Witness The
ARCTIC

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International Assessment Enumerates Climate Change Impacts Across the Arctic

By Robert W. Corell, Pål Prestrud, and Gunter Weller

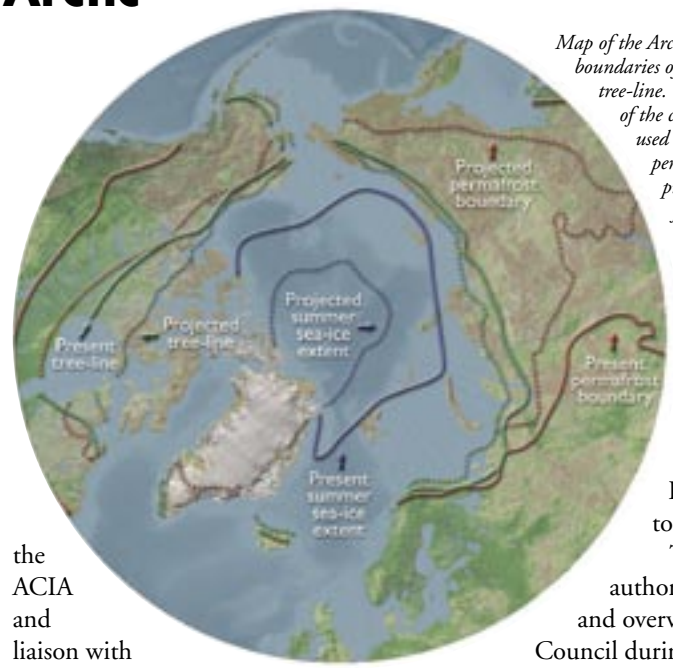
For the past four years, almost 300 scientists and experts, including elders and other insightful residents, have worked on a comprehensive analysis, synthesis, and documentation of the impacts and consequences across the Arctic of climate variability and changes, including the impacts induced by increases in ultraviolet (UV) radiation. The Arctic Council (see page 21) inaugurated the project in 2000, charging the Arctic Climate Impact Assessment (ACIA) to

- evaluate and synthesize knowledge of how climate and UV radiation have been changing in the Arctic, how they are projected to change in the future, and the likely impacts of those changes on environmental, human health, social, cultural, and economic systems; and
- provide useful information and recommendations to the governments, organizations, and peoples of the Arctic and the world to help them respond to the challenges and opportunities presented by climate change.

The Arctic Council tasked two of its working groups, the Arctic Monitoring and Assessment Programme (AMAP) and Conservation of Arctic Flora and Fauna (CAFF), to conduct the ACIA in association with the International Arctic Science Committee (IASC; see page 27). All eight of the arctic nations and the U.K. provided financial and in-kind support.

An Assessment Steering Committee (ASC), established by AMAP, CAFF, and IASC, provided overall coordination for the ACIA and liaison with relevant national and international organizations, including indigenous peoples' groups and the Intergovernmental Panel on Climate Change (IPCC). The ASC guided the development of the assessment through teams of authors, drawn from many disciplines and countries, who participated in a series of focused workshops. The assessment produced two reports:

- a scientific report, totaling over 1000 pages in 18 chapters, which was subject to a comprehensive external review by an independent group of more than 225 international scientists and other experts; and
- a 140-page overview report, designed for a broad non-scientific readership and also externally reviewed.



Map of the Arctic, showing present and future boundaries of summer sea ice, permafrost, and tree-line. The projected boundaries at the end of the century were derived from models used by the ACIA. The change in the permafrost boundary assumes that present areas of discontinuous permafrost will be free of any permafrost in the future; this is likely to occur beyond the 21st century. Figure from chapter 18 of the ACIA, courtesy G. Weller.

The ACIA reports will be used in the development of the IPCC Fourth Assessment Report, to be completed in 2007. The ACIA teams of authors submitted the scientific and overview reports to the Arctic Council during its ministerial meeting in Reykjavik, Iceland, in November 2004. Just prior to the ministerial meeting, the ACIA hosted an International Scientific Symposium in Reykjavik to examine issues connected to climate change in the circumpolar Arctic and its environmental and societal consequences, including indigenous peoples' perspectives and observations. More than 250 participants presented 150 papers and discussed the ACIA results and their background in an integrated circumpolar context and in light of global, regional, and sub-regional environmental management and policy development. Participants also identified knowledge gaps and priorities for new research and monitoring and outlined significant national, bilateral, and multilateral activities that have contributed to ACIA.

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At the ministerial meeting, the Arctic Council released a seven-page policy document responding to the ACIA findings and providing general recommendations for mitigation and adaptation measures.

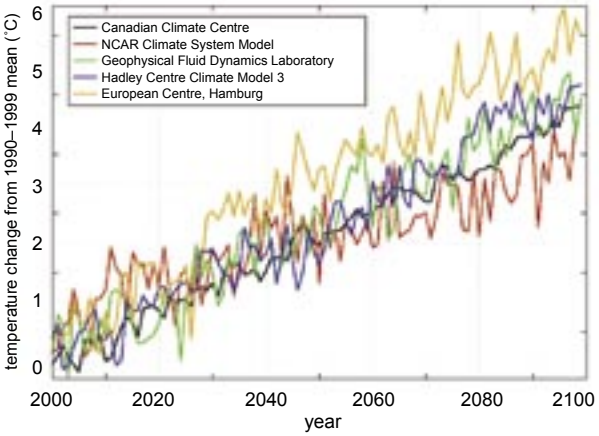
Major Findings

The ACIA details and projects significant disruptive impacts from climate change and UV radiation in the Arctic, while identifying a number of potential opportunities for indigenous and other residents, communities, economic sectors, and governments of the region. To develop its projections, the assessment used a single scenario of the future, the IPCC Special Report on Emissions Scenarios (SRES) B2 scenario. B2 is a "moderate" climate change scenario, which projects global carbon dioxide emissions more than doubling by 2100 from about six gigatons of carbon (GtC) in 1990 to about 14 GtC; under this scenario, nine Global Climate Models (GCMs) predict an average global temperature response of +2.2°C (range +0.9–+3.4°C) for the period 2071–2100 compared to 1961–1990. To provide model output specific to the ACIA, the B2 scenario was implemented on five selected GCMs (figure below). With some variation, these GCMs predict about twice as much warming in the Arctic compared to the global average over a similar time period; this result accords with other IPCC projections.

Evidence of recent warming in the Arctic includes records of increasing temperatures, melting glaciers, reductions in extent and thickness of sea ice, thawing permafrost, and rising sea level. There are regional variations and patterns within this overall trend; for example, in most places, temperatures in winter are rising more rapidly than in summer. In Alaska and western Canada, average winter temperatures have increased by as much as 3–4°C over the past 60 years, while the global average increase over the past 100 years has been only about 0.6 ± 0.2°C.

Ozone depletion in northern latitudes and the resultant changes in UV radiation have increased markedly during the past decade, with some sectors of the Arctic experiencing short-term reductions in ozone of about 20% and increases of more than 40% in incident UV radiation.

Over the past 30 years, arctic sea ice extent has decreased on average by about 10%, and this change has been 20% faster over the past two decades than over the past three decades. Arctic sea ice extent and seasonal duration are projected to decrease even more rapidly in the future, leading to seasonal opening of potentially important marine transportation routes and significant changes in albedo, cloudiness, humidity, exchanges of heat and moisture, and ocean circulation, particularly along coastlines and near ice margins. The average of the five ACIA model simulations project substantial and accelerating reductions in summertime sea ice around the entire Arctic Basin, with one model projecting an ice-free Arctic in the summer by the middle of this century. The average of the five ACIA models projects that the navigation season in the Northern Sea Route along the Eurasian coast from the Atlantic to the Bering Strait, currently 20–30 days per year, will increase to 90–100 days (150 days for ice-breaking vessels) by 2080, with one model indicating it is likely to open to this degree by mid-century. This could have important economic and political implications, increasing access to the region's resources and raising issues of sovereignty, safety, and environmental preservation.



Projections of change from the 1990–1999 mean in arctic surface air temperature from the five GCM models used by the ACIA. The region covered is from 60°N to the pole. Figure courtesy J. Walsh.

In addition, access to sea ice is critical to the survival and reproduction of many high latitude marine mammals. Scientists and arctic residents are concerned that the thinning and depletion of sea ice in the Arctic will cause the extinction of key marine mammals, including polar bear, walrus, and some species of seal. Loss of these species threatens the hunting culture of Inuit in Alaska, northern Canada, Greenland, and Chukotka, Russia.

The total land-based ice in the Arctic is estimated at 3,100,000 km^3, which corresponds to a sea-level equivalent of about 8 m. Recent studies of glaciers in Alaska already indicate an accelerated rate of melting, representing about half of the estimated loss of mass by glaciers worldwide. Over the past two decades, the melt area on the Greenland Ice Sheet has increased on average by about 0.7% per year (or about 16% from 1979–2002), with considerable interannual variation. IPCC estimated that a sustained increase in arctic temperatures of 3°C would lead to the melting of the Greenland Ice Sheet over a period of 1000 years—the ACIA models suggest that regional warming will be much higher than 3°C by the end of the 21st century.

