Pipeline, provide valuable insight into patterns of streamflow that influence the stability of the infrastructure and rural community safety. For example, a trend toward earlier breakup is seen at stations with long periods of record, such as gage on the Yukon River near Dawson, Yukon Territory, Canada. Four new stream gages were added in the Northern Petroleum Reserve-Alaska (NPR-A) in FY 2005 in partnership with the Bureau of Land Management, which will add valuable insight into water flow timing and intensity.

The USGS completed data collection activities for a focused Yukon River Basin water quality study in FY 2005. The Yukon River is the fifth largest contributor of fresh water to the Arctic and is a basin dominated by permafrost and glacial inputs. As such, studies of water resources in this basin contribution to understanding climate change in the Arctic. Over the last five years, five fixed sites—the Yukon River at Eagle, near Stevens Village, at Pilot Station, the Porcupine River near Fort Yukon, and the Tanana River at Nenana—were sampled seven times per year. In addition, six synoptic sampling trips were made down the Yukon, sampling other tributaries that flow into the Yukon as well as the main stem of the Yukon.

The USGS monitored the mass balance at two glaciers in Alaska, providing long-term insight into modern patterns of glacier growth or retreat. For example, Gulkana Glacier in south-central Alaska now has a continuous record of mass balance of 40 years, one of the longest records worldwide.

Date of spring breakup on Yukon River at Dawson, Yukon Territories. Spring breakup on the Yukon River has come earlier in the year since records have been collected beginning around 1900. The straight line represents the best linear fit of the data over the entire period of record. The curved line uses a smoothing function to give more weighting to nearby (in time) points, showing the possible influence of shifts in decadal or longer climate patterns.





Annual mass balance records for the Gulkana Glacier in south-central Alaska. (See http://ak.water.usgs.gov/glaciology.)

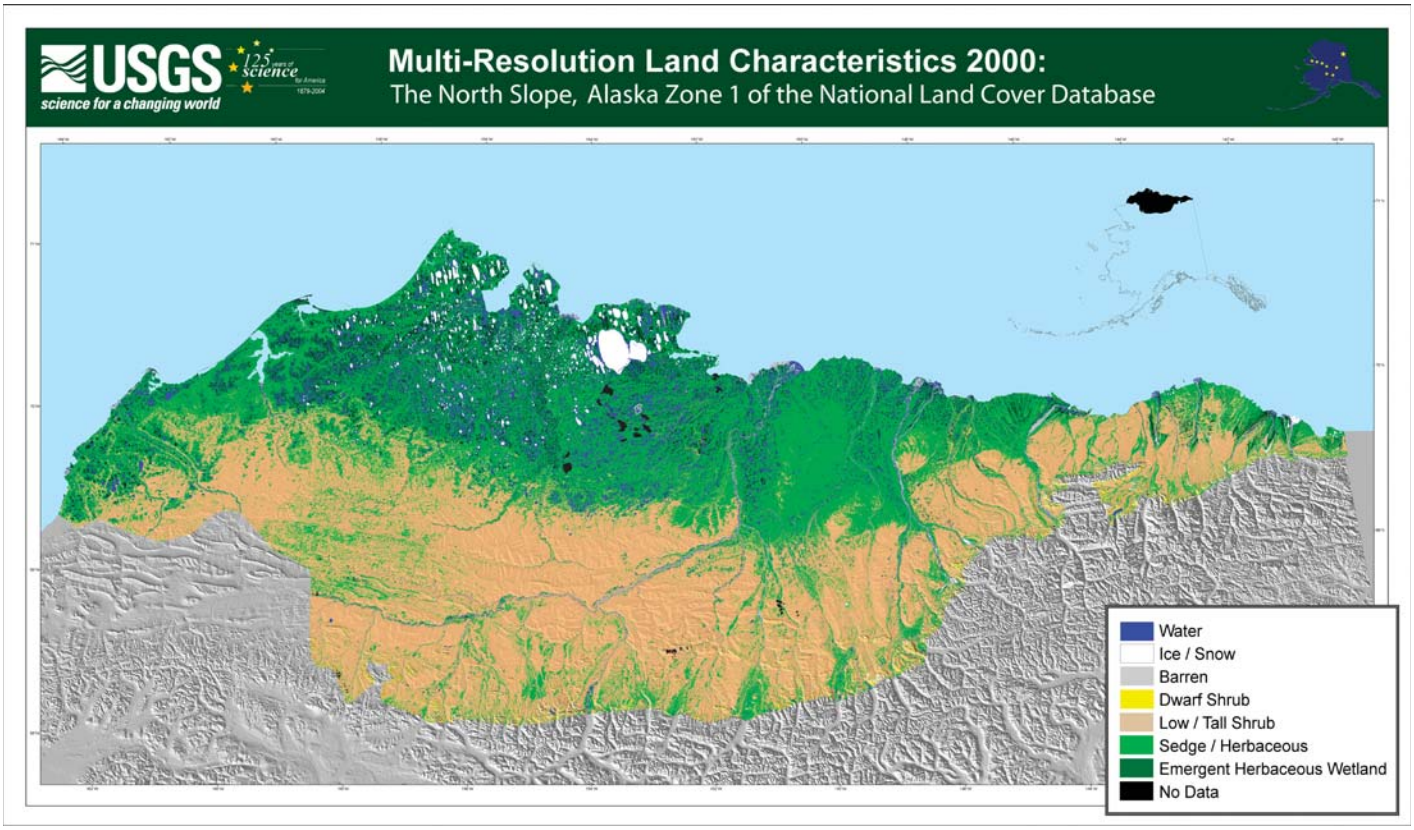
Gulkana Glacier shows a pattern of loss of mass balance over the past 20 years of nearly 15 meters of water equivalent.

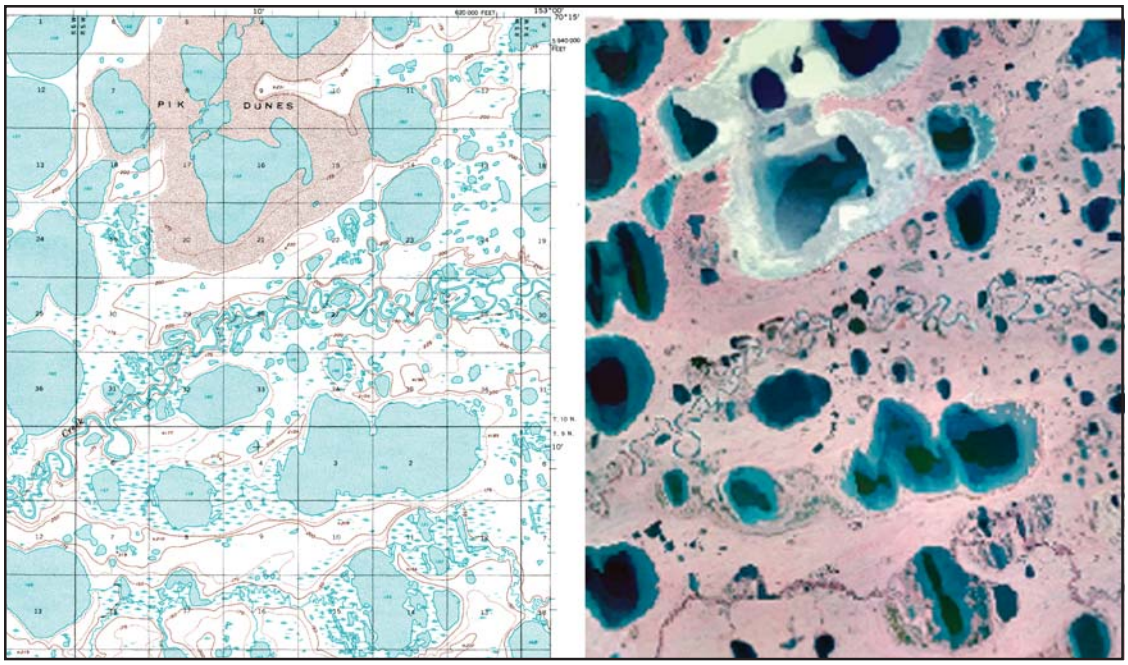
USGS Land Cover and Mapping Efforts

Land cover information is one of the highest-priority information layers requested by land management agencies, but there is little to no consistent medium-scale land cover information for Alaska. The 2001 National Land Cover Database project, established through the Multi-Resolution Land Characteristics consortium, is a national effort to provide such data. The state is divided into 11 mapping zones, and the database for Alaska Mapping Zone 1, covering the North Slope region, has been completed. This zone was a priority because of the need for sound environmental data for resource management and for assessing climate change in the Arctic. Database development involved acquiring existing field data from multiple Federal agencies and University of Alaska researchers and interpreting 1999 Landsat ETM+ satellite imagery. A decision-tree-based land cover classification was produced using the field data and ancillary raster data layers composed of Tasseled cap and reflectance imagery derived from Landsat imagery and elevation, aspect, slope, position index raster data sets. The land cover classification, ancillary data layers, and metadata are included within the final database along with the classification rules to allow modification of the decision tree by users seeking to derive land cover products specific to their local applications.

