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.

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 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, focuses on issues related to assessing and predicting potential environmental and socioeconomic impacts.

	Funding (thousands)	
	FY 02	FY 03
Technology Assessment/Research	400	500
Environmental Studies	4,866	4,273
Total	5,266	4,773

Technology Assessment and Research Program

The MMS supports an active research program to understand the engineering constraints for offshore operations, especially related to the structural integrity of oil and gas facilities 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 comprises two functional research activities: Operational Safety and Engineering Research (OSER) and Oil Spill Research (OSR).

The TA&R Program has four primary objectives:

- Technical Support: TA&R provides engineering support to MMS decision makers in evaluating industry operational proposals and related technical issues and ensuring that these proposals comply with applicable regulations, rules, and operational guidelines and standards.
- Technology Assessment: Industry applications of technological innovations are investigated and assessed to ensure that governing MMS regulations, rules, and operational guidelines encompass the use of BAST.
- Research Catalyst: The program promotes leadership in OSER and OSR by acting as a catalyst for industry research initiatives.
- International Regulations: The program provides international cooperation for research and development initiatives to enhance the safety of offshore oil and natural gas activities and the development of appropriate regulatory program elements worldwide.

The TA&R Program operates through contracts with universities, private firms, and govern-

ment laboratories to assess safety-related technologies and to perform necessary applied research. Participation in jointly funded projects with industry, other Federal and state agencies, and international regulatory organizations has become the primary funding mechanism in view of the overlap of issues and challenges. Participation in joint projects is the most effective and efficient means to leverage available funds.

The TA&R Program enhanced its research capabilities in FY 99 through the establishment of a five-year cooperative research program with the Offshore Technology Research Center in College Station, Texas. This cooperative agreement provides direct research support to MMS as well as a forum for identifying and jointly funding research projects with industry on a variety of topics.

For additional information regarding the TA&R Program, please contact Sharon Buffington at 703-787-1147 or sharon.buffington@mms.gov.

The 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 cleanup of oil spills. Ohmsett is the only facility in North America where full-scale response equipment (containment booms, skimmers, etc.) can be tested in a controlled environment, using real oil. (See below for a fuller discussion of Ohmsett.)

In the past the TA&R Program was motivated by the need to acquire basic engineering information necessary to oversee the general development of offshore operations. As a direct result of research funded by the TA&R program, regulatory changes were initiated on:

- The design and operation of diverter systems, well control procedures, and training requirements;
- The need for periodic platform inspections, methodologies for assessing the integrity of older or damaged platforms, and the reduction of exhaust pollution offshore; and
- The development of oil pollution plans to ensure that the proper equipment, personnel, and procedures were available to respond to an offshore oil spill, should one occur.

However, the future has provided new goals and directions for offshore oil and gas research initiatives. This new emphasis is a result of 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.

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 four 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 organizational factors and how they can be addressed to mitigate accidents;
- Aging offshore infrastructure, including platforms and pipelines; and
- Spill mitigation measures, including cleanup and containment technologies for an oil spill, should one occur.

The TA&R Program is a contract research program; that is, the research is not performed within the agency but is conducted by academic institutions, private industry, and government laboratories. Studies are performed in cooperation with the offshore industry or with other agencies or governments. This aspect of the program provides an important multiplier of funding support, but probably of equal importance is the discourse it provides with the industry.

The ability to work together to assess a particular technology or the rationale for future technical developments helps both industry and government. Such cooperation and dialogue allow us to understand each other's needs and eliminate possible conflicts or misunderstandings concerning the engineering feasibility of an operational decision. As a result of this dialogue, a valuable exchange of information is provided between MMS and the industry.

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 an increased interest by the oil and gas industry in Arctic offshore resources.

Sea ice is still the most severe environmental hazard posed by the Arctic relative to future offshore development. Such hazards include the forces that moving sea ice may exert against offshore structures, icing of structures resulting from freezing spray, gouging of the seafloor 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.

A final report called *Worldwide Assessment of Industry Leak Detection Capabilities for Single and Multiphase Pipeline* summarizes the current issues for pipeline leak detection by identifying the state-of-the-art technologies used in pipeline leak detection, assessing the effectiveness of current leak detection technology, and evaluating the effect of multiphase flow conditions on leak detection technologies. For offshore pipelines operating in the Arctic, leak detection systems are intensely scrutinized for their effectiveness in detecting and locating a leak. The results from this project identify which technologies can work in an Arctic offshore environment and how many redundant and complementary systems can be employed to minimize leak volumes. The final report is available from the MMS web site for TA&R Project 409 at http://www.mms.gov/tarprojects.

The 2003 International Offshore Pipeline Workshop was held during February 26–28, 2003, in New Orleans. The workshop was hosted by the MMS and the U.S. Department of Transportation (DOT) Research and Special Programs Administration and sponsored by major oil and gas companies, offshore pipeline contractors, offshore service companies, and other related entities. Information collected and shared at this successful event will lead to new research projects and updated and new codes and standards, define critical technology needs to maintain the aging pipeline infrastructure and enter frontier areas, and provide critical feedback and background knowledge for the MMS and DOT policymakers. The workshop proceedings also provide ample items that can be used to address a multitude of issues for the Arctic related to design, installation, leak detection, inspection, and repair. The final report is available at http://www.mms.gov/tarworkshops/pipelines.htm.

A project called "Strain-Based Design of Pipelines" had as its objective to develop a best-practice guide for strain-based design of pipelines. It was also jointly funded by MMS and the DOT Research and Special Programs Administration to help fill an industry need for a complete guide on offshore pipeline design. The final report constitutes the first of two efforts to complete this guide, which will cover design, assessment, and testing guidelines for designers of pipelines that may experience high strains in service. Historically, pipelines have been designed to codes that are stress based. This requires a less rigorous detailed engineering analysis to meet acceptable pipeline safety. For offshore pipelines, however, especially those in deep water and in the Arctic, an exacting site-specific analysis including loading conditions and material mechanical properties is needed to maintain the acceptable level of pipeline safety expected. This research project will investigate how the use of strain-based design of pipelines can better assure safe and pollution-free operations, especially in environmentally sensitive areas.

The Banff/03 Pipeline Workshop, held in Banff, Canada, during April 14–17, 2003, was the sixth in a series of workshops that Natural Resources Canada (NRC) has organized to address new pipeline technologies for the Arctic environment. The workshop reviewed the progress achieved from the 2001 workshop and carried out intensive group discussions on such topics as risk assessment/risk management, abandonment issues, strain-based design, and in-line inspections. The workshop was sponsored by NRC and a number of industry participants, including the MMS. Because of the aging condition of existing pipelines and the progression of the industry into deeper water and the Arctic, a need exists to be aware of new managing techniques for pipeline integrity. The workshop discussed such issues and provided a forum for the exchange of information.

Oil Spill Response Research

The MMS is the principal U.S. government agency funding offshore oil spill response research (OSRR). Through funding provided by MMS, scientists and engineers from worldwide public and private sectors are working to address outstanding gaps in information and technology concerning oil spill cleanup. Credible scientific research and technological innovations 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.

The MMS research supports the bureau's goal of safe and environmentally sound operations by improving capabilities to detect, contain, and clean up open-ocean oil spills. This research program complies with Title VII of the Oil Pollution Act of 1990 (OPA-90) and is conducted in cooperation with the Interagency Coordinating Committee for Oil Pollution Research, as called for in OPA-90. Oil spill response research is one tool that MMS uses to fulfill its regulatory responsibil-

Test burn with crude oil on frazil ice.

ities mandated by OPA-90. Information derived from the OSRR 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.

Funds for the OSRR Program are specifically appropriated from the Oil Spill Liability Trust Fund. The fund receives revenues from cost recovery and civil penalties incurred from oil spills and from an oil tax collected from the oil industry (five cents per barrel on domestically produced or imported oil). As intended by OPA-90, companies that produce or transport oil are required to support research and development to improve oil spill response capabilities.

The OSRR Program has funded a variety of projects to develop and improve Arctic oil spill response. The MMS research currently underway focuses on three main types of cleanup technology: in-situ burning, chemical treating agents, and mechanical response.

In-Situ Burning

In-situ burning technology includes the techniques and equipment required to ignite and sustain combustion of oil spills on the water, shorelines, and the marshland environment. In-situ burning is the most promising technique for removing large quantities of oil from the surface of the water as encountered during major and catastrophic spills. It is also effective for mitigating spills on land and in coastal areas. Potential impacts and benefits of developing this technology are high. Burning can be applied in remote areas where other response techniques cannot be used because of distance and lack of infrastructure. In some circumstances, such as when oil is mixed with or on ice, it may be the only option for dealing with an oil spill.

The MMS is designated as the lead agency for in-situ burn research in the Oil Pollution Research and Technology Plan prepared under the authority of Title VII of the Oil Pollution Act of 1990 (OPA-90). The TA&R Program has assembled *In-Situ Burning of Oil Spills: Resource Collection*, which is a comprehensive compendium of scientific literature on the role of in-situ burning as a response option for the control, removal, and mitigation of marine oil spills. All operational aspects of burning are covered in detail. The potential impacts of this technique on the environment and on human health and safety are also addressed. The 2-CD set includes a substantial percentage of the scientific and technical literature on research, development, planning, and implementation undertaken by hundreds of individuals and dozens of organizations. In-situ burning is not necessarily the preferred oil spill response tool for all incidents but is one that is considered by a growing number of responders.

The collection provides a wealth of information in a convenient format that can be used in the planning, response, or research environment. It contains more than 350 documents with over 13,000 pages and nearly an hour of video. For those new to the subject of in-situ burning, the collection includes a 13-minute video developed by the Alaska Department of Environmental Conservation and Alaska Clean Seas.

Publication of this in-situ burn literature collection fulfills MMS's mandate in the Oil Pollution Research and Technology Plan as well as its committment to the Interagency Coordinating Committee for Oil Pollution Research. The MMS distributes this 2-CD collection without charge.

A research project called Mid-Scale Tests to Determine the Limits to In-Situ Burning of Thin Oil Slicks in Broken Ice was designed to investigate the minimum ignitable thickness, combustion rate, residue amount, and effect of waves on thin oil slicks burned in situ on frazil or slush ice typical of freeze-up and on brash ice typical of break-up. The focus was on thin oil slicks, such as those that could be generated by blowouts or subsea pipeline leaks; previous laboratory and field experiments have adequately addressed the burning of thick oil slicks in broken ice. This project consisted of a literature review, small-scale burns in a chilled wave tank in Ottawa, Canada, and mid-scale burns in an outdoor wave tank at Prudhoe Bay, Alaska. A total of 114 burns of 40 cm and 42 burns of 170 cm were completed. Results from this project will be used to propose "rules of thumb" for burning thin oil slicks in broken ice relevant to existing production

For copies of In-Situ Burning of Oil Spills: Resource Collection, *please contact Joseph Mullin at 703-787-1556 or joseph.mullin@mms.gov.*

fields in Cook Inlet and Prudhoe Bay and to proposed fields in Alaska, Norway, and Russia.

Chemical Treating Agents and Dispersants

Dispersants are a specific type of oil spill chemical countermeasure that reduces oil/water interfacial tension so that oil can disperse into small droplets in the water column. 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 it is seldom used. Analysis of tradeoffs between dispersant use and conventional mechanical recovery techniques demonstrates 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. 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 mesoscale 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 sub-Arctic environments. The results of this research will facilitate the acceptance and use of dispersants throughout the U.S. and North America.

A project called "Dispersant Effectiveness Testing on Alaskan Crude Oils in Cold Water" studied whether Corexit 9500 and Corexit 9527 dispersants are effective in dispersing Alaskan crude oils in cold-water conditions. Dispersant effectiveness experiments completed at Ohmsett in 2002 demonstrated that Alaska North Slope (ANS) and Hibernia crude oils could be successfully dispersed in cold water. Four Prudhoe Bay crude oils (ANS, Northstar, Endicott, and Pt. McIntyre) and one Cook Inlet crude oil (Middle Ground Shoals) were selected for testing. This project consisted of small-scale dispersant experiments conducted in a chilled wave tank in Ottawa, Canada, and large-scale dispersant experiments conducted at Ohmsett. A total of 64 small-scale experiments were conducted to develop the final test matrix for the large-scale tests. A total of 14 large-scale tests were completed at the Ohmsett facility using various combinations of oil type and dispersant-to-oil ratios.

The chemically dispersed runs resulted in high percentages (75 to nearly 100%) of oil dispersing into the water column, with the exception of evaporated Northstar and evaporated Endicott. The dispersant effectiveness trends identified in the small-scale testing were mirrored in the large-scale test results. The heavily evaporated Northstar and evaporated Endicott crude oils were resistant to chemical dispersion in both the small-scale and Ohmsett tests. A higher percentage of the fresh Endicott crude oil was dispersed in the Ohmsett tests compared to the small-scale results (74 vs. 20–30%). This may be due to additional mixing energy present in the Ohmsett tests, in the form of breaking waves that do not develop in the small tank tests. Fresh Northstar was the only test where no visible oil was present on the surface at the end of the test. The initial Northstar crude oil slick was thinner (because of its lighter oil characteristics and its tendency to spread faster) than the other oils, so it received a somewhat higher dispersant dosage. The lighter oil characteristics and higher dispersant dosage may account for the complete dispersion and the absence of visible oil on the water surface at the end of this test.

Dispersant experiment in cold water and broken ice at Ohmsett.

Ohmsett: The National Oil Spill Response Test Facility

Ohmsett—The National Oil Spill Response Test Facility—is located in Leonardo, New Jersey. Ohmsett is the only facility in the world where full-scale oil spill response testing, training, and research can be conducted with oil in a marine environment under carefully controlled conditions. It 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

Preparing Ohmsett for mechanical oil-in-ice experiments.

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, the U.S. Navy, the National Oceanic and Atmospheric Administration, and the Environmental Protection Agency.

The heart of Ohmsett is a large outdoor concrete test tank that measures 203 m long by 20 m wide by 3.4 m deep. The tank is filled with 9.84 million liters of crystal clear salt water. There is a wave generator at one end and a moveable beach at the opposite end to reduce wave reflection when regular waves are desired for testing. The tank is spanned by a bridge system capable of towing floating equipment at speeds up to 6.5 knots. The tow bridge is equipped to distribute test oil on the surface of the water several meters ahead of the device being tested so that reproducible thicknesses and widths of oil can be achieved with a minimum of wind interference. The Ohmsett facility features a fully computerized data collection system, above- and below-waterline video capability, and complete oil storage and handling system. Ohmsett is the only facility in the U.S. where full-scale equipment can be easily tested without going into the ocean. If Ohmsett were not available, the only alternative would be at-sea testing, which is very expensive, requires permits, and does not allow reproducible testing conditions. More than 95% of all performance data on offshore oil spill response equipment have been gathered at Ohmsett.

For questions regarding the MMS Oil Spill Response Research Program, please contact Joseph Mullin at 703-787-1556 or joseph.mullin@mms.gov.

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 will enable the Ohmsett facility to remain open year-round, offering cold-water testing and training during the winter months. Recent testing activities include evaluations 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.

Alaska Environmental Studies Program

As the agency responsible for managing the OCS offshore oil and gas leasing program in Alaska, the MMS Alaska OCS Region has conducted environmental studies since 1974 to obtain information needed to make sound leasing decisions and to monitor the human, marine, and coastal environments. In Alaska, more than $275 million has been spent on studies in 15 OCS planning areas in the Arctic, Bering Sea, and Gulf of Alaska sub-regions. 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; traditional knowledge sources; research contractors; scientists and government personnel from Federal, state, and local agencies; and political entities—help the MMS to 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. Information regarding these studies can be found in the Alaska Region's Annual Study Profiles list available at http://www.mms.gov/alaska/ess/essp/

SP.HTM. As final reports become available, they will be added to the Environmental Studies Program Information System (ESPIS) web site at http://mmspub.mms.gov:81/search.html.

Coastal Marine Institutes (CMIs) were initiated by MMS to take advantage of the expertise of highly qualified scientifists at local levels and to achieve cooperative research goals in key OCS regions. In 2003 the MMS renewed funding of the CMI at the University of Alaska Fairbanks (UAF) to benefit from its scope and depth of scientific expertise. Under a recently extended cooperative agreement, the MMS committed $1 million per year for studies to be conducted by the CMI if matching state funds were available. The institute 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 internationally renowned UAF School of Fisheries and Ocean Science manages the CMI. The Institute creates an opportunity for the MMS and the State of Alaska to jointly accomplish research that could not otherwise be carried out. In addition to 22 ongoing studies, 8 new studies are being evaluated for funding through the CMI in 2004.

Endangered and Protected Species

The bowhead whale, an endangered marine mammal of high importance to Native cultures in the Arctic, migrates through areas of oil and gas exploration and development, including the Northstar offshore production site. Efforts to monitor the fall migration of bowhead whales and related environmental factors will continue through 2004 under the MMS-conducted Bowhead Whale Aerial Survey Project (BWASP) (OCS Study MMS 2002-061 is available at http://www.mms.gov/alaska/reports/BWASP/2002_061adobe6test.pdf) and the MMS-funded study called "Analysis of Covariance of Human Activities and Sea Ice in Relation to Fall Migrations of Bowhead Whales."

Northstar, the first offshore oil development in the Alaskan Beaufort Sea.

The BWASP results indicate that fall bowhead whale sightings tend to be farther offshore in heavy ice years across the central Alaskan Beaufort Sea (142–155°W longitudes). 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. The fall 2001 report showed a greater relative occurrence of feeding and/or milling behaviors of bowhead whales in six different years near the mouth of Dease Inlet, Alaska. It showed similar activity in four of those years near Cape Halkett, Alaska. The analysis of covariance study was funded in early 2003 and will further test hypotheses regarding the relative degree to which various human activities and sea ice may explain variance in observed bowhead whale distributions.

A multi-year study, "Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information," has been unique in the extent of its coordination with area whale hunters (http://www.mms.gov/alaska/reports/BowheadWhaleFeeding/2002_012.pdf). Residents of Kaktovik assisted in the study design, field implementation, report review, and knowledge sharing needed to determine the importance of the eastern Alaskan Beaufort Sea area to feeding bowheads. Other study components included aerial photography, behavioral observations, isotopic analysis of baleen and muscle tissue, stomach content analysis, and energetics modeling. The results of the study provided important information that was used in the environmental assessment for OCS Lease Sale 186.

Beluga whales are an important species for Native subsistence, with more than 300 harvested annually in Alaska. The movements of beluga whales were documented using satellite telemetry under the MMS/CMI study entitled "Satellite Tracking of Eastern Chukchi Sea Beluga Whales in the Beaufort Sea and Arctic Ocean." From 1998 to 2002, 23 whales were instrumented with the help of Native subsistence hunters in Kasegaluk Lagoon near the village of Point Lay. Data from this and a previous MMS-funded study suggest that female belugas may not move as far north in the Beaufort Sea as male belugas do. Belugas of all ages and both sexes were found most often in water deeper than 200 m and beyond the continental shelf break. Tagged females remained within about 60 km of shore and quite near the continen-

tal shelf break in the Beaufort Sea. Conversely, all instrumented males tended to travel north of latitude 75°N, past the shelf break over waters exceeding 3,000 m in depth. Belugas rarely used the inshore waters within the OCS lease sale area of the Beaufort Sea.

Another MMS-supported study, "Use of Sea Ice Habitat by Polar Bears in the Southern Beaufort Sea," correlated seasonal polar bear locations for the years 1998 through 2001 with sea ice and bathymetry data.

Ringed seals are the primary prey of polar bears and a significant source of food for Natives living in the Arctic. The MMS funded two studies during 2001–2003 addressing the distribution, abundance, and/or behavior of the species in order to evaluate potential effects from OCS development. An MMS/UAF CMI project entitled "Timing and Reinterpretation of Ringed Seal Surveys" began in 2001, building on the results of a previous study: "Correction Factor for Ringed Seal Surveys in Northern Alaska." During these studies, 60 ringed seals have been monitored with radio transmitters. The proportion of seals visible during aerial surveys has been found to vary as a function of snow conditions on the surface of fast ice. A correction factor has been developed, and density estimates derived from previous surveys are being re-analyzed.