Rising temperatures lead to taller, denser vegetation, promoting the expansion of forests into arctic tundra, and tundra into polar deserts. This change, along with rising sea levels, is projected to shrink tundra area to its lowest extent in at least the past 21,000 years, potentially reducing the breeding area for many migratory bird species and the grazing areas for animals that depend on tundra and polar desert habitats. Half the current tundra area is projected to disappear in this century. While arctic agriculture is a small industry in global terms, the region's potential for commercial crop production is projected to advance northward.

Inland peoples throughout the Arctic depend on caribou and reindeer herds, which need abundant tundra vegetation and good foraging conditions, especially during the calving season. In addition to reducing the area of tundra suitable for grazing, climate-induced changes are projected to increase incidence of freeze-thaw cycles and freezing rain, both of which prevent animals from eating iced-over vegetation. Further, migrations of other species (moose, red deer, etc.) into traditional pasturelands are likely to disturb

some populations. Although much of the redistribution of species is climate induced, the development of roadways, pipelines, and other infrastructure also contribute.

Marine fisheries are a vital part of the economy of virtually every arctic country and provide an important food source globally. Because they are largely controlled by factors such as local weather conditions, ecosystem dynamics, and management decisions, projecting the impacts of climate change on marine fish stocks is difficult. Based on available information, however, projected warming is likely to improve conditions for some important arctic fish stocks such as cod and herring, while negatively affecting others. For example, the extent of northern shrimp will probably contract, reducing the large catch (about 100,000 tons a year) currently taken from Greenlandic waters. While the total effect of climate change on fisheries will likely be less important than decisions regarding management, specific communities that are heavily dependent on fisheries may be dramatically affected.

Permafrost presently underlies most of the land surfaces in the Arctic, and thawing ground will disrupt transportation, buildings, and other infrastructure. Permafrost temperatures over most of the sub-arctic land areas have increased by up to 2°C over the past few decades, and the depth of the layer that thaws each year is increasing in many areas. Over the next century, permafrost degradation is projected over 10–20% of the present permafrost area, and the southern limit of permafrost is projected to shift northward by several hundred kilometers. Rising temperatures are already degrading land routes over frozen tundra and across ice roads and bridges, and the incidence of mud and rockslides and avalanches is likely to increase. The number of days per year in which heavy equipment travel on the tundra can be approved by the Alaska Department of Natural Resources has dropped about 50% in the past 30 years, limiting oil and gas exploration and extraction.

Across the Arctic, indigenous peoples accustomed to the wide range of natural climate variations report changes that are unique in the long experience of their peoples. Residents of the Arctic are likely to face major impacts due to climate and other environmental changes, which are occurring in the context of other interrelated changes. Environmental changes include chemical pollution, habitat destruction, and over-fishing. Social and economic changes include technological innovations, trade liberalization, urbanization, self-determination movements, and increasing tourism.

> "Nowadays snows melt earlier in the springtime. Lakes, rivers, and bogs freeze much later in the autumn. Reindeer herding becomes more difficult as the ice is weak and may give way… All sorts of unusual events have taken place. Nowadays the winters are much warmer than they used to be. Occasionally during wintertime it rains. We never expected this; we could not be ready for this. It is very strange… The cycle of the yearly calendar has been disturbed greatly and this affects the reindeer herding negatively for sure…"
>
> Larisa Avdeyeva, Lovozero, Russia, 2002

The impacts will vary with regional differences in climate change and will depend largely on the interactions among the various changes; people's resilience or vulnerability to climate change depends on the cumulative stresses to which they are subjected as well as their capacity to adapt to these changes. Individual and collective adaptive capacity is affected by political, legal, economic, social, and other factors, including age, lifestyle, gender, and access to resources. Rural arctic residents in small, isolated communities with a fragile system of support, little infrastructure, and marginal or nonexistent public health systems appear to be most vulnerable. People who depend on subsistence hunting and fishing, especially those who rely on just a few species, will be vulnerable to changes that heavily impact those species. Responses to environmental changes are multidimensional and include adjustments in hunting, herding, and fishing practices as well as alterations in the political, cultural, and spiritual aspects of life. Adaptation can involve changes in knowledge and how it is applied—for example, using new weather prediction techniques. Arctic people have historically altered their activities in response to changing conditions; they increasingly indicate, however, that the rapid rate of climate changes is limiting their capacities to adapt.

As the first comprehensive examination of climate change and its impacts in the arctic region, the ACIA represents the initiation of a process, rather than simply a set of reports. The ACIA brought together hundreds of scientists from around the world whose research focuses on the Arctic and incorporated the insights of indigenous peoples who have a long history of gathering knowledge in this region. Linking these different perspectives is an exciting process for both the science community and the residents of the Arctic, and it clearly has great potential to continue to improve understanding of climate change and its impacts.

An analysis of the knowledge gaps revealed by the ACIA suggests that three major topics should be priorities to improve future analyses:

- sub-regional impacts: assessments of climate change impacts focused on smaller regions have the greatest relevance and utility for residents;
- socioeconomic impacts: in most cases, only qualitative information on economic impacts is available; and
- assessing vulnerabilities: assessing vulnerability involves knowledge not just of the consequences of stresses and their interactions, but also of the capacity of the system to adapt.

The Arctic Council asked that ACIA continue its activities over the next decade. The ACIA executive committee will develop a proposed scope, strategy, and implementation plan for future efforts by spring 2005.

The ACIA overview report and policy document are available as PDF downloads from the AMAP web site: http://amap.no/acia; the overview report can also be ordered from Cambridge University Press: http://us.cambridge.org/titles/catalogue.asp?isbn=0521617782. The scientific report will be available in early 2005.

For more information, see the ACIA web site: www.acia.uaf.edu, or contact Robert Corell, ASC Chair (global@dmv.com), Pål Prestrud, ASC Vice Chair (pal.prestrud@cicero.uio.no), or Gunter Weller, Executive Director of the ACIA Secretariat (g.ands.weller@bigpond.com).

PRB Study Guides Design of Arctic Observing Network

The Polar Research Board (PRB; see page 20) has begun a new study, "Designing an Arctic Observing Network," sponsored by the NSF Office of Polar Programs (OPP). The two-year study, which will provide guidance in the design of an arctic land, atmosphere, and ocean observing network, is in part a response to a recommendation for such an analysis in the October 2003 report *Arctic Research Support and Logistics: Strategies and Recommendations* (see *Witness* Spring 2004).

The PRB solicited nominations for the study committee in the summer of 2004, initially appointed the 18 members (see box) in the fall, and held the first committee meeting in Washington, D.C., at the end of October. Plans include workshops in Anchorage, Alaska, on 9–11 February 2005 and in Copenhagen, Denmark, 15–17 May 2005. The committee is scheduled to report on their findings in late 2005.

The study committee will provide thoughts on the overarching philosophy and conceptual foundation for an international arctic observing network and, where possible, concrete advice to move the concept toward implementation. Specifically, the committee will:

- identify key variables that must be monitored for a comprehensive arctic observing network;
- briefly review the purposes and extent of existing and planned global observing systems and platforms, highlighting critical spatial, temporal, or disciplinary gaps of importance to the Arctic;
- describe the infrastructure needed to create a comprehensive arctic observing network, including advice on types, number, and the distribution of network components; where stations might be placed; and the role that remote sensing and novel technologies might play. This discussion will explore two levels—an "ideal" network and a "minimal" network—to help illustrate choices that may need to be made during implementation;
- comment on how to ensure sound data management in this type of network, using perspectives from data managers, those generating data, and those who use or might use the data; and
- recommend a technical strategy to ensure efficient, coordinated implementation and operation of an arctic observing network, including methods to ensure that data products from different sensors are spatially and temporally consistent, processes that could be used to design the optimal mix of observations and test for data redundancies, and approaches that could be used to keep the network current and cost effective.

The agenda of the committee's first meeting in October 2004 included:

- Tom Pyle (NSF) on NSF's motivation and expectations for the study;
- Keith Alverson, Molly McCammon, and Craig Tweedie on existing observing networks, including the Global Ocean Observing System (GOOS), Alaska Ocean Observing System (AOOS), and Circumpolar Environmental Observatory Network (CEON; see *Witness* Spring 2004);
- Terry Callaghan on observations at Abisko Scientific Research Station in arctic Sweden;
- Lars-Otto Reiersen on the Arctic Monitoring and Assessment Program (AMAP);
- Ronald Birk (NASA) on the Interagency Working Group on Earth Observations;
- Jamie Morison on proposed observing networks, including efforts related to the Study of Environmental Arctic Change (SEARCH; see page 15), the International Polar Year (IPY; see page 26), the Arctic Ocean Sciences Board (AOSB), and the Climate and Cryosphere project (CLiC); and
- Andrey Proshutinsky on NSF workshops on instrumentation for Arctic Ocean exploration and arctic observing based on ice-tethered platforms.

For more information, see the Arctic Observing Network web site: http://dels.nas.edu/prb/aon, or contact Paul Cutler (202-334-3479; fax 202-334-1477; pcutler@nas.edu).