An assessment of a new approach to facilitate detailed land cover database for Alaska was completed. The objective of this project was to evaluate the use of fused, airborne, high-resolution Inter-Ferometric Synthetic Aperture Radar (IFSAR) with Landsat ETM+ data against digital ortho-photo quads (DOQQs) for generating land cover maps using digital image processing tech-

Land cover classification of the Alaskan North Slope based on the multi-resolution land characteristics mapping protocols.





Comparison of a 1955-based USGS topographic map and a 2002-based DOQQ.

niques. The study area covers the majority of the Harrison Bay quadrangle in the National Petroleum Reserve–Alaska and consists of a 2.5-m IFSAR/Landsat fusion product, DOQQs produced using aerial photography, and IFSAR-derived digital terrain models (DTMs) and digital surface models (DSMs). An existing Ducks Unlimited land cover classification and associated field data were used to label unsupervised classifications of the IFSAR/Landsat fusion product and DOQQ products and to assess vegetation heights using the difference between the DTM and DSM data. The Ducks Unlimited data also provided a consistent accuracy assessment of each classification. The evaluation of the various classifications indicated that the DOQQ and fusion product are not recommended for digital image processing to generate land cover classifications of any sizeable area. The variation introduced by the aircraft flight lines and the aerial photo mosaic process resulted in significant error being introduced into the classification. Although the fusion product increases the resolution of the spectral information in the Landsat data from 30 to 2.5 m, it decreases the information content and thus is useful only for photo interpretation.

The USGS, in partnership with the Bureau of Land Management, continued its efforts to replace severely outdated (circa 1950s) USGS topographic maps with new DOQQs and DEMs for Alaska in 2004 and 2005 with the acquisition of new imagery over the NPRA. Using color infrared aerial photography and airborne Inter-Ferometric Synthetic Aperture Radar (IFSAR) data, new DOQQs and DEMs were produced for the north and central portions of the NRPA.

Mineral Resource Assessments

The goal of USGS mineral research in the Arctic is to provide current and impartial information on the occurrence, quality, quantity, and availability of such resources. This goal is met through a variety of research projects on the origin, resources, and environmental behavior of mineral deposits in the Arctic. During FY 2004-2005, several projects addressed this goal as well as helping to address the 2003 U.S. Arctic Research Commission recommendation “that the Department of the Interior resume its resource evaluation activities and cooperate with the other Federal agencies, the State of Alaska, and institutional partners to provide widely available and comprehensive coverage of all Federal lands in Alaska.”

In the southern NPRA, the USGS began various mineral resource assessments in support of and in cooperation with the Bureau of Land Management. The USGS conducted geologic mapping, stream sediment sampling, and ground geophysical studies to better characterize known lead-zinc mineralization through geochemical analysis of rocks and stream sediments; to define the size and extent of barite mineralization through gravity measurements; and to assess occurrences of bar-

ite, phosphate, and metalliferous oil shales in the area. Data analysis is underway.

The USGS, in cooperation with the Alaska Division of Geological and Geophysical Surveys, began a study of the base metal resources of the Seward Peninsula, Alaska. A major goal of this investigation is to evaluate whether the numerous stratiform lead-zinc (silver) occurrences represent a group of unrelated, small occurrences with limited resource potential or a large, regional mineralizing system that could produce a significant base metal resource such as at Red Dog in northwest Alaska or the Selwyn Basin in Canada. Preliminary analyses suggest that, indeed, the Seward Peninsula occurrences share mineralogical and host rock similarities with like deposits in the Selwyn Basin.

The Arctic Foothills of the Brooks Range contain an enormous accumulation of zinc (e.g., Red Dog deposit) and barite in Carboniferous sedimentary rocks. The resources surpass most deposits worldwide in terms of size and grade. Furthermore, prolific hydrocarbon source rocks generated considerable amounts of petroleum that contributed to the world-class petroleum resources of the North Slope. The USGS undertook a project that was aimed at understanding the petroleum maturation and mineralization history of parts of the Brooks Range that were previously poorly characterized and understood. The project was in collaboration with industry, academia, and other government agencies.

Arctic Foothills region, showing the typical topography of low rolling hills and broad valleys. This view is looking south in the north-central Brooks Range.

Significant findings to date include:

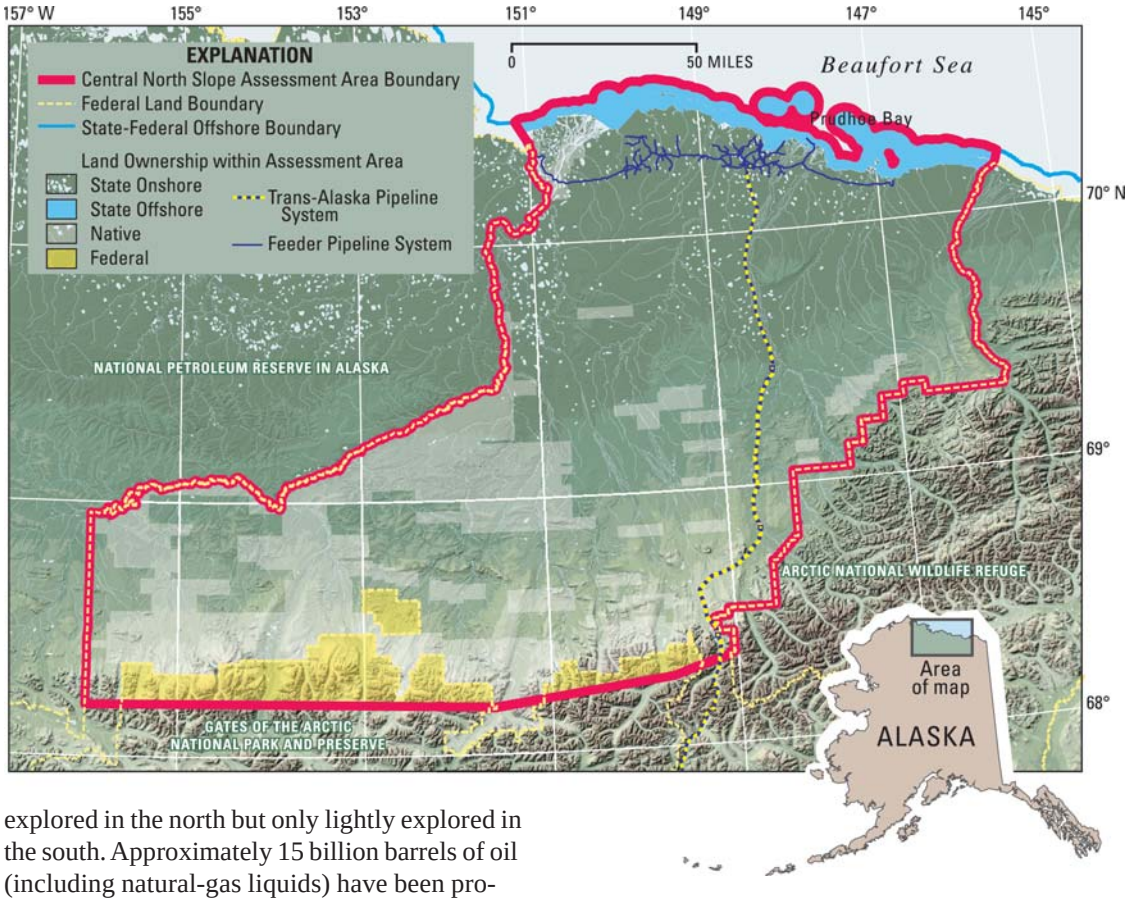
- Deep-water strata of the Kuna Formation (host to the massive sulfide zinc-lead-silver deposits) accumulated in a basin partly rimmed by carbonate platforms that preserved organic carbon.
- The local presence of red beds and/or supratidal dolostones suggest that the climate became increasingly arid during Late Mississippian time.
- Brines produced in shallow settings were a probable source of the ore-forming fluids.
- High hydrogen sulfide (H_2S) production rates may have led to the efficient precipitation of sulfide minerals and, thus, may explain the high grades of the zinc deposits
- Thallium is an especially valuable trace element in distinguishing areas of the Kuna Formation with potential for economic shale-hosted massive sulfide deposits.
- Rocks that were important for zinc mineralization (e.g., the Kuna Formation of the Lisburne Group) are also potential source rocks for sulfide-rich oils found in some wells on the North Slope.

