Department of Commerce

National Oceanic and Atmospheric Administration

NOAA performs research in the high-latitude regions of the planet in connection with its environmental assessment, monitoring, and prediction responsibilities. Research programs focus on scientific questions that address the Arctic environment and its relation to the global environment.

Office of Oceanic and Atmospheric Research

In the fall of 2005, NOAA's Arctic Research Office moved into NOAA's Climate Program Office and was renamed the Arctic Research Program. At this transition the program's goals were redefined to the following:

- To build and maintain a suite of Arctic climate observing networks (ocean, sea ice, atmosphere) in association with international partners;
- To support continuing analysis of Arctic climate data from program and other sources;
- To provide data and analyses to operational centers, climate assessment activities, and the research community; and
- To participate in public education and outreach.

	Funding (thousands)	
	FY 04	FY 05
Cloud Radiation	10	10
Atmos. Trace Constituents	400	425
Fisheries Assess./Manage.	17,000	17,500
Marine Mammal Assessment	6,675	7,325
Ocean Assessment	10	50
Stratospheric Ozone	250	250
Data Management	331	340
Remote Sensing	345	435
Aircraft/Vessels	950	1,100
Weather Research	25	50
Western Arctic/Bering Sea Ecosys.	2,100	2,100
Barrow Observatory	600	600
Ocean Exploration	355	2,300
Tsunami Warning/Env. Obs.	250	250
Arctic Research Initiative	1,650	1,060
Ocean Observations/Arctic Fluxes	360	360
Arctic Climate Research (SEARCH)	2,000	1,960
Undersea Research	2,530	0
Total	35,841	36,115

Observing Systems

The developing Arctic Observing networks include the development of atmospheric, ocean and ice systems.

The Arctic Climate Atmospheric Observatory Network is planned to consist of three to five observatories around the rim of the Arctic Ocean. The initial observatory is the NOAA Global Monitoring Division Barrow Observatory and the Department of Energy's Atmospheric Radiation Measuring Program Observatory. These co-located facilities have been in operation for 33 and 10 years, respectively, and together they provide the model for observatories planned for other portions of the Arctic. The second observatory in the network is distributed between Alert and Eureka, Canada, on Ellesmere Island. NOAA and Canadian partners have deployed instruments to the observatory with the goal of having the full observatory operational by the end of 2008. The third link in the planned network will be located at Tiksi in Siberian Russia. NOAA and NSF will be U.S. co-sponsors of this observatory. An implementation plan for the Tiksi observatory is under development, and initial measurements should start in the fall of 2006. NOAA will coordinate with an already established atmospheric observation program in Ny Ålesund, Norway, and the Greenland Summit Station to complete the circumpolar network. The goal of the observatory network is to provide long time-series data on clouds and cloud properties, aerosols, radiation, and trace gases. The data will support research on atmospheric climate processes, provide calibration and validation data for current and planned satellite sensors, and provide data to develop and test global and regional climate models with a goal of answering questions of attribution. The observatories will be sites at which shorter-term research projects can be conducted by scientists from the broad community.

NOAA has developed plans to support long-

term ocean and sea ice observations in the Arctic as a subcomponent of the NOAA Integrated Ocean Observing System. There are three elements to the Arctic component: ice-tethered buoys in the perennial Arctic sea ice, oceanographic moorings along the shelf and slope and in the deep basins, and ship-based observations.

A small network of autonomous ice mass-balance buoys (IMBs) has been continually deployed since late summer 2003. These buoys are unique in their ability to determine whether changes in the thickness of the ice cover occur at the top or bottom of the ice cover and hence provide insight on the driving forces behind the change. They can be used in validating and calibrating other ice-based and remote ice thickness measurement systems and numerical forecast models of the ice cover. The network of IMBs has been augmented by the establishment of a moored, ice-profiling sonar on the Chukchi Plateau in the summer of 2003. This region of the Arctic Ocean has experienced record extremes in ice retreat over the past few summers. Data from this mooring, designed to monitor ice thickness, have been successfully recovered in 2004 and 2005, and the analysis of the 2004 data will be available in 2006.

The International Arctic Buoy Program (IABP) provides a denser network of simpler buoys that measure only surface air temperature and pressure and location. All of these buoys are coupled to the Global Telecommunication System and support operational weather forecasting, ice trajectory and forecasting, and the creation of climate data sets from throughout the Arctic Ocean perennial ice zone.

A mooring deployed in the western Bering Strait in the summer of 2004 has been successfully recovered, and three new more-capable moorings were deployed for recovery in the summer of 2006. The data from the recovered mooring are the first obtained in this Russian area since the early 1990s. It is essential for blending with data from the U.S. side for computing net flow through the Bering Strait, which should be a critical indicator of global ocean circulation. Flow through the strait also is a determining factor in controlling ecosystem function in the Chukchi Sea.

The summer of 2005 marked the inauguration of a new NOAA-sponsored mooring program being conducted by the International Arctic Research Center (IARC) at the University of Alaska Fairbanks. This program, the Nansen–Amundsen Basin Observing System (NABOS), has deployed moorings along the shelf edge of the Russian Federation and will provide new data on internal Arctic Ocean circulation.

NOAA conducted its first Arctic Ocean research cruise with the Russian Academy of Sciences in the summer of 2004 through what has become known as the Russian–American Long-term Census of the Arctic (RUSALCA) project. One objective of RUSALCA is to document the changes in the physical state of the northern Bering and Chukchi Seas, regions that have experienced significant change over the past few decades and that models predict will experience even greater change in the decades ahead. General ocean and atmospheric warming and loss of sea ice should be accompanied by changes in water column structure and possible changes in circulation and flux through the Bering Strait, which may have implications for the entire Arctic Ocean. A second objective of RUSALCA is to observe changes in ecosystem structure and productivity that result from the physical changes and to identify a set of ecosystem indicators that might be applied throughout the Arctic marine region. Marine ecosystem alterations will affect Native subsistence harvests and possibly commercial fisheries and protected mammals and birds. RUSALCA was co-funded by NOAA's Office of Ocean Exploration. Planning is underway for a major international research expedition during the International Polar Year. The current strategy is to conduct a multidisciplinary cruise every four years, with mooring and physical oceanographic-based expeditions conducted annually.

Data Analysis

During 2004 and 2005, work continued to define an Arctic Climate Change Detection Protocol and to gather and analyze historical and current data from diverse sources to evaluate variability and change in the Arctic climate. One approach has been to gather different types of data from throughout the Arctic region and analyze spatial and temporal relationships. This effort has identified that widespread ocean, ice, and terrestrial changes are continuing their multi-decade trend even while the presumed driver, atmospheric circulation, is experiencing significant changes in trend. This work has been presented through a website (www.arctic.noaa.gov/detect) and through scientific publications. Another approach has been to gather historical data not yet in the digital archives to provide added context for more recent observations. During 2005, a project was initiated to "rescue" early 20th century radiosonde data from the

Russian Arctic. These data will be very useful in helping to quantify the period of Arctic warming in the early 20th century and will allow better comparison of it to the current warming period. The data rescue project should be completed in 2006.

The Arctic Climate Change Detection project will focus more explicitly on the northern Bering and Chukchi Seas during FY 2006. It will obtain all of the data collected by the program in this region since 2003 and as much relevant external data as possible. The data will be assembled in a form suitable for use in a GIS framework.

In 2005 the Arctic Research Office (now Program) contributed to the funding of a State of the Arctic (SOA) Report. Experts from several countries are preparing a report summarizing the current physical state of the Arctic that will be submitted for peer-reviewed publication during 2006. This will be an update to the Arctic Climate Impact Assessment. If well received, the SOA report may be produced every two to three years and may grow to include biological and other aspects of the Arctic environment. A workshop will be held during 2006 to explore the state of the Arctic carbon cycle and discuss how it might be expected to change under a global warming scenario. Results of the workshop will guide future program activities related to carbon in the Arctic.

Outreach

NOAA's Arctic Theme Page (www.arctic.noaa.gov) is a mechanism for describing NOAA's Arctic programs and for providing a scientific resource to the public.

In 2003–2005, NOAA's Arctic Research Office contributed funding to the Smithsonian's National Museum of Natural History to create a special exhibit called *Arctic: A Friend Acting Strangely*. This exhibit has been developed in collaboration with scientists at NASA, NSF, and the Department of Energy. The exhibition is an outreach contribution to the Study of Environmental Arctic Change (SEARCH) interdisciplinary research program being conducted by eight Federal agencies.

Office of Ocean Exploration

In 2005 the Office of Ocean Exploration sponsored the Hidden Ocean 2005 Expedition. The expedition focused on assessing the diversity of life and the environment in all three major realms of the Arctic—the sea ice, the water column, and the seafloor. For one month the U.S. Coast Guard Cutter *Healy* conducted round-the-clock science operations. The team visited 14 stations covering poorly known areas of the southwestern Canada Basin, Northwind Ridge, Northwest Abyssal Plain, and Chukchi Plateau. Core science operations included measuring sea ice properties, primary productivity, and pelagic (water column) and benthic (seafloor) community composition.

The sea ice team conducted research on and underneath the ice. Ice corers were used to collect samples of ice that are being analyzed to estimate the diversity and quantity of sea ice algae and fauna to search for rare and unidentified microscopic creatures living in the ice. The understanding of the sea ice realm was enhanced through the collection of temperature, salinity, fluorescence, and light profiles under the ice from all 14 stations. These measurements help to define the growing conditions for tiny, single-celled plants known as phytoplankton, which provide food for other microscopic animals. The growth rates of sea ice algae and phytoplankton were studied using primary production measurements conducted in the water column under the ice. Phytoplankton form the base of the Arctic marine food web, so understanding its growth is important to understanding the amount of food available to creatures living at different depths under the ice.

Ice divers collected video and still images of amphipods (small creatures living on the underside of the sea ice) and Arctic cod under the drifting pack ice. Two of the amphipod species studied were previously unknown to inhabit the region; one was known only as a pelagic species, and the other had been known only in association with coastal waters.

Built by Deep Sea Systems, Inc., the *Global Explorer* remotely operated vehicle (ROV), equipped with three standard cameras and one high-definition camera, provided scientists with an eye into the sea. During the expedition, the ROV descended as deep as 2,900 m, collecting samples of creatures in the water column and on the seafloor.

The pelagic team focused on identifying unknown or poorly known gelatinous zooplankton and the organisms they feed on in the Canada Basin. Tools including live nets, a multi-net, and the *Global Explorer* captured live specimens of zooplankton living from the surface to 2,900 m. Numerous first records of many of these species in the Amerasian Arctic were recorded, 6–10 of which represent undescribed "new" species.

The benthic team utilized a variety of tools to view and sample the seafloor. The ROV performed

eight benthic dives ranging from 880 to 2250 m deep, collecting high-definition video footage and samples of flora and fauna living on the seafloor. A photo platform was constructed and used for the expedition to conduct quantitative image sampling of the seafloor, and box cores were deployed to collect cookie-cutter-like samples of the sea bottom and the creatures living within it. Among the species viewed and collected were at least seven polychaete (marine bristle worm) species marking significant range extensions in geographical area and/or depth, at least three suspected new species of polychaetes, and many more samples and species in need of further analysis before conclusions can be made.

The creatures living in the water were not the only subjects studied; a science team on board focused on characterizing the environments in which the creatures live through instrument deployments as well as in situ experiments. In addition to a winch-operated CTD (conductivity, temperature, and depth sensor), one CTD was attached to the ROV and collected water mass characteristics to provide an oceanographic context for each sampling site; this information can be used to find where the water at each site originated and help explain the observed species composition and nutrient regime in the Canada Basin. Deep CTD water samples were also collected and analyzed for nutrients and plant pigments to assess the environment and food available for animals living in the deep sea.

This expedition represents the first comprehensive, multidisciplinary effort towards understanding and characterizing the diversity of life in all realms of the ice-covered Arctic Ocean.