Harbor seals, another important subsistence species, are abundant in the Gulf of Alaska region, including Cook Inlet. In 2003 the MMS funded two new studies of harbor seals through an interagency agreement with the National Marine Fisheries Service, National Marine Mammal Laboratory. The first of these, "Distribution and Abundance of Harbor Seals in Cook Inlet: Seasonal Variability in Relation to Key Life History Events," supports repeated, seasonal aircraft surveys of seals at haulouts. The second, "Development of Remote Sensing Survey Techniques for Marine Mammals and Birds in the Arctic: Assessing Variation in Harbor Seal Haulout Patterns," makes use of remote cameras for continuous monitoring of harbor seals at selected haulouts. The latter study will provide insight into factors causing variation in the observations of the aircraft surveys.

Two other studies of marine mammals were funded by the MMS through interagency agreements with the U.S. Fish and Wildlife Service. The first, "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 whalers near the village of Kaktovik (in the Arctic National Wildlife Refuge) and near a traditional whaling camp on Cross Island (near Prudhoe Bay). Increasing numbers of bears have aggregated and fed on whale remains at these locations, with concurrent risks to the resident human populations and to the bears. This study is expected to yield data on the patterns of use of these sites by individual bears and on other bear behaviors in order to establish better estimates of bear mortality in the event of an oil spill. The second study, "Development of Remote Sensing Survey Techniques for Marine Mammals and Birds in the Arctic: Development of Airborne Thermal Remote Sensing for Survey of Pacific Walrus," provided funds for the development of high-altitude thermal remote sensing for use in surveys of walrus. Survey flights were completed near St. Lawrence Island in the Bering Sea during April 2003, and data are being analyzed.

Eiders (a species of sea duck) are harvested for subsistence by Alaska Natives, who have expressed concerns that the abundance of all four species living in the Alaskan Arctic may be declining. From 2001 to 2003, the MMS funded five new studies through the MMS/UAF CMI that address issues related to the population biology of eiders and the potential risks from offshore oil and gas development. The study entitled "Importance of the Alaska Beaufort Sea to King Eiders," funded in 2001, was designed to provide information about how king eiders make use of the OCS waters or adjacent near-coastal areas. A total of 33 adult eiders were implanted with satellite transmitters. The investigators discovered that king eiders staged in the Beaufort Sea before migrating southward to molt along the Chukotsk Peninsula and Kamchatka Peninsula of Russia and in U.S. waters off St. Lawrence Island and the Alaska Peninsula.

Three eider studies were funded in 2002. The study titled "Breeding Biology and Habitat Use of King and Common Eiders on the Coastal Plain of Northern Alaska" will examine and compare the nesting timing, 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 oil field. Another study, "King and Common Eider Migrations Past Point Barrow," repeats a count of those species that has been conducted periodically for several decades. 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 suggest that those populations have not declined further and may have increased since 1996. The third study, "Population Structure of Common Eiders Nesting on Coastal Barrier Islands Adjacent to Oil Facilities in the Beaufort Sea," is 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. Results of this study will include a test of the discreteness of genetic stocks of common eiders inhabiting the Beaufort Sea region and an analysis of the risks posed to maintain those stocks by potential oil spills.

A study entitled "Foraging Ecology of Common Ravens (*Corvus corax*) 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 developed areas of Alaska's North Slope. Among the questions this study will address are whether industrial infrastructure is advantageous to ravens, and the extent to which proximity to such infrastructure increases raven depredation of eider nests and ducklings.

Physical Oceanography

Knowledge of predominant weather patterns and wind/current dynamics in the Beaufort Sea enables us to evaluate better the potential effects of an oil spill and to develop precautionary oil spill response strategies. A recently completed MMS/UAF CMI study that examined the seasonal and interannual variability of the Arctic Ocean and Beaufort Sea found that there has been a decadal cycle between wind-driven anticyclonic (ACCR) and cyclonic circulation regimes (CCR). Higher Arctic atmospheric pressure, lower wind speed, and lower winter temperatures characterize the ACCR compared with cyclonic summer winds, precipitation increases over the ocean, and decreases over land during the CCR. The cyclonic summer wind produces more openings in the sea ice, allowing upper ocean heat accumulation. The ice melt season lengthens, increasing freshwater content and leading to generally thinner ice. Anomalous weather patterns in recent years will receive additional scrutiny to determine whether a new pattern is emerging.

The study entitled "Synthesis and Collection of Meteorological Data in the Nearshore Beaufort Sea" completed over two and half years of meteorological data collection from five stations along the Beaufort Sea coast. A new station was added on Cottle Island in August 2002. This study will provide a completed time series of wind data to MMS ocean circulation modelers and researchers for use in their ongoing modeling of the nearshore Beaufort Sea. A project web site (http://www.resdat.com/mms) provides up-to-date project information, station locations and pictures, data downloading, and quarterly graphical data results. This information will assist MMS in improving oil spill trajectory modeling and is available to the general public.

An MMS/UAF CMI study completed three years of moorings, including the first successful winter-long measurements of currents directly under the ice in the nearshore Beaufort Sea. Three upward-looking acoustic Doppler current profilers were moored on the sea bottom within the barrier islands near the Northstar and Liberty offshore development prospects, and a fourth profiler was added offshore of the barrier islands in the third year. The project collected data on water and ice velocity, temperature, salinity, and water clarity (transmissivity) from August 1999 to August 2002. Once landfast ice formed and blocked the wind, current speeds dropped drastically, with less than 1% of current speeds exceeding 20 centimeters per second. A new study, "Beaufort Sea Nearshore Currents," will deploy three similar moorings for three years, starting in 2004, over a greater length of coastline, extending across most of the U.S. Beaufort Sea coast.

An MMS/UAF CMI study entitled "A Nowcast/Forecast Model for the Beaufort Sea Ice–Ocean–Oil Spill System" has developed a new 3-D coupled ice–ocean model with links to a regional mesoscale atmospheric model. The resolution of the model is currently 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.

In Cook Inlet the MMS/UAF CMI study "Water and Ice Dynamics of Cook Inlet" is using a combination of global positioning system (GPS)-equipped ARGOS drifters, satellite remote sensing, and oceanographic modeling to enhance understanding and to improve the predictability of water and ice dynamics. A parallel MMS/UAF CMI study, "High-Resolution Numerical Modeling of Near-Surface Weather Conditions over Alaska's Cook Inlet and Shelikof Strait," will provide a high-resolution meteorological model that can capture low-elevation wind jets known to occur in Cook Inlet and Shelikof Strait. This model will provide high-resolution grid wind fields to the oceano-

graphic modelers, ultimately enhancing the MMS environmental assessment of the potential effects of oil spills, which, although very unlikely, may occur after OCS development.

Fate and Effects

One of several MMS/UAF CMI laboratory studies documented synergistic effects of weathered North Slope crude oil and ultraviolet light on zooplankton. Establishment of a correlation coefficient between total lipid content and polycyclic aromatic hydrocarbon (PAH) uptake will allow estimates of the PAH load of predominant plankton on the basis of abundance data and their lipid profile. The possibility of further distribution of PAHs into the ecosystem through zooplankton feces is also being evaluated. Another study looks at the kinetics and mechanism of slow PAH desorption from sediments in the lower Cook Inlet and the Beaufort Sea. This study will lead to better capability for predicting the environmental fate of PAH in Arctic sediments. A third and related CMI study examines petroleum-degrading bacterial communities in Beaufort Sea sediments and will compare the current community to that existing at the onset of coastal Beaufort Sea development in the late 1970s.

In the first of four modeling studies, "Revision of the OCS Weathering Model, Phases II and III," the MMS is participating in a consortium to advance the state of the art in oil weathering models, including additions of Alaska-specific oils and ice conditions and the development of an experimental and observational spill database suitable for model validation. In the second and third studies, the MMS is investigating "Alternative Oil Spill Occurrence Estimators for the Beaufort/Chukchi Sea OCS" with parallel fault-tree and statistical engineering approaches. These latter studies include analyses of differences in potential spill causes in these Arctic areas versus elsewhere in the U.S. OCS, primarily in the Gulf of Mexico. In the fourth study, "Persistence of Crude Oil Spills on Open Water," the MMS is developing empirical statistical relationships among environmental and response factors related to the persistence of crude oil slicks at sea.

Research Monitoring

A multi-disciplinary, site-specific Beaufort Sea monitoring study, "Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA)" was initiated in June 1999. This study examines impacts associated with the first Federal oil development on the Alaskan OCS at Northstar and the anticipated Liberty prospect near Prudhoe Bay. Phase I of ANIMIDA reported the results of measured changes in ambient noise, resuspension of sediments, and sediment quality.

Designed to provide long-term continuity beyond what could be expected through industry-sponsored studies alone, ANIMIDA Phase II expanded monitoring in 2000–2002 by measuring:

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

The Phase II studies were reported in a special session at SETAC in November 2003, with the final reports expected in January 2004. A third phase, cANIMIDA (Continuation of ANIMIDA), is being procured in 2003 and will start field work in 2004.

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 and 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 nearshore Beaufort Sea has remained a relatively clean environment as far as trace metals and hydrocarbons are concerned, despite the adjacent petroleum-related industrial activities during the past 30 years. A follow-up CMI study continues the documentation of trace metals and hydrocarbons in sediments across the Beaufort Sea from Elson Lagoon near Barrow, to Prudhoe Bay, to Beaufort Lagoon in eastern Alaska.

The MMS/UAF CMI study "Seabird Samples as Resources for Marine Environmental Assessment" collects and curates seabird tissues in cooperation with the University of Alaska Museum to provide further resources for contaminant and other scientific researchers. Loans and tissue samples from this collection have already been made

available to scientists for contaminant and oil-spill-related studies. The MMS/UAF CMI has also arranged for the University of Alaska Museum to archive high-quality surface sediments and dated sediment cores from the MMS study "Sediment Quality in Shelikof Strait and Outermost Cook Inlet."

A greater knowledge of Arctic fishes is important to protecting subsistence and biological resources while developing offshore oil and gas resources. 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 to reduce the high cost of locating and evaluating overwintering habitats. Native Alaskans are concerned that a major subsistence species in the Colville River, Arctic cisco, has been less abundant during the last few years than in preceding years. An effort to quantify interannual variation in their abundance and estimate which environmental factors contribute to observed variation will provide better predictions, which will allow adjustment to natural cycles and help avoid potential development effects on this important resource.

Socioeconomics

Since its formation the MMS Alaska Region Environmental Studies Program has been unique in its emphasis on social and economic studies relating to the potential effects of offshore oil and gas development. Because of the distinctive nature of subsistence activities and sociocultural attributes throughout rural villages and coastal communities in Alaska, MMS social research goes well beyond conventional economic considerations.

In response to recommendations of community leaders of Alaska's North Slope, MMS initiated a study in 2001 entitled "Quantitative Description of Potential Impacts of OCS Activities on Bowhead Whale Hunting and Subsistence Activities in the Beaufort Sea." The study, to be completed in 2004, focuses on Native perceptions of the acute and cumulative effects of oil industry operations on bowhead whale hunting. The study will collect information from residents of Nuiqsut, Kaktovik, and Barrow through survey instruments and will consider both beneficial and detrimental potential effects.

Another North Slope project aims to develop and implement a GIS mapping system to describe subsistence hunting and fishing activities for selected species, including bowhead whales, ringed seals, caribou, Arctic cisco, broad whitefish, Arctic char, and various waterfowl. The project focuses on collecting and describing contemporary subsistence patterns while accommodating the addition of past and future harvest data to enable analyses of pattern changes over time. A sample of hunters in each community will be selected using systematic social networking methods. In addition, the project will document the locations of harvest campsites and travel routes.

In Cook Inlet the prospect of OCS oil and gas development presents some 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 entitled "Mitigation of Oil Industry Operations on Driftnet Fishing in Cook Inlet," begun in 2003, intends to explore and define specific ways to mitigate these potential conflicts and to analyze the significant tradeoffs of reasonable alternative proposals.

On Kodiak Island a new study is underway to collect and analyze data on the major socioeconomic 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 follow 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, even though the spill event did not occur under MMS jurisdiction or even within imaginable MMS offshore spill scenarios.

To document the extent of social research in Alaska and the substantial information accumulated over the past 20 years, MMS initiated a book project in 1998 that will enhance the accessibility of research products and summary findings for all interested parties. When completed, the project will produce a peer-reviewed book that will explain and synthesize the results of more than 160 MMS-funded studies.

A study entitled "North Slope Economy, 1965 to the Present" will provide detailed information on local government revenues and expenditures, including capital projects of North Slope commu-

nities (both prior to and after the formation of the North Slope Borough), as well as property tax and other categories that merit analysis. The study will:

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

Some of the empirical measures will include income and changes in quality of life, such as housing and sewer and water facilities. A draft of the study report was submitted in 2003 and is now under review.

GIS Databases

The study entitled "Evaluation of Sub-Sea Physical Environmental Data for the Beaufort Sea" was completed in 2002. It integrates all Federal Beaufort Sea OCS site-specific geological and high-resolution geophysical data results and similar data sets into a geographical information system (GIS) database in support of exploration and development projects. The GIS database includes spatial and attribute data on the location of strudel scour, ice gouge, and drain racks, in addition to data on bathymetry, faulting, near-surface stratigraphy, seismic anomalies, boulder patch, and earthquakes. The documentation is available at http://www.mms.gov/alaska/reports/SubseaGIS/evaluation_of_sub.htm.

An ongoing MMS/UAF/University of Alaska Anchorage CMI study is in the process of completing an updated sea ice atlas for Arctic and sub-Arctic Alaska marine waters. A web site (http://holmes-iv.engr.uaa.alaska.edu/), which is under construction, will provide statistical and GIS output of National Ice Center and National Weather Service sea ice data for the Alaska OCS, including Cook Inlet. This web site will contain a unique set of tools to query and graph historical meteorological data from first-order weather stations located throughout Alaska.

Information Transfer

An Information Update Meeting was convened by the MMS Alaska OCS Region in Barrow in March 2003. The MMS and officials of the North Slope Borough scheduled this meeting in Barrow, Alaska, 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. Also, MMS held its Ninth Information Transfer Meeting in Anchorage, Alaska, in March 2003. Principal investigators presented information on 37 ongoing studies in the Beaufort 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.

In cooperation with the U.S. Fish and Wildlife Service, the MMS also supported a 2003 workshop in Anchorage entitled "Polar Bear Population Monitoring Workshop." Management issues were identified, and recommendations for future research and monitoring were made by individuals representing a variety of organizations.

In 2003 the MMS Alaska OCS Region also sponsored two international workshops designed to produce recommendations regarding future Arctic oceanographic research needs. The MMS/UAF CMI "Workshop on Small-Scale Sea-Ice and Ocean Modeling (SIOM) in the Nearshore Beaufort and Chukchi Seas" brought together international sea-ice modelers and researchers to develop strategies to advance the state of the art in Arctic ice modeling. Following recommendations from this workshop, MMS and the National Aeronautics and Space Administration signed an Interagency Agreement in 2003 to research "Sea-Ice Modeling in Nearshore Beaufort and Chukchi Sea in the Arctic Ocean." The MMS Physical Oceanography of the Beaufort Sea Workshop brought together international experts in Arctic oceanography to review the state of knowledge concerning Beaufort Sea physical oceanography and to recommend long-range goals for oceanographic research to meet MMS needs.

Reports of MMS-sponsored information transfer meetings and MMS studies are available from the MMS Environmental Studies Information System (ESPIS) at http://mmspub.mms.gov:81/.

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 02	FY 03
Migratory Birds	3,884	3,800
Fisheries	4,068	4,300
Marine Mammals	1,768	2,255
CAFF	200	200
U.S.–Russia Environ. Agreement	150	350
Total	10,070	10,905

Fisheries and Ecological Services

Fisheries

Fishery research in the Arctic by the FWS continues to focus on Yukon River salmon shared by the United States and Canada in support of the U.S.–Canada Treaty. The FWS continues to develop enumeration techniques for Yukon River salmon to quantify abundance, apply genetic stock identification techniques to assess genetic diversity, and determine what portion of the U.S. harvest is of Canadian origin. These studies also generate data needed for in-season management of Canadian-origin salmon. Research includes a mark–recapture study of fall chum salmon at Rapids/Rampart and the use of video technology to determine marked-to-unmarked ratios of fall chum salmon and catch-per-unit-effort for chinook and fall chum salmon. To manage U.S. stocks of salmon, the FWS 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. Split beam sonar is used to count fall chum salmon on the Chandalar River. 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 becoming apparent. 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.

Fish stocks of Alaska's North Slope in the Arctic National Wildlife Refuge have also received considerable 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 results, length frequencies, length–weight relationships, and fish condition will be compared to baseline data collected on these species between 1988 and 1991. A second study will use dual-frequency induction sonar to estimate the number of Dolly Varden that return to spawn in the Hulahula River and provide the first quantitative information about population size of these fish on the North Slope. A third study focuses on locating the overwintering areas of Dolly Varden in the lower Canning River. These studies will provide valuable information to use for conserving viable populations should the area be available for oil and development.

The FWS's Conservation Genetics Lab continues to study Yukon River chinook and fall chum salmon and has collected both species from a number of drainages in the U.S. and Canada. A recent study concluded that genetic diversity of chum salmon in the Yukon River is widely distributed over a broad geographic area, whereas coho salmon populations are small and discrete. This has important implications for management of these species and suggests that the genetic diversity of coho salmon is at higher risk from habitat degradation than chum salmon.

Environmental Contaminants

The FWS and its partners have actively pursued scientific studies and management solutions concerning complex contaminants problems in the Arctic for several decades. International research programs such as the Arctic Monitoring and Assessment Program (AMAP) have shown that pollutants are a circumpolar, and indeed global, issue. The FWS conducted a number of contaminant-related studies during FY 2001–2003.

Chinook and Chum Salmon. In 2001 the FWS began collecting baseline data on contaminants in chinook and chum salmon from the Yukon and Kuskokwim Rivers. Runs of these salmon have declined in recent years, and subsistence users are concerned about the presence of environmental contaminants in their food. Analyses for heavy metals and persistent organochlorine compounds indicate that these fish have relatively low contaminant concentrations, and the State of Alaska recommends unlimited subsistence consumption of these stocks.

Spectacled and Steller's Eiders. Environmental contaminants specialists are investigating lead concentrations in threatened spectacled and Steller's eiders and other waterfowl from Alaska. Exposure to lead in breeding areas, presumably from ingestion of lead shot, can contribute to population declines. Recent research compared isotopic "signatures" in eider blood to known lead sources, including samples of lead shot and various wetland sediments. Initial results indicate that shot is the primary source of lead for eiders with high blood lead levels, while eiders with low lead levels have signatures that match the sediments in their breeding areas. Work is ongoing to further characterize these sources and determine thresholds for exposure to lead shot in eiders. Positive identification of shot as the lead source will contribute to ongoing FWS efforts to reduce lead shot use through education and enforcement.

Steller's eiders.

Wood Frog. The wood frog is the only amphibian that occurs across most of Alaska, including areas within the Arctic. Since 2001, surveys for abnormal wood frogs have been conducted on several National Wildlife Refuges in Alaska. Low numbers (<3%) of abnormal frogs have been found in Arctic areas of Alaska, with the most prevalent anomalies being missing hind limbs and digits. Initial sampling suggests that the dramatic abnormalities seen in frogs in more temperate climates, such as additional appendages and misplaced eyes, are not commonly observed in localized areas of northern and western Alaska.

Marine Mammals

Pacific Walrus. Research on Pacific walruses continues to focus on monitoring haul-outs in Bristol Bay, monitoring the spring subsistence harvest to collect information on the size and demographics of the harvest, and developing techniques to estimate the size and trend of the Pacific walrus population.

The size and trend of the Pacific walrus population remain unknown. Several approaches are under investigation for developing an accurate estimate, including genetic fingerprinting in a mark–recapture study. Computer simulations indicate that for a modeled walrus population of 300,000, even relatively large sample sizes (15,000–30,000 samples annually) produce poor population estimates. However, incorporating age into the mark–recapture analysis dramatically increased the efficiency and precision of the estimate and simulated sampling rates as low as 1,500 animals. The successful application of mark–recapture techniques to estimate the size and trend of the Pacific walrus population will require the ability to determine age and gender and identify individual animals with negligible error rates, but collecting representative samples from free-ranging animals across a wide-ranging, dynamic habitat presents significant logistical challenges.