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EarthSLOT Supplies Interactive Views of Terrain, Data

In recent years, major national and international efforts have considerably improved topographic mapping products for much of the world, but most have not included the Arctic (Nolan and Prokein, 2003). In an effort to improve the quality and accessibility of imagery and elevation data in the region, Matt Nolan of the University of Alaska Fairbanks developed an Earth Science, Logistics, and Outreach Terrainbase (EarthSLOT) as a pilot project. Funded by NSF's Arctic Research Support and Logistics program, EarthSLOT is an Internet-based system that allows users to explore the Earth interactively in 3D with high quality motion.

By visualizing digital elevation and imagery data in a format that is free and easily accessible, EarthSLOT aims to increase both the user base for such data and the demand for better products in the Arctic. EarthSLOT uses TerraExplorer software, made by Skyline Software, Inc., which allows users to

- view imagery and elevation data of various resolutions anywhere in the globe via the Internet,
- control navigation over the globe in 3D, and
- query internal or external databases that are in one of many standard formats.

The EarthSLOT web site features a global mosaic of 15 m resolution Landsat 7 imagery superimposed on 1 km resolution digital elevation models (DEMs), with NASA's Blue Marble dataset filling in several gaps in the 15 m mosaic. Several cities are augmented with data of substantially higher resolution—up to 30 cm—and most of the Kuparuk River watershed and the National Petroleum Reserve-Alaska (NPR-A) are at 2.5 m resolution. The Antarctic is overlain with a 125 m resolution mosaic of Radarsat imagery. The site also features examples of other types of earth models where shaded relief, color slices, and derived model data have been draped over topography.

While being able to "fly" around the planet in 3D via the Internet is a useful tool in itself, the real power of EarthSLOT is that scientists can superimpose their own field data on top of the earth models offered online, as well as control the links and objects that the end-user views. For instance, Nolan has posted an example from his own glacier research allowing his collaborators to visualize the locations of survey stakes, weather stations, and ice coring locations, as well as access data collected at the research sites. Users are welcome to contribute imagery and elevation data to the EarthSLOT site for public use.

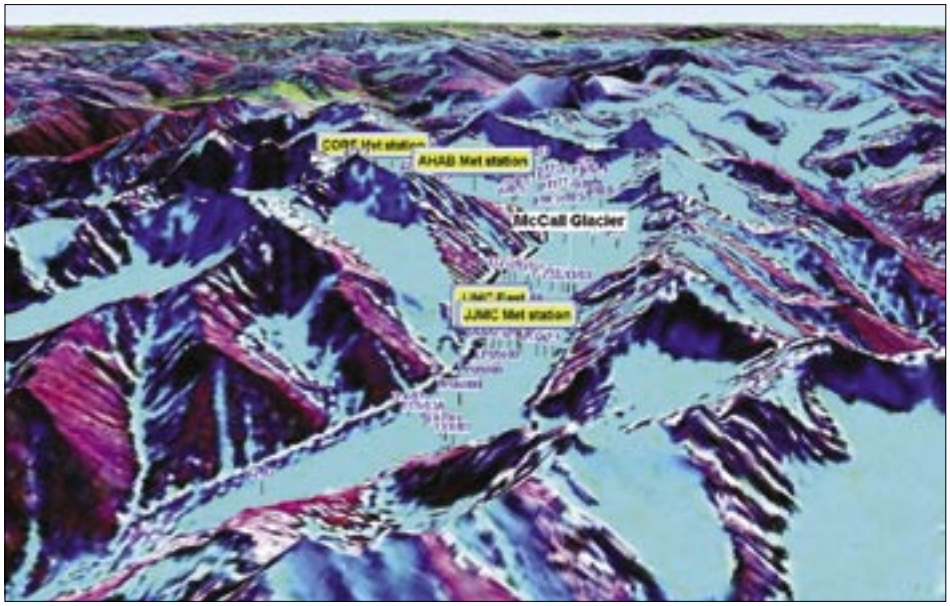
Nolan has also collaborated with other organizations to demonstrate the potential of EarthSLOT's Geographic Information System (GIS) capabilities. VECO Polar Resources incorporated their project database into the terrainbase so that users can look up an investigator's name, "fly" to one of their field locations, and view project-related background data and links for more information. Nolan is working with ARCUS to incorporate the terrainbase into the Teachers and Researchers Exploring and Collaborating program (TREC; see page 28) as a teaching resource. Participants will use movies created with EarthSLOT to better visualize arctic geography and the science based there.

Nolan expects that the inherent videogame quality of the interface combined with the high-resolution 3D imagery will attract users to the site, giving them the opportunity to learn about the Earth and current science activities. EarthSLOT will ultimately serve various earth models superimposed with different imagery, model output, or derived raster-data layers based on user needs. Nolan also is working towards incorporating ocean bathymetry in the highest resolutions available.

For more information, see the EarthSLOT web site: www.earthslot.org, or contact Matt Nolan (907-474-2467; fax 907-474-7979; matt.nolan@uaf.edu).

Reference

Nolan M. and Prokein P. 2003. Evaluation of a new DEM of the Putuligayuk Watershed for Arctic hydrological applications. In Phillips M, Springman SM, and Arenson LU (eds): *Proceedings of the 8th International Conference on Permafrost, Zurich, Switzerland, 21–25 July 2003.* Williston, VT: Ashgate Publishing Company, 1380 pp.



A screen shot from EarthSLOT showing the topography of the area around McCall Glacier in northeastern Alaska. The labels with blue text indicate the locations of survey stakes and yellow labels the locations of weather stations. Each label is hyperlinked to the actual data within the application. McCall Glacier, located in the Romanzov Mountains of the Brooks Range, has the longest history of scientific observation for any U.S. arctic glacier. The most detailed studies of the glacier began in 1957–58 as part of the International Geophysical Year and were continued by the University of Alaska Fairbanks in 1969–75 as part of the International Hydrological Decade; in the mid-1990s as part of a Ph.D. thesis; and from 2003–07 as part of the NSF ARCSS Freshwater Initiative (see Witness *Spring 2004). Image courtesy of Matt Nolan.*

GEOSummit's Year-Round Observation Program Expands

August 2004 through April 2005 marks the fifth season that station staff will "winter over" at the Greenland Environmental Observatory at Summit (GEOSummit). The station is located 3280 m above sea level on the summit of the Greenland Ice Sheet. From 1989 through 1993, this site was the location of the Greenland Ice Sheet Project Two (GISP2; see *Witness* Autumn 1998), which recovered one of the longest ice cores in the world with a continuous, detailed climate record for the past 110,000 years.

Seasonal field campaigns at the site followed to study the details of the transfer and preservation processes incorporating atmospheric compounds into ice to enable a more comprehensive analysis of the ice core record. Through these investigations it became evident that year round measurements would be required. The studies also revealed that the snowpack plays a significant role in the cycling of atmospheric compounds and does not act merely as a sink, as was earlier postulated. The unique characteristics of the station also became increasingly apparent in the years following the GISP2 drilling. Summit is the only high elevation station north of the Arctic Circle providing year round measurements of the "free" troposphere—the upper troposphere that is not directly influenced by the Earth.

To enhance access to data from this unique location, investigators who frequently used the station worked to establish Summit as an observatory. In 2003, the GEOSummit baseline measurement program was funded by NSF to provide a core set of climatic variables for investigators worldwide. The program is operated in cooperation with the National Oceanic and Atmospheric Administration (NOAA), and observatory operations are permitted by the Greenlandic Home Rule Government and the Danish Polar Centre. Currently, the suite of baseline measurements available to researchers includes:

- station meteorology,
- snow accumulation measurements from a 100-stake array and a 12 km transect,
- aerosols measured continuously with an eight-drum impactor sampler,
- weekly surface snow chemistry,
- monthly snow pit chemistry and stratigraphy, and
- filter sampled radionuclides.

NOAA Climate Monitoring and Diagnostics Laboratory (NOAA-CMDL) instrumentation is on-site to provide continuous ozone, black carbon, carbon cycle gas, and greenhouse gas sampling from a 15 m tower (see caption). Flasks are collected weekly for carbon cycle gasses, and halocarbon flasks are collected biweekly. This year, Biospherical Instruments installed two spectro-radiometers and a pyranometer as part of the NSF Office of Polar Programs UV Monitoring Network.

Geoff Phillips clears sample intake lines from one of GEOSummit's two sampling towers as the last rays of sun in 2004 light the station. Photo by John Burkhart.

In addition to baseline measurements and observatory operations, GEOSummit is an international station available for both campaigns and longer-term research. Currently, researchers from Switzerland are continuously measuring energy balance over the ice sheet on a 36 m tower, and two German projects are making seismic and stratospheric observations. In summer 2005, French researchers plan to deploy instrumentation to measure mercury. Other future projects include deployment of a multi-axis differential optical absorption spectrophotometer (MAX-DOAS) for the measurement of halogen oxides at various levels, and possibly the use of LIDAR instrumentation to measure polar mesospheric clouds (see *Witness* Spring 2002).