Petroleum Resource Potential of Northern Alaska and the Circum-Arctic Region

Alaska is rich in biologic and mineral resources and has more Federal land and more potential undiscovered energy resources than anywhere else in the U.S. Energy resource considerations play an important part in Alaskan land management decisions and in energy policy development. The USGS Energy Resources Program research activities in Alaska, through collaboration with Federal and state agencies and Native corporations, are focused toward the understanding, geologic evaluation, and resource assessment of energy resources throughout Alaska.

Undiscovered Oil and Gas Resources in the Central North Slope of Alaska

In 2005 the USGS completed an assessment of undiscovered oil and gas resources of the central portion of the Alaska North Slope and the adjacent state offshore area, and they found that a significant amount of oil and a large amount of gas remains to be discovered. The central North Slope area of Alaska lies between the National Petroleum Reserve–Alaska (NPRA) and the Arctic National Wildlife Refuge (ANWR) and extends from the Brooks Range northward to the state–Federal offshore boundary. Most commercial oilfields and virtually all petroleum-producing infrastructure in northern Alaska, including the Trans-Alaska Pipeline System, are located within the assessment area. This area, which consists mostly of state and Native lands covering about 23,000 square miles (about half the size of New York state), is maturely



Boundary of, and land ownership within, the central North Slope petroleum resource assessment area.

explored in the north but only lightly explored in the south. Approximately 15 billion barrels of oil (including natural-gas liquids) have been produced from the assessment area (most from the giant Prudhoe Bay field), and remaining (discovered) reserves include about 7 billion barrels of oil and about 35 trillion cubic feet of natural gas.

This assessment used the same geology-based methodology as in the recent USGS assessments of NPRA and the ANWR 1002 area. The assessment was based on a comprehensive review of all available geological, geophysical, and geochemical evidence, including hydrocarbon source rocks, reservoir rocks, and traps. The minimum accumulation sizes considered in the assessment were 5 million barrels of technically recoverable oil and 100 billion cubic feet of technically recoverable gas. These minimum accumulation sizes are smaller than those used in USGS assessments of NPRA and the ANWR 1002 area in recognition of the extensive infrastructure and recent development of relatively small oil accumulations in the central North Slope assessment area. Resources assessed include technically recoverable conventional oil, natural gas, and natural-gas liquids. Although six petroleum systems were defined, geologic evidence suggests significant mixing of hydrocarbons among those systems. Therefore, the assessment was conducted under the assumption of a single, composite total petroleum system. Twenty-four plays (assessment units) were defined and assessed.

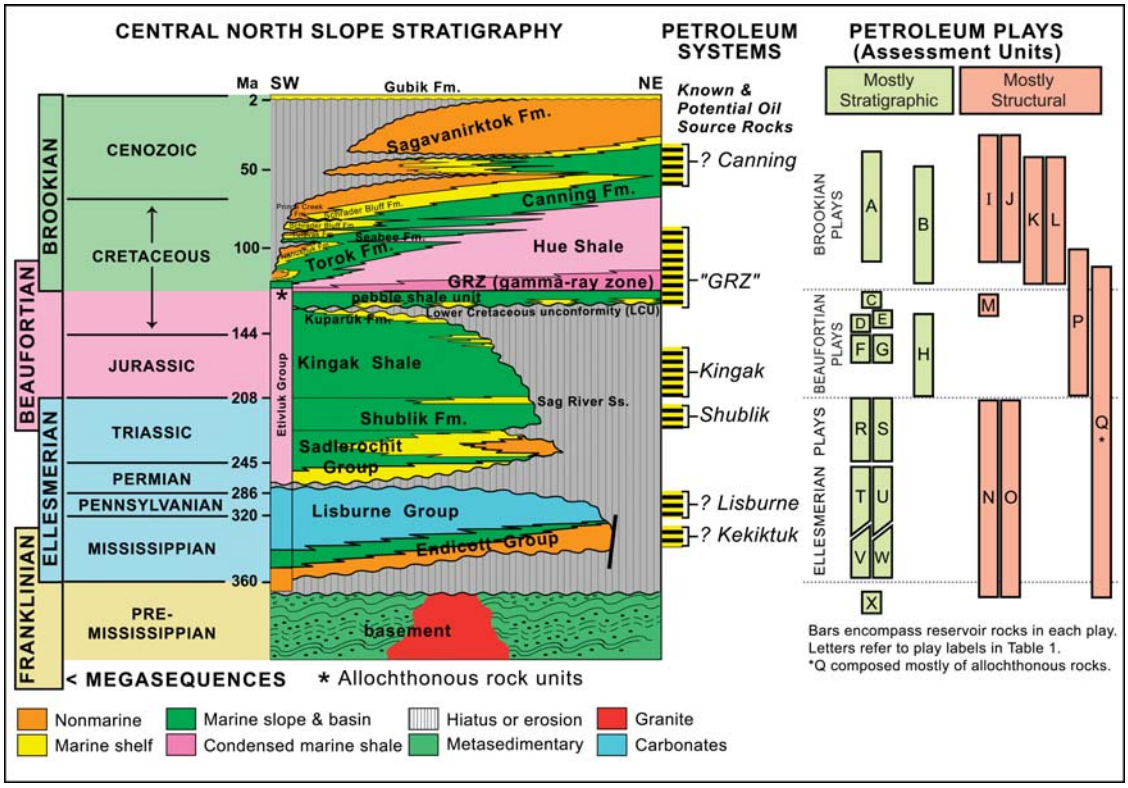
The USGS estimated technically recoverable, undiscovered resources of oil, natural gas (nonassociated and associated), and natural-gas liquids (from nonassociated and associated gas) in the central North Slope assessment area. Technically recoverable resources are the amount of petroleum that may be recovered using current technology. Oil resources are estimated to range between 2.6 and 5.9 billion barrels of oil (BBO) (95% and 5% probabilities, respectively), with a mean of 4.0 BBO. For comparison, recent USGS estimates of mean undiscovered oil in adjacent areas include 10.6 BBO in the entire NPRA and 10.4 BBO in the entire ANWR 1002 assessment areas. In the central North Slope, nonassociated gas resources range between 23.9 and 44.9 trillion cubic feet (TCF) (95% and 5% probabilities, respectively), with a mean of 33.3 TCF. In addition, means of 4.2 TCF of associated gas, 387 million barrels of natural-gas liquids (MMBNGL) from nonassociated gas, and 91 MMBNGL from associated gas are estimated to occur.