Earth System Research Laboratory

Global Monitoring Division

In October 2005 the former Climate Monitoring and Diagnostics Laboratory (CMDL) of NOAA was reorganized into the Global Monitoring Division (GMD) of the newly created Earth System Research Laboratory (ESRL) of NOAA/. Included in the new GMD division is the former Surface Radiation Research Branch (SRRB) of the NOAA Air Resources Laboratory. The total staff in GMD numbers 106, inclusive of Federal, joint institute, and contract employees. The GMD conducts sustained observations and research related to source and sink strengths, trends, and global distributions of atmospheric constituents that are capable of forcing change in the climate of earth by modifying the atmospheric radiative environment, those constituents that may cause depletion of the global ozone layer, and those that affect baseline air quality. GMD accomplishes this mission primarily through long-term measurements of key atmospheric species at 105 sites spanning the globe, including five well-instrumented and manned Atmospheric Baseline Observatories at Barrow, Alaska; Trinidad Head, California; Mauna Loa, Hawaii; American Samoa; and South Pole, Antarctica. A sixth station, at Summit, Greenland, is being developed and has been manned by GMD staff six months per year for the past two years. Depending upon FY 2007 funding, the station may be manned year-round by a GMD staff member from 2007 onward.

In the Arctic, GMD measurements include carbon dioxide, carbon monoxide, methane, nitrous oxide, surface and stratospheric ozone, halogenated compounds including chlorofluorocarbon (CFC) replacements, hydrocarbons, sulfur gases, aerosols, solar and terrestrial UV, and broadband and infrared radiation. In addition, field campaigns in key regions, utilizing an array of platforms including aircraft, balloons, ocean vessels, and towers, complement the long-term measurements. The GMD data are used to assess climate forcing, ozone depletion, and baseline air quality; to develop and test diagnostic and predictive models; and to keep the public, policy makers, and scientists abreast of the current state of our chemical and radiative atmosphere.

Arctic Baseline Atmospheric Observatory Operations. GMD has operated the Atmospheric Baseline Observatory at Barrow, Alaska (BRW), manned by a staff of two, for 32 years. In addition to 28 core atmospheric baseline measurement projects, BRW supports 20 cooperative research projects, with a majority coming from universities or agencies in Alaska. As part of the Barrow Arctic Science Consortium (BASC) facilities upgrade, GMD is in the design phase of a new observatory building at the present BRW site. This would triple the size of the 800-square-foot facility, which has reached operational capacity. This expansion of the NOAA BRW facility has not yet been funded. New housing for the Barrow staff is on the drawing board, and construction may begin in 2008. Initial funds for the housing construction are in hand.

At Summit, Greenland, an NSF-supported research facility, GMD initiated year-round carbon cycle air flask sampling and in situ surface ozone and black carbon measurements in the spring of 2003, conducted firn air measurements in June

2004 and June 2005 and surface ozone measurements from June 2000 to July 2003, and undertook continuous surface ozone measurements from August 2004 onward. Weekly balloon-borne ozonesondes were added in November 2004, and stratospheric water vapor sondes began operation in November 2005. A complete, high-quality surface meteorology system was added at Summit by GMD in August 2005. In addition to manning the facility with NOAA staff year-round, plans include adding a suite of instrumentation to measure a wide range of aerosol parameters, a solar radiation Baseline Surface Radiation Network program, and continuous trace gas measurements (up to 15 species).

GMD collects weekly pairs of discrete air samples from a 65-site global carbon cycle glass flask sampling network that includes Arctic or near-Arctic sites at Barrow, Cold Bay, and Shemya, Alaska; Ocean Station "M" in the Norwegian Sea; Heimaey, Iceland; Alert, Canada; Pallas, Finland; and Ny Alesund, Spitzbergen, in addition to the sampling at Summit, Greenland. Vertical profiles of a large suite of trace gases (including halocarbon species) are obtained over Poker Flats, Alaska, on a biweekly basis with an aircraft flying profiles to 8,000 m above sea level. Gases are also collected in high-pressure metal flasks at a much smaller number of sites for measurement of chlorofluorocarbon gases.

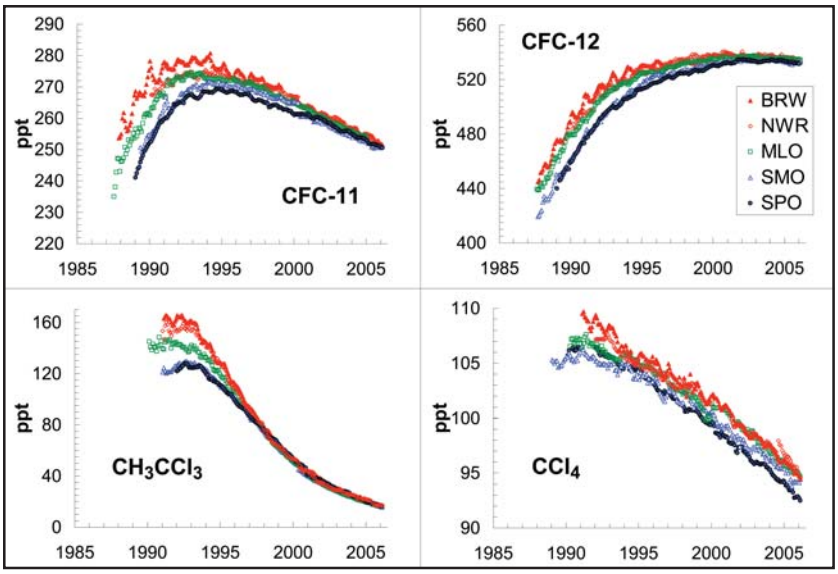
Surface Ozone Observations in the Arctic. Sites operated by GMD make surface ozone observations in three distinct regimes within the Arctic. Barrow represents an Arctic Ocean environment with seasonal ice cover. Summit, Greenland, is a high-altitude site on the permanent ice cap, while Westman Islands, Iceland, is representative of a high-latitude site on the permanently ice-free North Atlantic. At Barrow in the spring, there are numerous episodes of ozone depletion that may persist for several days and often completely remove ozone from the lower atmospheric boundary layer. At Summit and Westman Islands, on the other hand, events of this type are not seen. This demonstrates that both the ocean environment and sea ice formation are critical ingredients in the ozone depletion process. Halogen compounds (primarily those containing bromine) processed on the Arctic ice pack, in the presence of increasing spring sunlight, are the primary catalysts for ozone loss in what appears to be a natural process. At Summit, long-range transport of forest fire smoke from Alaska and Russia is regularly measured, and occasionally large-scale air pollution from Europe is observed at Westman Islands and Summit. These transport events bring elevated ozone levels to the Arctic.

Springtime Incursions and Impacts of Asian Dust and Air Pollution in the Arctic. During the spring of each year, frontal systems in Asia generate dust storms that push dust and air pollution eastward across the Pacific, and some of that dust reaches the Alaskan Arctic. GMD measurements show that when Asian dust is present in the Arctic atmosphere over the BRW observatory, the surface tends to cool, but to a lesser extent than at lower latitudes that are free of snow. Even though these Arctic dust events are episodic and occur mainly in late winter through spring, their effect is not insignificant when they are present. Should the Arctic atmosphere become more turbid in the future, projections of enhanced warming in the Arctic due to greenhouse gases could be episodically negated because of this dust-aerosol-induced negative feedback. On the other hand, should the dust contain high concentrations of carbonaceous particles that directly absorb sunlight, additional atmospheric heating could occur.

In the past, the focus of aerosol research at Barrow has been on Arctic Haze, which is air pollution transported from Eurasia to BRW each spring. Spectral aerosol optical depth measurements are used to differentiate dust from haze, as dust contains much larger particles and is often of higher optical depth. Because polar atmospheres are generally very clean, even small increases in aerosol concentrations can perturb the radiometric structure of the atmosphere and thus the surface energy balance.

Trace Gas Emissions Measured along the Trans-Siberian Railway. To study the trace gas emissions of a large sector of both Europe and Asia, a consortium of Russian, German, and U.S. scientists have instrumented a Russian railway car with a wide range of atmospheric measurement instrumentation, coupled the observatory carriage to regularly scheduled passenger trains, and conducted 17,000-km traverses from Moscow to Khabarovsk and back. These 13-day Trans-Siberian Observations into the Chemistry of the Atmosphere (TROICA) missions have been conducted seven times since 1995. This railway platform is ideal for atmospheric measurements because the railway is electrified between Moscow and Khabarovsk, minimizing the potential contamination of measurements by the train itself.

Russia ended the production of chlorofluorocarbons (CFCs, used as refrigerants), chlorinated



Concentrations of chlorofluorocarbons controlled by the Montreal Protocol measured by NOAA/GMD at Barrow, Alaska (BRW); Niwot Ridge, Colorado (NWR); Mauna Loa, Hawaii (MLO); American Samoa (SMO); and South Pole, Antarctica (SPO). Clearly evident are the north-to-south gradient with Alaska having the highest gas concentrations and the effects of the controls on the production of the gases.

solvents (methyl chloroform, CH_3CCl_3 and carbon tetrachloride, CCl_4), and halons (used as fire extinguishing agents) at the end of 2000 as a result of the Montreal Protocol, but emissions persist from banks of these chemicals (in existing refrigerators, air-conditioners, etc.). Measurements onboard the carriage include oxides of nitrogen (NO_x), ozone, aerosols, radon-222, CO, CH_4, CO_2, and meteorological parameters including vertical temperature profiles. In addition, continuous measurements are conducted on nitrous oxide (N_2O), sulfur hexafluoride (SF_6), CFC-12 (CCl_2F_2), halon-1211 ($CBrClF_2$), CFC-11 (CCl_3F), CFC-113 ($CClF_2$-CCl_2F), chloroform ($CHCl_3$), CH_3CCl_3, CCl_4, hydrogen (H_2), methane (CH_4), and CO. One goal of this program is to measure the expected reduction of the ozone-depleting substances between 2001 and 2004 and in 2007 when the next TROICA mission will occur.

Arctic Water Vapor Measurements, 2004–2005. Water vapor observations at Sodankylä, Finland, and Ny Ålesund, Spitzbergen, were continued in cooperation with the Finnish Meteorological Institute (FMI) and the Alfred Wegener Institut, with support from the European LAPBIAT and SCOUT projects. At Sodankylä these measurements continue the stratospheric water vapor data set, which was started in 1996. In January and February 2004, the intensive campaign LAUTLOS-WAVAP (Lapbiat Upper Troposphere, Lower Stratosphere Water Vapor Project) took place at Sodankylä, which compared a number of in situ and remote sensing instruments capable of measuring tropospheric and stratospheric water vapor. A total of 33 payloads were launched during this project, with 14 carrying instruments capable of measuring stratospheric water vapor, namely the fluorescent Lyman Alpha stratospheric hygrometer of the Central Aerological Observatory, Moscow, the NOAA/GMD frost-point hygrometer, and the University of Colorado cryogenic frost-point hygrometer. In addition, these payloads carried ozone sondes.

The comparison of these instruments showed excellent agreement in the stratosphere and upper troposphere and described and quantified several instrumental artifacts that had not been identified previously. This high density of water vapor and ozone observations during February 2004 allowed a detailed study of the composition of the lowermost Arctic stratosphere and its relation to cut-off lows, which are a regular feature over the northern Atlantic Ocean. This data set also allowed a detailed investigation of transport processes across the polar vortex edge. The winter 2004–2005 measurements collected data on a rare Arctic dehydration event first observed in 1996. Water vapor observations at Sodankylä and Ny Ålesund will continue, depending on available funds.

Physical Science Division

In October 2005, the former Environmental Technology Laboratory (ETL) of NOAA was reorganized into the Physical Science Division. One of the new groups in the division is the Polar Region Processes Group. The primary activity of this group is the NOAA Atmospheric Observatory Program.