The FWS is also evaluating remote sensing tools for use in developing a population estimate. Techniques under evaluation include high-resolution aerial photography and satellite imagery. Previous studies demonstrated the capability to detect and enumerate walruses with appropriate satellite imagery; additional work refined the technique for use in counting walruses on terrestrial haul-outs. Imagery of walruses on ice is currently under analysis. The results suggest that a walrus survey could potentially be flown with an airborne thermal scanner from a height of 3,500 m. The advantages of this technique are that a high-altitude, scanner-based survey would cover more than four times the area per survey hour compared to traditional visual-based observation methods. Also, a high-altitude, scanner-based survey would produce a permanent data record that could be re-examined, eliminate observer bias in estimating numbers of animals in groups, minimize disturbance to walruses, and increase safety for flight crews by eliminating low-altitude flights over open ocean and pack ice.

Northern Sea Otter. The FWS continues to focus its efforts on the stock-wide population decline of sea otters in southwestern Alaska. Abundance estimates for some areas have declined by as much as 93% since the surveys in the mid-late 1980s and early 1990s. Rates of decline have varied from 6.7% per year at Kodiak Island since 1989 to 17.5% per year in the Aleutian Islands. Sea otter population declines are similar among survey areas in the Aleutians, along the Alaska Peninsula, and in the Kodiak Archipelago in terms of severity and timing, and severe declines of pinniped populations have occurred in the same areas. The results of broad-scale aerial surveys prompted the FWS to designate the southwest sea otter population stock as a candidate species under the Endangered Species Act; the FWS published a proposal to list this stock as threatened under the Endangered Species Act on February 11, 2004. Site-specific surveys at representative islands in the central and western Aleutians in 2003 indicate that the decline is continuing, with an estimated 63% decline between 2000 and 2003 at these sites.

Polar Bear. The FWS, in cooperation with the North Slope Borough, the Alaska Nanuuq Commission, and the Native villages of Kaktovik and Nuiqsut, initiated a polar bear feeding ecology study during September 2002. In the southern Beaufort Sea, polar bears tend to migrate to nearshore coastal areas during the fall to look for dens and feed on seals and whale carcasses. In recent years the number of bears using the coastal habitat in the fall has increased. The objectives of the three-year study are to determine the number, sex, and ages of the bears and their behavior and habitat use at Cross and Barter Islands during the fall open-water period. These locations were chosen because of the presence of subsistence-harvested bowhead whale remains that attract numbers of polar bears. The maximum number of bears seen at Barter Island at one time was 51. A maximum of seven bears were observed at one time at Cross Island. The majority of bear use at both the Barter Island and Cross Island feeding sites was by single adult bears (41% and 76%, respectively) and by family groups of adult females with dependent cubs (26% and 13%, respectively). At both locations, all age/sex classes of bears fed predominantly at night. During the day the majority of bears were inactive. The study was continued in 2003–2004.

The FWS, in cooperation with BP Exploration and LGL Research, completed four years of weekly aerial surveys along the coastline and barrier islands of the Beaufort Sea (2000–2003). During the first three years, there were 706 polar bear observations. The number of observations between the fall open-water period and freeze-up was quite variable among years, with the greatest number of observations in fall 2002 (five surveys, 377 observations). A greater number of bears used coastal habitat during years when the pack ice remained farther offshore for extended periods of time. Adult females with dependent young comprised 45.5% of the observations. Habitats used by polar bears most frequently during the study were barrier islands and shore-fast ice.

Threatened and Endangered Species

Spectacled and Steller's eiders. In 2002 and 2003 the FWS continued to participate in a long-term study of the threatened Steller's eider in the vicinity of Barrow in cooperation with the North Slope Borough. The study focuses on documenting abundance and distribution and identifying the primary influences on survival and reproduction. Nesting effort and success of Steller's eiders vary tremendously from year to year. Predation is considered to be the main cause of Steller's eider nest failure near Barrow. Management strategies to improve nesting success may be necessary to maintain the population. Research projects in support of this objective include video monitoring of Steller's eider nests to identify predators that are responsible for egg loss and collaborative efforts with the Alaska SeaLife Center to develop artificial incubation techniques.

Satellite telemetry was used to determine 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. Aerial and boat surveys were conducted in western Chukotka in the summer of 2002 to locate key areas being used by both species. Large numbers (approximately 14,000) of Steller's eiders were observed there in 2002 and 2003 during the pre-molt period.

Virtually the entire Pacific population of Steller's eider molts and spends the winter in the nearshore waters of southwestern Alaska. This population is estimated at roughly 100,000 individuals and appears to be declining at over 6% annually. Currently the Alaska-breeding population includes, at most, 2,500 individuals. The FWS, in coopera-

tion with the Corps of Engineers, has conducted boat surveys of wintering eiders in a number of coastal areas where development may occur that could impact the protected lagoons and productive, shallow areas that eiders depend on for their over-winter survival.

In 2003 a nesting biology and survival study of spectacled eiders in the Chaun River Delta, Chukotka, was initiated. The long-term goal of this project is to compare the productivity and survival of spectacled eiders in Russia and Alaska. The FWS also sponsored a pilot subsistence harvest survey in villages in the Yakutia and Chukotka regions in 2002 and 2003. Data from 2002 indicated that hunting pressure on eiders may be greater than previously thought and that local knowledge of waterfowl conservation issues, such as the effects of lead shot, is very low.

Short-tailed albatross. Once numbering in the millions, the short-tailed albatross was driven to the brink of extinction by feather hunters. Today, fewer than 1,800 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. 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.

National Wildlife Refuges

The National Wildlife Refuge system in Alaska encompasses 16 refuges and approximately 77 million acres. Staff of each refuge conduct 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 Alaska.

Yukon Delta National Wildlife Refuge

The bar-tailed godwit is the most abundant large shorebird in the East Asian–Australasian Flyway. Each fall, approximately 100,000 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 staff in collaboration with the USGS have studied flocks of godwits staging on the coast of the refuge to determine the wintering grounds, migration routes, and racial identity of godwits staging on the Yukon–Kuskokwim Delta and determine the proportion of juveniles in the staging flocks in order to estimate annual reproductive success. By reading site-specific color-flags on the godwits' legs, field crews have been able to identify godwits that have wintered in northeastern and southeastern

Bar-tailed godwit with leg bands at the Yukon Delta National Wildlife Refuge.

Braids at the Yukon Delta National Wildlife Refuge.

Australia, as well as on the North and South islands of New Zealand. Godwits banded on spring migration in both China and Japan have also been observed in Alaska. The proportion of juveniles in the fall staging flocks has been consistently low, never exceeding 3% since the study began and averaging considerably lower than age ratios among small samples of birds captured on the wintering grounds. Therefore, refuge scientists, along with researchers from Australia and New Zealand, are evaluating hypotheses to explain this discrepancy. A population model to assess the impact of chronically low productivity on population growth is being developed in collaboration with the USGS. The refuge plans to initiate a pilot study of godwit breeding biology in 2004 to begin exploring the factors contributing to the apparently low reproductive success.

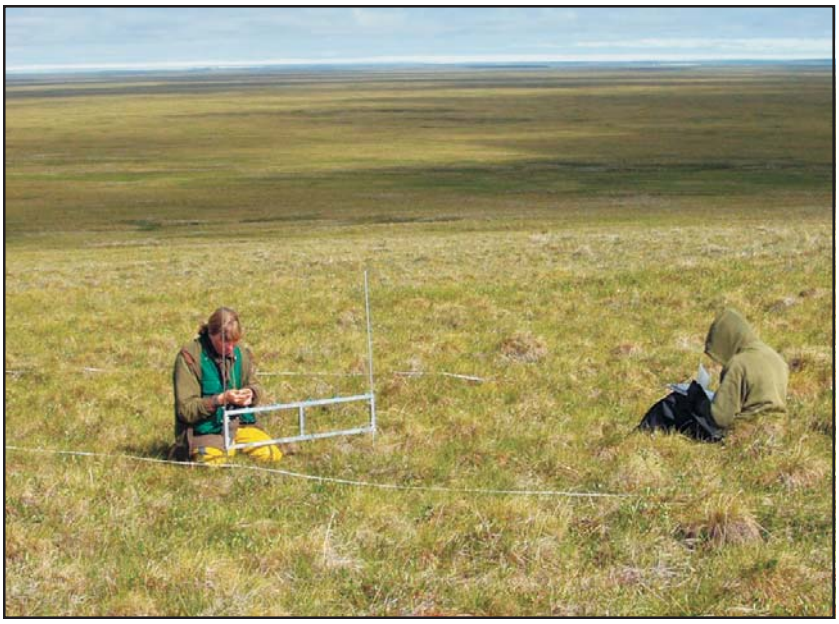
About 42,000 pairs of black scoters, or 47% of the western North American breeding population, nest on the Yukon Delta National Wildlife Refuge. Black scoters remain the least known of all waterfowl species. Because of a steady decline in Alaska's breeding population, refuge staff and USGS researchers initiated a multi-year study of black scoter breeding ecology. The study, designed to identify nesting habitat and timing, has found more scoter nests than any previous research effort. Preliminary results indicate that black scoters are one of the latest-nesting waterfowl species, with onset of nesting occurring between late June and early July. Nests contain an average of eight eggs and are difficult to find. They are often situated far from large water bodies in dense thickets of knee-high (or taller) dwarf birch and willow along the sides of pingos, drainages, and dry lake basins. Researchers have only found about 40 nests per year, despite several weeks of intensive searching in areas identified as having high concentrations of pairs. Black scoters are sought by subsistence hunters in late May and early June on large lakes and along rivers of the refuge as they migrate to breeding areas. They are heavily harvested on the refuge, averaging about 6,000 birds per year. Ultimately the results of the study will assist refuge staff with the management and conservation of this little-known species.

Black scoter research at the Yukon Delta National Wildlife Refuge.

Arctic National Wildlife Refuge

Temperatures in northern Alaska have warmed over the past 30 years. To determine whether tundra vegetation has changed, botanists from the refuge in northeastern Alaska examined data from 26 plots that were sampled 5–6 times each between 1984 and 2002. The plots represented all of the major vegetation types on the coastal plain of the refuge. The investigators used point sampling to estimate percent cover of all plant species, measured the depth of thawed soil above the permafrost, took photographs from permanent photo points, and measured the height of willows at four plots. They used linear mixed-effects regression models to test for changes over time in plant species cover, willow height, and active-layer depth. The investigators detected small but significant decreases in cover of nonvascular plants (i.e., mosses, liverworts, and lichens) but no trend in vascular plant cover or willow height. The depth of thawed soil increased over the 18-year period. Refuge staff plan to continue monitoring the permanent vegetation plots every five years to develop a long-term record of changes in plant cover and active-layer depth and will examine relationships between observed changes and climatic conditions in the region.

The Arctic coastal plain of northern Alaska provides important breeding habitat for over 70 species of birds, including shorebirds, waterfowl, loons, and passerines. The coastal plain is also increasingly influenced by human activities, especially oil exploration/development and growth of Native villages. Human food sources may enhance populations and alter the distributions of preda-



Vegetation sampling at the Arctic National Wildlife Refuge.

tors such as arctic foxes, common ravens, glaucous gulls, and grizzly bears. Predator populations may also be influenced by man-made structures that are used for nesting, denning, or surveillance. Increased numbers of predators in the vicinity of human developments could negatively affect the productivity of breeding birds via increased predation on eggs and young. The FWS, Wildlife Conservation Society, BP Exploration (Alaska), Inc., ConocoPhillips Alaska, Inc., ExxonMobil Corporation, and Manomet Center for Conservation Sciences initiated a project in 2002 to investigate the effects of development on populations of nest predators and productivity of shorebirds on the coastal plain. Study sites were established across the North Slope. At each site, investigators are collecting data on nest density, nest fate (hatch vs. fail), and causes of nest failure. They are also investigating the relationship between nest survival, predator abundance, and proximity to human developments.

A rope drag being used to find nests of birds on the coastal plain of the Arctic National Wildlife Refuge.

Yukon Flats National Wildlife Refuge

Breeding scoter populations have declined over 50% in North America since 1955. The Yukon Flats National Wildlife Refuge (NWR), the largest interior wetland basin in Alaska, supports the largest breeding population of white-winged scoters in Alaska. Refuge staff, in collaboration with the University of Alaska, initiated a study in 2002 to estimate nesting success, nest habitat selection, and duckling survival for white-winged scoters. They captured female scoters with mist nets prior to breeding and marked them with prong and suture radios to locate nests. They performed nest searches and extensive brood surveys. Preliminary data suggest low nesting success, high adult female mortality, and earlier nest initiation dates than previously estimated. Nesting habitat ranged from densely vegetated shrubby areas near lakeshores to sites up to 400 m inland in black spruce forest. Brood surveys showed that large numbers of scoter arrive on the brood-rearing lakes in late July and August. This study will provide information essential for modeling the population dynamics of this species and making sound management decisions.

White-winged scoter study at the Yukon Flats National Wildlife Refuge.

The Yukon Flats NWR and the USGS are collaborating to develop a baseline earth cover inventory of the Yukon Flat NWR using Landsat thematic mapping (TM) imagery that meets the requirements for the National Land Cover Database (NLCD) 2001 project administered by the USGS. The refuge's goal is to produce an integrated GIS database that can be used to improve natural resources planning. The field effort has focused on purchasing, classifying, field verifying, and producing high-quality, high-resolution, digital and hard copy resource-based maps. Over 800

ground-truthed points have been archived. A draft map, which will include 35–40 earth cover types, will be constructed in the winter of 2004. An accuracy assessment is scheduled for the summer of 2004.

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 sea ducks and other waterfowl that inhabit areas undergoing exploration and development by the oil and gas industry.

Breeding Population Surveys of Waterbirds on the North Slope of Alaska

Since 1992 the FWS has conducted systematic aerial surveys of waterbirds on the North Slope of Alaska. One of the objectives of the study is to determine the breeding range and relative abundance of the threatened spectacled eider on the North Slope. To date, significant positive growth rates have been observed for Arctic terns, red-breasted mergansers, greater scaup, king eiders, snow geese, and black brant, while a significant negative growth rate was observed for red-throated loons.

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 estimating abundance (not just an index to it); 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 actual population size and thus of change in size since the last major survey.

To date, 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. Full implementation of the program awaits additional funding.

International Activities

Because of its strategic location in the North and its wealth of diverse and productive habitat, Alaska shares populations of wildlife with many other countries. To successfully achieve its conservation mission, the Fish and Wildlife Service frequently participates in international cooperative research, management, and conservation activities.

Arctic Monitoring and Assessment Program

FWS contaminants data figure prominently in the latest round of assessment reports published by the Arctic Monitoring and Assessment Program. In particular, a long-term peregrine falcon monitoring study was highlighted in recent reports on heavy metals and persistent organic pollutants. Long-term contaminants data sets are rare, both in the Alaskan Arctic and within the United States. The FWS also contributed Alaskan polar bear tissue data, which fill a significant data gap identified in the first AMAP assessment report. In addition to helping complete the circumpolar database for contaminants such as PCBs, DDT, and mercury, the FWS cooperated with researchers at Michigan State University to investigate some "new" compounds of concern, including perfluorooctane sulfonate (PFOS) and brominated flame retardant chemicals, both of which have recently been identified as emerging issues for Arctic wildlife.

Conservation of Arctic Flora and Fauna

The Fish and Wildlife Service is the designated Federal agency for participation in the Arctic Council's CAFF program. For the period 2002–2004, FWS employees are chairing CAFF as well as its Flora Group and the Circumpolar Seabird Working Group. CAFF recently produced two significant products. The vegetation map of the cir-

cumpolar Arctic was published in 2003. CAFF also published a major review of the status and conservation of Arctic fauna and flora.

Area V

Under Area V of the U.S.–Russia Conservation Agreement, the FWS continues to support scientific exchanges with Russia to promote research and monitoring of key Arctic species and small grants to Russian colleagues to further scientific inquiry and conservation of species of mutual concern in Russia.

U.S.–Asia Activities

The FWS became a part of the Asia–Pacific Migratory Waterbird Committee. Under the auspices of the APMWC, the FWS is participating in a study of the migration and wintering of four Arctic-nesting subspecies of dunlin. The FWS is also participating in the South Pacific Regional Environment Program. Under the auspices of this program, the FWS participated in an expedition to document the wintering range of the bristle-thighed curlew, as well as the ranges of several shorebird species endemic to south Pacific islands.

National Park Service

NPS Goals

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.

The NPS's goals for Arctic research stem from the specific authorizing legislation that established Arctic parks, preserves, monuments, and programs and from strategic planning and management policies. An overarching goal is to ensure that management of units of the National Park system is enhanced through a broad program of high-quality science and information.

The NPS's Natural Resource programs in Alaska emphasize four priorities: preserving Alaska's ecosystems, visitation and access, balancing preservation and consumptive uses, and building a scientific foundation for park management. The natural resource Inventory and Monitoring program is intended to provide consistent databases of information about natural resources, including species diversity, distribution, and abundance and to determine the current condition of park resources and how they change over time. The NPS's Cultural Resource programs in Alaska are focused on preserving Alaska's cultural resources and contributing to knowledge about cultural resources and human populations. The Shared Beringian Heritage Program recognizes and celebrates the contemporary and historic exchange of biological resources and cultural heritage shared by Russia and the United States on both sides of the Bering Strait. The Beringia program seeks local resident and international participation in preserving and understanding natural resources and protected lands as well as working to sustain the cultural vitality of Native peoples in the Central Beringia region. All projects address Interagency Arctic Research Policy Committee (IARPC) program areas of natural ecology and cultural resources.

	Funding (thousands)	
	FY 02	FY 03
Cultural Resources	1,400	1,296
Natural Ecology	2,486	2,810
Inventory and Monitoring	0	3,500
Total	3,886	7,606

Biological Inventory Program in Alaska's Arctic Network

What is Inventory and Monitoring in the National Park Service?

The NPS established the Inventory and Monitoring Program in 1992 to provide a consistent database of information about our National Parks' natural resources, including species diversity, distribution, and abundance, and to determine the current condition of these resources and how they change over time. Inventory and monitoring are two key strategies of the Natural Resource Challenge, a multi-year funding initiative begun in FY 2000 to revitalize and expand the NPS's resource management program.

For administrative purposes, parks have been organized nationally into 32 ecosystem-based networks. Alaska has four such networks: the Southeast, Southwest, Central, and Arctic Networks.

The Arctic Network (ARCN) consists of five parks: Gates of the Arctic National Park and Preserve (GAAR), Noatak National Preserve (NOAT), Kobuk Valley National Park (KOVA), Cape Krusenstern National Monument (CAKR), and Bering Land Bridge National Preserve (BELA). The Arctic Network spans much of the Brooks Range ecosystem. To the east, the network encompasses a large expanse of mostly mountainous Arctic ecosystems at the northern limit of treeline. To the west, the network extends to the coast and has strong biogeographic affinities to the Beringian subcontinent, the former land bridge between North America and Asia.

Why Inventory?

The Alaskan Arctic represents some of the least biologically documented ecoregions in our country. Covering approximately 21 million acres, the ARCN alone represents about 25% of all of the National Park Service land in the country.

Understandably this huge area of remote land, which contains no publicly maintained roads, provides a logistical challenge for systematic and rigorous scientific investigation. These challenges have resulting in significant geographic and taxonomic gaps in knowledge of species occurrence, distribution, and abundance. The Biological Inventory Program represents an important step in filling these large gaps in knowledge. The true extent of these gaps, and the success of the inventory program in beginning to fill them, is demonstrated by the large proportion of new species and range extensions revealed through this effort.

Beach ridge flowers at Cape Krusenstern National Monument, part of the vascular plant inventory.