Most undiscovered oil and gas accumulations in the central North Slope assessment area are

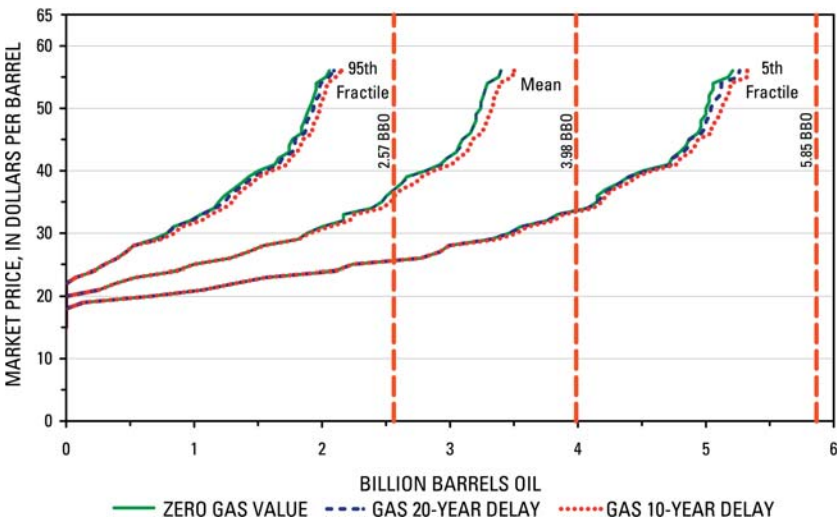
estimated to be relatively small compared to those already discovered: 91% of undiscovered oil resources are estimated to occur in accumulations of less than 250 million barrels of oil (MMBO) recoverable, and 96% of undiscovered nonassociated gas resources occurs in accumulations smaller than 3.0 TCF recoverable. The occurrence of larger oil and gas accumulations is unlikely. In total, there is estimated to be approximately 37 TCF of undiscovered natural gas in the central North Slope, with the majority located in the southern half of the assessment area in the foothills of the Brooks Range. This total is about half of what has been estimated to occur in NPRA (73 TCF of natural gas) and significantly more than has been estimated to occur in the ANWR 1002 area (9 TCF of natural gas). The natural gas resources in the central North Slope are accessible to existing infrastructure and to the route of the proposed gas pipeline.

In a report published in 2005, the costs and product prices required to transform these undiscovered, technically recoverable resources into producible reserves were evaluated. This economic component of the central North Slope assessment is intended to place the geologic resource analysis into an economic context that is informative and easily understood by policy makers and decision makers. This analysis estimates the part of the assessed distribution of undiscovered accumulations that can be commercially developed at particular market prices based on the incremental costs of finding, developing, producing, and transporting the oil and gas. The economic analysis is limited to the evaluation of general finding costs, development costs (including the costs of primary recovery and some aspects of secondary recovery), and the costs of transporting the product to market. Undiscovered technically recoverable conventional oil and gas resources are resources that are estimated to exist in undiscovered accumulations outside of known fields. Economically recoverable resources are the portion of the assessed technically recoverable resource for which the costs of finding, developing, and producing them, including an after-tax 12% rate of return on capital, can be recovered by production revenues at a particular price.

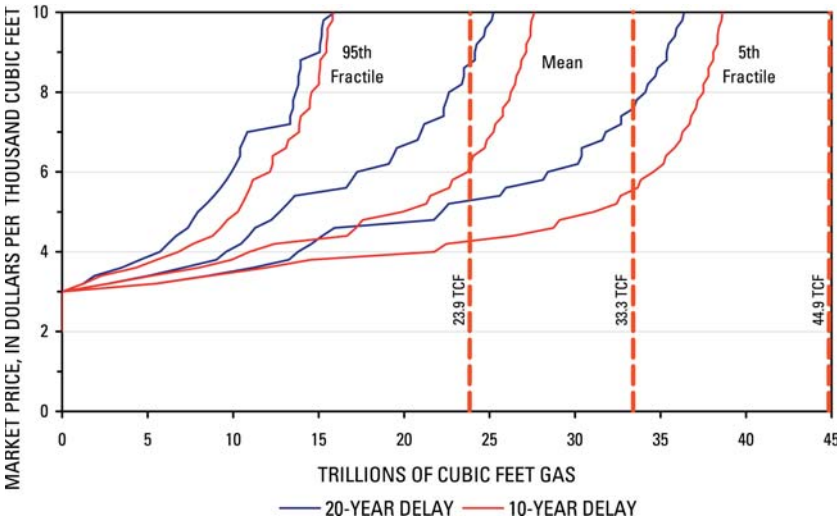
Recent economic analyses of undiscovered hydrocarbon resources of the North Slope have not considered natural gas because there is currently no infrastructure for transporting gas to markets located outside the North Slope. There is also a large inventory—in excess of 25 TCF—of very low cost stranded gas in rapidly depleting oilfields that may have priority access to a gas product pipeline when it is built. This study attempts to gauge, by a scenario analysis, the



Summary of ages, names, and rock types present in the central North Slope petroleum resource assessment area. The colored bars at the right show the stratigraphic position of the 24 petroleum plays evaluated in the 2005 assessment. The letters on the colored bars refer to play labels assigned in the assessment report.



Incremental costs, in 2003 dollars per barrel, of finding, developing, producing, and transporting crude oil from undiscovered oil accumulations in the central North Slope study area, where computations were prepared assuming that gas is valued at two-thirds the value of oil and that the present value of gas accumulations are 1) valued at zero (Scenario 1), 2) discounted for a 10-year delay (Scenario 2), and 3) discounted for a 20-year delay (Scenario 3). The 95th, mean, and 5th fractile estimates refer to the oil estimates with the concomitant gas assessed in gas accumulations. The vertical lines represent the technically recoverable oil at the 95th fractile, the mean, and the 5th fractile estimates of the geologic assessment as reported in U.S. Geological Survey Fact Sheet 2005–3034.



Incremental costs, in 2003 dollars per thousand cubic feet, of finding, developing, producing, and transporting nonassociated gas from undiscovered gas accumulations in the central North Slope study area, where computations were prepared assuming that gas is valued at two-thirds that of oil at the market and that the present values of commercial gas accumulations are discounted for a 10-year delay (Scenario 2) and a 20-year delay (Scenario 3). The 95th, mean, and 5th fractile estimates refer to gas estimates. The dashed vertical lines represent the technically recoverable nonassociated gas at the 95th fractile, the mean, and the 5th fractile estimates of the geologic assessment as reported in U.S. Geological Survey Fact Sheet 2005–3034.

economic influence that potentially commercial but currently undiscovered non-associated gas resources could have on exploration decisions. Past exploration in the study area has resulted in discoveries of more than 17 BBO and more than 35 TCF gas. Of the crude oil discovered, about 12.4 BBO has already been produced. At the mean estimates, the assessed undiscovered oil is 3.98 BBO and 37.52 TCF gas (4.20 TCF associated gas and 33.32 TCF non-associated gas). Almost 90% of the assessed undiscovered oil is assigned to plays that have already had discoveries. In contrast, less than half of the undiscovered gas in gas accumulations was assigned to plays with discoveries.

The USGS economic analysis shows that an increase in the commercial value of natural gas has a small but positive effect on the volume of economically recoverable oil. If gas is assigned no commercial value, above a market price of $40 per barrel for oil, the volume of economically recoverable oil is reduced by about 2–4%. (All calculations and costs were in constant 2003 U.S. dollars.) This analysis assumes sharing of processing facilities with adjacent oil fields, thus permitting development of smaller oil accumulations. At a market price of $55 per barrel, economic oil represents 79–88% of the assessed technically recoverable oil.