The NOAA Atmospheric Observatory Program is establishing sites for long-term, intensive measurements of clouds, radiation, aerosols, surface energy fluxes, and chemistry in Eureka/Alert, Canada, and Tiksi, Russia. These measurements will allow comparison with similar observatory measurements in Barrow, Alaska. The three sites in combination encompass three major Arctic climate regimes. The locations and measurement suite have been carefully designed so that the collected data can be used to determine the mechanisms that drive climate change through a combination of process studies, satellite validation, and modeling work. It is anticipated that the Atmospheric Observatory sites will also be the focus of a number of interdisciplinary measurements of regional hydrology, permafrost, ecosystems, and the cryosphere that will link the atmospheric measurements into the broader Arctic system. The program is heavily leveraged against Canadian and Russian programs and has a vigorous interagency cooperation with NSF and DOE.

Originally, the principal hypothesis of the SEARCH program was that Arctic climate change is related to the Arctic Oscillation (AO). There appeared to have been large-scale spatial covariability between a number of climatic variables and the primary modes of the AO. However, the most recent research indicates that during 2000–2005, new climate patterns have evolved, and there now appears to be less of a correlation between the AO and other physical parameters of the Arctic system. This may be the first sign of new climate regimes that have resulted from recent feedbacks such as evolving albedo, cloud properties, and reduction of sea ice. Investigating and monitoring these climate shifts in detail may well require the detailed measurements proposed by the NOAA Atmospheric Observatory Program.

At present, the only continuous measurements of Arctic surface radiation, clouds, aerosols, and chemistry sufficient for detailed evaluation of interactive climate change processes in the lower atmosphere (0–15 km) are made in Barrow, Alaska. The Barrow facilities include the National Weather Service observatory (with records from the 1920s), the NOAA/CMDL Baseline Observatory (in operation since 1972), and the DOE ARM North Slope of Alaska (NSA) site (in operation since 1998). It is the intention of the Atmospheric Observatory Element of the NOAA SEARCH program to mirror the Barrow atmospheric measurements, first in northeastern Canada and later in central Siberia.

The NOAA Atmospheric Baseline Observatory at Barrow, Alaska (Longitude: 71.3°N; Latitude: 156.61°W).

The full complement of proposed instruments is designed to acquire long-term records of cloud properties, aerosol properties, radiative fluxes, and surface energy exchanges. It is expected that these data sets will provide information necessary for understanding the processes that determine the regional climate, with a focus on how clouds and aerosols affect the balance between the surface and the atmosphere. These data sets will also allow statistical validation of satellite retrievals in the Arctic.

A microwave radiometer was installed in Eureka in July 2006. In collaboration with the NSF, it is expected that infrastructure improvements and first gas and aerosol measurements will begin in Tiksi, Russia, in the spring of 2007, followed by cloud and radiation measurements in the fall of 2007.

As part of the NOAA SEARCH program, the observatory was deployed to improve atmospheric and sea ice observations. These observations will be combined with historical data to better understand Arctic change.

This installation represents almost a decade of technological development, resulting in research-grade instruments adapted for long-term studies in remote regions. The data collected by these instruments will be critical for untangling natural and anthropogenic influences on cloud properties that may be a key factor in changing atmospheric radiation budgets in the Arctic.

Many indicators suggest that the impacts of climate change will be observed most rapidly in the Arctic. This is a critical region of the global atmospheric and ocean system where changes in deep ocean circulations, the distribution and thickness of Arctic Ocean ice, the extent of the Greenland ice, and terrestrial carbon dioxide storage could have far-reaching impacts for our environment.

While there is a history of basic measurements in the Arctic that are measuring *how* the Arctic climate may be changing, there are almost no monitoring programs that provide information to determine *why* the Arctic climate is changing. Consequently, NOAA has teamed with Canadian and U.S. university researchers to deploy a comprehensive suite of atmospheric sensors in Eureka, Canada, at 80°N/ 86°W. This site will collect detailed measurements of clouds radiation, aerosols, surface fluxes, and chemistry in the lower atmosphere, as well as key measurements in the middle and upper atmosphere, that will be sufficient to determine the processes driving climate change.

The International Polar Year committee has received over 1000 expressions of intent (EoI) in 2005 from researchers from around the world regarding activities that could contribute to the International Polar Year. The IPY committee organized these into a number of clusters along disciplinary lines. The International Arctic Systems for Observing the Atmosphere EoI that originated in NOAA was chosen to lead a cluster of about 20 separate EoIs from 10 countries. The main mission of the IASOA is to coordinate efforts to collect atmospheric data at existing and newly established intensive Atmospheric Observatories, distributed networks, and field campaigns during the IPY. A second mission of the IASAO is coordinate Arctic atmospheric measurements with those of other IPY activities that are coordinating hydrology, permafrost, terrestrial, cryospheric, and oceanographic measurements. The primary IASAO mechanism will be to establish a Program Coordination office that will facilitate planning meetings as well as maintain a dynamic website that can be used as a coordination tool internationally for Arctic atmospheric research (http://www.ipy.org/development/eoi/proposal-details.php?id=196).

Chemical Science Division

In the fall of 2005, the former Aeronomy Laboratory of NOAA was reorganized into the Chemical Science Division.

In 2004, NOAA scientists participated in the DOE-sponsored Atmospheric Radiation Measurement (ARM) program, a multi-laboratory, interagency program that is a key contributor to national and international research efforts related to global climate change. A primary objective of the program was to improve scientific understanding of the fundamental physics related to interactions between clouds and radiative feedback processes in the atmosphere, with the ultimate aim of promoting the advancement of climate models. Aeronomy Laboratory scientists were at the North Slope of Alaska ARM site, which is centered at Barrow, throughout much of September and October 2004 to take part in an Intensive Operational Period project known as the Spectral Water Phase. The site is the highest latitude site in the U.S., and the measurements made there have provided data about cloud and radiative processes at high latitudes. The Aeronomy Lab made measurements with a near-infrared spectrometer. The instrument analyzes the sunlight that is scattered by clouds and distinguishes between absorption by the vapor, liquid, and ice phases of water.

Pacific Marine Environmental Laboratory

NOAA's Pacific Marine Environmental Laboratory (PMEL) conducts ecosystem-based fisheries oceanography (Eco-FOCI) studies in the Bering Sea and the western Gulf of Alaska, principally through two programs, North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) and Fisheries–Oceanography Coordinated Investigations (FOCI). These are cooperative programs among PMEL, NMFS's Alaska Fisheries Science Center, and other academic and government partners. Eco-FOCI's goals are to increase understanding of the Alaskan marine ecosystem, to document the roles of commercially valuable and endangered species in the ecosystem, to determine factors that affect their survival, and to develop and test annual indices and models that predict ecosystem and commercial fish stock status for guidance to marine resource managers.

Eco-FOCI scientists conduct research on the character and dynamics of the biophysical environment through field and laboratory experiments, computer simulations, and conceptual models. Eco-FOCI investigates decadal climate variability and its effects on North Pacific and western Arctic ecosystems, particularly in light of the development of an ecosystem-based approach to fisheries management.

In the Gulf of Alaska, FOCI since 1992 has predicted annual walleye pollock recruitment from relationships of fish survival to baroclinicity, transport, wind mixing, and climate forcing. Recent investigations have disclosed the importance of near-coastal eddies to the transport of nutrients and other water properties across the continental shelf between nearshore areas and the basin. Such processes may explain, in part, why the Gulf of Alaska is so productive.

In the Bering Sea, Eco-FOCI, principally through NPCREP, has extended monitoring of the eastern shelf environment northward toward St. Lawrence Island. Seasonal Bering Sea ice has diminished significantly in extent, duration, and thickness in the past decade. This has caused a gradual warming of the southeastern shelf waters to the degree that the regional composition and distribution of species is changing.

PMEL also participates in the Study of Environmental Arctic Change (SEARCH). PMEL, with support from NSF, maintains a weather station at the North Pole and is currently developing protocols for monitoring and detecting Arctic change.

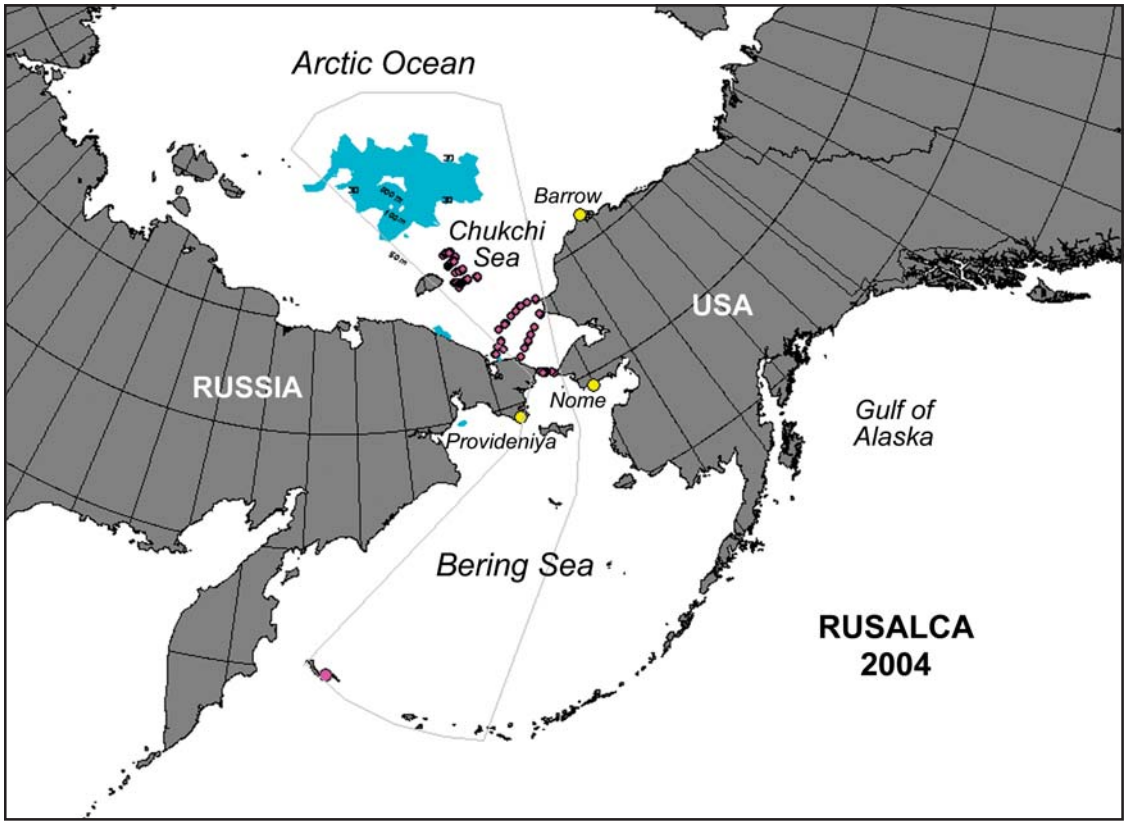
Cooperative Institute for Arctic Research

Arctic Climate Impact Assessment

The Arctic Climate Impact Assessment, an activity of the Arctic Council to assess the impacts of climate and UV radiation changes in the Arctic, was completed in 2005. An ACIA Secretariat, supported by the U.S. through NSF and NOAA, was located in the Cooperative Institute for Arctic Research (CIFAR) at the University of Alaska Fairbanks and was responsible for the conduct of the assessment, including support of the ACIA Executive Committee and coordination of the technical editors, production manager, and lead authors. During 2003–2005, the 200 international authors of the assessment participated in various meetings and forums to prepare the assessment. After an internal review, an extensive external review of the assessment by about 190 international experts took place. Responses to thousands of specific reviewer comments were documented and incorporated into the final text. The final report, which is 1046 printed pages, deals with impacts of climate and ultraviolet radiation on the environment, on economic sectors, and on peoples' lives. A 140-page overview report entitled *Impacts of a Warming Arctic* and an 18-page highlights document were also produced for a more general readership. The overview report and the highlights document were released at a final ACIA scientific conference in Reykjavik, Iceland, on 9–12 November 2004. The complete report was published by Cambridge University Press and released in November 2005. The ACIA report received an honorable mention for the ASLI (Atmospheric Sciences Librarians International) Choice Award in 2005. Post-ACIA activity at CIFAR has included responses to many inquiries from the media, science communities, nongovernmental and other organizations, and the general public, in addition to distributing the ACIA documents.