NPS's Approach

Initial work involved compiling a bibliography of research conducted within the ARCN and developing lists of species known, or suspected, to occur within the ARCN boundaries. These lists serve as a baseline to help direct inventory efforts in the field and are a starting point for data collection. This information is stored in a species database (NPSpecies) and bibliography (NatureBib). These are being updated with new information as the Biological Inventories progress. The current emphasis for inventory fieldwork in the ARCN is on vascular plants, montane-nesting birds, and small mammals. NatureBib and NPSpecies will ultimately be made available to the public. Inventory fieldwork is complete, and final products will be completed in 2005.

Interesting Finds

Vascular plant inventories in the ARCN during the 2001 and 2002 field seasons resulted in many new plant records for each of the five parklands, including many rare species, and five species new to Alaska or North America. In CAKR, which was floristically understudied prior to the surveys, 305 species were documented as new to the monument. New species included the first record of *Dupoa labradorica* in Alaska, and the documentation of six other rare plants (listed as rare to critically imperiled by the Alaska Natural Heritage Program). In KOVA, 131 species were documented as new to the park, including five new rare species and a second population of *Saussurea triangulata*, recently found to be new to North America during a previous survey. In BELA, 32 new species were documented for the park, including one new rare species and additional populations of *Dupoa labradorica*. In NOAT, 151 new species were documented for the park, including 11 new rare species. In GAAR, 168 new species were documented, including 12 new rare species and *Draba pauciflora* and *Festuca edlundiae*, both new to Alaska. Range extensions (more than 150 km) within Alaska were also documented for numerous rare and widespread species.

Small-mammal inventories of the ARCN during the 2001–2003 field seasons have resulted in major range extensions for several small mammals. The tiny shrew, one of the most poorly documented small mammals in North America, only recently discovered in Alaska, was found in BELA, GAAR, and CAKR, extending its range by 300 km. Major range extensions of 200–300 km were also documented for the barren ground shrew, which was

Approximately one square meter of late-successional lichen tundra dominated by Cladina stelaris, *BELA lava beds. This area has not been grazed in hundreds of years because of natural landscape barriers. A one-acre plot is likely to have more than 60 lichen species.*

collected for the first time in BELA, CAKR, NOAT, GAAR, and KOVA, and the pygmy shrew, which was found in CAKR. In total, 12 small mammal species were documented for the first time in one or more of the ARCN parks through this effort.

Inventories of montane-nesting birds were conducted in all of the parks except BELA during 2001–2003. Initial examination of the survey results provides documentation of 115 bird species, at least 17 of which were previously undocumented in one or more of the four ARCN parks surveyed. Of these, three are shorebirds considered to be of high regional and national conservation concern: the bar-tailed godwit in GAAR, the pacific golden plover in NOAT, and the surfbird in GAAR and NOAT.

Looking Forward

As these biological inventories are completed, the Arctic Network turns to designing a program to monitor the status and long-term trends in the condition of the ecosystems under National Park Service stewardship. This program will identify and monitor indicators of ecosystem condition, or "vital signs," to develop scientifically sound information for use in management and research. The results of the biological inventories provide a much needed foundation for this important next step.

Other Arctic Projects

Reindeer Impacts to Lichen Ecosystems

Reindeer grazing was established as a Native industry on the Seward Peninsula in 1892 to help Natives overcome food shortages caused by overhunting of marine mammals by international fleets. The enabling legislation of BELA requires the National Park Service to continue to permit reindeer grazing according to sound range management practices without allowing damage to preserve resources. All of BELA (2.8 million acres) is included in active reindeer grazing allotments. This project will provide data needed for a comprehensive, scientifically based reindeer management plan focused on protecting sensitive lichen habitats. The major objectives were to assess and model the condition of lichen communities for each landscape stratum and to quantify the relationship between condition class and grazing intensity. During FY 2003, fieldwork consisting of range assessment and non-vascular plant collections was completed. Data analysis, voucher identification, and overall synthesis are ongoing. A publishable, peer-reviewed manuscript describing lichen community gradients and their relationship to major environmental variables and successional state is estimated to be completed in FY 2005.

Alaska Park Science *Publication*

During FY 2003, 2500 copies of the first two issues of *Alaska Park Science* were produced and distributed. Both issues can also be viewed online at http://www.nps.gov/akso/AKParkScience/index.htm. The purpose of *Alaska Park Science* is to provide information about scientific investigations within and relevant to Alaska's National Parks. Articles were contributed by scientists from several agencies and institutions. An editorial board recommended content, and the Alaska Natural History Association designed, edited, and produced the publication.

Population Ecology of Wolverines in Northwestern Alaska

Wolverine ecology has been studied within Noatak National Preserve and Kobuk Valley National Park, Alaska, since 1996. The project was initiated to gather baseline population parameters for evaluating the impacts of harvest by hunting and trapping. Specific project objectives include

Veterinarian holding anesthetized wolverine after surgery.

Muskoxen group exhibiting defensive behavior, which makes them particularly vulnerable to hunting.

survival estimation, harvest assessment, reproductive performance, and testing of prototype satellite-transmitting radiocollars. Nine VHF radiocollars, 12 VHF implants, and 9 satellite transmitters have been deployed on 17 male and 8 female wolverines. Wolverines fitted with VHF radiocollars or implants have provided over 130 locations, but distance to the study area and inclement weather have inhibited consistent efforts to obtain radiotelemetry locations at regular intervals. Satellite transmitter performance has been variable but has provided accurate locations; however, transmissions have been intermittent because satellite signals are impeded when wolverines are presumably in snow or rock caves or dens.

Home range and habitat use data have been analyzed. Eleven animals (44%) have died because of predation, harvest, starvation, or unknown causes. As expected, the harvested wolverine sample is male biased (66% of 137 individuals). Fifteen of 17 females harvested were more than two years old. Examination of stomach contents from harvested wolverines indicate that caribou are an important diet item. Preliminary isotope analyses of liver, muscle, and femur samples from harvested wolverines indicate seasonal variation in diet.

North and West Alaska Cooperative Ecosystem Studies Unit

The North and West Alaska Cooperative Ecosystem Studies Unit (CESU) was established in August 2003. This CESU, which is administered through the University of Alaska Fairbanks, will focus on providing research, education, and technical assistance for Federal agencies in studies of high-latitude ecosystems. The NPS, along with the Geological Survey, Bureau of Land Management, and USDA Forest Service, demonstrated their support for the proposal developed by the University of Alaska System, University of New Hampshire, and Alaska SeaLife Center by joining the CESU. During early 2004, the cooperating agencies and institutions met to develop a role and mission statement, first-year work plan, and multi-year strategic plan. Future activities will include the development of specific research, education, and technical assistance projects involving university faculty, students, and cooperators.

Cape Krusenstern Muskoxen Range Use

Muskoxen were extirpated from Alaska in the late 1800s. In 1935–1936, 27 animals from Greenland were reintroduced to Nunavak Island, and from that stock, 70 were brought to northwest Alaska in 1970 and 1977. The muskoxen population within the monument is an extension of the latter. Fieldwork was done in 2002, and will be completed in 2004, on a study of the muskoxen population composition and behavior in Cape Krusenstern National Monument The objective is to determine conditions necessary to maintain the NPS-mandated "natural and healthy" population and to assess the feasibility of providing an opportunity for local Eskimo hunters to harvest these muskoxen as a subsistence resource. A final report and Ph.D. dissertation are due in FY 2004.

Nutritional and Contaminant Assessment of Lynx and Snowshoe Hare

The area of the Brooks Range near Wiseman, Alaska, is the location of a project investigating the presence of heavy metals in lynx and hare. It will also assess the nutritional status of lynx and analyze hare forage. Post-mortem analysis will be preformed on carcasses acquired from local trappers, and samples will be collected. Analysis will be directed at determining if there is a link between hare and lynx body condition. Lynx in the Wiseman area appear to exhibit unhealthy characteris-

Selection of spear points from the Caribou Crossing site. All but one of the over 150 points found at the site are basal fragments like these, which would remain hafted in spears after the tips were broken. The bases were discarded when re-arming spear shafts with new points. This is an activity hunters probably engaged in at these hilltop locations while watching for game.

tics while the hare population is at its peak. Tissue will be examined to determine levels of heavy metals, nutritional status, reproductive status, and the presence, abundance, and significance of potential pathogens. The study will provide the NPS with information regarding the park's dynamic ecosystem where the populations of hare and lynx exhibit unique characteristics absent in neighboring populations.

Ancient Hunters of the Western Brooks Range

In 2002 NPS archaeologists from Western Arctic National Parklands, along with students and researchers from Washington State University, Brown University, University of Alaska Anchorage, and the Russian Academy of Sciences, conducted test excavations at the Caribou Crossing site in northwestern interior Alaska. The site, estimated to date to approximately 10,000 B.P., has contributed key information to a multi-year project aimed at understanding the lifeways of the early inhabitants of eastern Beringia at the end of the last ice age. More than 150 large spear points were recovered at Caribou Crossing, more than at any other site of this age in Beringia. It seems that people were visiting this location repeatedly, perhaps on a seasonal basis over the course of several years, and were harvesting animals in fairly large numbers. However, despite the site's name, there is no direct evidence for caribou hunting, and the prey targeted at the site remains an open question.

Excavations at the Caribou Crossing site.

Bureau of Land Management

Mineral Assessments

BLM Solid Minerals has completed its second year of a mineral resource assessment of the Delta River Mining District and has began a four-year mineral resource assessment of the Aniak Mining District. 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. Bureau work includes locating, sampling, mapping, and evaluating historic mines, prospects, and occurrences and investigating newly discovered mineralization. This assessment is part of BLM's mining district evaluation program authorized under the Alaska National Interest Lands Conservation Act (ANILCA), which has been ongoing since the early 1980s.

The Delta Mining District study area encompasses approximately 2.9 million acres in east-central Alaska. BLM geologists have collected and analyzed approximately 960 samples since the beginning of the study. In addition, 264 U.S. Geological Survey stream sediment samples have been re-analyzed. Fieldwork during 2002 consisted of a five-week field season, focusing on property examinations and sample collection

The Aniak Mining District study area encompasses approximately 27 million acres in southwestern Alaska and includes parts of the adjacent Anvik, Iditarod, Innoko, Marshall, and McGrath mining districts. The area contains over 405 mineral sites, including those located in the historic mining areas of Iditarod–Flat, Nyac, Crooked Creek–Donlin Creek, Candle Creek, Ganes Creek, Nixon Fork, Illinois Creek, and Red Devil, to name a few.

	Funding (thousands)	
	FY 02	FY 03
Natural Ecology	2,700	2,500
O&G Minerals Research	1,000	1,100
Solid Minerals Assessments	720	580
Cultural Resources	210	160
Pipeline Monitoring	600	600
Fire Control	380	380
Total	5,610	5,320

Minerals field assistant exposing mineralized bedrock at the Red Knob Occurrence.

Placer gold has been the main commodity produced from the area since the late 1900s. Placer platinum and mercury, as well as lode gold and mercury and its byproducts silver and antimony, have also been mined. Placer gold production totals nearly 2.6 million ounces of gold, along with minor amounts of mercury and platinum. Lode production totals nearly 197,000 ounces of gold and over 35,000 76-pound flasks of mercury and byproduct antimony between 1902 and 1967. Other commodities prospected in the region include barite, copper, lead, molybdenum, silver, tin, tungsten, uranium, and zinc.

Fieldwork during 2003 consisted of a seven-week field season, focusing on property examinations and sample collection in the eastern third of the district. Bases of operation were McGrath and Farewell Lake. BLM geologists collected 351 rock, stream sediment, pan concentrate, soil, and placer samples from the Ganes Creek–Beaver Mountains and Nixon Fork areas southeast to the headwaters of Windy Fork and the Post River area.

Shallow Unconventional Hydrocarbon Resources

The Alaska North Slope (ANS) contains enormous potential in the form of unconventional oil and gas (viscous oil, gas hydrates, and coalbed methane). As production of conventional oil and gas resources declines, unconventional resources take on a more important role in supplying energy needs. Large onshore viscous oil and gas hydrate deposits exist beneath the current ANS infrastruc-

ture. Estimates of in-place shallow gas resources on the ANS are 590 TCF (trillion cubic feet), with 100 TCF or more beneath the existing development infrastructure. In-place shallow viscous oil resources exceed 18 billion barrels. Research has focused on:

- Assessing known ANS unconventional oil and gas resources, which promotes BLM understanding for potential unconventional resources leasing and permitting;
- Reviewing and evaluating existing best-production methods for shallow resource extraction;
- Developing technology to encourage ANS shallow unconventional resource development;
- Identifying shallow drilling and completion methods applicable on ANS; and
- Identifying existing, emerging, and new technologies to enable economically viable production of the vast shallow ANS unconventional resources, with a focus on economy of scale, low impact, and low cost. Technologies may include highly portable, lightweight rigs and simple shallow well completions, with options to consider complex horizontal and multi-lateral well completions.

Alaska Rural Energy

BLM Alaska partnered with U.S. Geological Survey, the State of Alaska, the University of Alaska Fairbanks, and the Department of Energy in evaluating the potential of exploring for and developing coal bed methane (cbm) resources for rural Alaska villages. These villages currently rely on expensive diesel fuel for transportation, heating, and electricity. In places, this fuel costs up to $3.50 per gallon. This high cost deters development of other resources that would help generate income for the villages. This fuel is transported to these villages on prime fish-spawning rivers and streams, where a spill would be a disaster.

Weed Management

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 2002 and 2003, through a National Fish and Wildlife Foundation matching grant awarded to the Northern Field Office, BLM was successful in developing preliminary weed awareness programs targeting citizens and agency managers. BLM was able to pool resources and work across agency boundaries to initiate weed inventories on public and private lands. Through the project, BLM also developed a statewide weed database, housed in a central clearinghouse. A Plant Management Area (PMA) was established by CNIPM partners in Juneau, driven by the invasion of such plants as garlic mustard. A research needs assessment was developed and prioritized and will be published in the journal *Agroborealis*.

BLM initiated an invasive plant inventory on BLM-managed lands in 2002, completing a survey of 20,000 acres of the Steese National Conservation Area. During 2003, an inventory was conducted in the White Mountains National Recreation Area and in the Glennallen area (40,000 acres).

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

Fortymile Caribou Herd Recovery

During 1994, BLM joined state and Federal agencies and concerned citizens to begin planning for the recovery of the Fortymile Caribou Herd (FCH). This effort was triggered by requests from subsistence hunters throughout Alaska and Yukon, Canada, to develop a broad management plan by all agencies and organizations. The FCH management plan was completed in 1995, and implementation began in 1996 and was completed in June 2001. Results of the implementation have been monitored in 2002 and 2003.

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, it numbered about 568,000. In 1994 the FCH occupied less that a quarter of its original range and numbered 22,104. Years of research showed that wolf predation was the primary factor limiting the survival of calves and thereby the growth of the FCH. The management plan included actions to

increase calf survival. Today the herd is growing because of the recovery efforts and has begun to expand west and south into former ranges, including the highlands of the Steese National Conservation Area, and east into former ranges in Yukon. During the winter of 2002, Fortymile caribou crossed the Yukon River in Yukon, Canada, for the first time in 30 years. Calf/cow ratios have improved from 22 calves per 100 cows in 1994 to 38.7 calves per 100 cows in 2002, and the herd has grown by about 10% annually since implementation of the management plan began (22,104 in 1994 to 43,373 in 2003). Harvest bag limits have increased, beginning in regulatory year 2001–2002, and will continue to increase modestly over the next few years based on herd growth.

The management plan was carefully crafted by subsistence and sport hunters, wildlife enthusiasts, animal rights advocates, environmental advocates, ecotourism representatives, and agency representatives from Alaska and Yukon. Implementation of the plan included reduced harvest, monitoring of land use within the FCH range, fertility control of alpha wolves, and translocation of subordinate wolves. The BLM has formed a partnership with the Alaska Department of Fish and Game to continue to monitor calf survival and population growth.

Neotropical Migratory Bird Surveys

BLM Alaska wildlife biologists continued to participate in the Neotropical Migratory Bird (NTMB) Conservation program during FY 2002 and 2003. The program is better known as Partners In Flight.

In an effort to monitor trends in North American bird populations, 11 breeding bird surveys and 7 off-road breeding bird surveys 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.

Breeding bird surveys were also conducted along the Unalakleet and Anvik Rivers in western Alaska, adapting standard protocols to a river, rather than roadside, setting. Thirty-five species have been recorded on the Unalakleet route and 42 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 survey 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 continued to be run in FY 2002 and 2003. 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 off-road breeding bird survey was also established in 1998 on Old Woman Mountain 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. The BLM bander conducted a demonstration for local children at the Unalakleet site this summer, taking advantage of the project to teach about migratory birds.

Forest Age Profiles

A study to gather baseline data on the fire history of the Steese National Conservation Area and White Mountains National Recreation Area in the Yukon–Tanana Uplands of interior Alaska was begun in 2001. In addition to documenting current forest stand age profiles of this area, the study attempts to examine the relationship between spruce stand age and lichen abundance. During late July and early August 2001 and 2002, 225 randomly selected sites were visited, resulting in more than 1,100 tree samples (disks or increment cores). With University of Alaska Fairbanks cooperators, these samples are being dated. Also in cooperation with UAF scientists, sediment cores were collected from two lakes in the study area to examine past changes in vegetation (pollen) and fire frequency (charcoal). Sample dating and data analysis continue. Congress directed in ANILCA

that caribou habitat was a special value to be considered in the management of the Steese National Conservation Area. Because fire can impact caribou habitat, this study and similar studies will provide an improved basis for caribou habitat management.

Fuels Reduction

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. Cleared fuel breaks or prescribed burns have been employed, but sometimes less dramatic treatments are desirable for ecological, aesthetic, or engineering reasons. The BLM Alaska Fire Service (AFS) and Tanana Chiefs Conference, Inc. initiated a three-year Fuels Treatment Demonstration project in 2001, 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 with the concomitant risk reduction, visual impact, environmental effects, and cost/benefit ratio.

Preliminary results after two years of monitoring the treated and control sites have demonstrated changes in live moss cover, shrub and seedling development, microclimate, permafrost, and forest floor moistures. Attempts to predict changes in fire behavior indicated tradeoffs between increased rates of spread due to higher average wind speed in thinned and pruned treatments versus an increase in the fire intensity threshold required for sustaining a crown fire.

Fire Management of Landscape

The University of Alaska Fairbanks (UAF) is leading an effort along with AFS, U.S. Geological Survey, and several Federal and state partners to develop a computer model for landscape-level analysis of fire–human interactions, vegetation change over time, and prediction of regional fire risk in interior Alaska's boreal forest. The interagency Joint Fire Science Program granted funding of $442,000 for this project for 2002–2004. The goal is to build a model that will provide land managers with thematic representations spanning years to centuries into the future of how forest cover and the probability of large fire events respond to different scenarios of fire management and climatic change. The model utilizes physical, biological, and human thematic layers and simulates boreal forest ecosystem dynamics that influence wildlife, hydrology, and soil processes. UAF field crews have been systematically sampling trees to establish stand age and fire regimes across interior Alaska in 2002–2003.

Student Conservation Association volunteer measuring duff moisture in a research plot that demonstrates thinning and pruning for mitigation of fire hazard in boreal black spruce forest (Delta, Alaska, July 2003).

Fallen, shallow-rooted black spruce along a monitoring transect at Chena Lakes Prescribed Fire. Deep burning into the dry moss/duff from a low-intensity surface fire caused the spruce to topple (July 2003).

Fire Effects Research

The USFS Pacific Northwest Research Station (PNW) is determining how weather and fuel dryness affect the reduction in moss/duff forest floor during fire. This question is integral in targeting revegetation with desired plant species in many wildlife habitat improvement projects, as well as in determining erosion potential and the extent of smoke pollution during wildfires and prescribed fires. In June 2003 the Joint Fire Science board granted funding for a proposal by PNW, AFS, the National Park Service, and the U.S. Fish and Wildlife Service entitled "Forest Floor Consumption and Smoke Characterization in Boreal Forested Fuelbed Types of Alaska." Fuel consumption and smoke emissions data were collected on active wildfires and prescribed fires in June–August. The data will be used to develop forest floor fuel consumption models (i.e. how much bare soil is exposed by burns under various conditions) and to develop emission rate equations for boreal forest types. Because of the thick layer of moss and organic material in boreal forests, large quantities of pollutants can be released by fire; this issue is only beginning to be understood, thanks to ongoing research.