One asset of the station is the relative ease of access for campaign research. Logistical operations are arranged in advance by VECO Polar Resources (VPR), and investigators are typically deployed via the 109th Air National Guard Unit in Scotia, New York. Once in Greenland, scientists are flown to the GEOSummit along with their cargo. The station consists of several structures, including a 26' by 56' building that serves as a summer kitchen, dining hall, bathroom, and laundry facility; a generator module that supplies power and includes a snow melter for water production; and two connected structures that serve as a laboratory, winter kitchen and berthing area, and bath unit. During the summer field season, which extends from early April through late August, visitors sleep in unheated Arctic Ovens—tents made with sturdy frames and breathable, water resistant material. The facility can accommodate up to 50 researchers at a time for as little as a few days or up to the duration of the season.

Multidisciplinary research programs at Summit are coordinated through the Science Coordination Office (SCO), which is run cooperatively between the University of California, Merced, and the University of New Hampshire, both under contract with NSF.

For more information, see the GEOSummit web site: www.geosummit.org, or contact John Burkhart at the SCO (209-658-7142; sco@geosummit.org).

Toolik Aims for Minimal Disturbance on Research Lands

Since 1975, Toolik Field Station (TFS) has provided logistical support to investigators conducting scientific research in the Alaskan Arctic. Managed by the University of Alaska Fairbanks (UAF) through the Institute of Arctic Biology (IAB), TFS is located next to Toolik Lake at mile 284.5 on the Dalton Highway, on federal land under Bureau of Land Management (BLM) jurisdiction. In 1991, BLM recognized the importance of the research conducted at TFS and designated the Toolik Lake watershed and the nearby headwaters of the Kuparuk River as a Research Natural Area (RNA) protected from non-scientific human disturbance. There is high demand for the facility, with 5733 science days supported in 2004.

In December 2004, scientists met in an NSF-sponsored workshop to set future directions for science support at TFS. The last meeting on science planning for TFS in 1995 resulted in the publication of *Toolik Field Station, the Second 20 Years: Recommendations on the Development of Toolik Field Station* (1996, ARCUS). One goal of the 2004 meeting was to address whether, and to what extent, TFS should develop multi-use core lab facilities providing more sophisticated scientific services, and to prioritize what those facilities and services should be. Participants identified desirable goals for the station including:

- enhanced environmental monitoring that would complement data already collected by the Arctic Long Term Ecological Research program;
- improved nutrient analysis facilities and services; and
- enhanced Geographic Information System (GIS) and data management.

A white paper summarizing the recommendations of the workshop, including a prioritized plan for implementing multi-use core facilities, will be published later this year.

Development in Adjacent Areas

As plans for natural gas development on the North Slope of Alaska and construction of a natural gas pipeline appear to be moving ahead, TFS has experienced a recent increase in nearby economic development activities; station management has been working to ensure that research activities are not disturbed as a consequence.

During summer 2004, Alyeska, the Trans-Alaska Pipeline service company, located a 40-person work camp for pipeline repair at the north end of Toolik Lake on a gravel pad formerly occupied by a work camp during original pipeline construction in the 1970s. With advice from IAB, Alyeska project managers ensured that camp personnel avoided experimental sites and discharged grey water where impact to the lake was minimal. Alyeska removed the camp at the end of the 2004 season and currently has no plans to use the site in 2005. TFS management met with the Joint Pipeline Office, the Anchorage-based state and federal office that permitted the Alyeska project, to ask for early communication about any similar activities planned for the future.

State lands west of the Toolik Lake RNA have been leased for natural gas exploration to PetroCanada, Ltd. Seismic exploration is planned for the winters of 2004–05 and 2005–06. If marketable gas is found, extraction activities would not begin until 2013, and then only if a natural gas pipeline is constructed along the Dalton Highway pipeline corridor. PetroCanada has been cooperating with IAB to ensure that the access route for gas exploration and seismic activities will not impact areas where intensive research occurs.

Another issue related to TFS planning is a bill introduced by Alaska state senator Ralph Seekins (R-Fairbanks) to remove the current Alaska state prohibition on off-road vehicle travel within five miles of the Dalton Highway. If the bill becomes law, management would be given to the agencies with jurisdiction along the corridor. In the Toolik Lake area, the northern office of BLM would govern and enforce restrictions on off-road vehicle use. In February 2005, TFS managers plan to participate in a forum with state and federal agencies to discuss the best response to the bill and advocate a management plan for the RNA.

For more information, see the TFS web site: www.uaf.edu/toolik, or contact Mike Abels (907-474-5063; fnmaa@uaf.edu), Brian Barnes (ffbmb@uaf.edu), or Donie Bret-Harte (ffmsb@uaf.edu).

Healy to Join *Oden* for Beringia Expedition

With funding from NSF, the USCGC *Healy* will join the icebreaker *Oden* for the third portion of the Beringia 2005 expedition (see *Witness* Spring 2004). The expedition, planned for June–September, is organized by the Swedish Polar Research Secretariat and will include three legs supporting marine and terrestrial research.

The *Healy* will sail from Barrow and meet the *Oden* in early September on the edge of the Alpha Ridge to transit in tandem out of the basin across the North Pole. Investigators onboard the *Oden* will focus on oceanographic and biogeochemical research. Researchers on the *Healy* will concentrate on a geological and geophysical program, collecting an integrated data set consisting of multi-beam swath bathymetry and sidescan sonar, sub-bottom profiler, multi-channel seismic reflection, and seismic refraction and gravity data. These data will be supplemented by periodic cores, which will be used to create a cross-basin sedimentary transect. The cores collected during the cruise will be intensively studied for what they can reveal about the climate of the last ten thousand years. The seismic reflection and refraction data will enable study of the history of the ridges and basins that subdivide the Arctic Ocean.

As part of the Teachers and Researchers Exploring and Collaborating program (TREC; see page 28) a K–12 teacher will work with Bernard Coakley from the University of Alaska Fairbanks and Dennis Darby from Old Dominion University to investigate the largely unexplored Arctic Ocean floor and sub-bottom.

For more information, see www.polar.se/beringia, or contact Magnus Tannerfeldt (magnus.tannerfeldt@polar.se), Bernard Coakley (bernard.coakley@gi.alaska.edu), or Dennis Darby (ddarby@odu.edu).

Group Details Fluxes Through Canadian Archipelago

The two main freshwater outputs from the Arctic Ocean to the Atlantic pass through the Canadian Arctic Archipelago (CAA) and along the East Greenland Shelf. Estimates suggest that the main passages of the CAA (Nares Strait, Jones and Lancaster sounds; see map) combined carry about the same amount of freshwater as flows through Fram Strait. Nares Strait and Jones Sound carry roughly half the freshwater flux of the CAA; the other half exits through Lancaster Sound. For the first time, collaborating programs are monitoring fluxes through all these gateways simultaneously. An NSF contribution to this effort, funded through the Arctic System Science (ARCSS) Freshwater Initiative (FWI; see *Witness* Spring 2004), began in 2003 to quantify and determine driving forces of fluxes through Nares Strait and Jones Sound.

Led by Kelly Falkner of Oregon State University (OSU; see member insert) and Andreas Muenchow of the University of Delaware, "Variability and Forcing of Fluxes through Nares Strait and Jones Sound: A Freshwater Emphasis" involves Canadian collaborators from the Institute of Ocean Sciences, Meteorological Service of Canada, and Bedford Institute of Oceanography, as well as colleagues from several U.S. and Canadian universities. The project objectives include:

- monitor water properties and currents over 3.5 years in Nares and Cardigan straits and Hell Gate via mooring arrays;
- measure ice fluxes through satellite-based and moored observations;
- track remote and local forcing of throughflow via a moored pressure sensor array and mesoscale atmospheric modeling for Nares Strait;
- determine water mass origins and transformations via modern tracer hydrographic time series in the straits and northern Baffin Bay;
- explore bivalve shell records as a proxy of historical throughflow variability and retrieve sediment cores that can be used to address longer time-scale variability in future studies; and
- use the findings to improve parameterization of CAA throughflow in arctic and global models.

The project fieldwork began in 2003 aboard the USCGC *Healy* (see *Witness* Spring/Autumn 1999). Thirty-three scientists and 92 crew members sailed from St. John's, Newfoundland, via Baffin Bay and Nares Strait to the Lincoln Sea. From 21 July to 19 August, the team:

- conducted 79 casts of the CTD-rosette system to produce detailed hydrographic sections in Baffin Bay, Smith Sound, Kennedy and Robeson channels, the previously unsampled Petermann Glacier Fiord, and deep Hall Basin;
- obtained four piston cores that appear to extend to the last glacial period (more than 10,000 years ago) from off the slope of Bylot Island and a gravity core in deep Hall Basin;
- deployed 18 moorings in southern Kennedy Channel to monitor current speed and direction as well as temperature, conductivity, and ice draft;
- deployed five shallow pressure-sensing moorings at sites in Nares Strait;
- collected bivalves for a project using shell layers to reconstruct past chemical conditions in the strait;
- carried out hull-mounted Acoustic Doppler Current Profiling (ADCP) surveys at several locations;
- collected the first swath mapping data for the region via the ship's Seabeam sonar system; and
- acquired underway surface properties via the thermosalinograph system along the majority of the ship's track.