Russian–American Long Term Census of the Arctic

In 2003, NOAA and the Russian Academy of Sciences signed a Memorandum of Understanding for World Ocean and Polar Regions Studies. The first of the joint projects mentioned in the memorandum is a collaborative U.S.–Russian Federation oceanographic expedition to the Arctic seas regions shared by both countries: the Bering and Chukchi Seas. These seas and the life within are thought to be particularly sensitive to global climate change because they are centers where steep thermohaline and nutrient gradients in the ocean



Stations sampled during the voyage of the Professor Khromov, *a Russian research vessel engaged in the 2004 RUSALCA cruise. The colored area in the Arctic Ocean indicates a region of enhanced ice melting between 1970 and 2001.*

coincide with steep thermal gradients in the atmosphere. The Bering Strait acts as the only Pacific gateway into and out of the Arctic Ocean and as such is critical for the flux of heat between the Arctic and the rest of the world. Monitoring the flux of fresh and salt water and establishing benchmark information about the distribution and migration patterns of the life in these seas are also critical pieces of information needed prior to the emplacement of a climate monitoring network in this region.

Sorting samples during the 2004 RUSALCA cruise.

The Russian–American Long Term Census of the Arctic (RUSALCA) objectives include support the U.S. interagency Study of Environmental Arctic Change (SEARCH) program (psc.apl. washington. edu/search/) and the NOAA Ocean Exploration Program (www.oceanexplorer.noaa. gov). Because of the trend in reduction of the ice cover in the Arctic and the possibility of permanent loss of seasonal ice cover in the study region as shown by climate models, it is thought that this area might be subject to significant ecosystem change. RUSALCA is intended to help provide a foundation for detecting future ecosystem change and to provide the potential for discovery of new marine resources.

In November 2003, a workshop on the RUSALCA expedition mission was held in Moscow, Russia, to define the main research topics and geographical scope. Calls for Letters of Interest were released by CIFAR for response by scientists from the U.S. and by the Russian Academy of Sciences for response by scientists from Russia. In February 2004, after panelists met in Russia and the U.S., fourteen programs were funded for a joint U.S.–Russian cruise in the summer of 2004.

The primary study area for the first RUSALCA cruise was the northern Bering Sea (north of 60°N) and the Chukchi Sea to the extent that ice conditions permitted. The cruise took place 23 July–24 August 2004 on the R/V *Khromov*, a Russian ice-strengthened research ship. Hydrographic, biochemical, and productivity data were collected from the northern Bering and Chukchi Seas and are being combined with other data from RUSALCA investigators (both in the U.S. and Russia) to assess nutrient and productivity processes.

Participants included individuals from the following organizations through funding provided by NOAA and the Russian Academy of Sciences:

- University of Alaska Fairbanks
- Smithsonian Institution
- University of Tennessee
- University of Texas
- University of Washington
- Woods Hole Oceanographic Institution
- NOAA Fisheries
- NOAA's Arctic Research Office
- NOAA's Ocean Exploration Office
- Fish and Wildlife Service
- U.S. Army Cold Regions Research and Engineering Laboratory
- Shirshov Institution of Oceanology, Moscow
- VNIIOkeangeologia, St. Petersburg
- Zoological Institute, St. Petersburg
- Institute of Microbiology, Moscow
- Arctic and Antarctic Research Institute, St. Petersburg
- Pacific Oceanographical Institute, Vladivostok
- Roshydromet, Vladivostok
- Russian Federation Navy
- ECOSEA, Group Alliance.

Benthic macrofaunal biomass was found to be very high in the southern Chukchi Sea in a known region of high water column production. Several specimens of northern Pacific crab were collected in the southeastern Chukchi Sea, which is the third northernmost documentation of this species in the Chukchi Sea. In addition, the Pacific crab *Oregonia gracilis* and the bivalve *Pododesmus macrochisma* were also found, which appears to be the first time in the Chukchi Sea. These findings of Pacific taxa in Arctic waters are indications of an ecologically significant warming trend.

Clear and persistent patterns in species composition of the copepod *Pseudocalanus* exist in the study area tied to the different water masses, but

there was no obvious pattern in weight-specific egg production despite strong chlorophyll gradients associated with these water masses.

In the Chukchi Sea, benthic communities varied along an east–west gradient, with the same species feeding on higher trophic levels in the east compared to the west, suggesting a stronger pelagic link in the food web in eastern areas, where pelagic primary production is limited. In western areas, the higher primary production results in a significant amount of fresh phytodetritus reaching the seafloor and feeding benthic communities directly.

A second RUSALCA cruise is planned for the summer of 2007. An announcement of opportunity, issued through CIFAR in February 2006, has led to the submission of approximately 20 proposals now under review.

Workshop on NOAA Arctic Priorities

A Workshop on Arctic Priorities, convened by NOAA on 2–3 February 2005, was coordinated by CIFAR. The workshop served to focus input to NOAA's planning process for 2008–2012, particularly for the International Polar Year and SEARCH. Additional objectives were to identify priorities for NOAA's response to the Arctic Climate Impact Assessment. Approximately 30 scientists, primarily from NOAA and the Cooperative Institutes, participated in the workshop. The workshop report was provided to NOAA in March.

The workshop's recommendations were intended to foster the environmental and economic missions of NOAA's Office of Oceanic and Atmospheric Research by identifying priorities for Arctic research, product development, and the provision of scientific understanding and leadership in the Arctic. Among the recommendations were the establishment of several intensive atmospheric observatories around the periphery of the Arctic; the development of a network of ice-based and moored observing sites to monitor and permit attribution of changes in the Arctic Ocean and its ice cover; the extension of operational and retrospective analyses of snow cover to include Alaska and the Arctic; an Arctic system reanalysis in coordination with the next global reanalysis; the development of regional decision support for Alaska; and an assessment of the state of the Arctic on a regular basis. An additional priority—measurements of Arctic aerosols and their roles in cloud and radiative processes—emerged from a presentation of the workshop report to the NOAA Climate Working Group in March 2005.

Copies of the workshop report can be obtained from CIFAR or from the NOAA Climate Program.

Office of Marine and Aviation Operations

Eco-FOCI had extensive field seasons in 2004 and 2005, and the *Miller Freeman* was the primary platform for the deployment and recovery of the program's biophysical moorings in the Gulf of Alaska and Bering Sea. In 2004 approximately 34 sea days over three cruises were dedicated to mooring work and hydrography.

In 2005 the *Miller Freeman* continued to be the primary platform for the deployment and recovery of the program's biophysical moorings, ecosystem observations, and process studies on recruitment of larval fish. Mooring deployment and recovery cruises on the *Miller Freeman* were lasted 42 days. Ecosystem observations and recruitment process studies were also conducted in the early spring in the Bering Sea (12 days). A humpback whale survey was also conducted in the summer by the *Oscar Dyson* (20 days) in and around the Aleutian Islands and Bering Sea.

National Environmental Satellite, Data, and Information Service

National Ice Center

The National Ice Center (NIC) is a cooperative, interagency organization responsible for providing Arctic, Antarctic, and Great Lakes ice information to U.S. and allied armed forces, U.S. government agencies, and various segments of private industry. Manpower and fiscal resources for the NIC are provided by the U.S. Navy, NOAA/NESDIS, and the U.S. Coast Guard. The Office of Research and Applications (ORA, soon to become STAR, the Center for Satellite Applications and Research) is the NESDIS research organization that, among other things, supports research activities at NIC. Real-time global, regional, and tactical-scale ice guidance products are generated by NIC in support of mission planning, navigation safety, and climate research. Routine products include satellite-derived sea ice analyses of current ice conditions and forecasts depicting future changes to the sea ice pack. Ice analyses are distributed in a variety of formats including geographic information system (GIS)-compatible files via the NIC web page (www.natice.noaa.gov). Metadata that detail the data sources integrated into routine ice analysis products are also available on the NIC web

page. As of 2006, the NIC has added a daily marginal ice zone (MIZ) product to augment the enhanced daily ice edge product already provided for the Alaska and Great Lakes region to the National Weather Service. These products are being used to enhance the forecast within the Advanced Weather Interactive Processing System (AWIPS). Through a collaborative project with the National Snow and Ice Data Center and the NIC, extension of the High-Resolution Arctic Sea Ice Climatology to encompass historical data from 1972 to 2004 is near completion. This product is scheduled to be publicly released by the end of 2006. The NIC has also begun work on a 1972–2004 sea ice climatology project for the Antarctic region.

During 2004–2005, the NIC Science and Applied Technology Department reorganized and increased interaction with outside research and operational groups in government and academia, both nationally and internationally. These relationships are being leveraged to support the main goals of the department, which include the following:

- Evaluate new developments in remote sensing, digital image processing, automated sea ice analysis, and forecasting methods and determine potential applications for NIC operations:
  - Automate the analysis and classification of data;
  - Improve operational ice forecasting models;
  - Optimize active and passive microwave algorithms for operational sea ice analysis;
- Develop and execute plans and programs, both evolutionary and revolutionary, which enhance the quality and efficiency of ice analysis and forecasting processes to fulfill current and emerging operational requirements;
- Select and transition mature scientific research to operations, maintain oversight of the distribution of research and development resources dedicated to the NIC program from supporting agencies, and recommend appropriate courses of action based on these investments;
- Improve efficiency of data processing and analysis through the development of automated data fusion techniques; and
- Develop new ice products by applying new techniques and by incorporating data from new sensors.

The NIC science team transitioned a wide number of data and products from models, satellites, and in situ sensors to operations. In particular, ENVISAT Advanced Synthetic Aperture Radar (ASAR) Global Monitoring Mode (GMM), Advanced Microwave Scanning Radiometer - EOS (AMSR-E), Moderate Resolution Imaging Spectroradiometer (MODIS), and WindSat data and products were evaluated for operational ice analysis. Daily remote sensing and ice model products are available in near-real time on the improved NIC experimental products web page (science.natice.noaa.gov). The cross-validation and use of submarine ice draft data, shipboard observations, thickness estimates from ice age and buoy tracking, shipboard observations, ice mass balance buoy data, and NIC chart ice thickness proxy estimates are now under study. ORA has also continued to explore the application of airborne and satellite altimetry data for estimating sea ice thickness, notwithstanding the failed launch of CryoSat, through the support of NASA P3 altimetry campaigns for the validation of IceSat freeboard measurements.