Forest Service researchers from the Fire and Environmental Research Applications team in Seattle and Missoula Fire Lab preparing to measure smoke emissions and duff consumption on a wildfire near the Arctic Circle along the Dalton Highway (June 2003).

NASA approved a proposal by the Veridian Systems Division to fund a project entitled "Remotely Monitoring Plant and Soil Fuel Moisture for Wildfire Danger Assessment using Satellite Radar Data." The proposal will study the relationship between the Fire Weather Index and Alaska fire occurrence and soil moisture as detected by synthetic aperture radar.

Fire Monitoring Studies

The BLM Alaska Fire Service and field offices have established long-term vegetation monitoring plots at several prescribed fire or fuel treatment sites to look at vegetation changes that may impact land users and wildlife. Partners include the State of Alaska, the Army Corps of Engineers, and the Tanacross Village Corporation. An interagency Fire Effects Task Group meets regularly to exchange information on fire research and monitoring studies and to look at means of standardizing some data collection on certain types of studies.

National Petroleum Reserve—Alaska

In April 2003 the BLM, in cooperation with the Alaska Department of Fish and Game, conducted a study of the effects of vibroseis (seismic exploration) on fish overwintering in lakes. In two trials, one or five vibroseis trucks were operated over lake ice while arctic char (from a hatchery near Anchorage) were suspended beneath the ice in traps. Two control trials, with no vibroseis trucks operating, were also run with fish placed under the ice either for a brief exposure to lake water or for the same period of time as for the fish that experienced vibroseis. None of the fish (108 in each of four trials) was observed to suffer any adverse effects from the experiments. All were alive and apparently healthy after removal from the lake. None had ruptured gill filaments prior to euthanasia, and subsequent necropsy revealed no ruptured blood vessels in their eyes and no ruptured swim bladders.

Another series of vibroseis trials, conducted over wild, free-swimming broad whitefish in a nearby river, was conducted while the fish were

The 120,000-acre Erickson Creek fire looming over the Dalton Highway, which follows the Alaska pipeline along its track to the North Slope oil fields. This fire provided good access for research teams to study smoke emissions and fire effects in the northern boreal forest (June 2003).

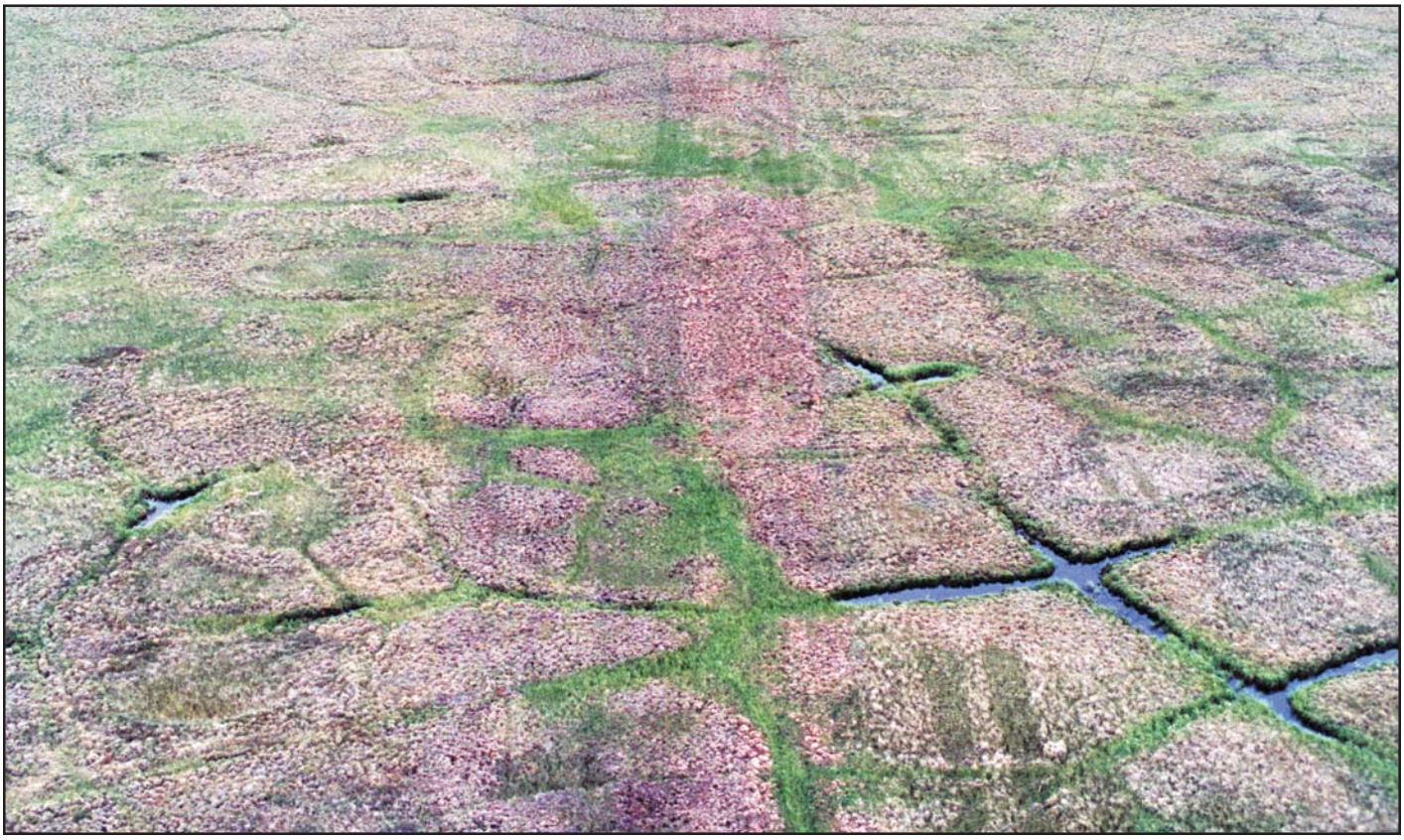
observed by underwater cameras. In each trial the fish were observed to swim slowly away from the vibroseis source and then to slowly return. By the sixth trial, little response to the vibroseis application was observed. Apparently seismic exploration using vibroseis over lake ice has no adverse impact on overwintering fish, nor does it cause displacement from preferred areas of the waterbody on more than a temporary basis.

A study by the BLM of the effects on tundra vegetation of overlapping, multi-winter ice roads was begun in 2002 and continued in 2003. This was intended as a pilot study, and the sample size (5) was limited by the availability of overlapping ice road paths in suitable vegetation cover types. The resulting power of statistical tests was low. The four treatments in the study were control, ice road path from 2001 only, ice road path from 2002 only, and overlapping ice road paths from both winters. The characteristics measured were the depth of thaw (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.

No statistically significant differences in thaw depth were observed among the four treatments, but the overall depths were significantly greater when measured in 2003 than when measured in 2002. This could be caused by a warmer summer in 2003, or a cumulative effect of greater sunlight absorption by impacted vegetation over two summers, or both. Weather records for the two summers have not yet been investigated.

Tussock damage was significantly greater in all three manipulated treatments than in the control, greater in the "2002 only" treatment than in the "2001 only," and significantly less overall in the second summer of data collection. The difference between 2001 and 2002 treatments may indicate that ice road construction techniques or snow cover differed between the two years. The overall difference between measurements in each of the two summers indicates that recovery is occurring regardless of treatment.

The percent cover of eight vegetation types was the only measure that showed a significantly greater effect in the overlap treatment than in either single-season treatment. In a comparison of the ratio of live versus dead vegetation, especially among shrubs and forbs, the control had the highest ratio, the single-year treatments had an intermediate level, and the overlap treatment had the lowest ratio of live to dead vegetation. This



Vehicle effects on tundra in the National Petroleum Reserve–Alaska, July, 2003. BLM is studying the effects on tundra vegetation of overlapping, multi-winter ice roads to determine whether it may be beneficial to construct the roads over new paths each year, increasing the area affected but decreasing the intensity of the effect per unit area.

implies that the effects of ice road construction are additive over multiple years. It may be beneficial to construct ice roads over new paths each year, increasing the area affected but decreasing the intensity of the effect per unit area.

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.

A river trip was conducted along the Colville River in 2003 to assess the occupancy of cliff-nesting raptors. Peregrine falcons, gyrfalcons, and rough-legged hawks were the targeted species, although information was also collected on common ravens. The trip was conducted in June and July, and all suitable cliff-nesting raptor habitat along the Colville River, beginning just below the mouth of the Etivluk River and ending at Ocean Point, was surveyed, a distance of 347 km. The survey team detected 56 territorial pairs of peregrine falcons, 63 of rough-legged hawks, and 13 of gyrfalcons. A total of 41 nests were located for peregrine falcons, 57 for rough-legged hawks, and 12 for gyrfalcons. This 2003 survey was a continuation of a long-term data set documenting the presence of cliff-nesting raptors on the Colville River. Surveys were first conducted along the Colville River in 1952. After that first survey, 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 detected in 1973 and a high of 62 pairs in 1998. The U.S. Fish and Wildlife Service (USFWS) has taken the lead on conducting this survey for the past 15 years, with some financial and personnel help from BLM. In 2003 the USFWS was unable to participate, so BLM conducted the survey with the assistance of a consulting raptor biologist.

BLM-USGS Bering Glacier System Program

The BLM and the U.S. Geological Survey (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 between Federal, state, local, academic, and non-governmental 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 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, genetically distinct populations of wolf and goat, 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. The NTM contributions are coordinated through the Civil Applications Committee (CAC). 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 (GIS) 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.

Wildlife Project Work on the Dalton Highway

In cooperation with the Alaska Department of Fish and Game, the BLM performed a herd composition count of the Ray Mountains Caribou Herd. During this study three new animals were radio-tagged in this herd, bringing the number of collared caribou in the Ray Mountains to 12. In addition, the BLM also cooperated on a herd composition count of caribou inhabiting the Dalton Corridor in the vicinity of the Hodzana Hills southeast of Bettles, Alaska, and also radio-tagged four of these animals.

The BLM surveyed five Areas of Critical Environmental Concern (ACEC) for important Dall sheep habitat in 2003. Sheep use by season and the presence of sheep licks were noted during this work.

In FY 2003 the BLM cooperated with the Kanuti National Wildlife Refuge and the Alaska Department of Fish and Game in a moose trend count in the northern part of Game Management Unit 24 near and in the Dalton Highway Corridor.

BLM personnel and a volunteer conducted three 25-mile breeding bird survey routes along the Dalton Highway in 2003.

BLM personnel began a nest box monitoring study for raptors along the Dalton Highway in the Brooks Range in 2002. In 2003 the BLM checked these boxes and found five active nests of American kestrels and five of boreal owls. Prey remains and unhatched eggs were collected from each nest for later food habits and contaminant analysis, respectively.

The BLM funded a cooperative study with the University of Alaska Herbarium to search for rare plants in the Toolik Lake Research Natural Area. This project was begun in 2002, and 8000 acres have been surveyed.

U.S. Geological Survey

Biological Resources Discipline

	Funding (thousands)	
	FY 02	FY 03
Marine Mammals	1,660	1,560
Migratory Birds	2,390	2,250
Fisheries Research	360	360
Cooperative Research	330	330
Terrestrial Ecology	1,130	1,060
Park Research	1,140	1,070
Total	7,010	6,630

The U.S. Geological Survey (USGS) Biological Resources Discipline (BRD) conducts research in the Arctic to generate information that will help Department of the Interior agencies and other partners in Alaska meet their resource management responsibilities. These responsibilities include conservation of migratory birds, certain marine mammals, endangered species, anadromous fishes, and all biota inhabiting National Wildlife Refuges and National Parks and Preserves. Research is designed to address the effects of development, disturbance, hunter harvest, and natural environmental cycles on fish and wildlife populations. Other research will help develop improved census and survey methods that will better detect trends in populations. All research has the ultimate goal of providing information that will lead to better management decisions and actions to promote conservation of living resources in the vast ecosystems of the Arctic. 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.

Most Arctic research of the BRD is conducted from the Alaska Science Center (ASC), Anchorage, and the Cooperative Fish and Wildlife Research Unit at the University of Alaska Fairbanks. Some additional research is performed by others of the 15 national research centers or the more than 50 cooperative research units, each of which has special capabilities that may be applicable to problems in Arctic research.

Ecological research in Arctic ecosystems is difficult, given the harsh conditions, frequently inaccessible habitats, and often wide-ranging movements of Arctic biota. It is also very costly. Since it has often been necessary to develop new methods of obtaining information, some of the most advanced technologies have been developed for, or first applied to, research in the Arctic. Satellite-linked biotelemetry and heavy metal tracers are but two of many new techniques that have been successfully applied to the problems of fish and wildlife conservation in the Arctic.

Fisheries

Fisheries biologists from the Alaska Science Center are conducting several studies in the region dealing with a broad range of aquatic resource issues. These studies range from detailed ecological investigations to determination of the genetic population structure within species. Current research projects in the region focus on chum salmon, chinook salmon, sockeye salmon, rainbow trout, and blackfish.

The USGS and the National Park Service share a collaborative study of microevolution looking at genetic and phenotypic differences in sockeye salmon in Albert Johnson Creek and the recently colonized Surprise Lake, Aniakchak National Monument and Preserve, Alaska. Aniakchak caldera was formed by a massive eruption 3500 years before the present (BP). The caldera filled with water and subsequently breached the caldera wall roughly 1800 BP. Additional sizable eruptions occurred in the caldera 500 and 72 BP. Sockeye salmon populations in Aniakchak caldera were established naturally by colonization following the collapse of the caldera wall, and they perhaps re-established following the eruptions 500 and 72 years ago. In comparison, most other sockeye salmon populations in southwest Alaska were established 10,000 years ago following glacial recession. Sockeye that spawn in Surprise Lake, inside the caldera, exhibit the typical lake-type life history, with juvenile access to a lake for one to two years of rearing before the seaward migration. The likely colonizing population at the base of the volcano exhibits a river-type life history, with no juvenile lake access. The juveniles of this life history must rear in the less-productive river. This study will determine if the populations have genetically diverged with respect to nuclear microsatellite markenjrs. It will also determine if divergence in juvenile body shape has occurred, and if so, the role different food and foraging tactics play in these local adaptations.

The USGS Global Change Initiative funded recent research on non-linear systems and sockeye salmon growth in the Bering Sea, 1955–2002. Non-linear systems present a challenge to conceptual thinking in reductionist science. When the rate of change of one or more variables is a non-

linear function of one or more states or conditions, we find evidence of unexpected thresholds beyond which change occurs much more rapidly and qualitative changes in behavior that can lead to cyclic extremes in abundance and diversity. There are few biological models that cross as many thresholds and follow such divergent life-history trajectories as Pacific salmon. The dynamics of non-linear systems is an essential part of understanding how and where this culturally and economically important group of fishes will be modified by global change.

Most research on Pacific salmon has focused on freshwater growth and marine harvest. However, the interactions among important ecosystem components for Pacific salmon are not proportional and therefore are non-linear. The transitions salmon make between freshwater and marine environments are critical times during which fish undergo physical, behavioral, and morphological changes. These changes are a response to challenges associated with water ion balance, food requirements, diseases, parasites, predators, and the shift between riverine and pelagic ecosystems. The timing of these transitions is regulated by climate, hydrology, oceanography, development rate, growth, and genetics. Changes in ecosystem conditions, including nutrients, food distribution and abundance, predators, currents, and temperature, are important factors that interact to support salmon at these critical stages of their life history. All of these non-linear factors are subject to extreme shifts and discontinuities with global change. The degree that changes in ecosystem condition in both freshwater and marine habitats are non-linear will impact the survival of salmon populations adapted to a particular schedule or sequence of change.

Salmon live in the ocean as pelagic fish for various lengths of time and return with unique fidelity to their stream of origin to reproduce and create subsequent generations. Human-induced changes to both freshwater and marine environments have greatly complicated this relationship. The impacts of marine harvest, habitat destruction, and development on salmon stocks have been well documented in the scientific literature. Hatchery production and supplementation of salmon stocks were linear fixes for a complex system that have not worked out as expected. Recent studies of Alaskan sockeye salmon in the Bering Sea, 1955–2001, showed a strong negative relationship between late marine growth in sockeye and Asian hatchery releases of odd-year pink salmon. Pink salmon have a distinct two-year life history, and hatchery production originating from northern Japan and wild pink salmon production from streams in eastern Kamchatka are especially abundant in odd-numbered years. These populations overlap both temporally and spatially with wild Alaska sockeye in the Bering Sea. Density dependence for Alaskan sockeye in the ocean appears to result from prey reduction caused by large numbers of hatchery pink salmon feeding in the Bering Sea in June and July before they migrate back to Asian coastal waters. This results in a sharp reduction in prey availability for Alaska sockeye salmon because of mortality and ontogenetic vertical migrations of some prey during the summer. Subsequently Alaskan sockeye, in years when they overlap with hatchery pink salmon, suffer poor marine growth and lowered reproductive potential.

Migratory Birds

In 1999 the ASC initiated a cooperative survey and research program with the U.S. Fish and Wildlife Service, Region 7 (Alaska), to examine the distribution, abundance, and life histories of sea ducks and other marine birds in the nearshore waters of the Beaufort Sea. This work was designed in response to information needs identified by the Minerals Management Service, Alaska Outer Continental Shelf Region. Presented here are the results from four field seasons of a multifaceted research program designed to assess the breeding ecology of Pacific common eiders and the molting ecology of long-tailed ducks along the Beaufort Sea coast of Alaska. The study area was divided into an Industrial Area adjacent to current oilfield development to the west of Prudhoe Bay and an undeveloped Control Area around Flaxman Island.

Long-tailed ducks congregate in the lagoon system of the Beaufort Sea for a post-breeding molt period from mid-July through mid-September. During this time the lagoons host 10,000–30,000 flightless long-tailed ducks. The combination of their large numbers, limited mobility, and nutritional demands, along with a declining population trend, had led to concern for this species. In 1999 and 2000 the ASC collected ducks through the molt period for a study of body condition, molt timing, and flight parameters. The dynamics of body composition during the molt act to minimize the flightless period for long-tailed ducks. These ducks meet their nutritional demands by foraging during the molt period, but there is no indication

that they are resource limited. Body condition was not affected by experimental boat disturbances or proximity to industrial development. During 2000–2002 the ASC studied aspects of movement, site fidelity, habitat use, and foraging ecology using radiotelemetry. In general, long-tailed ducks forage in the lagoons by day and roost along the barrier islands at night. Movement patterns of long-tailed ducks among years and areas were highly variable, with some individuals showing a great deal of mobility. There were no apparent effects of disturbance (including underwater seismic gunning) on movement, habitat use, or foraging; rather, weather (especially wind) appears to be the primary influence on these behaviors.

To examine the role of disease and contaminants on long-tailed ducks, the ASC analyzed blood and cloacal samples taken from live ducks and tissue samples from carcasses. Blood levels of lead were low, and there were no major differences in concentrations of trace elements between the Industrial and Control Areas. The ASC identified an adenovirus outbreak as the cause of poor body condition and mortality of long-tailed ducks in the Control Area in 2000. The data suggest that molting long-tailed ducks are more influenced by natural phenomena such as wind and disease than by human disturbance.