During the cruise, two teachers posted daily journal entries to the project web site, a member of the Nunavut community of Grise Fiord participated in on-board activities, and a professional photographer documented both science and the environment.

Future Analyses and Plans

The team will obtain estimates of the location, amount, and motion of sea ice from the Advance Microwave Scanning Radiometer on NASA's latest Aqua satellite platform, which can "see" the sea ice surface through clouds and during the dark winter months, and compare the satellite data with information from moorings in Nares Strait, Jones Sound, and Lancaster Sound.

Map of the Baffin Bay region. Pressure sensing moorings in blue. Main array in pink. Planned site for base camp for 2005 and 2007 aircraft operations in red. Bathymetric map from the U.S. Geological Survey Coastal and Marine Geology Program.

The steep topography rimming Nares Strait steers winds along the channel. A regional atmospheric model takes advantage of this steering effect to estimate local winds from daily analyses of the large-scale atmospheric state. Preliminary results suggest a correspondence between the estimated along-strait winds and satellite measurements of ice motion through the strait.

In conjunction with other research activities in the region, expendable CTDs are being deployed whenever possible. The project team plans to retrieve the 2003 moorings, download their data, and refurbish and redeploy them via aircraft operating out of a camp in Greenland in spring 2005, with recovery planned for spring 2007. Tentative plans include a Canadian-sponsored ship-based repeat tracer hydrographic survey in the region in 2006.

For more information, see the project web site: http://newark.cms.udel.edu/~cats, or contact Kelly Falkner (541-737-3625; kfalkner@coas.oregonstate.edu). For more information on the coordinated Canadian Archipelago to Labrador Sea efforts, see the ASOF-West web site: http://asofw.apl.washington.edu.

ARCSS Committee Advances Community Synthesis Efforts

The Arctic System Science (ARCSS) Committee (AC) is taking a proactive role in working with the research community and Neil Swanberg, the NSF ARCSS Program director, to further the overall goals of ARCSS by developing synthesis activities that

- contribute to the integration of current knowledge,
- improve our ability to predict arctic environmental change, and
- offer research opportunities for a broad spectrum of ARCSS scientists.

The past research components of ARCSS, including Land-Atmosphere-Ice Interactions (LAII), Ocean-Atmosphere-Ice Interactions (OAII), Paleoenvironmental Arctic Sciences (PARCS), and Human Dimensions of the Arctic System (HARC, see page 10), have contributed an abundance of data and have advanced knowledge of many aspects of the Arctic. Each of these efforts also have pursued community-driven synthesis and integration activities to advance system-level understanding, while targeted interdisciplinary efforts such as the Freshwater Initiative (FWI; see *Witness* Spring 2004) have focused on unifying research themes. These analysis and integration activities provide a compelling foundation for a major synthesis enterprise.

A synthesis workshop, held during summer of 2003 in Big Sky, Montana, brought arctic researchers together in an interdisciplinary mode to construct conceptual models of the entire arctic system (see *Witness* Spring 2004). Workshop participants have submitted a paper to *EOS* describing insights into the future state of the arctic system.

In early 2004, an ARCSS announcement of opportunity (AO) focused on the integration of key elements of the Land-Shelf Interactions (LSI) and Pan-Arctic Cycles, Transitions, and Sustainability (PACTS) science plans into a new three-year research focus. The resulting group of projects, the Study of the Northern Alaska Coastal System (SNACS; see page 10), focuses on the arctic coastal zone of Alaska as a locus of research that naturally integrates knowledge and provides a test bed for a true systems approach.

To further develop ARCSS synthesis strategies and conceptual models of the arctic system, a second synthesis retreat was held in summer 2004 in Lake Tahoe, California. Workshop groups discussed a model of a two-state (modern and future seasonally ice free) arctic system, and are now preparing papers and disseminating the results of this workshop.

The recent ARCSS synthesis AO ("Synthesis of Arctic System Science"; NSF 05525), announced November 2004, builds on ARCSS maturity in the disciplinary sciences and achievements in synthesis, with potential for major advances in understanding of the Arctic. The AO is available at www.nsf.gov/pubs/2005/nsf05525/nsf05525.htm. The deadline for submission is 18 March 2005.

A Developing ARCSS Structure

To support these synthesis efforts, the AC is working to develop a new well-integrated structure for the ARCSS program that will

- promote interdisciplinary research initiatives while allowing disciplinary groups to maintain community contacts;
- foster communications within the ARCSS research community;
- allow flexibility and rapid response in a difficult budget environment;
- maximize the effectiveness of ARCSS Program research; and
- enable ARCSS to work closely with other efforts, such as the Study of Environmental Arctic Change (SEARCH; see page 15).

The developing structure will be composed of "Communities of Practice," through which disciplinary and interdisciplinary groups of investigators self-organize to lead topical aspects of synthesis science coordination and planning. These groups of investigators will not be organized by formal infrastructure, membership, or duties, but will be able to receive a nominal level of support to facilitate communications, such as teleconferences, web site resources, and similar assistance from a centralized ARCSS Science Management Office (SMO). Currently at ARCUS, the ARCSS SMO will act as a conduit of communication between the broad community, the various "Communities of Practice," the AC, other programs, and NSF, as well as providing support to the AC and to the synthesis process. The new ARCSS structure will also contribute to the development of an updated ARCSS science plan in 2006. The details of this structure will be further developed over the coming months, with input and guidance from the broader community.

Tools for Community Input

A variety of community planning activities and tools are available or planned to solicit input on the developing ARCSS structure and priority needs:

- an online community feedback form for comments about proposed ARCSS structure, communication issues, and related themes is available at www.arcus.org/ARCSS/survey_feedback.html.
- an online survey on key components and processes of the arctic system and other synthesis issues is available at www.arcus.org/ARCSS/survey_synthesis.html.
- an ARCSS Program electronic listserve broadcasts announcements about research initiatives, funding opportunities, meetings, and related activities focused on the ARCSS Program. To subscribe, go to www.arcus.org/ARCSS/list/.
- a web seminar, tentatively scheduled for February 2005, will provide an open forum on any aspect of the ARCSS program planning and development.
- a community workshop with in-person and electronic participation to further develop ARCSS synthesis and program integration is in the planning stages for early Fall 2005.

More information about community activities and meetings will be announced on the ARCSS web site and through other means as details become available.

For more information, including a message from the AC with more details, background, and context, see the ARCSS web site: www.arcus.org/ARCSS, or contact Jonathan Overpeck (520-622-9065; jto@u.arizona.edu), Neil Swanberg (703-292-8029; nswanber@nsf.gov), or Helen Wiggins (907-474-1600; fax 907-474-1604; helen@arcus.org).

New ARCSS Projects Focus on Northern Alaska Coast

Lying at the intersection of the land, ocean, and atmosphere—and the locus of much human activity—the coast is a critical interface in the arctic system and an ideal test bed for tackling the kinds of complex scientific issues required to develop a true systems approach to the Arctic. In early 2004, NSF released an announcement of opportunity for the Study of the Northern Alaska Coastal System (SNACS; see *Witness* Spring 2004). The solicitation drew on two science plans from the Arctic System Science (ARCSS) research community:

- Land-Shelf Interactions (LSI; http://arctic.bio.utk.edu/screen_LSI_science_plan.pdf) and
- Pan-Arctic Cycles, Transitions, and Sustainability (PACTS; www.laii.uaf.edu/pubs/PACTS-Oct02.pdf).

The announcement defined the coastal system very broadly, from the Brooks Range to the ice edge. In response, NSF received proposals for 23 projects requesting a total of $24 million, not including logistics costs. NSF was able to fund six projects for a total of $7.27 million in FY 2005 and 2006 (see box).

To ensure a high degree of cross-project collaboration and coordination, the projects will co-locate as much as possible to investigate coastal processes, with the larger goal of understanding how interactions and linkages in all arctic coastal regions affect arctic and global systems. The SNACS investigators met in December 2004 to share plans and information and facilitate project integration.

The six SNACS projects represent a partial contribution to the interagency Study of Environmental Arctic Change (SEARCH; see page 15). All six projects have plans for substantial education and outreach components, including internships for local students, production of a children's book, and involvement of local residents.

For more information, contact Carin Ashjian (508-289-3457; fax 508-457-2134; cashjian@whoi.edu), Matthew Sturm (907-353-5183; fax 907-353-5142; msturm@crrel.usace.army.mil), or Neil Swanberg (703-292-8029; fax 703-292-9081; nswanber@nsf.gov).