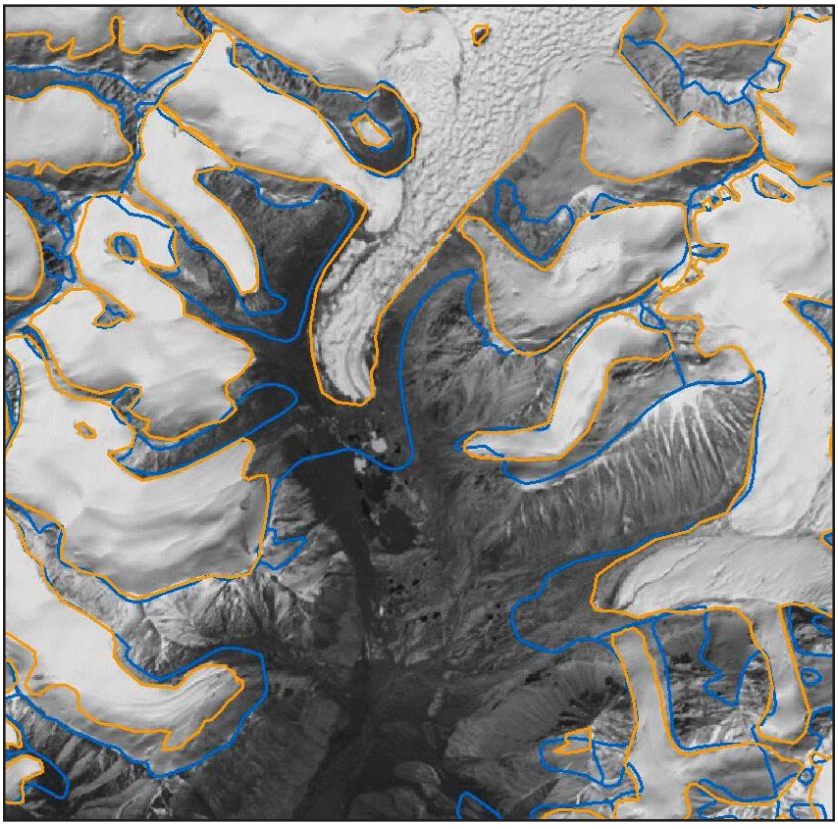
ORA implemented a new capability to track winds in the polar regions using observations from the MODIS sensor aboard the polar-orbiting satellites Terra and Aqua. The winds are derived by tracking water vapor structures in successive MODIS swaths. This new product provides unprecedented coverage of the polar wind field and has shown a positive impact on medium-range global weather forecasts. The MODIS winds are now assimilated operationally at the National Centers for Environmental Prediction (NCEP) and the European Centre for Medium Range Weather Forecasts (ECMWF). Access to MODIS polar winds is available through the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison web page (stratus.ssec.wisc.edu/projects/polarwinds).

ORA has continued to maintain and develop the Alaska synthetic aperture radar (SAR) demonstration (AKDEMO), which provides experimental, high-resolution (1-km), SAR-derived winds and vessel positions for open water areas in the Bering Sea and other Arctic seas (www.orbit.nesdis.noaa.gov/sod/mecb/sar). Studies show that these winds are accurate to better than 2 m/s. The experimental wind product is useful for understanding gap winds, barrier jets, and wind shadowing by islands such as the Aleutians. Such knowledge can be beneficial to safety of coastal transportation. SAR wind products are being evaluated as a tool for the site selection and placement of offshore and coastal wind farms. AKDEMO SAR imagery, along with vessel positions, has been used in Alaska to improve guidance to fishing

vessels operating near the ice edge. SAR imagery is also used for monitoring river ice breakup in the larger Alaskan rivers, such as the Yukon and Kuskokwim, and the Yellowstone River in Montana.

NIC manages the U.S. Interagency Arctic Buoy Program (USIABP), which provides an important source of surface meteorological data and ice drift information in the Arctic. Since its inception in 1991, the mission of the USIABP has been to establish and maintain a network of 40 evenly spaced meteorological buoys on the drifting Arctic ice pack. NIC achieves this goal through the coordination of deployments and the cooperation of USIABP participants in the International Arctic Buoy Program (IABP). Areas of cooperation include the development of new buoy technologies, the acquisition of replacement buoys, the monitoring of sea ice buoy network, and the exploitation of the buoy network observations. During 2004–2005, nearly 95% of all Arctic drifting meteorological buoys reported data in real time over the Global Telecommunications System. Real-time buoy data are used to initialize operational weather and ice forecast models. In 2005, NIC joined the Steering Committee of the International Programme for Antarctic Buoys (IPAB) as it seeks to participate in expanding the in situ sea ice observational network globally.

ASTER image showing part of the glacier system of the Akshiyrak Range, Tien Shan Mountains, central Asia, with glacier outlines from a 1943 map in blue and from the 2001 ASTER image in orange. The image and outlines are from the GLIMS Viewer.

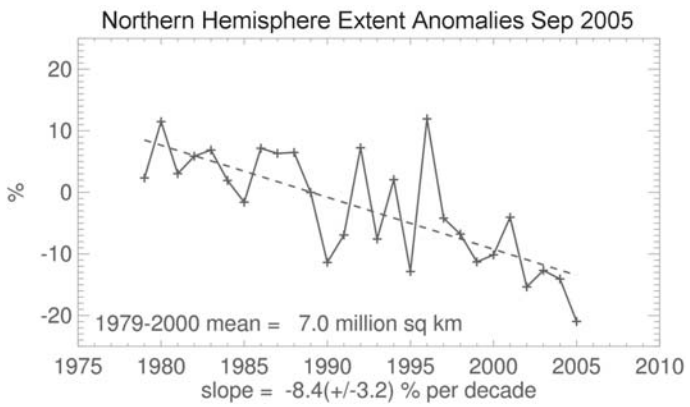


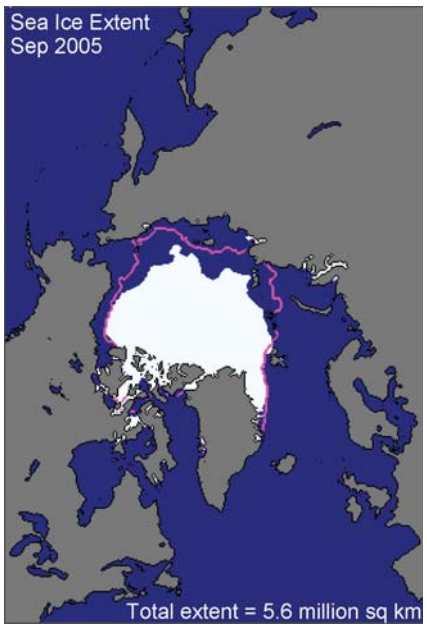
National Snow and Ice Data Center/ World Data Center for Glaciology

The National Snow and Ice Data Center (NSIDC) was chartered by NOAA/NESDIS in 1982 to provide a focus for cryospheric data management activities. NSIDC is operated under an agreement between NOAA and the University of Colorado's Cooperative Institute for Research in Environmental Sciences and is affiliated with the NESDIS National Geophysical Data Center (NGDC), Boulder (1976– present). NSIDC is co-located with the World Data Center for Glaciology, Boulder, as well as several agency-funded data management activities. These include the NSF-funded Arctic System Sciences Data Center, U.S. Antarctic Data Coordination Center, and Antarctic Glaciological Data Center; the Frozen Ground Data Center, supported by the International Arctic Research Center, University of Alaska Fairbanks; the NOAA@NSIDC program; and the NASA Distributed Active Archive Center (DAAC) for Snow and Ice. The latter program provides more than 80% of NSIDC's annual budget and supports Earth System Enterprise data sets such as AMSR-E and MODIS products, as well as "heritage" data sets such as the nearly 30-year record of sea ice concentration from satellite passive microwave data and numerous in situ records of snow, ice, and frozen ground.

The number of data management centers at NSIDC implies a compartmentalization that in fact is largely absent. All programs share the expertise of each, and NSIDC's scientists, through their interactions with data management staff, help keep data management efforts focused on science support. In 2004 and 2005, 106 data sets were added to the catalog. The online interface provides access to 562 data sets. These data sets exemplify the spirit of cooperation that the cryospheric research community shares, as it would not be possible to make them available without support from several agencies and many individual investigators.

NSIDC is exploring new methods of data management and data access. The Global Land Ice Measurements from Space (GLIMS) project, for example, uses map server technology with an Open Geospatial Consortium-compliant interface. This collaborative effort between NASA, the U.S. Geological Survey (USGS), and more than sixty institutions worldwide is creating a glacier inventory containing information about the current extent and rates of all the world's glacial resources derived from satellite imagery (largely Advanced Spaceborne Thermal Emission and Reflection Radiometer, or ASTER, and Landsat).





Graphics from the Sea Ice Index site, updated monthly, showing Arctic ice in retreat. The magenta line on the right image is the median September ice extent for 1979–2000.

One of the top science stories in 2005 was the marked decline of the Arctic sea ice cover. In a March press release, NSIDC scientists noted that while summertime ice extent had been trending downward for some time, the sea ice tended to recover its full extent in the Arctic winter. That has changed: ice reached new record lows in December, January, and February 2005. The trend in winter ice extent is now about –3% per decade. The downward trend in summertime extent is steeper (–8% per decade). The September minimum marked the fourth consecutive year of exceptionally low Arctic ice extent. In a joint press release with colleagues at the NASA Goddard Space Flight Center and the University of Washington, NSIDC scientists argued that beyond the continuing influence of higher temperatures on the ice pack, we may be seeing the beginning of an acceleration as feedbacks in the climate system take hold. NSIDC's Mark Serreze called 2005 the year that "puts an exclamation point on the pattern of Arctic warming we've seen in recent years."

The Sea Ice Index interactive web site allows scientists and the public to track ongoing changes in ice extent. The site received almost 40,000 visits in September 2005, as ice reached a new record low extent.

On an international level, activity in 2004 and 2005 built toward NSIDC's planned role in the International Polar Year (IPY), which begins in 2007. NSIDC leads or is involved in about 10% of the over-200 IPY lead projects. NSIDC has a proposed leading international coordination role for IPY data management, with an IPY Data and Information Management Service Expression of Intent. NSIDC scientists are also involved in the Fourth Assessment Report for the IPCC for The Cryosphere (Working Group 1) and Polar Regions (Working Group 2).

NSIDC is the repository for data from the USIABP. All buoy data are quality controlled within six months of receipt and then assembled into a historical (1979–2004) database that is analyzed by the Polar Science Center of the University of Washington (iabp.apl.washington. edu) and archived at NSIDC. These data have been useful in validating global climate models and in climate change research. Buoy data are also used to generate a three-hour spatially and temporally interpolated data set of surface pressure and temperature.

National Oceanographic Data Center

NODC and the co-located World Data Center for Oceanography (WDC Oceanography) in Silver Spring, Maryland, continue to have an active data exchange program and engage in collaborative joint projects with many Arctic countries, academic institutions, other Federal agencies, and international organizations. In June 2006, NODC/Ocean Climate Laboratory (OCL) will release the World Ocean Database 2005 (WOD05), which will contain oceanographic physical, chemical, and biological data dating back to 1827. These profiles reflect data obtained from bottles, conductivity–temperature–depth instruments and plankton measurements, mechanical bathythermographs, expendable bathythermographs, surface-only instruments (bucket, thermosalinograph), subsurface drifting floats, and surface drifting buoys with thermistor

The point of contact for the Ocean Climate Laboratory, the World Data Center for Oceanography, and the World Ocean Database is Sydney Levitus, U.S. Department of Commerce, National Oceanic and Atmospheric Administration/Ocean Climate Laboratory, 1315 East-West Highway (E/OC5), Silver Spring, MD 20910; 301-713-3290, ext. 194. For the Arctic databases, the point of contact is Igor Smolyar, U.S. Department of Commerce, NOAA/OCL, 1315 East-West Highway (E/OC5), Silver Spring, MD 20910; 301-713-3295, ext. 206.

Further information about and access to the NOAA Library can be found at http://www.lib.noaa.gov/. The point of contact for the NOAA Library is Janice Beattie, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Central Library, 1315 East-West Highway (E/OC4), Second Floor, Silver Spring, MD 20910; 301-713-2607, ext. 139.

The point of contact on access to the on-line publications listed in the International Polar Year 2007–2008: Resources on Polar Research in the NOAA Central Library Network: A Selected Bibliography *is Anna Fiolek, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Central Library, 1315 East-West Highway (E/OC4), 2nd Floor, Silver Spring, MD 20910; 301-713-2607, ext. 147.*

chains. Approximately 20% of these data were added since the 2002 publication of World Ocean Database 2001. The exchange of data is facilitated under the auspices of the Intergovernmental Oceanographic Commission (IOC) Global Oceanographic Data Archaeology and Rescue (GODAR) project and the World Ocean Database (WOD) project. These efforts are supported by NOAA's Office of Global Programs (OGP) and NOAA's Environmental Science, Data, and Information Management (ESDIM) program.