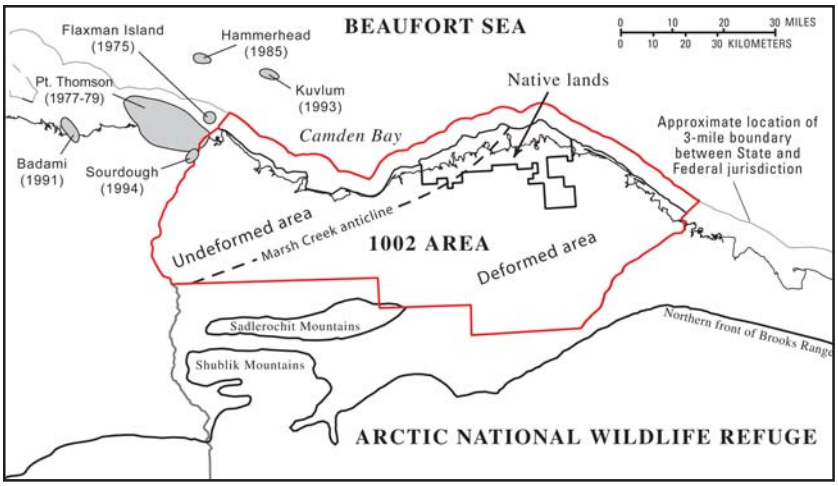
Available information on Arctic gas field development and operational costs are limited because there is no gas market transport system. It is estimated that it would take about 10 years from the decision to construct a gas pipeline to the lower 48 states until the pipeline was complete. Recent estimates of Alaska natural gas export pipeline tariffs of just under $3.00 per thousand cubic feet (mcf) limit the effects that gas commercialization have on oil development when the after-tax net present values are discounted for 10- and 20-year delays in development. The plot for economically recoverable gas reflects the results of analyzing the two scenarios of pipeline access and discounting to net present value. Even though the proportion of economically to technically recoverable gas is low, significant amounts of economically recoverable gas would still be present. However, more than 25 TCF of stranded gas is currently ready to market from existing oilfields on the North Slope at much lower cost than what it would take to discover and develop new gas accumulations. Assuming an Alaskan natural gas export pipeline tariff under $3.00 per mcf and a ready but delayed market, given the primitive gas field development

cost data used in this study, the volumes of undiscovered gas that could be identified and produced at $5 per mcf range from 7.9 to 22.1 TCF.

An Economic Update of the 1998 USGS Assessment of the ANWR 1002 Area

The Alaska National Interest Lands Conservation Act (1980) established the 19-million-acre Arctic National Wildlife Refuge (ANWR). In section 1002 of that Act, Congress deferred a decision on the permanent status of the 1.5-million-acre Federal part of coastal plain ("1002 Area") in recognition of its potential oil and gas resources and its importance as a wildlife habitat. The USGS released in 2005 two reports updating the economic analysis of their 1998 petroleum assessment of the combined lands consisting of the Federal 1002 Area of ANWR, Native Lands inside the boundary of the 1002 Area, and the lands underlying the adjacent Alaska State waters. The updates include newer field development practices based on horizontal development wells and satellite/cluster field development, as well as an update of the 1996 base costs to a new base year of 2003. The 1998 USGS assessment of undiscovered oil resources (in-place and technically recoverable) was retained as the geologic basis for the economic analysis. The mean technically recoverable undiscovered oil for the entire study area (Federal 1002 Area, Native Lands, and lands under adjacent State waters) is 10.36 BBO, while the 95th fractile estimate is 5.72 BBO and the 5th fractile estimate is 15.96 BBO. The Federal 1002 Area averaged about 74% of the assessed resources of the entire study area. The minimum accumulation size considered in the assessment was 50 million barrels of oil in place. Although the 95th and 5th fractile estimates show a wide range in total volumes, for each estimate a substantial fraction of the assessed oil was assigned to large accumulations (500 million barrels or greater), which are of economic interest even though they are located far from infrastructure.

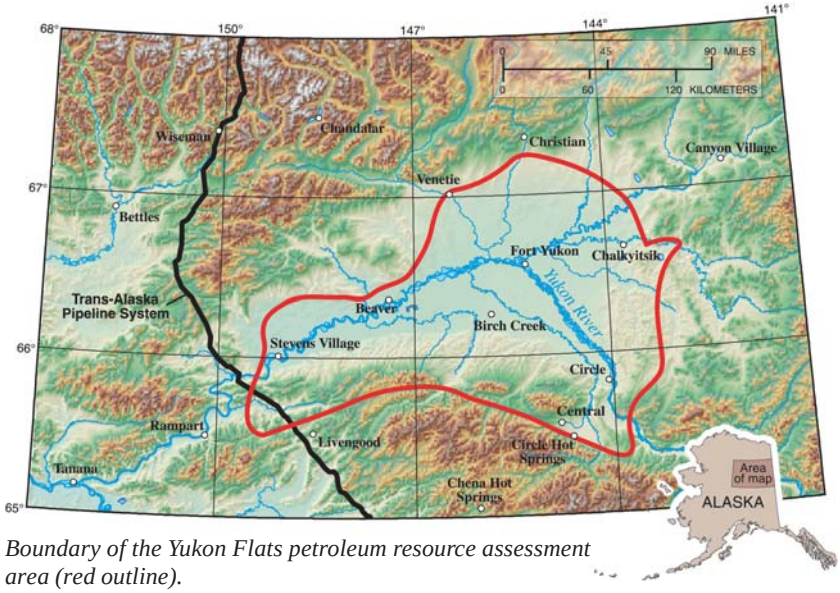
The results of the economic analysis are summarized as incremental cost functions that included the full costs (including a return to capital) of finding, developing, producing, and transporting the oil. The functions show that at $30 per barrel (2003 dollars), between 73 and 82% of the assessed technically recoverable resources are economic. At $55 per barrel, the economic resources represent more than 90% of the assessed technically recoverable resource estimate, that is, between 5.37 and 14.65 BBO. These estimates are generally within 10% of the estimates of the economically recoverable resources published earlier for the entire study area, when those estimates were adjusted to 2003 dollars. This finding suggests that improvements in productivity have to a large extent offset increased costs that occurred between the 1996 and 2003 base years.



The study area (red outline) of the USGS economic update for undiscovered oil in the ANWR 1002 Area. The study area included the Federal part of the 1002 Area, Native lands within the 1002 Area, and lands underlying adjacent Alaska state waters. The black, dashed line labeled "Marsh Creek anticline" marks the approximate boundary between the undeformed area (where rocks are generally horizontal) and the deformed area (where rocks are folded and faulted). Also shown are oil accumulations discovered near the entire Study Area during the past three decades.

Petroleum Resource Assessment of the Yukon Flats Area

Yukon Flats is a region of low, forested hills and flatlands with numerous streams and lakes, situated generally to the east of the TAPS in east-central Alaska. The USGS recently completed its first detailed assessment of the undiscovered oil and gas potential of the Yukon Flats region. At present, there is no commercial petroleum production in the Yukon Flats region, but the new USGS assessment indicates the probable existence of technically recoverable oil and gas resources—in other words, those resources that can be discovered, developed, and produced by using current technology—in rocks of Tertiary age (about 1.8 to 65 million years old). The assessment was based on the general geologic elements used to define a Total Petroleum System (TPS), which include hydrocarbon source rocks (source-rock maturation, hydrocarbon generation, and hydrocarbon migration), reservoir rocks (sequence stratigraphy and petrophysical properties), and hydrocarbon traps (trap formation and timing). The Yukon Flats TPS is a "composite" petroleum system because



Boundary of the Yukon Flats petroleum resource assessment area (red outline).

available geologic evidence suggests that it contains multiple horizons of petroleum source rocks—including shale, mudstone, and coal of Tertiary and Mesozoic age—rather than a single horizon of source rock, as in some other petroleum systems of the world. Using this geologic framework, the USGS quantitatively assessed undiscovered, conventional oil and gas resources in four assessment units within the Yukon Flats Tertiary Composite TPS. The Coalbed Gas Assessment Unit, which may contain continuous (unconventional) gas resources, was not quantitatively assessed for this study and will be considered at a future date, along with other potential coalbed gas units in Alaska.