There is concern for the common eider of the Beaufort Sea because of recent dramatic population declines. Along the Arctic coast of Alaska, the greatest concentration of breeding common eiders is in the central Beaufort Sea, where they nest almost exclusively on barrier islands. The ASC used aerial surveys and ground-based nest monitoring to assess the breeding ecology of common eiders in the study areas. Both aerial surveys and ground-based nest searches showed a continued decline in nesting effort since 1999. This decline parallels increasingly late break-up of the sea ice between the mainland and the barrier islands, and it may be in part due to eiders forgoing nesting because of poor conditions on the breeding grounds. All of the measures of productivity (nesting effort, clutch size, hatch success, and fledging success) were low and substantially below those of Pacific common eiders nesting on the Yukon–Kuskokwim Delta in western Alaska. Predation by Arctic foxes and glaucous gulls was the greatest contributor to nest failure of common eiders. Of 52 broods followed in 2000 and 2001, none were known to survive until fledging. A reovirus, similar to one responsible for a major die-off of common eiders in Finland, was isolated from two duckling carcasses collected in 2000. Disease and predation may be responsible for poor duckling survival. Concentrations of lead and mercury in blood and eggs were lower than on the Yukon–Kuskokwim Delta. The data do not show an effect of industrial development on common eiders, with the possible exception of an increased risk of predation for eiders breeding near the oilfields. With the breeding success that the ASC documented since 2000, this population will not persist on its own. There are three possible scenarios for this population: the population may be declining rapidly, the population is maintained by recruitment from other populations, or the population is maintained by infrequent years of high recruitment. Regardless, there is cause for significant concern about the long-term viability of this population.

The ASC is engaged in research on other aspects of the life history of sea ducks in Alaska. Little is known about the migration and winter ecology of most sea ducks, which is considered a priority information need by the Sea Duck Joint Venture of the North American Waterfowl Management Plan. New and smaller satellite transmitters that can be surgically implanted in the abdominal cavities of sea ducks has permitted significant advances in understanding links between breeding areas and staging and winter habitats.

The ASC used satellite telemetry to study the migration routes and wintering areas of two allopatric breeding populations of Pacific common eiders in Alaska: the Yukon–Kuskokwim Delta and the western Beaufort Sea coast. Only 6% (2 of 36) of females wintered within the wintering area of the other breeding population. Both breeding populations wintered in the closest available ice-free habitat, perhaps to minimize migratory distance. Beaufort Sea breeding birds wintered primarily in the Chukchi Sea near the Chukotka Peninsula, Russia, and St. Lawrence Island, Alaska. Those birds that were marked in nesting areas on the Yukon–Kuskokwim Delta wintered in marine habitats off the Yukon and Kuskokwim Rivers and in Bristol Bay, Alaska. Two Beaufort Sea females wintered in areas used by Yukon–Kuskokwim Delta females, implying potential gene flow among breeding areas. The ASC concluded that these two populations are largely geographically isolated throughout the annual cycle, and the environmental factors influencing survival and reproduction likely differ between these groups of birds. Thus, regardless of the potential gene flow among breeding populations, birds from these two

breeding areas should be managed as separate populations.

Spectacled eiders were listed as threatened in 1993 under authority of the Endangered Species Act. The ASC has studied the life history of spectacled eiders in Russia, on the Yukon–Kuskokwim Delta in western Alaska, and on the North Slope of Alaska in an effort to identify factors that may be limiting their recovery. However, too little information, especially away from their breeding grounds, existed to determine the causes of the significant population decline on the Yukon–Kuskokwim Delta. The ASC described characteristics of the wintering area used by spectacled eiders in the Bering Sea, Alaska, and evaluated these characteristics in relation to long-term population trends. Remoteness, limited daylight, and extreme weather conditions precluded direct observations, so they derived the location of the wintering area from satellite telemetry, ice conditions from remotely sensed data, weather conditions from archived data sets, and benthic communities from the literature. Based on analyses of two indices spanning 1957–2002 and 1988–2002, they identified no single environmental parameter that explained the precipitous decline in nesting populations in western Alaska. In general, the number of days with extreme sea ice in winter, extreme winds, and winds in spring explained the greatest variability in annual indices. 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. Examination of population indices did not support the hypothesis that changes in benthic communities on the wintering grounds have contributed to the decline or inhibited the recovery of the spectacled eider breeding population in western Alaska.

The ASC and the National Park Service (NPS) recently agreed to collaborate on a multi-year project to inventory montane-nesting birds in National Parks of northwest Alaska. The NPS administers five large land units in northwest Alaska: Cape Krusenstern National Monument, Noatak National Preserve, Bering Land Bridge National Preserve, Gates of the Arctic National Park and Preserve, and Kobuk Valley National Park. Together they comprise the Arctic Network of Parks and cover almost 81,000 square kilometers (20.4 million acres), or about 5% of Alaska's land area. These parks host between 150 and 200 species of birds, but adequate documentation is lacking for 20–40% of these. The poorest documented avifauna occurs in montane habitats, especially in the larger parks. Recent regional and national shorebird conservation planning efforts have identified certain shorebird species and habitats as being of high conservation concern, primarily because of documented or perceived population declines and/or restricted distributions. In Alaska, 14 such species have been identified. Six of them nest in montane regions, including Pacific golden plovers, wandering tattlers, whimbrels, bristle-thighed curlews, bar-tailed godwits, and surfbirds. Despite the obvious importance of the Arctic Network Parks to regional, national, and international populations of montane-nesting birds, particularly shorebirds, information on species distribution and abundance is limited or nonexistent for most geographic areas of the parks. The goal of this project is to document the occurrence of 90% of the species of montane-breeding birds likely to occur in the Arctic Network of Parks. The ASC has employed a repeatable, scientifically valid sampling design suited to expansive areas with limited access to address three principal objectives:

- Collect and summarize all existing information on the distribution and abundance of all avian species occurring on upland habitats;
- Obtain geographic data layers needed to characterize elevation, slope, habitat, and measures of seasonal green-up; and
- Determine species-specific associations between distribution, abundance, and habitat characteristics, particularly for species of shorebirds and passerines occurring on upland areas during the breeding season.

Results from the 2001 and 2002 field seasons revealed a total of 100 species of birds on sampled plots, including 53 in Cape Krusenstern, 54 in Kobuk Valley, and 87 in Noatak. Overall, there were 23 species of shorebirds; 13 species of potential predators of shorebird adults, eggs, or young, including 8 raptors, 3 jaegers, and 2 corvids; 35 species of passerines; 22 species of waterfowl; 2 species of gulls; 2 species of ptarmigan; 1 species of grouse; 1 species of tern; and 1 species of crane. On average the ASC detected 30.4 species on Cape Krusenstern plots, 25.0 species on Kobuk Valley plots, and 26.0 species on Noatak plots during and between surveys.

Observers were able to directly associate a bird with a vegetation class for 27% of the detections of shorebirds and their potential predators. Among these, 52% of bird detections were associated with mesic graminoid herbaceous vegetation (MGH) and 13% with *Dryas* dwarf shrub (DDS)

vegetation. The remaining birds were associated with 20 other vegetation classes or combinations of classes. Habitat associations also varied by species. For example, whimbrels were almost always associated with MGH (76%), whereas American golden plovers were usually found among various classes, including MGH (38%), DDS (26%), and dry forb herbaceous vegetation (12%).

The ASC classified the behavior of 79% of 1,423 detections of shorebirds and potential shorebird predators. Based on this subsample, the behavior of most shorebirds was characterized as courtship or breeding display (47%); standing, preening, or sleeping (26%); or flying or walking (14%). For potential predators, most detections were of individuals flying or walking (68%), or standing, preening, or sleeping (24%). They were likewise able to determine the behavior for a high proportion of passerines (90% of 2,916 detections) because behavior can be inferred from vocalizations. Most passerines were performing courtship or breeding displays (81%), or flying or walking (14%). Very few passerines were seen feeding or engaged in maintenance or agonistic behaviors. Waterfowl were typically seen as pairs or groups on water bodies (24%) or flying (45%) over plots. Most detections of gulls (64%) were of birds flying low along creeks or rivers, and most detections of ptarmigans (54%) were of males standing on prominent shrubs or rock outcroppings.

Additional data analyses are in progress. The ASC will use logistic regression to estimate the probability of detecting a species at any location in the study area. To do so, they will construct a resource selection probability function by comparing characteristics of the sample points that are used or unused by each species. The presence or absence of the species will be the dependent variable, and habitat and topographic characteristics around the point will be used as explanatory variables. For those variables for which information is available on a park-wide GIS, resource selection probability functions will be developed by comparing points used by each species with a randomly selected sample of points available in the study area. Habitat composition at the points is currently being summarized.

Marine Mammals

The Department of the Interior has trust responsibility for managing three species of marine mammals: polar bear, Pacific walrus, and sea otter. Polar bears and Pacific walruses are apical carnivores in Arctic regions. The USGS is responsible for conducting research to satisfy U.S. Fish and Wildlife Service information needs for these two species. The U.S. shares both species with Russia, and polar bears are also shared with Canada. The international nature of the populations requires the U.S. to coordinate research programs with both Russia and Canada. The focus of current research relates to international actions necessary to conserve shared populations. Both species are subject to legal harvests by Alaska Natives, and research seeks to develop methods for defining and monitoring populations to establish sustainable population goals. Resource development in the Arctic habitats and their potential impacts on populations of polar bears and Pacific walruses are also topics of research interest.

*Walruses.*The USGS Pacific walrus research program focuses primarily on studies related to the estimation of walrus abundance, animal diving behavior and patterns of migration, and population genetics.

Pacific walruses occur throughout the Chukchi and Bering Seas and are important to Native subsistence in Alaska and Russia, where thousands of animals are harvested each year. Reliable abundance estimates for walrus are currently unavailable. Estimates of the potential biological removal (PBR) for all marine mammal species are required under the 1994 amendment to the U.S. Marine Mammal Protection Act. PBR estimates require an estimate of population size with estimable precision. The status of the walrus population is poorly known, but there are indications that the population declined from its most recent peak in abundance in the 1980s. Estimates of walrus population trends are critical for effective management. The purpose of the USGS studies is to evaluate trends in the walrus population by establishing new surveys, evaluating past data collected from monitoring programs in U.S. and Russia, and investigating potential genetic structuring in the walrus population.

To estimate the total population abundance from an aerial survey, the number of animals enumerated on ice and land haulouts must be divided by the proportion of the population hauled out, and thus available for sighting, at the time of the survey. Because walruses are distributed over vast areas of sea ice, an estimate of the proportion of time hauled out is best obtained using satellite telemetry data. The USGS is investigating methods to remotely affix satellite transmitters to walruses in order to estimate an availability correction

factor that can be used by the U.S. Fish and Wildlife Service in future aerial surveys. This method of affixing transmitters would alleviate the need for animal captures, which have been problematic. If funding permits, 40–60 transmitters will be deployed across a range of age and sex classes throughout the Bering Sea. The success of this year's efforts will dictate whether the development of these methods will continue into 2005.

Relatively few studies have investigated the population structure of the Pacific walrus. No genetic studies of the Pacific walrus have utilized microsatellite DNA, which is now commonly used in population genetic investigations. Comprehensive genetic studies using microsatellite and mitochondrial DNA might reveal distinct subpopulations within the Pacific walrus and aid in identifying the migration patterns of animal groups. Subpopulations may be uniquely adapted to given areas and may respond to harvest or habitat alterations in different ways, so they may warrant special management considerations. In addition, an increased understanding of walrus distributions and movement patterns will help in planning and interpreting future population studies, such as aerial surveys. The USGS is using microsatellite and sequence information from the hypervariable portion of the control region of the walrus mitochondrial DNA to investigate potential population structuring within the geographic range of the Pacific walrus. Tissue samples are derived from past research cruises, subsistence hunts, and live animal biopsies using crossbows. Preliminary results are expected to be completed by 2005.

Measures of heavy metal concentrations along the axis of growth in hard tissues such as teeth can provide a history of environmental or dietary exposure of animals to metals such as mercury, lead, copper, zinc, strontium, and calcium. Furthermore, if isotopic and metal profiles are known for geographic regions of the animal's environment, measures of these profiles can provide information on the animal's residency within geographic areas.

The USGS is collaborating with the Geological Survey of Canada to use measures of heavy metals from walrus teeth to determine walrus group affiliation and the distribution of segregated segments of the population. The study requires coordination with U.S. Fish and Wildlife Service, University of Alaska Fairbanks, and Alaskan and Russian hunters. Lab analyses have been completed on over 250 teeth, and results will be published in 2005.

*Polar Bears.*USGS polar bear studies have focused for nearly two decades on ways to manage human activities so as to eliminate or reduce the possible impacts of those activities on polar bears and their habitat. As a result, we now have information on populations to more effectively manage the harvest of polar bears. We also have developed knowledge that can dramatically reduce the impacts that may occur as a result of hydrocarbon exploration and development in the Arctic. Whereas these proximate effects of human activity can be managed, understanding and managing the ultimate effects of the dramatic decline in the habitat upon which polar bears depend may present much more challenging problems. The USGS polar bear project will be focusing on those issues surrounding large-scale climate change for the next several years.

Radio-collared polar bears have been shown to travel from the Canadian Beaufort Sea into the eastern Chukchi Sea of Alaska. Recognition that these animals are shared by Canada and Alaska prompted the development of the Polar Bear Management Agreement for the Southern Beaufort Sea. This agreement between the Inupiat hunters of Alaska and the Inuvialuit hunters of Canada was ratified by both parties in 1988. The text of the agreement included provisions to protect bears in dens and females with cubs, and it mandated that the overall harvests from the southern Beaufort Sea (SBS) polar bear population would be split between the two jurisdictions. It also dictated that the quota for each jurisdiction would be set according to the best available scientific information and would be reviewed annually.

A principal assumption of the agreement is that hunters from villages between Cape Bathurst, NWT, and Wainwright, Alaska, are harvesting polar bears from the same SBS population. The assumption that there is one group of bears in the SBS was based on analysis of radiotelemetry data collected between 1981 and 1988. Ensuing analyses of those data indicated that the concept of one homogeneous group is probably not accurate.

The studies first reported in 1999 have been re-examined. This re-assessment benefits from improved methodologies, new radio tracking data from the eastern and southern portions of the Beaufort Sea collected through June of 2003, and all available data from the Chukchi Sea. Previous research concluded there were three populations of polar bears in the study area. This conclusion was drawn from a variety of scientific data collected over a period exceeding 30 years, as well as local knowledge. Quantifiable evidence of three populations discrete enough to be managed separately,

however, has been lacking. The recent analysis corroborates the earlier suggestion that three groups of bears occur in this area.

Most human activities of concern for polar bear conservation, notably hunting and oil and gas exploration and development, occur in the very near shore zone. This is the area in which our predictive abilities are strongest. Also, it is a simple matter to convert our relative probabilities of encountering a bear from each population to absolute probabilities of encountering any polar bear. Hence, managers could advise recreationists of the likelihood of bumping into a polar bear when they are out on the land, and they can address questions such as which areas proposed for industrial developments will minimize the risks of incidental bear encounters. They also can now calculate the numbers of bears that might be exposed to oil in the event of a spill. This is the sort of information that makes risk assessments for environmental impact statements meaningful.

Another focus of these new findings will be their application to population estimates for polar bears in the Beaufort Sea. Previous capture–recapture efforts illustrated how recognition of different populations with different capture probabilities could impact population size estimates. Knowing not only that capture probabilities differ, but what the different probabilities are, is currently being built into ongoing population modeling for polar bears in the Beaufort Sea.

Polar bears in the southern Beaufort Sea are currently managed as a single population. An accurate assessment of the status of this population is needed to maintain sustainable levels of harvest by Native peoples, to understand the impact of hydrocarbon development along Alaska's North Slope, and to monitor the effects of long-term environmental change on the Arctic ecosystem. Unfortunately, despite over 30 years of capture–recapture data, conventional capture–recapture models have produced unreliable estimates of the size of the SBS population. The problematic structural features in the historic data set are sporadic capture–recapture effort and, more generally, small sample size. These issues, which are a direct result of the financial and logistical challenges of operating in the Arctic, make it difficult to take advantage of recent advances in capture–recapture theory (for example, the robust design).

In recent years the USGS has taken major steps to address the difficulties associated with estimating SBS polar bear abundance and has improved our understanding of the size and trend of this population. Spring 2004 will mark the fourth year of five years of a new capture–recapture effort in the SBS. These five years (2001–2005) of more consistent, uniform capture–recapture data should allow an expanded analysis that includes more state-of-the-art capture–recapture models (e.g. the multi-state model) and will also mitigate bias and precision problems associated with modeling the historic (1967–2000) data.

Spring 2003 capture–recapture operations were based out of Prudhoe Bay, Kaktovik, and Barrow, Alaska. The goal in using multiple logistical bases was to distribute the capture effort as evenly as possible throughout the SBS, thereby obtaining a representative sample of the polar bears utilizing this area. USGS scientists attempted to identify and/or capture every polar bear they observed regardless of age, sex, reproductive status, or previous capture history. They encountered 118 individual polar bears during the spring 2003 capture–recapture season, 104 of which were captured. Of the captured individuals, 89 were located by standard searching techniques (not by radiotelemetry). Only 21 of these bears had been captured and marked in a previous year, giving a recapture rate of about 24%. The remaining 15 captured individuals were located by radiotelemetry.

One of this year's goals was to develop a new capture–recapture model that can handle some of the difficulties specific to the SBS data set and would also be useful in other capture–recapture studies. In response to these issues a new model was developed by extending an existing model, and the model's behavior is being investigated under a wide variety of conditions. Manuscripts describing the model's performance in computer simulations and on real-world data sets are in preparation.

The USGS polar bear research program will initiate a new study in 2004 examining issues related to global climate change. Abundant evidence suggests that climate patterns are changing. The effects of this change may be greatest in the Arctic. Because of their reliance on the sea ice for all aspects of their survival, polar bears are especially vulnerable. How those changes will affect polar bears in the Beaufort Sea is not understood. The new research program is a five-year study of the effects of a changing sea ice environment on polar bear population parameters. It will examine how sea ice quality and condition have changed and will change for the period 1985–2008, and it will establish how polar bears adapt to those changes

spatially and will test whether there is evidence that spatial responses, mediated by climate change, alter polar bear condition, productivity, and survival of young.

Studies of polar bear post-denning behavior have been conducted in areas with high den concentrations, including Russia's Herald Island and Norway's Kongsøya Island. In contrast, the low density of maternal dens in Alaska usually precludes such an opportunity. During the winter of 2001-02 and 2002-03, however, several polar bear dens occurred relatively near the Prudhoe Bay oilfield. This allowed one of the first opportunities to observe the post-emergence behavior of family groups at den sites in Alaska.

The activity budgets of undisturbed animals provide a basic understanding of their behavior patterns as well as a benchmark against which human impacts can be evaluated. Polar bears are especially susceptible to disturbance during the denning period. Cubs are unable to leave dens for at least two months after birth, and even after the bears emerge, a disturbance may cause den abandonment before the cubs are developed enough to endure the rigors of life on the ice.

During the winter of 2001-02 and 2002-03, polar bear maternal dens were located near the Prudhoe Bay oilfield by conventional aerial radio tracking or by forward-looking infrared (FLIR) mounted on aircraft. In late winter, observation blinds were established at den sites. Den emergence dates were determined by fixed-wing aircraft or ground-based observations. The mean emergence date was earlier and the mean length of stay at the den site shorter than den observation studies in other parts of the Arctic. Weather factors were similar to those reported in other studies during the emergence period.

Bear response to human activity near den sites ranged from slight to significant, underscoring a need for further research investigation. Determining what comprises disturbance events as well as measuring individual variation in bear responses to disturbance can provide managers with information to mitigate potential stressors.

Contaminants and Ecology

The banking of environmental specimens under cryogenic conditions for future retrospective analysis is an important part of wildlife health and environmental monitoring programs. The goal of the Alaska Marine Mammal Tissue Archival Project (AMMTAP) is to collect tissue samples from marine mammals for archival in the National Biomonitoring Specimen Bank (NBSB) at the National Institute of Standards and Technology (NIST).

Along with the continuation of sample banking, a new emphasis of collaborative research between AMMTAP cooperators is polar bear–ice seal ecology. This Arctic focus appropriately addresses U.S. Department of the Interior strategic goals for research and management of trust resources. Further, it brings attention to rural concerns related to subsistence resources as well as larger-scale international environmental concerns being addressed by the Arctic Monitoring and Assessment Program.

In 2003 the USGS initiated a collaborative effort with the North Slope Borough Department of Wildlife, the Alaska Nanuuq Commission, and the University of Alaska Fairbanks titled "Influence of Diet on Biomagnification of Organochlorine Pollutants in Polar Bears." Varying concentrations of organochlorine contamination have been found in the tissues of polar bears throughout their range. Many of these organic pollutants are biomagnified with each trophic transfer in the food web.