Data exchange and collaborative activities have been particularly fruitful with the Russian Federation for many years. Another product has been published, *Climatic Atlas of the Arctic Seas 2003: Part 1, Database of the Barents, Kara, Laptev, and White Seas*. It was prepared jointly with the Murmansk Marine Biological Institute (MMBI), Russian Academy of Sciences. This atlas contains data from about 400,000 oceanographic stations from 1810 to 2002. There are more than 20,000 plankton samples, including 260 collected during cruises of nuclear icebreakers in regions previously inaccessible for studies during the winter. The atlas also includes about 100 benthos samples collected along the Kola Meridian in 1921–1922 and 1977. All of these data are incorporated into the World Ocean Database and made available online.

Further information about and access to the World Ocean Database and the products associated with the International Ocean and Atlas Information Series can be found at www.nodc.noaa.gov/OC5/indprod.html.

The NOAA Central Library, located in Silver Spring, Maryland, is the largest oceanic and atmospheric sciences library in the western hemisphere and has extensive holdings related to Arctic exploration and Arctic science. The library's online catalog has over 1,800 entries related to Arctic activities and another 1,000 entries related to oceanography and fisheries of the Arctic marginal seas. The library's on-site collection is supplemented by an additional 1,200 historical documents that can be found through the library's traditional card catalog. Access can be gained to the full range of publications that are dedicated specifically to Arctic science and issues. Pages of climate data from the polar areas of Alaska, Norway, and Russia beginning from 1824 are also available online, funded by the NOAA Climate Data Modernization program.

As an adjunct to textual material, the Central Library also manages the NOAA Photo Library Collection. There is an archive of over 1,000 black and white Arctic photographs and negatives and an online collection of over 600 public domain images related to Arctic themes.

In support of the International Polar Year 2007–2008, the Central Library has created a comprehensive bibliography entitled *International Polar Year 2007–2008: Resources on Polar Research in the NOAA Central Library Network: A Selected Bibliography*. The bibliography is formatted by title from entries in the library's online catalog and from the library's historical collections. The data and listings are comprehensive from the 18th century to the present. This resource contains many formats, including print, CD-ROM, online full-text documents, digital videos, digital images, online cruise data, and web resources. This document provides full-text links, copyright permitting, to significant polar documents in the NOAA library collections. Over 150 of the publications were scanned as full text, and there are also links to scientific data sets available from the National Oceanographic Data Center (NODC) Ocean Archive System. This bibliography is also an Internet locator for printed and online resources in polar research.

The bibliography is available online for downloading in Microsoft Word and in PDF formats at docs.lib.noaa.gov/rescue/Bibliographies/IPY2007.doc and docs.lib.noaa.gov/rescue/Bibliographies/IPY2007.pdf. Publications listed in the bibliography may also be requested through interlibrary loan.

National Climatic Data Center

NCDC was actively engaged in the Arctic Climate Impact Assessment, which was published in 2005. Specifically, two NCDC researchers were contributing authors to Chapter 2 ("Arctic Climate: Past and Present"). NCDC contributions focused on changes in land-surface air temperature and precipitation in the Arctic during the 20th century.

National Marine Fisheries Service–Alaska Fisheries Science Center

Resource Assessment and Conservation Engineering Division

The Alaska Fisheries Science Center (AFSC) of NMFS continued its long-standing commitment to assessment studies of U.S. living marine resources in the Bering Sea, Aleutian Islands, and Gulf of Alaska during 2004 and 2005. This effort included fishery-independent resource surveys, collection of data from commercial fisheries through fisheries

observers, collection of recreational and commercial harvest statistics, and basic population biology and ecological research. The scientific information generated by these activities supports Federal fishery conservation and management responsibilities in the 200-mile U.S. Exclusive Economic Zone.

During 2004 and 2005, living marine resource populations in western U.S. Arctic waters were sampled at sea aboard NOAA ships, chartered fishing vessels, and cooperating foreign research vessels. Significant area-extensive survey efforts were conducted in the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska. The principal survey methods included bottom trawls for demersal fish and crabs and a combination of hydroacoustics and trawls (both midwater and bottom gear) for semipelagic fish. Trawl and acoustic surveys were used to estimate biomass and define community structure, and biological collections were taken to examine variability in growth, mortality, and stock recruitment. Besides providing a time series, annual assessment surveys provide opportunities and platforms for intra- and interagency programs for collecting physical and biological data for understanding ecological processes in the Arctic region over a range of spatial and temporal scales. Universities and other outside organizations also participate in and benefit from collaborative research done during assessment surveys.

In addition, researchers launched a new NOAA program—Climate Regimes and Ecosystem Productivity (NPCREP) —whose focus is to monitor and understand climate-induced change in marine ecosystems and apply this knowledge to NOAA's ecosystem approach to management. The program is a partnership between the AFSC and NOAA's Pacific Marine Environmental Laboratory (PMEL). The program's major efforts are in the eastern Bering Sea, where researchers maintain a network of biophysical buoys and conduct monitoring and process cruises to examine how variations in atmosphere–ice–ocean coupling modulates the production at lower trophic levels and the abundance, distribution, and transport of larval fishes. Sea time included three cruises on NOAA vessels, one on a UNOLS vessel, and one on a foreign research vessel. Field operations included mooring deployments and recovery, deployment of satellite-tracked drifters, measurements of water column properties (heat, salt, nutrients, chlorophyll), and net tows for zooplankton and larval and juvenile fishes. Studies to understand the linkages to higher trophic levels will begin in FY 2006.

To manage the Arctic ecosystem, we need to accurately assess species diversity and composition. To greatly improve the identification of known species, the Groundfish Assessment Program's Systematics Laboratory publishes field guides and scientific papers on taxonomic revisions. One of the publications involved collaboration with the Recruitment Processes Program to describe the complete developmental series (larval to adult fish) of one family of fishes. The Systematics Laboratory instituted a vouchering system for documenting occurrences of unusual species and depositing specimens in university and museum collections. In 2004 –2005, the Systematics Laboratory described nine new species from three families of fishes in the Arctic. Fish specimens potentially representing at least 12 more new species have been collected and still need to be described. New invertebrate species from the Arctic also continue to be collected, and the staff is collaborating with experts from universities and other institutions to have them cataloged and described. Accurate identification and enumeration of every marine species in the Arctic is essential if we expect to understand the dynamics of the Arctic ecosystem.

Indices of ecosystem status and recruitment success are continually being developed, refined, and evaluated by the Ecosystem and Fisheries Oceanography Coordinated Investigations (Eco-FOCI), a collaborative program between the AFSC and PMEL. The indices generated by the FOCI and NPCREP programs are included in the "Ecosystems Considerations" chapter of the council's Stock Assessment and Fishery Evaluation (SAFE) reports and the PICES North Pacific Ecosystem Status Report. They are also available on NOAA's Bering Climate web page (www.beringclimate.noaa.gov). They are one source of information available for an ecosystem approach to management. In addition, the program is actively working on models that couple physics and lower trophic levels to fishes. One goal of such models is to generate predictions on the future recruitment success of fish populations with enough lead time to be of use to resource managers.

Resource Ecology and Fisheries Management Division

The REFM Division conducts research to assess the abundance, dynamics, and ecosystem interactions of crab and groundfish stocks off Alaska in support of their optimal utilization and management. It also conducts socioeconomic

studies to assist NMFS in meeting its stewardship responsibilities. Research is focused towards providing fishery, socioeconomic, and ecosystem assessment advice to decision makers to advance an ecosystem approach to management of Alaska's living marine resources. The REFM Division provides scientific support to U.S. delegations to international commissions and bilateral fisheries agreements, as well as central coordination of the AFSC's responsibilities involving the National Environmental Policy Act (NEPA) and the Freedom of Information Act (FOIA). The following is a brief summary of key research activities and accomplishments during FY 2004–2005 by the REFM Division's four main research programs: Status of Stocks and Multispecies Assessments, Resource Ecology and Ecosystems Modeling, Economic and Social Sciences Research, and Age and Growth Studies.

Status of Stocks and Multispecies Assessments. The Stock Assessment and Multispecies Assessments (SSMA) program is responsible for determining the condition of fisheries resources in the U.S. Exclusive Economic Zone off Alaska using data collected by AFSC scientists and others and for developing strategies for managing those resources. Research in FY 2004–2005 focused on updating information on population trends, estimating acceptable biological catch and overfishing levels, and developing management strategies as presented in annual stock assessments. Research conducted by the SSMA program staff has included retrospective studies of processes underlying shifts in production, distribution, or abundance of groundfish in the Bering Sea, Aleutian Islands, and Gulf of Alaska regions. The SSMA program has focused on developing next-generation analytical methods for evaluating stock condition, including new methods for improving the accuracy and predictability of stock status and trends and developing improved modeling techniques. Scientists within the group conducted numerous studies to assess key vital rates, including growth, mortality, and maturity schedules. SSMA staff also designed and implemented field studies to improve data collection on ships of opportunity. Finally, forecast models were developed by SSMA staff to assist in the analysis of environmental impacts of fishing.

The Fishery Interaction Team (FIT), a component of the SSMA program, investigates the effects of commercial fishing on top trophic level consumers. During FY 2004–2005, members of the team conducted studies to determine whether commercial fishing operations are capable of impacting the foraging success of sea lions, either through disturbance of prey schools or through direct competition for a common prey. Research focused on the three major groundfish prey of sea lions: walleye pollock, Pacific cod, and Atka mackerel. FIT investigated the potential effects of commercial fishing on sea lion prey fields in two ways: by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones; and by studying fish distribution, behavior, and life history at spatial scales relevant to sea lion foraging (tens of nautical miles).

Resource Ecology and Ecosystems Modeling. The Resource Ecology and Ecosystem Modeling program focuses on the collection and analysis of data relating to trophic interactions in the North Pacific and Bering Sea regions. During FY 2004–2005, these data were incorporated into environmental assessments and single-species, multispecies, and ecosystem models. Groundfish food habits data were systematically collected and analyzed, and groundfish feeding ecology was studied. Research on quantifying seabird–fishery interactions was conducted, along with efforts to work with industry in reducing these interactions. Ecosystem indicators have also been developed and incorporated into ecosystem-level assessments of the effects of climate and fishing on ecosystems. A variety of predator–prey models are being developed to forecast the effects of fishing and climate on marine ecosystem production and food web structure.

Economic and Social Sciences Research. The primary mission of the Economic and Social Sciences Research program is to provide economic and sociocultural information that will assist NMFS in meeting its stewardship responsibilities. Research activities in FY 2004–2005 in support of this mission have included collecting economic and sociocultural data relevant for the conservation and management of living marine resources; developing models to monitor changes in economic and sociocultural indicators and to estimate the economic and sociocultural impacts of alternative management measures; providing baseline sociocultural information and analyses of fishing communities of the North Pacific and Bering Sea regions; and improving the economic analysis of bycatch regulations in Alaskan fisheries.

Age and Growth Studies. The Age and Growth Studies program provides age data that contributes to the basic understanding of a species,

whether it is in the context of sustainable fisheries, species conservation, or species ecology. During FY 2004–2005, the program focused primarily on the production of age data for age-structured modeling of exploited fish populations, such as yellowfin sole, walleye pollock, Pacific cod, Atka mackerel, northern rockfish, and Pacific ocean perch populations in the Bering Sea and Aleutian Islands regions. In FY 2005 alone, the program aged over 33,000 individual groundfish specimens from Alaska waters. The program also conducts research in age validation to assess the accuracy of the aging methods that are being applied. Also being studied is the aging of new species, such as Greenland turbot and shortraker rockfish, which may require new aging methodologies.