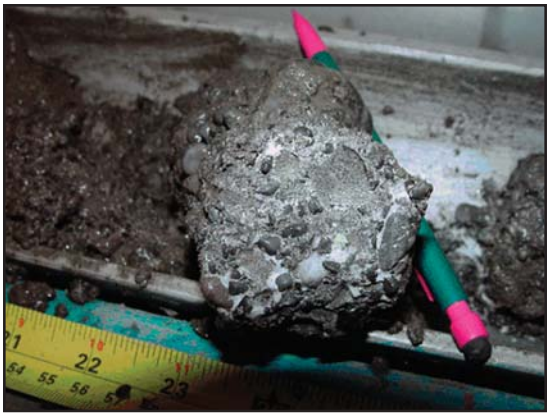
For the Yukon Flats Tertiary Composite Total Petroleum System, the USGS estimates a mean of 5.46 trillion cubic feet of gas (TCFG), a mean of 172.66 million barrels of oil (MMBO), and a mean of 126.67 million barrels of natural-gas liquids (MMBNGL). Nearly all of these undiscovered resources are estimated to be within the Tertiary Sandstone Assessment Unit.

Gas Hydrates

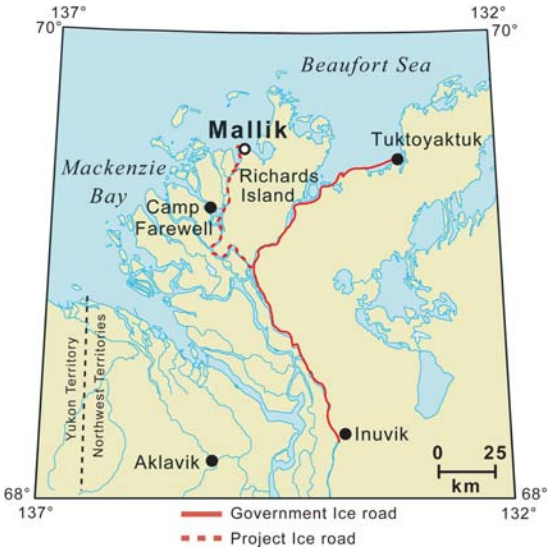
Gas hydrates, which are unconventional accumulations of natural gas (methane) trapped in ice-like structures with water, represent an immense energy resource underlying large portions of the world's Arctic continental areas and marine continental shelves. While these accumulations ultimately may yield important sources of energy for the world, additional scientific and engineering research needs to be undertaken to render feasible gas production from these accumulations. The potential future contribution of gas hydrate to the world energy mix depends on the availability, producibility, and cost of extracting methane from the hydrate phase. The immense potential of this resource has garnered significant national and international attention, and the USGS is involved in several partnerships with Federal and international agencies to collectively leverage resources and improve the understanding of this unconventional energy resource.

One of these partnerships, known as the Mallik International Research Consortium, is a cooperative research project with numerous research partners, including the USGS, the Geological Survey of Canada, the Japan National Oil Corporation, the Japan Petroleum Exploration Company, the GeoForschungsZentrum Potsdam, the DOE, and the India Ministry of Petroleum and Natural Gas. USGS scientists have provided scientific leadership, including one of two project co-leaders, management of all production modeling and testing efforts, management of all downhole logging efforts, scientific leadership of the gas geochemistry program, and scientific leadership of the gas hydrate core analysis efforts.

In 2002 the Research Consortium drilled three dedicated gas hydrate research wells at the Mallik site in the Mackenzie Delta, Canada. The goal was to establish a benchmark contribution by producing hydrates using various production methods, characterizing the engineering properties of gas-hydrate-bearing sediments, determining the geophysical properties of gas hydrates as they apply to surface prospecting techniques, and continuing research to improve drilling, coring, and well completion methods. The Mallik International Research Consortium, for the first time, proved that it was



Sample of core material, recovered from the Mallik Research Consortium drilling effort, showing the presence of gas hydrate (white).

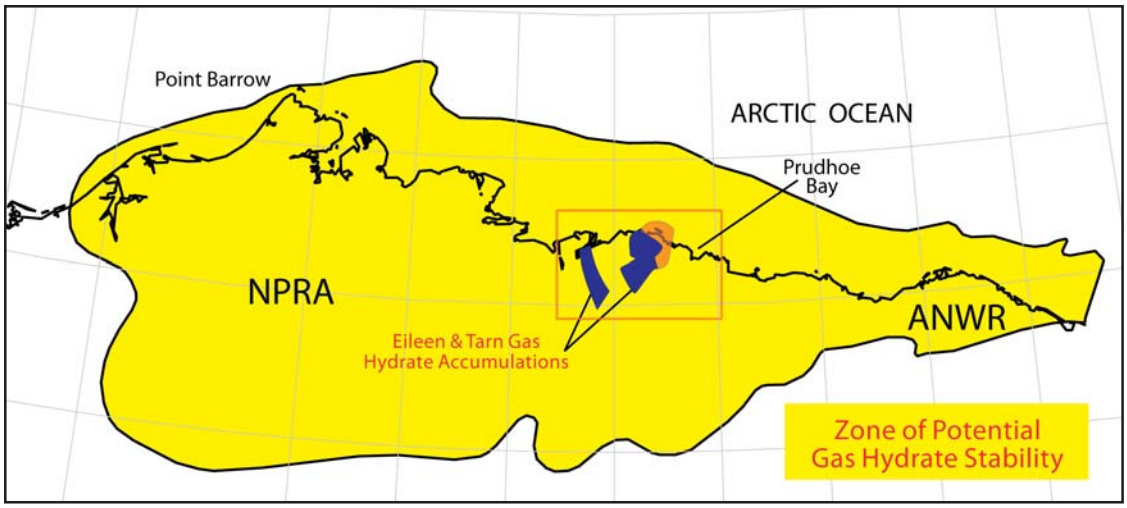


Location of the Mallik Research Consortium drilling site on the Mackenzie Delta of northern Canada.

technically feasible to produce gas from gas hydrates. Depressurization and thermal heating experiments, with real-time formation monitoring, were successful at the Mallik site. One test demonstrated that gas could be produced from gas hydrates with different concentrations and characteristics, exclusively through pressure stimulation, which will have implications for the economic viability of hydrate production. The resulting data support the interpretation that the gas-hydrate-bearing sediments are much more permeable and conducive to flow from pressure stximulation than previously thought. In another test, the gas production rates were substantially enhanced by artificially fracturing the reservoir. This work demonstrated that gas hydrates are a producible energy source, but much research remains to be done to translate these results into technically recoverable resource assessments for gas hydrates.

Results of these efforts were released at a meeting in Chiba, Japan, in December 2003 (abstracts can be found at http://www.mh21japan.gr.jp/english/index.html). Some of the findings from this work were also highlighted in a 2004 Hedberg Research Conference entitled "Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards," which the USGS helped to organize and co-hosted. This conference brought together scientists from around the world representing government agencies, academia, and industry to critically examine and discuss gas hydrate research efforts. The Geological Survey of Canada and the USGS co-edited a special volume, *Scientific Results from the Mallik 2002 Gas Hydrate Production Research Well Program, Mackenzie Delta, Northwest Territories, Canada,*

The Mallik drilling site.



Zone of potential gas hydrate stability in permafrost and shallow continental shelves along the Alaska North Slope. Note the locations of the Eileen and Tarn accumulations.

which was published in 2005 as Geological Survey of Canada Bulletin 585.

In addition to the Mallik Consortium, the USGS has ongoing efforts to assess the recoverability and production characteristics of permafrost-associated natural gas hydrates and associated free-gas accumulations in the Prudhoe Bay–Kuparuk River area on the North Slope of Alaska. The objective is to examine the resource potential of two known gas hydrate/free-gas accumulations (Eileen and Tarn) and possibly to drill and test a viable gas-hydrate/free-gas prospect. Technical support and data access are being supplied by industry and academic cooperators on the North Slope. In addition, the USGS is assessing the recoverability, resource potential, environmental effects, and production characteristics of Alaskan permafrost-associated natural gas hydrates in cooperation with the BLM and the State of Alaska Department of Natural Resources (DNR) through the Division of Geological and Geophysical Surveys. The primary goal of the research effort is to lay the groundwork for assessing the recoverability and potential production characteristics of the onshore natural gas hydrates and associated free-gas accumulations on the North Slope. Work will include identifying and mapping gas-hydrate/free-gas accumulations, as well as evaluating well log and seismic studies of existing North Slope developments. The primary goal of this cooperative effort is to assess the resource potential of known and undiscovered gas hydrate and associated conventional gas accumulations on both Federal and state lands in northern Alaska. This work builds on the efforts described above that focus on the known gas hydrate accumulations overlying the Prudhoe Bay and Kuparuk River oilfields and will develop a framework from which to assess the occurrence of gas hydrate accumulations on unexplored state and Federal lands. USGS's cooperators (BLM and Alaska DNR) are responsible for oil and gas development on Alaskan public lands, as well as for most pipeline rights of way. With the basic and applied research in support of this study provided by the USGS, the BLM, and the Alaska DNR will have the knowledge of where potential gas hydrate development will take place.