SNACS Projects Funded in 2004

Environmental variability, bowhead whale distributions, and Iñupiat subsistence whaling—linkages and resilience of an Alaskan coastal system. Carin Ashjian (lead PI; Woods Hole Oceanographic Institution), Stephen Braund (SRB Associates), Robert Campbell (Univ. Rhode Island), Craig George (North Slope Borough Department of Wildlife Management), Jack Kruse, Craig Nicolson (Univ. Massachusetts Amherst), Wieslaw Maslowski (Naval Postgraduate School), Sue Moore (Univ. Washington), Stephen Okkonen (Univ. Alaska Fairbanks), Barry Sherr, Evelyn Sherr, Yvette Spitz (Oregon State Univ.) *$2,477,877*

Developing an understanding and predictive capability of the interconnections among arctic terrestrial, atmospheric, and marine systems. Walter Oechel (San Diego State Univ.), John Cassano (Univ. Colorado), Larry Hinzman (Univ. Alaska Fairbanks), John Kimball (Univ. Montana), Wieslaw Maslowski (Naval Postgraduate School) *$1,600,000*

Flux and transformation of organic carbon across the eroding coastline of northern Alaska. Chien-Lu Ping, Laodong Guo, Yuri Shur (Univ. Alaska Fairbanks), Torre Jorgenson (Alaska Biological Research, Inc.) *$988,014*

Halomethane gas exchange in northern Alaskan coastal ecosystems. Robert Rhew (Univ. California Berkeley) *$291,034*

Synthesis and scaling of hydrologic and biogeochemical data on the north slope and coastal zones of Alaska: a basis for studying climate change. Marc Stieglitz (Georgia Institute of Technology), Robert M. Holmes (Woods Hole Research Center), James McClelland, Bruce J. Peterson (Marine Biological Lab) *$677,402*

Snow and ice processes in the deposition and fate of mercury in the Arctic. Matthew Sturm, Thomas Douglas (Cold Regions Research & Engineering Lab), Joel Blum, Bjoern Klaue (Univ. Michigan Ann Arbor), William Simpson (Univ. Alaska Fairbanks) *$844,696*

HARC Office Broadens Participation

The Human Dimensions of the Arctic System (HARC), a component of the Arctic System Science Program (ARCSS), is connecting with the broader North American and global human dimensions community and bringing the results of ARCSS research into this wider forum.

Much of this work is being done by the HARC Core Office, which transferred in July 2004 from ARCUS to the Center for Global Change at the University of Alaska Fairbanks (UAF). Archaeologist and UAF associate professor of anthropology Maribeth Murray directs the core office, with guidance from a HARC steering committee, whose membership is pending ARCSS Committee approval. The core office and steering committee will work over the coming three years to integrate HARC and human dimensions research into the larger ARCSS program (see page 9).

HARC investigators presented papers at the Fifth International Congress of Arctic Social Sciences (ICASS V) meeting in May 2004 (see *Witness* Spring 2004) and at the American Association for the Advancement of Science 55th Arctic Science Conference in September 2004. Discussions at both meetings are contributing to HARC goals for improved communications with the general public and interested stakeholders.

Murray plans to participate in the Human Security and Climate Change Workshop, sponsored by the Center for International Climate and Environmental Research (CICERO) in Oslo, Norway, 21–23 June 2005. The goal is to introduce HARC research to an international forum and to connect with global change and human dimensions researchers working outside of the Arctic.

Murray and the steering committee have developed a proposal for the International Human Dimension Program (IHDP) meeting in Bonn, Germany, in October 2005. Pending acceptance, HARC will organize a session of invited papers linking human dimensions research in the Arctic to the larger IHDP framework.

For more information, contact Maribeth Murray (907-474-6751; fax 907-474-7453; ffmsm@uaf.edu).

Project Compares Quality of Benthic Food Sources

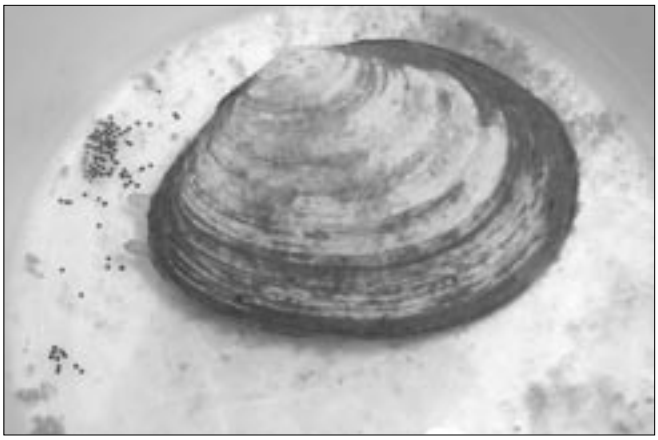
Arctic marine ecosystems include unicellular algal species that bloom in the water column (phytoplankton) and species that live in and below sea ice (ice algae). Over time, both algal types sink to the sea floor, providing food for benthic fauna, including bacteria, meiofauna (small species such as copepods and nematodes) and macrofauna (larger species such as bivalves, polychaetes, and crustaceans). The larger benthic macrofaunal species serve as important food for higher trophic levels, including several species of fish, marine mammals, and seabirds.

Recent studies show that ice algae contribute a large fraction of the annual primary productivity in ice-covered seas. If the extent and thickness of sea ice in the Arctic continue to decline, the types of algae reaching the sea floor will likely shift from a mix of ice algae and phytoplankton to phytoplankton only. If these two food sources have different digestibilities and/or nutritional values to the benthic fauna of the Arctic, then such a shift will potentially impact the food requirements of the benthos.

The NSF Arctic Natural Sciences Program and the Norwegian Research Council have funded an international team of researchers to compare the digestibility of ice algae and phytoplankton-derived organic matter. The project aims to determine if it makes a difference to arctic clams and worms if they are eating phytoplankton or ice algae. Given that ice algae usually contain higher amounts of energy-rich polyunsaturated fatty acids, perhaps ice algae are the better food source.

Lisa Clough (East Carolina University), Will Ambrose, Jr. (Bates College), Michael Carroll (Akvaplan-Niva in Tromsø, Norway), Glenn Lopez (Stonybrook University), Ming-Yi Sun (University of Georgia), and their team of graduate and undergraduate students have examined both selection and assimilation of the different food materials by individual taxa as well as by intact functioning communities. In addition, experiments in both the Norwegian Arctic (Svalbard Archipelago, Barents Sea) as well as in Alaska (Kotzebue Sound) allow the team to assess geographic differences in food sources and responses of the benthos.

Results show that the chemical composition of ice algae varies dramatically. During a May 2003 cruise near the Svalbard archipelago, very little chlorophyll-a was present in the ice algae samples despite the presence of abundant fucoxanthin (a secondary pigment). By contrast, both chlorophyll-a and fucoxanthin were abundant in the ice algae samples collected from Kotzebue, Alaska, during April 2003. Initial analysis of ice algal material from a May 2004 cruise to the Barents Sea shows it to be both chlorophyll-a and fucoxanthin rich, suggesting both a regional and a temporal component to the compositional variation of ice algae in the Arctic.



A feeding experiment with the common arctic clam Macoma calcarea. *The diffuse material in the water is phytoplankton and the dark pellets are feces. Photo by Glenn Lopez.*

The team uses both whole core and individual feeding experiments to examine the benthic organisms' response to different algal types. For the whole core experiments, they collect intact cores of sediments, fauna, and overlying water from the seafloor, then add varying amounts and types of algal materials to the cores. For individual feeding experiments, they separate the benthic macrofauna from the sediment, then feed the different macrofaunal species either ice algae or phytoplankton.

Regardless of the type and composition of the algal material added to the intact cores, the benthos responded very quickly to the added food, with active mixing of the material throughout the core within one week. In the 2003 whole core experiments, macrofauna did not appear to selectively ingest one food type relative to another, as indicated by similar losses of polyunsaturated fatty acids. A faster loss of saturated fatty acids derived from phytoplankton, however, relative to those from ice algae, implies that bacteria and meiofauna may utilize fresh phytoplankton more efficiently.

In the larger individual organism experiments, researchers used the ash ratio method to compare differences in the make-up of what is going in (the food) relative to what is coming out (the feces). In all cases, absorption efficiencies for both ice algae and phytoplankton were always above 50%. In the 2003 ash ratio experiments with the chlorophyll-a depleted ice algae and Barents Sea phytoplankton, ice algae was absorbed more efficiently than phytoplankton in five of eight cases. In the first analysis of the 2004 ash ratio experiments with chlorophyll-a replete ice algae, all cases showed more efficient digestion of ice algae. The team is still analyzing results from an extensive number of feeding experiments with fresh, frozen, and cultured ice algae and phytoplankton in both Svalbard and Alaska in the summer of 2004 to address the absorption question in more detail before drawing definite conclusions.

Clearly the species of the arctic benthos are capable of using both phytoplankton and ice algae as food sources, as is to be expected since both types of algal communities reach the seafloor. The project's early results, however, suggest that ice algae may be more digestible than phytoplankton, at least with regards to the macrofaunal community. The investigators caution extrapolating from the absorption efficiencies to assimilation efficiencies (incorporation of absorbed material into biomass) and point out that the microbial response may be different than the macrofaunal response.

For more information, contact Lisa Clough (252-328-1834; fax 252-328-4178; cloughl@mail.ecu.edu).