National Marine Mammal Laboratory

The National Marine Mammal Laboratory (Alaska Fisheries Science Center) and the Protected Resources Management Division (Alaska Regional Office) are responsible for research on and management of 22 species of marine mammals that commonly occur in Alaska. These marine mammals include five endangered cetacean species (bowhead, fin, humpback, North Pacific right, and sperm whales), one pinniped species (Steller sea lion) that is threatened in one portion and endangered in another portion of its range, and three depleted stocks (Cook Inlet beluga whale, northern fur seal, and AT1 killer whales). Field research by NMML staff on marine mammals off central and northern Alaska focused on seven pinniped and two cetacean species during 2004 and 2005: Steller sea lions, harbor seals, northern fur seals, bearded seals, ribbon seals, ringed seals, spotted seals, Cook Inlet beluga whales, and bowhead whales in the Bering Sea. In addition, passive acoustic technology has recently been used to provide new information on the seasonal distribution of large whales.

Northern Fur Seals. Population assessment studies during the 2004 and 2005 breeding seasons established that the Pribilof Island population declined at 6% per year since 1998, while the Bogoslof Island (nearer the Aleutian Island chain) population increased at 12% per year since 1997. Long-term declines of the Pribilof Island population, which account for about 56% of the global fur seal population, had previously stabilized since 1983 and 1988 at Saint Paul and Saint George Islands, respectively. A suite of studies were continued or initiated investigating multiple hypotheses that may account for these trends, including studies of diet habits, foraging and migratory behavior, and causes of pup mortality. An at-sea tracking study in 2004 examined foraging site fidelity of lactating fur seals in the Bering Sea and will compare results with similar studies conducted in the previous decade. In collaboration with researchers from the University of Alaska Fairbanks and Dalhousie University in Nova Scotia, Canada, with funding from NOAA and the North Pacific Research Board, studies were conducted during 2004–2005 investigating the consequences of adult female foraging strategies during summer (in the Bering Sea) and winter (in the North Pacific Ocean) on condition, pup production, and growth. NMML's telemetry data on fur seal foraging and migration behavior are also combined with satellite-derived oceanographic data to investigate the importance of oceanographic features. In the fall of 2005, a total of 99 weaned pups at the Pribilof and Bogoslof Islands were instrumented with satellite telemeters to investigate post-weaning dispersal from rookeries.

Steller Sea Lions. NMML continued to monitor sea lion population status, foraging behavior, and health and condition to test hypotheses about the decline or lack of recovery of endangered Steller sea lions in the Bering Sea and Aleutian Islands. This research was composed of a suite of studies including aerial and ship-based surveys of abundance, survival and vital rate estimation, genetic stock differentiation, satellite tracking of dive behavior and movements and relationships with oceanographic features, and dietary habits. Although there were small increases in pup numbers at trend rookeries in the Kenai–Kiska area (4%) and in the western stock overall (3%) during 2001–2005, there were strong regional differences in the recent trends, suggesting that the magnitude or number of factors affecting the western stock of Steller sea lions also varied regionally. The largest decline in pup counts (–30%) occurred in the western Aleutian Islands, while smaller declines were observed in the central Gulf of Alaska (–4%) and central Aleutian Islands (–2%). In the Bering Sea, counts of Steller sea lion pups on Walrus Island (near St. Paul Island in the Pribilof Islands) in 2005 were the smallest on record.

Ice-Associated Seals. The four species of ice-associated seals (bearded, spotted, ribbon, and ringed seals), collectively known as "ice seals," are important resources for northern coastal Alaska Native communities and are likely to be key ecological components of Arctic marine ecosystems. Yet, despite mandates by the Marine Mammal Pro-

tection Act to assess the status of these species, relatively little is known of their abundance, population trends, seasonal distributions, stocks, and food habits. The distributions and densities of ice-dwelling seals are highly sensitive to suitable sea ice conditions, and as such, these seals may be particularly vulnerable to climate change. Changes in sea ice extent have been non-uniform; therefore, the effects on seals are likely to occur on regional scales, emphasizing the need for quality data throughout their range. NMML researchers have recently initiated projects to address these issues by supporting the genetic analyses of tissues collected during field research projects and by instrumenting these species with satellite-linked data recorders (SDRs). The SDRs, which fall off when the seals molt in the spring, provide data on a seal's location and the timing and depths of its dives. The data, received through the Argos system, can be analyzed to provide correction factors for seals missed (not hauled out) during sightings surveys, information on habitat selection (foraging and haul-out locations) and seasonal movements (post-molt migration routes), and information on foraging behavior.

In October 2004, in cooperation with the Kotzebue Native village and researchers from the University of Alaska Fairbanks and the Alaska Department of Fish and Game, two female young-of the-year bearded seals were captured in set nets in Kotzebue Sound and instrumented with SDRs. An additional seven female and eight male young-of-the-year bearded seals and two adult male and three female young-of-the-year spotted seals were captured and instrumented in October 2005. The 17 bearded seals were the first to be instrumented with SDRs in Alaska. Data from instrumented individuals are being collected on a continuing basis. Further analyses of these data will include investigations of the potential effects of bathymetry, ice concentration, and ice extent on their movements and diving behavior.

In June 2005, NMML researchers successfully live-captured ten ribbon seals off the coast of eastern Kamchatka, Russia. The seals were captured in hoop nets on the ice floes where they were resting, and they were physically restrained and instrumented. The two adult males, three adult females, and five pups were outfitted with SDRs, representing the first instance of live-capture and instrumentation of ribbon seals. Unlike ringed seals, which follow the ice edge north as it melts, some researchers have speculated that most ribbon seals remain in the Bering Sea and become pelagic during the summer. If true, the impact that ribbon seals may have on the Bering Sea's invertebrate and fish stocks could be significant. Preliminary results indicate that these pagophilic seals may, after the molt, remain primarily in the ice-free areas south of the Bering Strait. Most of the seals dispersed southeast into ice-free areas soon after they were tagged, with some adults traveling into the North Pacific, foraging south of the central Aleutian Islands. Data from instrumented individuals are still being collected, and a cruise to capture and instrument additional ribbon seals at the southern ice edge of the eastern Bering Sea was completed in the spring of 2006.

Accurate population estimates will be of little value without proper identification of stock structure, and while collecting tissue samples for genetic analysis from the subsistence harvest is useful, the harvest rarely takes place during the breeding season, so it is not possible to relate those samples to stock structure. In June 2005, researchers from NMML, University of Alaska Southeast, and the North Slope Borough conducted a pilot study at Peard Bay, Alaska, which utilized small, location-only SDRs, mounted on flipper tags, to determine whether ringed seals returned to the same breeding locations in successive breeding seasons. Such a result would indicate that dispersal rates are low and that populations are therefore more susceptible to depletion or extinction. The genetic diversity within a breeding location could also provide strong evidence for or against philopatry, so researchers collected genetic samples from captured ringed seals and from molted skin found on the ice around seals' breathing holes that will be analyzed for indications of site fidelity and stock structure. This work was continued and expanded in the summer of 2006.

The best way to conserve and provide stewardship of marine mammal populations that are critical to the subsistence of Alaska Natives is through a partnership between NOAA Fisheries—the Federal agency with management authority—and the Alaska Native resource users. Such a partnership should provide for the full and equal participation by Alaska Native tribes in decisions affecting the subsistence management of marine mammals. Recent workshops have resulted in the creation of an ice seal co-management committee consisting solely of representatives of Alaska Native tribes. The AFSC has the responsibility for scientific research and stock assessments of ice seals in Alaska and therefore has expertise and data relevant to many issues of concern of the potential ice

seal co-management partners. The AFSC is an active participant in their meetings and has taken a lead role in developing the Alaska ice seal statewide research plan.

In 1999 the first phase of a multi-year program to advance the use of passive acoustics for detection and assessment of large whales in offshore Alaskan waters was initiated at NOAA's National Marine Mammal Laboratory and Pacific Marine Environmental Laboratory (PMEL). To date, autonomous recorders have been successfully deployed in the Gulf of Alaska (1999–2001), the southeastern Bering Sea (2000–present), and the western Beaufort Sea (003–2004). Seasonal occurrences of six endangered species (blue, fin, humpback, North Pacific right, bowhead, and sperm whales) have been documented based on call receptions in these remote ocean regions (www.magazine.noaa.gov/). Detection of North Pacific right whale calls was given highest priority in the southeastern Bering Sea because of the whale's critically endangered status. Analyses to date show that right whales occur there from May through November, with the greatest number of calls recorded in September and October. In addition, calls from fin and humpback whales were ubiquitous on recorders deployed in the Bering Sea. Three recorders deployed in the Beaufort Sea were placed near an oceanographic mooring line in collaboration with the Western Arctic Shelf–Basin Interaction (SBI) project (sbi.utk.edu). Although the target species in this case was the bowhead whale, data analyses revealed calls of North Pacific gray whales each month from October 2003 through May 2004. The discovery of these calls through the Arctic winter was truly a surprise and may indicate a shift in range and behavior for this species.

Cook Inlet Beluga Whales. Systematic aerial surveys have been conducted in Cook Inlet to document beluga distribution and abundance each June or July since 1993. During this period, the distribution has shrunk to only the northern portions of the inlet. Abundance declined until 1998, when unregulated hunting was stopped, but since then the abundance—approximately 340 whales—has not changed appreciably. This stock was designated as depleted under the Marine Mammal Protection Act in 2000, and a status review is underway to determine whether this stock should be listed as threatened or endangered. In addition to the aerial surveys, the research program includes tagging effort to determine location, dive timing, and movements of belugas; aerial photography to discriminate color phases of whales (belugas become whiter as they age); fatty acid analysis to record beluga diet; genetic analysis to document how distinct belugas of Cook Inlet are from other stocks; and habitat modeling. Scientists from NMML work in cooperation with the Alaska Beluga Whale Committee, the Cook Inlet Marine Mammal Council, the Alaska Native Marine Mammal Native Hunters Committee, the Alaska Department of Fish and Game, and NMFS's Alaska Regional Office.

Bowhead Whale Stock Structure. Concerns were expressed at the 2004 Scientific Committee meeting of the International Whaling Commission that there might be more than one stock of bowhead whales in the seas around Alaska. These discussions initiated a research program that led to a range of proposed studies, including analysis of aerial photographs of bowheads (comparing images provides ratios of re-identifications of individual whales between years and sample areas); genetic analysis for stock discreteness; satellite tagging to track individual whales through their migrations; moored recorders to provide acoustic monitors of whales in the sample area year-round; interviews to collect traditional knowledge from whaling villages; reviews of historical whaling records to better determine the distribution of bowheads during the time of commercial whaling; and modeling exercises to provide a probability analysis of various hypothetical scenarios. These studies were underway in 2005 and 2006 in preparation for a critical review of bowhead information at the 2007 IWC meeting.

Auke Bay Laboratory

Nearshore Fish Assemblages near Barrow, Alaska. In 2004 and 2005 the Auke Bay Laboratory assisted the U.S. Army Corps of Engineers in a Coastal Storm Damage Reduction Study near Barrow, Alaska. The objective of the study was to evaluate the potential effects of beach erosion and replenishment on nearshore fishery resources. Fish assemblages were sampled with a beach seine at 26 sites. The beach adjacent to Barrow is eroding at a rapid rate, and Cooper Island, Point Barrow, and Skull Cliff have been proposed as possible sources of replacement sediment or rock. The total catch at all sites was over 3,000 fish in 2004 and 718 fish in 2005. The mean catch per seine haul was greatest for sites near Barrow and least at Cooper Island. At Cooper Island, the mean catch per seine haul was greater on the Beaufort Sea side of the island than in Elson Lagoon. The most abundant fish captured on the seaward side

of Cooper Island were juvenile cottids, whereas the most abundant species captured in Elson Lagoon was least cisco. The most abundant fish near Barrow and Skull Cliff were juvenile poachers, juvenile gadids, and capelin. Overall, the most abundant fish captured were juvenile gadids, comprising 51% of the total catch in 2005. A third year of the study will be completed in 2006 to provide a better understanding of the inter-annual variability in species composition and fish abundance.