Polar bears are one of the top carnivores in the Arctic marine ecosystem, with ringed seals likely representing the majority of their annual diet. However, polar bears also feed on bearded seals, beluga whales, and walruses, as well as scavenge on the carcasses of bowhead whales landed by Native subsistence hunters. Stable isotopes are an important tool in identifying trophic relationships within an ecosystem. By using two isotopes and mass balance equations it is possible to estimate what proportions of three isotopically distinct prey items may make up the diet of the predator. To estimate prey composition the USGS used ^{15}N and ^{13}C values from packed blood cells collected from 43 free-ranging polar bears along Alaska's Beaufort Sea coast in the spring of 2003. The results suggest that these polar bears may not be feeding on a single prey species; prey from a lower trophic level, such as scavenged bowhead whale carcasses, may make up as much as 33% of the diet of an average South Beaufort Sea polar bear. Isotope data on Beaufort Sea walrus are lacking.

Comparisons of the isotope signature of these bears to existing data from Canadian subpopulations reveal significantly lower ^{15}N values than those reported for bears sampled in Resolute Bay and Lancaster Sound. This may be because bowhead whale carcasses are more available to polar bears in the southern Beaufort Sea or because of the varying types of tissue analyzed.

Climate and Sea Ice

Arctic sea ice is not only critical habitat for polar bears, walruses, and several species of seals; it is also a significant component of the global climate system. The Arctic Ocean's ice cover governs heat exchange between the ocean and the atmosphere, and changes in sea ice affect large feedback mechanisms that can amplify climate change and variability. The USGS Alaska Science Center recently concluded a study with the Russia Academy of Sciences, Moscow, that investigated spatial and temporal changes in duration of the summer melt season over Arctic sea ice during 1979–2001. Because liquid and frozen water possess different emissivity signatures, passive microwave satellite images were used to document the onset dates of spring melt and autumn freeze. Details of the study are presented in the January 2004 issue of the *Journal of Climate*.

On average, melt began in the peripheral seas during late May and early June, then advanced rapidly over the Arctic Ocean, reaching the pole near the end of the third week of June. Freeze onset at the northernmost latitudes began, on average, during the fourth week of August, reaching the East Siberian and Laptev Seas in mid-September and the Chukchi, Barents, and Kara Seas in late September. In the Arctic Ocean, melt duration varied from a 75-day minimum season in 1987 to a 103-day maximum in 1989. On average, annual ice (ice that does not survive the summer melt season) began to melt 10.6 days earlier and freeze 18.4 days later than perennial (multiyear) ice. Melt duration in annual ice averaged 30.6 days longer than perennial ice and was nearly constant over the 23-year record.

Average annual melt and freeze onset dates, and melt season duration, were significantly correlated with the Arctic Oscillation (AO). The AO index is a commonly used parameter for characterizing alternating high- and low-pressure anomalies over the Arctic. Under high-index AO conditions, sea level pressures over the central Arctic Ocean are substantially lower and the vorticity of the gradient wind fields are more cyclonic. Following high-index AO winters (January–March), spring melt tends to be earlier and autumn freeze later, leading to longer melt seasons. Northward expansions of earlier melt and later freeze during the high-index AO period were most apparent in the northern East Siberian and Chukchi Seas, where the mean annual melt duration was 2–3 weeks longer after the AO shifted to a more positive phase in 1989, compared to prior years.

During high-index AO winters, atmospheric low-pressure systems in the eastern Arctic establish wind-forcing patterns that contribute to earlier sea ice melt by advecting warm southerly air into the East Siberian and northern Chukchi Seas. The low-pressure systems also force cyclonic sea ice motion anomalies that reduce ice transport into the eastern Arctic and increase divergence within, promoting the formation of thin ice and open leads. A greater abundance of open water, leads, and thin ice enhances heat flux from water, decreases surface albedo, and amplifies the summer melt through positive feedbacks. Hence, both dynamic and thermodynamic processes associated with winter AO conditions can imprint signatures that persist later into the year through their influences on spring melt and summer feedbacks.

Invasive Species

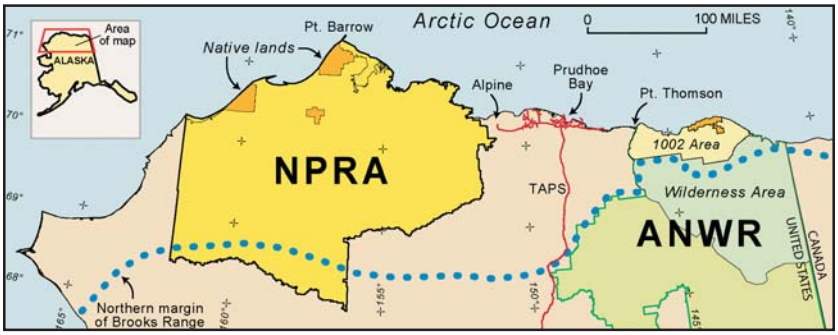
Alaska's National Parks have few invasive species compared to National Parks in other states, but the rate of exotic plant invasion and spread is increasing rapidly in developed areas of Alaska. In response, the Alaska Science Center is cooperating with the National Park Service (NPS) to conduct the first comprehensive study in Alaskan NPS units for early detection and rapid eradication of invaders. They have determined location, population size, and general site conditions of exotic plants, entered data in a statewide database (http://agdc.usgs.gov/akepic), and coordinated with NPS personnel to rapidly eradicate or control the spread of invasive plants. Starting in 2000 they

White sweet clover, a nonnative species that has invaded hundreds of acres of the gravel bars of the Nenana River in interior Alaska. This infestation could spread down the Nenana River, then down the Tanana River, and on down the Yukon River. The infestation was discovered in 2003, and quick-response interagency control efforts are underway. Sweet clover is considered a severe threat to riparian wildlands throughout Alaska.

have worked in Denali National Park and Preserve, Gates of the Arctic National Park and Preserve, Kenai Fjords National Park and Preserve, Sitka National Historical Park, Wrangell–St. Elias National Park and Preserve, and Yukon–Charley Rivers National Preserve and will expand to additional parks in 2004. The results vary among parks. In Gates of the Arctic, a remote park with few visitors and no road access, they documented near-pristine baseline conditions; the only non-native plant they found was one patch of common dandelion. In contrast, in Denali, the park with the most visitors, easy road access, and ongoing construction disturbance, non-native plants were widespread in human-disturbed areas. In 2003 they discovered, in conjunction with USDA staff, that dense stands of sweet clover had invaded undisturbed riparian areas downstream of Denali. This is the first exotic plant to invade wildlands in Interior Alaska, and this population can spread downstream all the way down the Yukon River. They consider sweet clover a serious threat to Alaskan parks, as it has the potential to invade riparian areas in every park. They are organizing an interagency team to develop a rapid response to the sweet clover invasion.

In 2002 they began two invasive plant research projects in Denali. The first project addressed the question of whether planting native legumes and/or fertilization had a long-term effect on the invasion of exotic plants. They studied cut-and-fill road construction disturbances that included areas without assisted revegetation and areas revegetated in 1991 by seeding with native legumes and grasses and adding slow-release fertilizer. Measurements on sample plots included density and cover of exotic plants, cover of native plants, and soil nitrogen, phosphorus, and potassium levels. They found no relationship between revegetation methods, soil nutrient levels, and the density and cover of exotic plants. Microclimate, however, was an important factor, with exotic plants concentrated in the warmest sites. Based on these results, revegetation with a native legume/grass mix is continuing on new construction areas. The results also show that climate warming will expand the range of invasive plants in Denali.

The surveys in Alaskan National Park units showed that exotic plant invasion was concentrated in a few small areas, primarily the road entrances. A second project tested methods for intensive early detection and rapid eradication at an invasion "hot spot," the entrance area to Denali. Repeated surveys throughout the growing season increased the number of exotic plants detected. They detected and, in coordination with NPS, eradicated four new invaders.



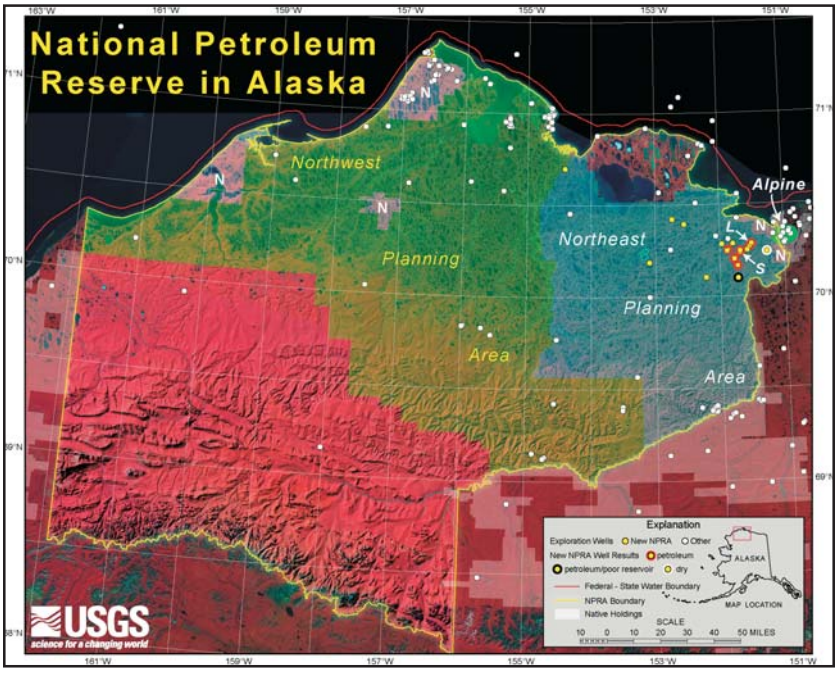
Locations and relative sizes of the National Petroleum Reserve–Alaska (NPRA) and the Arctic National Wildlife Refuge (ANWR). ANWR's 1002 Area was evaluated for petroleum potential by the USGS in 1998. The Trans-Alaska Pipeline System (TAPS) and "feeder" pipelines extending east and west of Prudhoe Bay show the extent of the existing petroleum infrastructure. Locations of the Alpine and Prudhoe Bay oil fields and the Point Thomson gas and oil accumulation are also shown.

Geology Discipline: Petroleum Resource Potential of the National Petroleum Reserve in Alaska and Recent Exploration Activities

"Whereas there are large seepages of petroleum along the Arctic Coast of Alaska and conditions favorable to the occurrence of valuable petroleum fields on the Arctic Coast...." President Warren G. Harding used those words in 1923 to describe the apparent petroleum potential of a tract of land on the western North Slope of Alaska, as he issued a one-page executive order establishing the 23-million-acre (36,000 square miles) Naval Petroleum Reserve No. 4.

During the following six decades, the U.S. Government conducted two petroleum exploration programs in the reserve, one in the wake of World War II and the second in the wake of the 1970s oil embargo. These programs found only a handful of oil and gas fields, none of them large enough to be commercial. Management of the reserve was transferred to the Department of the Interior, and the name was changed to the National Petroleum Reserve–Alaska (NPRA) in 1976. Four lease sales were held in the 1980s, but only two exploration wells were drilled by industry within the NPRA boundary—one on a Federal lease and another on Native land—and neither resulted in the development of petroleum resources.

Following a 10-year hiatus in exploration activity, NPRA again became a focus of interest



National Petroleum Reserve–Alaska (NPRA; boundary shown by yellow line), with locations of wells and the Alpine oil field. Native lands within the NPRA boundary also are labeled with "N." Northeast and northwest planning areas are shown in blue and green, respectively. Exploration wells drilled in NPRA during the 2000–2004 winter drilling seasons are shown by yellow symbols ("new NPRA" in legend). Wells proposed for development are labeled as follows: L = Lookout wells; S = Spark wells. The map base is a false-color composite Landsat image.

with the 1996 announcement of the discovery of the Alpine oilfield, located just outside NPRA. A Federal lease sale was held in part of the northeast planning area of NPRA in 1999, and a number of exploration wells in that lease sale area were completed by industry during the 2000, 2001, and 2002 winter drilling seasons. Another Federal lease sale was held in the northeast planning area in 2002, and additional exploration wells were drilled during the 2003 and 2004 winter drilling seasons.

Several of the wells drilled following the 1999 lease sale were announced in 2001 to have encountered oil and gas. The operator of those wells proposed in 2003 to develop the discovered oil accumulations as satellites to the Alpine oilfield, and that proposal is under evaluation by the Department of the Interior and other Federal and Alaska state agencies. The Department of the Interior during 2003 also initiated procedures to make available for leasing part of the northwest planning area and to expand the portion of the northeast planning area available for leasing.

In light of the recent and proposed exploration activity, it is timely to review recent estimates of oil and natural gas volumes that may occur beneath NPRA. The USGS in 2002 released an assessment of undiscovered oil and gas resources in NPRA. The results of this study provide a context for understanding recent exploration activity in NPRA and for anticipating activity that may occur in coming years.

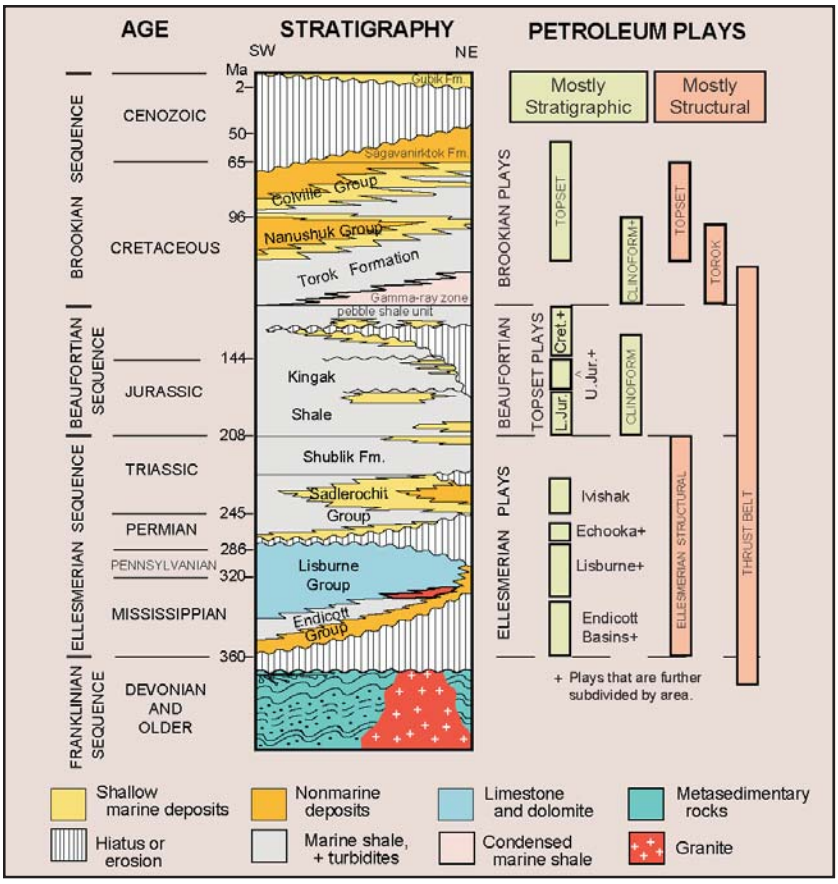
2002 USGS Assessment

The NPRA assessment involved nearly four years of study by a team of USGS scientists. Research was coordinated with colleagues in other Federal agencies, Alaska state agencies, and several universities. New field studies were conducted, new well and sample data were analyzed, some new geophysical data were acquired, and public technical workshops examining core samples were held. Data and interpretations from previous U.S. Government exploration programs were incorporated. About one-third of the 14,000 line-miles of two-dimensional seismic data collected by the the U.S. Government between 1974 and 1981 were reprocessed and reinterpreted. Special attention was focused on understanding the more recent oil discoveries immediately east of NPRA and the potential for those productive geologic trends to extend westward beneath NPRA. All available information was integrated and used as basic input to the 2002 petroleum resource assessment. Significantly, none of the data from newer, three-dimensional seismic surveys or new wells drilled in NPRA since the 1999 lease sale were available for this study, as all those data were proprietary during the assessment.

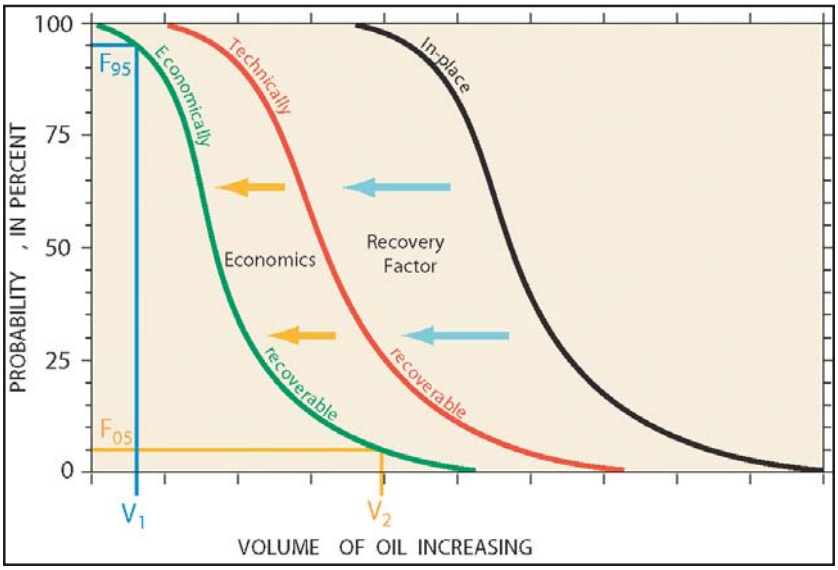
In keeping with the USGS responsibility for assessing the petroleum potential of all onshore and state water areas of the U.S., the total area considered in this assessment was extended offshore to the boundary between State and Federal jurisdiction. Thus, in addition to Federal lands of NPRA, this assessment includes resources beneath State waters offshore from NPRA and beneath Native lands within the NPRA boundary. The total assessment area consists of 24.2 million acres, of which 22.5 million acres are Federal and 1.7 million acres are non-Federal (State and Native).

The methodology used in this assessment is essentially identical to that used in the earlier USGS assessments of NPRA (1978–1980) and the Arctic National Wildlife Refuge (1987 and 1998). Twenty-four petroleum plays were defined as the initial step of the assessment. A play is a volume of rock that contains similar geological parameters (such as petroleum charge, reservoir, and trap) that determine petroleum potential. The term "petroleum" is used to include crude oil, natural gas, and natural gas liquids.

For each play, distributions of the number and size of potential petroleum accumulations were estimated on the basis of a probabilistic range of values for certain geological attributes, such as reservoir thickness and porosity. These



Ages, names, and rock types present in NPRA. The colored bars on the right show the stratigraphic position of the 24 petroleum plays evaluated in the 2002 assessment. Note that the bars with a "+" symbol indicate multiple plays in different areas. Plays indicated by bold outlines include those with the greatest oil and/or gas potential.