Geology and Energy Resource Potential of the Circum-Arctic

The Circum-Arctic is an area of high energy resource potential, low data density, sensitive environmental conditions, and great geologic uncertainty. A large portion of the remaining global endowment of oil and gas resources is known to exist in the high northern latitudes of Russia, Norway, Greenland, the U.S., and Canada. Although a few Arctic basins are known to be world-class petroleum provinces, including the West Siberian Basin, the Arctic has not been extensively explored. The quantity, distribution, and quality of resources in this region are poorly understood.

As part of its ongoing mission to provide up-to-date, objective assessments of oil and gas resources of the world, the USGS is conducting a resource assessment of the Circum-Arctic region as part of its World Energy Assessment project. The USGS World Petroleum Assessment (WPA) 2000 indicated that a significant portion of the world's undiscovered technically recoverable petroleum resources may reside within this region. A relatively small portion of the Arctic region was evaluated in the WPA 2000; the remaining areas

with high resource potential are currently being investigated. The Arctic Petroleum Assessment will utilize a methodology similar to that used in the WPA 2000 but with modifications to accommodate the unique circumstances surrounding this area, such as disparate data density, environmental quality concerns, high development costs, and technological requirements. The development of a modified methodology is the focus of an international collaborative effort to delineate the geologic framework and assess the resource potential of this province. The USGS, together with the Geological Survey of Denmark and Greenland, convened an international workshop devoted to exploring and discussing the issues surrounding the assessment of petroleum resource potential of the Circum-Arctic. Participants in the workshop included geoscientists from the U.S., Canada, France, Greenland, Denmark, Norway, and the United Kingdom, including assessment methodologists from various government agencies, industry, and academia. As part of the framework-building process, the USGS published in 2003 a digital geologic map of the Circum-Arctic region, representing a synthesis of data from multiple sources, including the *Circumpolar Geological Map of the Arctic* (published by the Geological Survey of Canada in 1989), bathymetric data, and oil and gas field centerpoints. Map units were kept as close as possible to the original map (more than 100 unique values).

Biological Studies

The USGS conducts research in the Arctic to generate information that will help DOI agencies and other partners in Alaska meet their resource management responsibilities. These responsibilities include the conservation of migratory birds, certain marine mammals, endangered species, anadromous fishes, and all biota inhabiting National Wildlife Refuges and National Parks and Preserves. In addition, fish and wildlife populations in the U.S. Arctic are extensively shared with Canada and Russia, and a portion of the research effort is directed toward treaty and other international requirements to jointly manage shared resources.

The USGS continued to serve as the Federal representative to the Scientific and Technical Committee of the Arctic–Yukon–Kuskokwim Sustainable Salmon Initiative, overseeing the internal and external review of proposals and developing a research and restoration plan for salmon in western Alaska. A draft of this plan was developed in July 2005 and was reviewed by the National Research Council, other Federal agencies, and the public. Completed in June 2006, the plan will direct research conducted by Federal and state agencies, non-governmental organizations, and others.

A multi-year study of spectacled eiders provided the first assessment of characteristics of Bering Sea wintering habitats and evaluated these characteristics in relation to long-term trends. Extreme sea ice in winter, extreme winds, and winds in spring explained the greatest variability in annual indices of eiders. Further, these analyses support the conclusion that annual population estimates on the breeding grounds can be negatively impacted by extended periods of dense sea-ice concentration and weather during the previous winter. These findings are of importance to the Spectacled Eider Recovery Team in understanding factors limiting the recovery of nesting birds, especially on the Yukon–Kuskokwim Delta, Alaska, where the breeding population has been reduced by 96%.

USGS scientists and multi-disciplinary cooperators are assessing how recent and ongoing ecological change affects the distribution and abundance of important bird populations on the North Slope of Alaska. The primary goal is to understand how physical variability in the environment manifests biological change. The resulting models will allow better prediction of species responses to various future habitat conditions and inform long-range planning for resource development. Preliminary analyses (2004-2005) of the long-term distribution of four species of geese molting on lakes near Teshekpuk Lake within NPRA reveal that their distribution has shifted from 20 years ago. One hypothesis for these distributional changes is that habitats have changed. USGS's analyses of a time series of aerial photographs show that lakes used by molting geese have increased in size by 3–36% between 1979 and 2002. There is evidence that much of this lake change is caused by shoreline erosion driven by wind, waves, and ice gouging. Photo interpretation of habitats favored by foraging geese at one study lake reveals that flooded tundra has decreased by 81%, whereas the proportions of moist tundra, wet tundra, and shoreline moss have all increased. These results are consistent with higher evaporative water loss caused by elevated temperatures in recent decades. Further analyses of this time series of photos document substantial amounts of Beaufort Sea coastal erosion. In some areas, hundred of

meters of shoreline were lost between 1979 and 2002. Coastal erosion has led to saltwater intrusion into freshwater habitats, particularly in the northeastern NPRA. Such saltwater intrusion is expected to quickly alter foraging habitats for geese.

Satellite telemetry has been used to document the migration of yellow-billed and red-throated loons from breeding areas in Alaska to their wintering areas. Of the 24 red-throated loons captured at various breeding areas in Alaska, all 19 loons marked at breeding areas south of the Brooks Range wintered within North America. The five marked loons that bred on Alaska's North Slope migrated along the east Asian coastline, completed their annual molt along the northern shores of Hokkaido Island, Japan, and the southeastern shore of Sakhalin Island, Russia, and wintered in the coastal waters of South Korea. The eleven breeding yellow-billed loons initially marked on Alaska's North Slope migrated along the east Asian coastline, where six wintered along the coast of Hokkaido Island. USGS researchers measured organic and inorganic contaminant levels in eggs, including specific types of PCBs. These analyses documented 35 different PCB congeners in eggs from loons breeding in northern Alaska and wintering in east Asia that were not present in any eggs from loons from the other areas. They also documented greater occurrences of dieldrin, DDT, and HCB in the eggs of loons from the North Slope. These results are significant in understanding factors that may be limiting populations of yellow-billed loons, which were recently petitioned for listing under authority of the Endangered Species Act

A multi-year study described the importance of key habitats used by four nesting populations of nearctic brant and the relationship between changes in these habitats and population dynamics of brant. Nearctic brant rely on marine habitats and native intertidal plants during the non-breeding season, particularly the seagrass *Zostera* and the macroalgae *Ulva*. Atlantic and eastern high Arctic brant have experienced the greatest degradation of their winter habitats and have also shown the most plasticity in feeding behavior. Black and western high Arctic brant of the Pacific Flyway are the most dependent on *Zostera* and are undergoing a shift in winter distribution that is likely related to climate change and its associated effects on *Zostera* dynamics. Variation in the breeding propensity of the black brant associated with winter location and climate strongly suggests that food abundance on the wintering grounds directly affects reproductive performance in these geese. In summer, salt marshes, especially those containing *Carex* and *Puccinellia*, are key habitats for raising young, while lake shorelines with fine freshwater grasses and sedges are important for molting birds. The availability and abundance of salt marshes has a direct effect on the growth and recruitment of goslings and ultimately plays an important role in regulating the size of local brant populations.