Contaminant Research in the Bering Sea and Gulf of Alaska. Auke Bay Laboratory collected forage fish species from the Bering Sea and eastern Gulf of Alaska and examined them for organochlorines between 2001 and 2003. They have since reported on a comparison of walleye pollock from the perimeter of the Bering basin and southeastern Alaska, which indicated that the highest levels of polychlorinated biphenyls (PCBs) and DDTs were found among southeastern Alaska fish. In addition, data describing organochlorines in demersal species (Pacific cod, arrowtooth flounder, and Atka mackerel) collected from the Aleutian Islands suggest that Adak Island is a significant point source of contamination.

Yukon River Radio Telemetry Program. The Yukon River chinook salmon radio telemetry program, a cooperative study between the Alaska Department of Fish and Game and the National Marine Fisheries Service, conducted a full-scale, basin-wide tagging and monitoring program in 2004. A total of 995 fish were radio-tagged during the study and monitored during up-river migration by 39 remote tracking stations and aerial tracking surveys. Movement rates averaged 55 km/day for fish returning to the upper Yukon River, whereas fish returning to the lower basin traveled substantially slower (34–38 km/day). A total of 320 fish that moved up-river were harvested in fisheries, including 276 fish in the U.S. and 44 fish in Canada. A total of 719 fish were tracked to specific reaches within the basin: 283 fish to the Alaska portion of the Yukon River; 8 fish to the Porcupine River; 195 fish to the Canadian portion of the Yukon River main stem; and 58 fish to Canadian reaches of the Yukon River main stem or to associated tributaries not monitored by tracking stations or surveyed by aircraft.

Pacific Salmon: Bering Sea and Western Alaska Salmonid Populations. To provide critical information on the marine ecology of Pacific salmon and other important commercial fish species, scientists from the Alaska Fisheries Science Center's Ocean Carrying Capacity (OCC) program conducted fall surveys in 2004 and 2005 on nekton along the eastern Bering Sea shelf. The surveys were extensive, covering eastern Bering Sea shelf waters from the Alaska Peninsula to Kotzebue Sound. The research is part of a larger Bering Sea salmon ecology study conducted by the North Pacific Anadromous Fish Commission, the Bering–Aleutian Salmon International Survey (BASIS) program. The goal of the OCC/BASIS salmon research is to understand the mechanisms underlying the effects of the environment on the distribution, migration, and growth of juvenile salmon on the eastern Bering Sea shelf. The primary objectives of the survey are to determine the extent of offshore migrations of juvenile salmon from rivers draining into the eastern Bering Sea, to describe the physical environment of the epipelagic waters along the eastern and northeastern Bering Sea shelf occupied by juvenile salmon, and to collect biological information of other ecologically important species.

Results indicate that juvenile salmon are widely distributed across the eastern Bering Sea shelf; species-specific distributional patterns of juvenile salmon can exist; distributional patterns are likely related to principal prey sources (for example, age-0 pollock for juvenile sockeye and chum salmon, larval and juvenile sand lance for juvenile chinook); size and relative abundance of juvenile sockeye salmon, chum salmon, and age-0 walleye pollock were greatest during 2002 through 2004 compared to 2000 and 2001; size of juvenile salmon is related to marine survival (for example, larger fish have higher marine survival); sea surface temperatures have warmed considerably during 2002–2005 compared to 2000 and 2001; and oceanographic characteristics can influence distribution, migration pathways, and early marine growth (for example, warm sea surface temperatures are associated with offshore distribution and increased early marine growth for juvenile sockeye salmon).

Sablefish Longline Survey, 2004–2005. The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska since 1987, a continuation of Japan–U.S. cooperative longline surveys conducted from 1978 to 1994. The survey is a joint effort involving two AFSC research divisions: the Auke Bay Laboratory and the Resource Assessment and Conservation Engineering Division. The continental slope of Bering Sea and Aleutian Islands are sampled on alternate years at depths between 200 and 1000 m. In 2005, 20 Bering Sea stations were sampled between 59 and 53°N latitude, while in 2004, 21 stations were

sampled in the Aleutians from 179 to 165°W longitude. Sablefish is the most frequently caught species, followed by giant grenadier, shortspine thornyhead, and Pacific cod.

Deep-Sea Coral Distribution and Habitat in the Aleutian Islands 2004. Two studies were completed in the Aleutian Islands in the summer of 2004 on the distribution and habitat of deep sea corals and the associated biological communities. The first study used the piloted submersible *Delta* in June and July to complete the second and final phase of a project to assess Aleutian Islands coral habitat in waters less than 365 m deep (the maximum depth at which the submersible can operate). Scientists visited 10 sites and collected video of the seafloor on 23 strip transects. Previously undocumented beds of sponges, predominantly demosponges, were documented on an additional six dives. More than 150 coral specimens were collected for molecular and morphological taxonomic identification and for studies on reproduction. More than 100 sponge specimens were also collected, and 5 of the first 10 specimens analyzed microscopically were confirmed as species new to science.

The second study in late July used the RV *Roger Revelle* as a support vessel for the remotely operated vehicle (ROV) *Jason II*, attended by a team of biologists, fisheries scientists, and geologists to study deep sea coral habitat at depths ranging from 131 to 2,948 m in the central Aleutian Islands. Coral and sponge habitat was documented and a number of deep-water specimens—many new to science—were collected for ecological and taxonomic studies. This cruise was the final component of a comprehensive study initiated in 2003 and funded by NOAA Fisheries, NOAA's Undersea Research Program, and the North Pacific Research Board. The team hopes to use their findings to construct a model to predict where coral habitat is located throughout the Aleutian Islands region. The model will provide fisheries managers with a powerful tool to conserve the region's coral habitat.

Survey Strategies for Assessment of Bering Sea Forage Species, 2005. In June 2005, two research cruises were conducted in the southeastern Bering Sea, with one group of scientists onboard the F/V *Great Pacific* targeting offshore waters of the continental slope and continental shelf and a second group of scientists onboard the F/V *Kema Sue* targeting nearshore waters. A third group of scientists employed lidar and visual surveys from a chartered airplane. The primary objective of this study was to test a suite of methods for estimating forage species abundance in the Bering Sea. Aerial surveys covered 23,125 km; acoustic surveys covered 540 km; 24 stations were completed by the offshore vessel and included 22 MultiNet (multi-opening zooplankton net) deployments, 18 CTD casts, 2 ZOOVIS-SC (zooplankton camera) deployments, and 21 midwater trawl deployments; and 18 stations were completed by the nearshore vessel, which included 70 beach seine deployments and 11 jigging locations.

The dominant forage species catch in the midwater trawl was northern smoothtongue. Common forage species were the myctophids, northern lampfish and California headlight fish, squid, and Pacific herring. Shallow nearshore stations were dominated by walleye pollock and Pacific herring.

The dominant forage species in nearshore surveys was Pacific sand lance; approximately 35,000 were captured, and they occurred in 60% of the seine hauls. Other commonly captured forage fish species were Pacific sandfish and young-of-the-year gadids. Aerial surveys offshore found a surface layer from 2 to 5 m deep and varying in thickness; net sampling showed that it consisted mainly of large copepods. Patchy, larger targets lay from 8 to 30 m deep and probably extended below attenuation range (30 m). Aerial surveys also located "hot spots" mainly along the continental shelf break. The hot spots consisted of 3–40 humpback, fin, and sei whales, thousands of seabirds (mostly shearwaters), concentrated patchy targets characteristic of fish schools, and obvious foraging activity (for example, bubble feeding by humpback whales and regurgitated euphausiids from shearwaters). These hot spots were observed on multiple days and appeared to move northeast along the shelf break at about 20 km per day. Fewer signal targets, seabirds, and marine mammals were located nearshore; however, a few fish schools were visible and may have been sand lance and herring.

Habitat and Ecological Processes Research Program. The AFSC initiated the Habitat and Ecological Processes Research (HEPR) program in February 2005 to develop scientific research that supports implementation of an ecosystem approach to fishery management. The HEPR program focuses on integrated research studies involving habitat and ecological processes.

An identified research area for the HEPR program is the Loss of Sea Ice (LOSI) study. Specific research questions are: How can AFSC scientists improve their understanding of the natural and

anthropogenic processes in the Bering Sea that influence sea ice thickness, timing, and seasonal extent, and how do changes in sea ice properties influence living marine resources? How can this information enable more accurate forecasts of future ecosystem status and trends? How can this information be incorporated into management advice and thresholds for regulatory actions? Three LOSI research areas are planned: expand existing surveys to cover apparent northern migration of species; create new surveys of ice-dependent species not presently assessed; and acquire the understanding to create spatially explicit models to predict the effects of loss of sea ice on fish and marine mammal abundance trends. LOSI funding is scheduled to begin in FY 2008.

National Weather Service

NOAA's National Weather Service focuses mostly on operations and spends the bulk of its associated research time collaborating with others in NOAA and academia. The NWS's most significant efforts have involved sponsoring and collaborating on research associated with coastal erosion and climate change.

The NWS has also collaborated with the Cooperative Institute for Arctic Research on the development of the Alaska Regional Integrated Sciences and Assessments Program, tsunami operations and research (the Tsunami Warning and Environmental Observatory at the University of Alaska Fairbanks), and climate change (including participation in the ACIA report development). They are active participants in the Alaska Ocean Observing System (AOOS) and have sponsored and/or collaborated in numerous research and operational endeavors with other AOOS participants. The NWS worked with the National Academy of Science on the requirements and needs associated with establishing the Arctic Observing Network and with International Polar Year (IPY) collaborators on potential IPY research activities.

In 2005 the NWS sponsored a workshop in collaboration with the International Arctic Research Center, Fairbanks, Alaska entitled "Toward an Alaskan Wind/Wave Climatology." This workshop was organized as part of an Alaskan sector contribution to the NOAA Pacific Regional Integrated Data Enterprise (PRIDE) initiative call for proposals that took place in FY 2005. The objective of this proposal was to initiate work leading to an improved operational capacity for predicting coastal erosion and flooding with a demonstration project in place by IPY (FY 2007–2008). The project's specific FY 2005 objective was to initiate work in support of this objective using directed research activity and a workshop. Another important objective at this stage was to map out linkages with corresponding needs and activities in Hawaii and the U.S. Pacific regions.

The specific goals for the workshop were to identify capacity and needs for wave modeling in the Alaska region, stakeholder requirements, data availability, and aspects of the terrestrial zone. Given that relevant experience in many of these areas is available in various agencies, a wide range of participation was solicited from a variety of Federal, state, academic, and other research groups.

Solid links between Alaska, Hawaii, and the broader Pacific region were identified. These included:

- Aspects of a conceptual coastal dynamics model framework that can be imported and exported to various regions to build complete models at all locations;
- Partnerships with the existing Hawaii PRIDE data teams;
- Guidance from an established template outlined by the NOAA Pacific Risk Management 'Ohana (PRiMO) project (www.csc.noaa.gov/psc/FHMPPI/);
- Inclusion in the Integrated Ocean Observing System initiative;
- Identification of a denser ocean observing network in the Pacific that would greatly enhance the ability of the Global Forecast System to predict the heavy storms that start life as Pacific typhoons and then curve back to the northeast and can hit Alaska.

This material was summarized at the 2nd PRIDE workshop in Honolulu, which was held the following week. At that time, meetings were held with Hawaii representatives, and as a result of those, to further the integration of Alaska into the NOAA Pacific sphere, arrangements are being made with NOAA Hawaii to have the talks, participant lists, and other information related to the Anchorage workshop placed on a web site hosted in Hawaii.