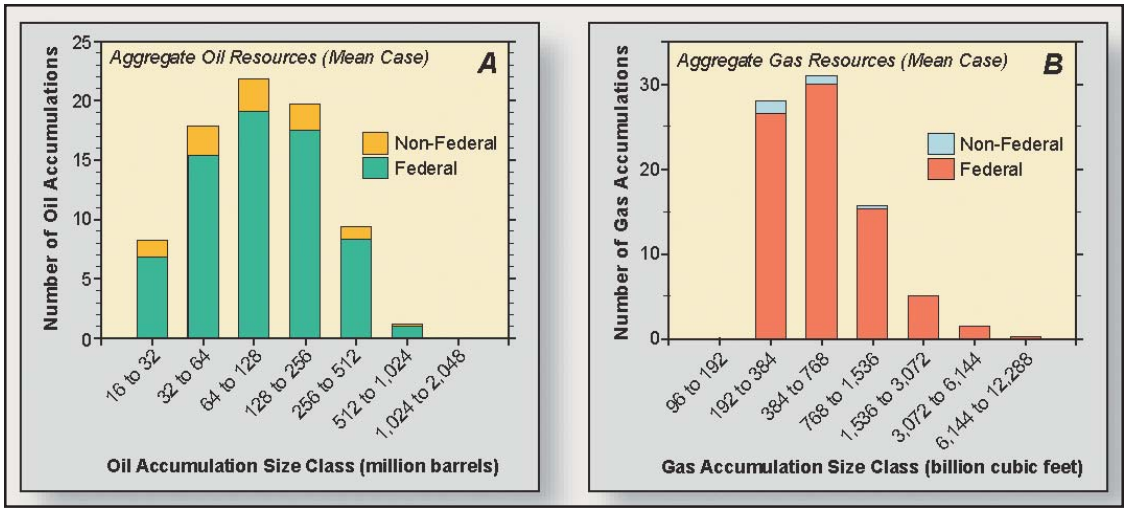
Petroleum volumes and probabilities. The curves represent categories of oil assessment. How one reads this graph is illustrated by the blue and orange lines projected to the curve for economically recoverable oil—in this example, there is a 95% chance (probability F_{95}) of at least volume V_1 of economically recoverable oil, and there is a 5% chance (probability F_{05}) of at least volume V_2 of economically recoverable oil.

distributions were restricted to potential accumulations larger than 50 million barrels of oil-equivalent (MMBOE) "in place," so that the assessment would not be influenced by smaller accumulations that are generally noneconomic on the North Slope.

The resulting distributions were subjected to a geologic risking procedure designed to weigh the likelihood that petroleum charge, reservoir, and trap conditions were sufficient to generate a 50-MMBOE in-place accumulation. In turn, a probabilistic estimate of in-place petroleum resources was calculated on the basis of the risked distributions of size and number of potential petroleum accumulations in each play. A recovery factor appropriate to each play was applied to the estimates of in-place petroleum resources to calculate technically recoverable petroleum resources. Typically only 30–50% of in-place oil resources are recoverable with existing technology. Estimates for each play were aggregated to calculate total technically recoverable petroleum resources for the entire assessment area, the Federal area, and the non-Federal areas.

This assessment methodology yields results that include probabilistic expressions of uncertainty. To stress the importance of this uncertainty, results reported here include 95% and 5% probabilities, in addition to mean values. The 95% probability level means that there is a 19 in 20 chance that the amount of petroleum present will be at least as large as the amount shown; the 5% probability level means that there is a 1 in 20 chance that the amount of petroleum present will be at least as large as the amount shown. Volumes of petroleum associated with the 95% and 5% probabilities are considered reasonable estimates of minimum and maximum volumes that may be present, and the mean is the average or expected value.

Commercial viability of undiscovered oil resources was estimated by considering costs associated with finding, developing, producing, and transporting to market (the west coast of the lower 48 states) the technically recoverable oil resources estimated to be present. The cost functions are calculated in constant 2001 dollars and are based on the expectation that production will repay all operating costs, including taxes and transport to market, and all investment expenditures and will provide an after-tax rate of return of at least 12% on the investment. The economic analysis simulates exploration by assuming that larger accumulations will be discovered early and that these accumulations may be developed



Expected (mean) numbers of oil and nonassociated gas accumulations estimated to exist in various size categories of technically recoverable resources according to the 2002 USGS assessment of NPRA. Each histogram bar is divided into Federal and non-Federal portions. The left sides of the histograms appear truncated because the methodology assesses only accumulations larger than 50 million barrels of oil-equivalent (MMBOE) in place (typically only 30–50% of in-place oil resources and 60–70% of in-place gas resources are technically recoverable). A. *Expected (mean) numbers of oil accumulations, read as follows: It is estimated that the assessment area contains approximately ten accumulations containing between 256 and 512 million barrels of technically recoverable oil; eight of those accumulations are under Federal jurisdiction and two are non-Federal.* B. *Expected (mean) numbers of nonassociated gas accumulations, read as follows: It is estimated that the assessment area contains approximately fifteen accumulations containing between 768 and 1,536 billion cubic feet of technically recoverable gas; fourteen of those accumulations are under Federal jurisdiction and one is non-Federal.*

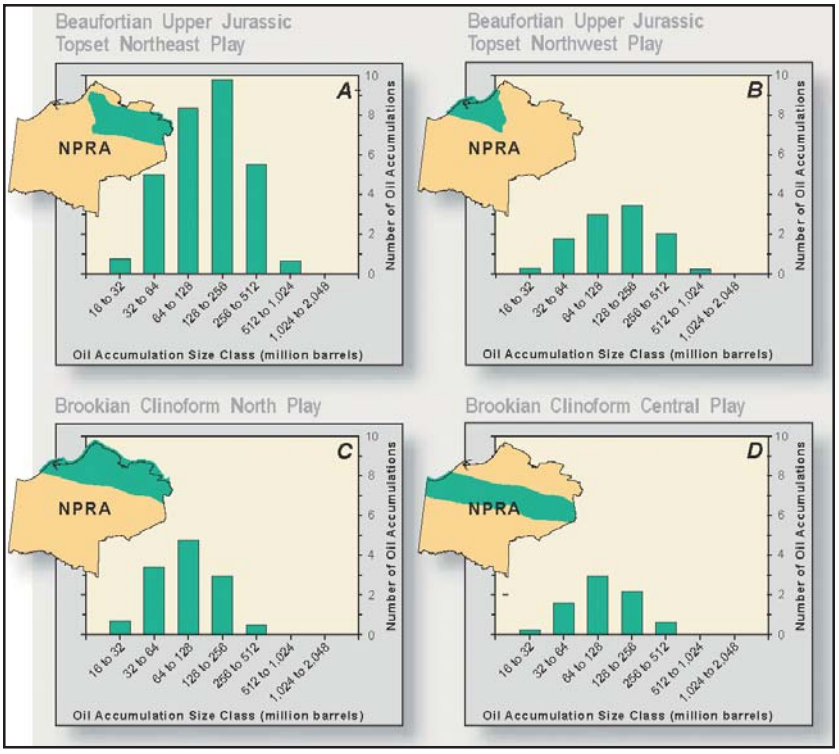
depending on their size and location. Any accumulation large enough to be developed at a specific location will support the costs of constructing processing facilities and extending infrastructure into the area. Smaller accumulations then may become economically viable if they can be developed as satellites to the larger fields. Results of the economic analysis are presented in terms of oil volume as a function of market price.

No analysis of the commercial viability of undiscovered gas resources has been made by the USGS. Such analysis is deferred until plans for a natural gas transportation system are more firmly developed.

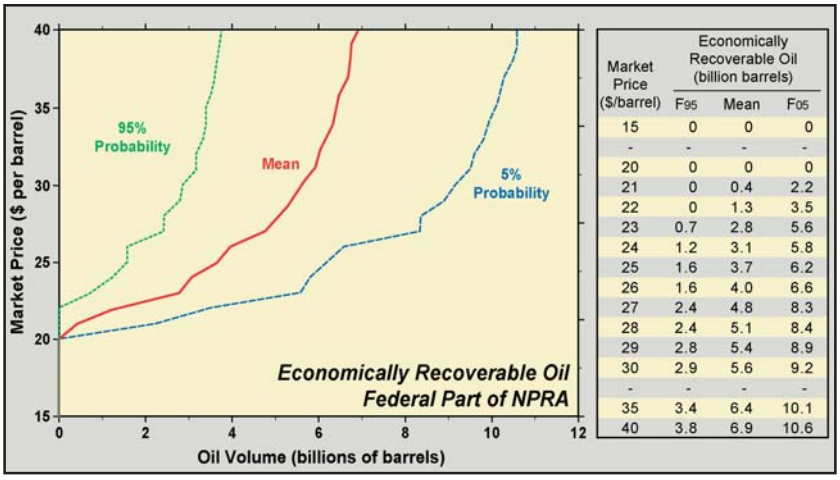
Assessment Results

Oil. The total quantity of undiscovered, technically recoverable oil within the entire assessment area is estimated to be between 6.7 and 15.0 billion barrels (BBO) (95% and 5% probability range), with a mean value of 10.6 BBO. The quantity of undiscovered, technically recoverable oil beneath Federal lands in NPRA (excluding State and Native areas) is estimated to be between 5.9 and 13.2 BBO (95% and 5% probability range), with a mean value of 9.3 BBO.

Most oil accumulations are expected to be of moderate size, on the order of 30–250 million barrels (MMBO) each, and large accumulations like Prudhoe Bay (ultimate recovery approximately 13 BBO) are not expected to occur. This conclusion is consistent with the fact that numerous exploration wells previously drilled in NPRA and in adjacent State and Federal waters tested prospects that were geologically similar to Prudhoe Bay, without success. Significantly NPRA is expected to contain many accumulations in the size range commonly developed on the Alaska North Slope in recent years. Some of these recently developed accumulations have been developed as "stand-alone" fields, which include processing facilities to prepare the oil for transport through the TAPS, whereas others have been developed as "satellite" fields, which do not have processing facilities and must use existing processing facilities of a nearby field. The determination of whether a newly discovered accumulation will be developed as a stand-alone or satellite field, or not developed at all, depends largely on the size of the accumulation and the distance from existing infrastructure. For comparison, announced estimates of ultimate recoveries from recently discovered fields near NPRA include 429 MMBO for Alpine, 70 MMBO for Tarn (20 miles southeast of Alpine), 50 MMBO



Maps of petroleum plays with histograms showing the expected (mean) numbers of undiscovered petroleum accumulations estimated to exist in various size categories of technically recoverable oil resources in the four plays estimated to hold the greatest oil potential in NPRA. About 80% of the technically recoverable oil resources, on the basis of the mean estimate, are thought to occur in northern NPRA within these four plays, which are westward continuations of the geologic trends that host Alpine and nearby oil pools just east of NPRA.



Market Price ($/barrel)	Economically Recoverable Oil (billion barrels)		
	F_{95}	Mean	F_{05}
15	0	0	0
-	-	-	-
20	0	0	0
21	0	0.4	2.2
22	0	1.3	3.5
23	0.7	2.8	5.6
24	1.2	3.1	5.8
25	1.6	3.7	6.2
26	1.6	4.0	6.6
27	2.4	4.8	8.3
28	2.4	5.1	8.4
29	2.8	5.4	8.9
30	2.9	5.6	9.2
-	-	-	-
35	3.4	6.4	10.1
40	3.8	6.9	10.6

USGS estimate of economically recoverable oil that may occur beneath the Federal part of NPRA. Left: *Relationship of market price to the volume of oil estimated to be profitably recoverable. The three curves are based on estimates of technically recoverable oil volumes at the mean (expected) value and at the 95% (F_{95}) and 5% (F_{05}) probabilities. Included are the costs of finding, developing, producing, and transporting oil to market (west coast of the lower-48 states) based on a 12% after-tax return on investment, all calculated in constant 2001 dollars. The chart is read as follows: At a market price of $25 per barrel, there is a 95% probability of at least 1.6 billion barrels of economically recoverable oil and a 5% probability of at least 6.2 billion barrels, and the mean or expected value is at least 3.7 billion barrels of economically recoverable oil.* Right: *Economically recoverable oil resources estimated to occur in the Federal parts of the NPRA at various market prices. Values for the 95% (F_{95}) and 5% (F_{05}) probabilities as well as the mean (expected) values are shown. The NPRA results are calculated in constant 2001 dollars.*

for Meltwater (25 miles southeast of Alpine), 50 MMBO for Fiord (just north of Alpine), and 40 MMBO for Nanuq (just south of Alpine).

Quantities of technically recoverable oil are not expected to be uniformly distributed throughout NPRA. This is illustrated by accumulation-size histograms and maps for the four plays estimated to hold the greatest oil potential in NPRA. Based on the mean estimate, about 80% of the technically recoverable oil resources are likely to occur in northern NPRA within plays that are westward continuations of the geologic trends that host Alpine, Fiord, Tarn, Meltwater, and Nanuq oil pools, just east of NPRA.

The economic analysis of undiscovered resources is particularly important in an area as large as NPRA, because some of the oil resources may be far from existing infrastructure. Over a range of market prices between $25 and $35 per barrel, between 3.7 and 6.4 billion barrels of oil are estimated to be economically recoverable from the Federal part of the study area on the basis of the mean estimate of technically recoverable oil volumes.

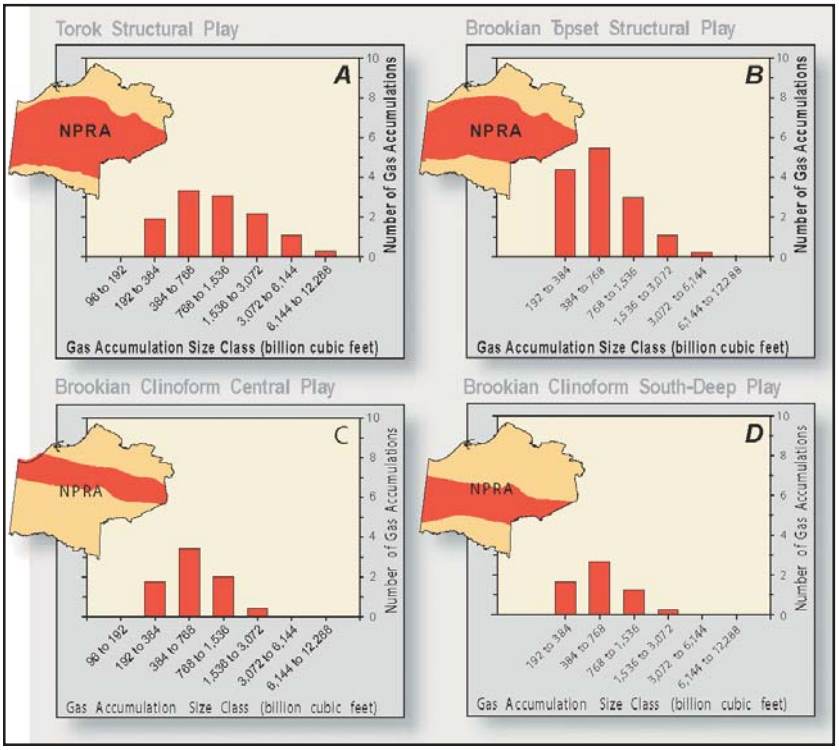
Gas. Significant volumes of natural gas also are estimated to occur in the NPRA. Although North Slope gas is currently noncommercial for lack of a transportation system, it is of growing interest because of recent discussions and proposals of gas pipeline construction. The total quantity of undiscovered, technically recoverable, nonassociated gas within the entire assessment area is estimated to be between 40.4 and 85.3 trillion cubic feet (TCF) (95% and 5% probability range), with a mean value of 61.4 TCF. The quantity of undiscovered, technically recoverable nonassociated gas beneath Federal lands in NPRA (excluding State and Native areas) is estimated to be between 39.1 and 83.2 TCF (95% and 5% probability range), with a mean value of 59.7 TCF.

Most gas accumulations are expected to range between about 200 and 1,500 billion cubic feet (BCF) each. For comparison, the gas cap at the

Prudhoe Bay oilfield contains more than 23,000 BCF, the Point Thomson gas and oil accumulation may contain more than 6,000 BCF, and a recently announced discovery in the Mackenzie River delta of Canada (about 150 miles east of the U.S.–Canada border) is estimated to contain 200–300 BCF recoverable reserves. Quantities of technically recoverable gas are most abundant in central and southern NPRA.

Recent Exploration and Development Activity in NPRA

A total of 18 exploration wells were drilled in NPRA during the 2000 through 2004 winter drilling seasons. Data from six of these wells have been released by the State of Alaska; data from the other wells are not yet available because of confidentiality restrictions. Although little information has been released by the companies that have drilled the exploration wells in NPRA, announcements by two companies indicate that at least seven wells have encountered oil or gas and condensate in amounts that may be commercial. One additional well drilled during the 2002 winter season encountered hydrocarbons in a rock unit characterized by poor reservoir quality. Significantly, all eight of these wells in which hydrocarbons have been encountered targeted the rock unit that is the main reservoir in Alpine field. Another well, announced in 2001 to be a dry hole, targeted a different rock unit. No information has been released on the remaining nine wells.



Maps of petroleum plays with histograms showing the expected (mean) numbers of undiscovered petroleum accumulations estimated to exist in various size categories of technically recoverable gas resources in the four plays estimated to hold the greatest gas potential in NPRA. About 60% of the technically recoverable gas resources, on the basis of the mean estimate, are thought to occur in central and southern NPRA within these four plays.

ConocoPhillips Alaska, Inc., which operates the Alpine field and has drilled most of the exploration wells in NPRA since the 1999 lease sale, has submitted to the Bureau of Land Management a proposal to develop NPRA discoveries as Alpine satellites. The proposed plan specifies the development of three production pads in NPRA. Two of the pads are located near the Spark and Lookout well sites, apparently indicating that those discoveries are large enough to be developed as satellite fields. The third pad (Alpine West), located in the easternmost part of NPRA, appears to be an extension of the Alpine field proper.

The limited information available from the wells drilled in NPRA during the 2000 through 2004 drilling seasons indicates that the main exploration target is the western extension of the Alpine play. The USGS 2002 assessment of undiscovered petroleum resources divided this play into two parts: the Beaufortian Upper Jurassic topset northeast play and the Beaufortian Upper Jurassic topset northwest play. These two plays were assessed to have the greatest potential for undiscovered oil across NPRA, and together these two plays extend across the entire width of both the northeast planning area and the northwest planning area. This correlation suggests that exploration during the next several years is likely to continue westward across northern NPRA.

Several other plays also have the potential to become exploration objectives in NPRA. However, these plays are estimated to contain a lower total volume of oil, and the oil is inferred to occur in smaller accumulations than the Alpine-type plays. These plays are likely to become secondary exploration objectives if additional discoveries in the Alpine-type plays sustain continued exploration across NPRA.

Summary

Anticipating the need for updated scientific information to support policy decisions, the USGS in 2002 completed a new assessment of undiscovered petroleum resources in NPRA. This new assessment concluded that the volume of technically recoverable, undiscovered oil beneath Federal

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lands in NPRA ranges between 5.9 and 13.2 billion barrels (95% and 5% probabilities), with a mean (expected) value of 9.3 billion barrels. Over a range of market prices between $25 and $35 per barrel, between 3.7 and 6.4 billion barrels of oil are estimated to be economically recoverable, on the basis of the mean estimate of technically recoverable oil volumes.

Most of the oil is estimated to occur in the northern third of NPRA, to be distributed among several plays, and to occur in accumulations of moderate size. It is unlikely that a Prudhoe Bay-size accumulation occurs in NPRA. The plays estimated to contain the greatest potential for undiscovered oil accumulations are westward extensions of the Alpine play, which hosts the 429-million-barrel Alpine field on the eastern border of NPRA. Information released from exploration drilling in NPRA during the 2000 through 2004 winter drilling seasons confirms that the Alpine play is the main objective of industry activity.

Estimates of technically recoverable, undiscovered, nonassociated natural gas resources for the same area range between 39.1 and 83.2 trillion cubic feet (95% and 5% probabilities), with a mean (expected) value of 59.7 trillion cubic feet. The economic viability of these natural gas resources will depend on the availability of a pipeline to transport the gas to market.

The results of the NPRA assessment should be viewed in the context of the larger North Slope oil and gas picture, which includes spare capacity in the oil pipeline, multiple proposals for a gas pipeline, and changing makeup of the group of companies exploring for oil and gas. An important factor affecting the future of existing North Slope oil fields and all future oilfield development is the continued operation of the Trans-Alaska Pipeline System (TAPS). Currently TAPS transports about 1 million barrels of oil per day (bpd), about half of peak production of 2 million bpd achieved in 1988. A basic, but unanswered question is the minimum throughput rate required for efficient, cost-effective operation. Multiple proposals for a natural gas pipeline are being considered to tap more than 30 trillion cubic feet of gas known to occur in the Prudhoe Bay and nearby accumulations. An important consideration is the amount of gas available beyond what is currently known. A gas pipeline would likely renew and expand exploration efforts in the foothills province. With the failure to find additional multi-billion-barrel oilfields, most of the larger, “major” oil companies have reduced or abandoned North Slope exploration. At the same time, smaller, “independent” companies have expanded their exploration activities. This shift in activity is a common pattern observed in petroleum-producing basins as they mature.