The USGS completed a significant effort to monitor long-term trends of passerines and other landbirds breeding in remote areas of Alaska, including lands under management by Federal and state agencies, using survey protocols and a stratified random sampling design developed by the USGS. This program, the Alaska Landbird Monitoring Survey (ALMS), has been adopted by Boreal Partners in Flight as a state-wide monitoring program for Alaska. A Memorandum of Understanding supporting ALMS was approved by the leaders of nine agencies and organizations in Alaska, including the U.S. Fish and Wildlife Service, National Park Service, Bureau of Land Management, USDA Forest Service, Alaska Department of Fish and Game, National Audubon Society, Alaska Natural Heritage Program, Alaska Bird Observatory, and USGS.

Research on demographic parameters such as survival and dispersal and gene flow is ongoing to better understand the population biology of a group of sea ducks, which are in decline across North America. Three important contributions in this area were made during FY 2005. Population genetic assessments of king eiders and the threatened Steller's eider were completed, and a demographic analysis of band-recovery data was completed for common mergansers across much of North America. These contributions highlight the need for multiple marker assessments of migratory waterfowl, such as jointly examining data from both genetic and demographic markers.

Breeding and molting locations and migration patterns of the Atlantic population of Steller's eiders were studied applying satellite telemetry techniques. This study, concluded in 2005, provides the first information on the staging distribution, migration routes, and timing of migration of the Atlantic population of Steller's eiders. The wintering population in northern Norway was linked to staging and breeding areas from the Kola Peninsula to the eastern Taymyr Peninsula, which confirmed and expanded information on the breed-

ing distribution of this little-known population. The previously unknown molting region for the majority of the Atlantic population was also located in remote Russia. The findings of this study will be used in Norwegian and Russian recovery and management plans and for updating the EU Action Plan for Steller's eiders.

The USGS concluded an inventory of montane-nesting birds in the Arctic Network of National Parks in 2005, providing the first comprehensive assessment of breeding range and habitat associations for the majority of avian species across the vast National Parks of northwestern Alaska. The data from this inventory provide a framework upon which to design future monitoring programs.

Between late July and mid-October 2005, the USGS, in conjunction with the Yukon Delta NWR, Lund University in Sweden, Groningen University in The Netherlands, and the University of Otago in New Zealand, participated in a multi-faceted research program on long-distance migration of shorebirds. This research is part of the Swedish Polar Research Secretariat's Beringia 2005 Expedition to the Bering and Chukchi Seas.

The Department of the Interior has trust responsibility for managing two marine mammal species in Arctic waters: polar bears and Pacific walruses. Research continues on developing and implementing an effective survey method for estimating the Pacific walrus population size. The results include:

- An analysis of pilot study data that established the potential for integrating scanner technology with digital photography in a two-stage aerial survey of walruses on sea ice;
- The development of a population size estimator for the new survey methodology with an explicit variance estimator; and
- An extension of the simulation method developed to incorporate new data and refine estimates of sample size requirements.

This work will ultimately provide managers with a reliable estimate of the Pacific walrus population size and a technique for continued monitoring of its status and trends. Also, a remotely deployed satellite radio transmitter for walruses has been developed that is attached with a crossbow, the first such deployments on a pinniped. This system enabled the collection of unique haul-out behavior data from female walruses in ice habitats in 2004 and 2005. In addition, USGS has summarized data from walrus radio-tagging efforts in Bristol Bay over a 15-year period. The data were used to estimate haul-out fidelity, broadly describe seasonal foraging distributions, and determine the approximate timing of autumn migration from Bristol Bay. This study documented the use of terrestrial haul-outs and at-sea foraging areas and demonstrated year-round residence in the bay by some animals. It provided baseline information on changes in the distribution of walruses in the bay, which is of interest to both Federal and state resource managers.

USGS polar bear studies have focused for nearly two decades on providing research results that help management agencies in decisions concerning the possible impacts of human activity on polar bear populations and habitats. In FY 2004, the USGS completed forward-looking infrared (FLIR) viewing research, which has provided another tool to mitigate the impacts of human activities on denning polar bears. Polar bears give birth in snow dens in mid-winter and remain in the dens until early spring. The survival and development of neonates depends on the stable environment within the maternal den. Development activities are a potential threat to polar bears, especially as they might disturb denning females. USGS scientists described tests to determine whether FLIR could be effective at detecting heat rising through the roofs of polar bear dens and thus be a potential monitoring tool. Biologists surveyed 23 dens on 67 occasions, with 9 dens always detected, 10 dens visited more than once detected on some flights and not on others, and 4 dens visited under marginal conditions never detected. Models of how detection probability varied with environmental conditions revealed that the odds of detecting a den increased three times for every one degree centigrade increase in the temperature–dewpoint spread. The odds of detection also were 4.8 times higher when airborne moisture (snow, blowing snow, fog etc.) was absent than when it was present. While the data suggested that some dens never will be detectable with FLIR, surveys conducted during conditions that maximize odds of detection will locate most dens most of the time and can be an important management tool.

Also in FY 2004, the USGS completed a new method of analyzing radiotelemetry data that greatly expands the utility of telemetry data to delineate and manage wildlife populations. Radiotelemetry has provided previously unavailable insights into the movements and activities of many wild animal species. Unfortunately, the inability to estimate the error in animals' utilization distributions (UDs) has prevented probabilistic linkage of radiotelemetry data, which are always retrospective, with future management actions. In 2004, the

USGS used the example of the harvested population of polar bears in the southern Beaufort Sea to illustrate a method that provides that linkage. With this method, wildlife biologists can derive previously unavailable information from radiotelemetry data and apply it across a broad spectrum of management and research topics.

Since 1990, the USGS Alaska Science Center has collaborated with the Russia Academy of Sciences in Moscow on studies of Arctic sea ice as it pertains to habitat for shared marine mammal populations. During FY 2004, two papers were published about the summer melt season over Arctic sea ice that show that the summer sea-ice melt season was positively correlated with strength of the previous winter's Arctic Oscillation (AO) index, based on analyses of passive microwave satellite data from 1979 to 2001. Following high-index AO winters, spring melt tended to be earlier and autumn freeze later, leading to longer melt seasons. The largest increases in melt duration were in the eastern Siberian Arctic, coincident with cyclonic atmospheric circulation and ice motion anomalies associated with high-index AO phases. These results contribute to a growing body of literature about Arctic Ocean processes. During FY 2005, and through collaborations with the Russia Academy of Sciences and the Cooperative Institute for Research in Environmental Sciences, several papers were published about the diminishing extent of perennial sea ice, the decreasing age of the ice, and the role of atmospheric circulation patterns in determining the timing of spring snow melt in the western Arctic. Globally, the products of these collaborations are contributing to a growing understanding of the integrated ocean–ice–atmosphere system. Locally, the products are providing knowledge about how climate variability is affecting the habitats of Arctic wildlife populations (see http://alaska.usgs.gov/announcements/sea_ice.html).

Gray wolves are viewed as obligate predators of ungulates, with other prey contributing little nutritional benefit. In northwestern North America, Pacific salmon have largely been ignored as a potential food source for inland wolves. However, salmon are seasonally abundant during summer–fall spawning and are widely distributed at great distances from the coast. The USGS tested the hypothesis that salmon could contribute substantially to wolf diets in non-coastal areas (i.e., Denali National Park). Using $^{15}N/^{14}N$ ratios, USGS researchers estimated the proportion of wolf's diets that were composed of salmon. Overall, salmon averaged 7% of the diets of the 46 wolves sampled. Ninety percent of the wolves with home ranges encompassing salmon spawning areas consumed salmon, and their diets averaged 11% salmon. These findings indicate that Pacific salmon can be important prey for wolves where spawning salmon occur and may represent a substantial marine influence on terrestrial wolf/prey systems, even at great distances inland.

The USGS analyzed aerial methods for surveying Dall's sheep in Alaska to provide insights to wildlife managers on the quality of survey data currently being collected. The sightability of sheep was generally high and related to group size. Sightability did not differ between helicopters and fixed-wing aircraft, as commonly believed. Double-count methods were difficult to apply to sheep because groups tended to change in size between successive observations by two aircraft. The development and use of sightability models based on group size would improve the accuracy of sheep surveys and provide a measure of precision.