Cultural Differences Shape Land Claim Negotiations

Land claim negotiations between northern aboriginal people and the Government of Canada began in the early 1970s. Agreements resulting from these negotiations are redefining relations between aboriginal people and the state. Although land claim negotiations seem to be straightforward discussions about rights to land and resources, they often entail broader disagreements over cultural meanings, symbols, and processes. Government and aboriginal negotiators frequently have very different ideas about everything from how negotiations should be structured to the meanings of seemingly agreed-upon terms such as "land," "wildlife," and "heritage." Resulting misunderstandings reflect cultural differences among negotiators, and they affect the practice of negotiating and implementing land claims agreements.

In October 2003, the Government of Canada, the Yukon Territorial Government, and the Kluane First Nation (KFN) signed land and self-government agreements. Paul Nadasdy (University of Wisconsin, Madison) is studying the negotiations that led up to this accord with support from the Arctic Social Sciences Program. "A Cultural Analysis of Kluane First Nation Land Claim Negotiations, Yukon" combines participant observations and interviews, archival research, and in-depth social/linguistic analysis to examine

- different cultural understandings that various participants in the land claims process bring to the negotiating table,
- resulting cross-cultural interactions, and
- their relationship to the meanings and interpretations that ultimately become accepted and acted upon in wider political and legal contexts.

Nadasdy carried out fieldwork between August 2003 and August 2004. During that time, he was involved with KFN's Land Claims office, observing KFN's transition from an Indian Act band into a fully self-governing First Nation. He monitored several intergovernmental processes, including a formal nine-year review of existing land and self-government agreements in the Yukon. Much of the review was necessarily interpretive, as parties sought to characterize what they thought negotiators had originally intended in an effort to determine whether the parties have lived up to those intentions. Nadasdy's participation allowed him to observe the meanings different parties assigned to various provisions of the agreements.

The structure of the Yukon land claim is such that KFN's agreements are largely the same as those of other First Nation agreements that have already been in effect for ten years. Because of this, the review process enabled him to observe issues and difficulties that are likely to arise in the course of implementing KFN's agreements. For instance, one probable issue involves territorial research permitting. The additional authority KFN will have in granting applicable permits puts them in the position to compel researchers to consult with the community prior to conducting the research and to disseminate results to the community.

Meetings of the Senior Financial Arrangements Committee, a tripartite body set up under Yukon self-government agreements to monitor and periodically renegotiate the fiscal relationship between the federal government and self-governing First Nations, provided Nadasdy with an understanding of the financial relationship KFN has entered into with the federal government. Although discussions at this table were often quite technical, implicit in the talk about Gross Expenditure Bases, Own Source Revenue, and tax room were underlying assumptions about the nature of the First Nation self-government and its relationship to federal authority.

During the year, Nadasdy also conducted interviews with key negotiators and implementation officials from all three parties to the agreements to ascertain

- participants' perceptions of what took place at the negotiation table,
- the nature of their government's mandating process including the "internal negotiations" that took place within each government, and
- insight into the social relations among the negotiators.

The interviews revealed government officials' various understandings of, and approaches to, the agreements. They also illustrated how social relations, values, and practices in which these officials are enmeshed can inform and constrain the positions they can take at the table.

To reveal the historical context of the negotiations, Nadasdy conducted archival research in KFN's Land Claims Office and in the Yukon Archives. The repositories contain documentation on KFN's land claim negotiations, including drafts of agreement chapters and maps tabled by all three governments during the negotiations; minutes and materials from negotiations and caucus meetings; negotiation workplans and funding reports; and correspondence dating back through the 1970s.

KFN recorded nearly all the negotiations that led to their agreements (approximately 70 tapes recorded between 1994 and 1998), as well as other land claim related meetings in the 1970s and 1980s (20 tapes). These tapes provided a verbatim record of the conversations that took place at the negotiations, enabling Nadasdy to analyze the micro-linguistic mechanisms through which power relations manifested themselves at the negotiating table.

With his fieldwork complete, Nadasdy has begun to analyze the data. As the first detailed ethnographic study of aboriginal land claim negotiations, this project will contribute to the understanding of aboriginal-state relations not only in Canada, but wherever aboriginal peoples are engaged in land and resource disputes with the states that encompass them. Cultural misunderstandings, like those with which this project deals, can occur in any cross-cultural interaction, not only those involving aboriginal people. By exposing the ways in which cultural differences can translate into very real political problems, often without the participants even being aware of it, this project aims to provide insight on how to study cross-cultural interactions of all types and provide understanding of the mechanisms through which power is exercised in formal legal settings, especially cross-cultural ones such as international peace or trade negotiations.

For more information, contact Paul Nadasdy (608-262-2187; fax 608-265-4216; penadasdy@wisc.edu).

Mask Making Reflects History of Anaktuvuk Pass

"Masks is like gold."

—Simon Paneak
Anaktuvuk Pass, 1971

For nearly 50 years, the Nunamiut of Anaktuvuk Pass, Alaska, have made caribou skin masks destined for the tourist market. This craft might be dismissed as another example of tourist art, but closer examination points to the importance of the masks in the lives of the more than 300 Nunamiut who live in the mountains of the Brooks Range.

When caribou populations declined in 1926–27, the Nunamiut people, who are inland Iñupiat, left their traditional home in the Brooks Range and moved to the coast. Several families returned to the mountains in 1938 and established a permanent settlement at Anaktuvuk Pass in 1949. The caribou skin mask originated as a Christmas holiday gag in 1951 (Atamian, 1966). It became a saleable craft in 1956 when a villager invented a labor saving method of making masks by molding a wet caribou skin on a carved wooden mold of a human face. Anaktuvuk masks continue to be made by this method today. They are finished by sewing on hair, eyebrows, eyelashes, and a fur ruff.

By the late 1960s, mask sales provided needed income for cash-strapped villagers, and most village adults made masks. Schoolteachers introduced Halloween to villagers in the 1970s at a time when commercial Halloween masks were not available in the village store. Enterprising mask makers created original caribou skin Halloween masks for their children and later sold them. The highly individual faces of Anaktuvuk Pass masks and their unique method of construction captured the attention of tourists interested in Alaska mementos, and their subsequent popularity and success invited imitation. Other Iñupiat and even non-Iñupiat Alaska Natives from other villages began to make and sell Anaktuvuk masks. Today 16 or 17 mask makers remain in Anaktuvuk, most of them elderly.

By the 1980s, the mask had become a familiar symbol of the Nunamiut and their village. A mask face serves as the village corporation's logo, and another mask face welcomes visitors to the Simon Paneak Memorial Museum in Anaktuvuk Pass. The mask has been silk-screened onto T-shirts and jackets. School children learn its history, see the mask exhibit at the museum, and try their hands at making masks in their classes.

As villagers say, "If you want to make a mask, first you have to get a caribou." Mask making rides on the success of the fall caribou hunt, and caribou are still at the very heart of Nunamiut culture. All the raw materials from which the masks are made—caribou skins, caribou hair and hooves, arctic fox, wolf, and wolverine furs—reflect the depth and breadth of Nunamiut knowledge about the interior Alaskan Arctic and its resources.

Funded by the NSF Arctic Social Sciences program, "Faces of the Nunamiut: Tourist Art and Traditional Knowledge in Northern Alaska," is documenting the history, development, and future of mask making in Anaktuvuk Pass, its place in the local and regional tourist art market, and its relationship to Nunamiut cultural identity and traditional knowledge about arctic fauna. Anthropologist Margaret Blackman of the State University of New York (SUNY) Brockport is collaborating with James H. Barker, a professional photographer, and Grant Spearman, curator of the Simon Paneak Memorial Museum, as well as with more than a dozen mask makers who have been interviewed for this project.

This comprehensive study addresses cultural and economic aspects of mask making through

- semi-structured interviews with current mask makers, focusing on raw materials for masks, techniques of manufacture, aesthetics, marketing, and individual artist careers;
- photo and tape-recorded documentation of all steps in the mask making process;
- surveys of shops and art galleries that carry Anaktuvuk masks and interviews with owners/managers in Fairbanks and Anchorage;
- documentation of more than 100 masks from museum and personal collections and from sales venues, including

Mask maker Doris Hugo of Anaktuvuk Pass, Alaska, uses an "ikun" to remove the excess tissue from a caribou hide. The hair will also be removed using an "ulu" before the skin is formed around a wooden face mold. Photo © James H. Barker.

  information on construction, raw materials, key measurements, and record photos;
- recording of all local mask sales at the Simon Paneak Memorial Museum in Anaktuvuk Pass over a one-year period;
- apprenticeship of the PI to a mask maker to learn first hand the process of making a mask;
- follow-up interviews in 2004 with mask makers to obtain commentary on photographs of old and contemporary masks;
- documentation of an artist selling masks in Fairbanks; and
- following aftermarket sales of masks on e-Bay to determine public perception of the masks.

An amply illustrated book, *Faces of the Nunamiut*, is in the planning stages, along with a museum exhibit focusing on the many-faceted role of caribou in the lives of the Nunamiut.

For more information, contact Margaret Blackman (585-395-5705; fax 585-395-2684; mblackma@brockport.edu).

Reference

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Record Wildfires Scorch Boreal Forests in 2004

Throughout summer 2004, over six million acres burned across the state of Alaska, making it the worst fire season on record; combined federal-state firefighting costs will likely exceed $100 million. Northern Canada also experienced a severe fire season with over five million acres burned. The Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra satellite captured images indicating extensive burning in eastern Russia during 2004 as well.

Increases in fire frequency, severity, and extent in the boreal forest are consistent with current climate change projections and can affect carbon flux in the Arctic. This biome accounts for about one-third of the carbon sequestered in terrestrial ecosystems, and increased fire activity could provide a strong positive feedback on climate warming through increased atmospheric carbon dioxide concentration.

As fire scientists and natural resource managers have moved away from total suppression fire policies, they face a myriad of logistical and planning challenges. Multiple agencies must work together to coordinate support, protection responsibilities, and information. To support this coordination, the National Interagency Fire Center (NIFC) was established in 1965, evolving from efforts by the Bureau of Land Management and U.S. Forest Service to improve fire and aviation support throughout the western U.S. Today, the NIFC is the nation's primary logistical support center for wildland fire suppression, working with state and local agencies to provide a national, and increasingly international, response to wildland fire and other emergencies. The seven cooperating agencies at the NIFC include:

- Bureau of Land Management,
- Bureau of Indian Affairs,
- National Park Service,
- U.S. Fish and Wildlife Service,
- U.S. Forest Service,
- Office of Aircraft Services, and
- National Weather Service.

The center employs wildland fire experts in a wide range of fields, including fire ecology and behavior, fire weather and communication technology, and aviation.

For more information on the NIFC, see www.nifc.gov.

A complementary program, the Joint Fire Science Program (JFSP), was established in 1998 to identify the science and tools needed to address issues facing fire and fuels managers and policy makers. With an annual budget of approximately $16 million, the JFSP funds research and science application projects to help answer current fire science questions and anticipate and address questions of the near future. Also national in scope, the JFSP is possible through a partnership between

- U.S. Forest Service,
- Bureau of Indian Affairs,
- Bureau of Land Management,
- National Park Service,
- U.S. Fish and Wildlife Service, and
- U.S. Geological Survey.

Initially, Congress directed the JFSP to address issues related to wildland fuels: fuels inventory and mapping, evaluation and scheduling of fuels treatments (ways to modify fuels to reduce risk of unwanted fire), and development of protocols for monitoring and evaluation. In 2001, Congress directed the JFSP to expand research efforts in post-fire rehabilitation and stabilization, local assistance, and aircraft-based remote sensing. Research sponsored by the JFSP also investigates issues such as air quality, smoke management, and social aspects of fire and fuels management.

Of 43 research projects funded by the JFSP in FY 2004, two examined fire processes in the boreal forest. One such investigation, conducted by Roger Ottmar with the U.S. Forest Service, collected fuel consumption data and characterized smoke emissions on the 2004 Alaska wildland and prescribed fires. Data was collected from 34 sets of plots and will be used to develop and modify existing forest floor fuel consumption models and emission rate equations.

For more information on the JFSP, see http://jfsp.nifc.gov.

As a major ecological disturbance that interacts with longer-term changes in distribution and function of boreal forests, fire in high latitudes has also received attention from a scientific research perspective. In early July 1999, the University of Alaska Fairbanks (UAF) and the U.S. Forest Service, with financial support from NSF and U.S. Forest Service Research, conducted Frostfire, a high intensity landscape-scale prescribed burn, in the boreal forest of interior Alaska (see *Witness* Autumn 1998). The first landscape-scale research burn in terrain dominated by permafrost, Frostfire differed from previous experimental fires in the boreal forest because it focused on the large-scale ecological consequences of fire and took place on an NSF Long Term Ecological Research (LTER) site, enabling long-term experimentally controlled research. The primary purpose of this project was to study the effects of fire on climate change, carbon cycling, and habitat changes, as well as increase understanding of fire behavior. Over 50 research teams from the U.S., Canada, and Japan conducted experiments in the Caribou Poker Creeks Research Watershed, north of Fairbanks, Alaska.

According to UAF professor Larry Hinzman, one of the principal investigators on Frostfire, the fires of 2004 were particularly severe because they occurred late in a very dry summer when the active layer—the layer of soil above permafrost that thaws each summer—was near its seasonal maximum thickness. When most of the surface organic soil is burned, the underlying permafrost is susceptible to thermal and fluvial erosion. Frostfire was conducted under more moderate weather conditions, so the fire did not consume the organic soils in wet valleys near streams, leaving a protective buffer to eroded sediments and nutrients. In contrast, the 2004 fires even burned riparian zones, making streams vulnerable to bank erosion and sedimentation from adjacent uplands. Fires on such unprecedented scales present many new problems to private, state, and federal land managers, while also offering new research opportunities to investigators trying to understand what may be a more common occurrence under a warmer climate.

For more information on Frostfire, see www.fs.fed.us/pnw/fera/frostfire, or contact Larry Hinzman at UAF (907-474-7331, ffldh@uaf.edu).

SEARCH Leadership Reviews Progress, Outlines Plans

The Study of Environmental Arctic Change (SEARCH) Science Steering Committee (SSC) and Interagency Program Management Committee (IPMC; formerly the Interagency Working Group) met in Washington, D.C., in September 2004 to

- review developments since the SEARCH Open Science Meeting of October 2003 (see *Witness* Spring 2004);
- discuss the SEARCH panel and working group structure as well as the next steps in SEARCH implementation activities;
- plan for SEARCH participation in the International Polar Year 2007–2008 (see page 26); and
- discuss the interaction between SEARCH and its emerging international counterpart, the International Study of Arctic Change (ISAC).

The SSC selected members for the three SEARCH panels that will develop and oversee research and implementation plans for specific SEARCH activities:

- the Observing Change panel will move forward the design of the system-scale, multi-disciplinary SEARCH observing system to continue existing and initiate new critical long-term observations;
- the Understanding Change panel will plan the scientific assessment of data and models with the aim of advancing our understanding of the nature and causes of change and projecting it into the future; and
- the Responding to Change panel will incorporate and test the application of the new understanding to predicting impacts on ecosystems and societies.

The work of the panels will be complemented by ad-hoc working groups dealing with specific aspects of the three overarching tasks. The SSC, panels, and working groups will meet 23–25 May 2005 in Washington, D.C., to help prioritize the next steps of SEARCH implementation.

As part of its Forces of Change program, the Smithsonian Institution is developing a new exhibit based in part on SEARCH science. Called "The Arctic: A Friend Acting Strangely," it will open in May 2005 and run for one to two years at the National Museum of Natural History.

International Efforts

The Arctic Ocean Sciences Board (AOSB) and International Arctic Science Committee (IASC; see page 27) jointly sponsor an international SEARCH planning group, which met in April and August 2004 to draft a science overview document, building on the SEARCH science plan, outlining science objectives and content for a proposed International Study of Arctic Change (ISAC). The group submitted the document to AOSB and IASC for review and will present it at the 2005 Arctic Science Summit Week (see page 27), when a decision on how to proceed with science and implementation plans will be made.

Both U.S. SEARCH and ISAC submitted expressions of intent to participate in the International Polar Year 2007–2008 to the International Council for Science (ICSU).

The SEARCH Project Office is transitioning from the University of Washington to ARCUS. For more information, see http://psc.apl.washington.edu/search or www.arcus.org/SEARCH, or contact Peter Schlosser (845-365-8707; fax 845-365-8155; schlosser@ldeo.columbia.edu) or Neil Swanberg (703-292-8029; fax 703-292-9081; nswanber@nsf.gov).

Bering Sea Planning Efforts Advance

Recent evidence of change in Bering Sea ecosystems has raised concerns and engendered research efforts by several agencies. One of these efforts is the Bering Ecosystem Study (BEST; see *Witness* Spring 2004), initiated with support from the NSF Office of Polar Programs and developed under the auspices of SEARCH (see article this page).

The BEST Science Plan, published in October 2004 and available on the ARCUS web site: www.arcus.org/bering/science_plan.html, outlines a multi-year initiative to improve understanding of the effects of climate variability, at multiple temporal and spatial scales, on eastern Bering Sea marine ecosystems. The proposed studies focus on mechanisms and processes that determine biological production and the fate of this production as it is transferred through the ecosystem to upper-trophic-level consumers, including humans.

An Open Implementation Workshop for BEST will be held 16 May 2005, during the Global Ocean Ecosystem Dynamics (GLOBEC) Symposium on Climate Variability and Sub-arctic Marine Ecosystems in Victoria, B.C., Canada, 16–20 May 2005. The symposium will also include an Implementation Workshop for Ecosystem Studies of Sub-arctic Seas (ESSAS), a new regional program under GLOBEC. For more information, see the GLOBEC web site: www.globec.org.

To complement the BEST natural science research program, a committee is developing a social sciences research plan, with support from the NSF Arctic Social Sciences program, to investigate how humans use and organize themselves around the Bering Sea system. Capitalizing on interest in collaborations among resident communities and natural and social scientists, the committee held a community forum in March 2004 to discuss how to develop a better understanding of

- the dynamic relationships between the Bering Sea, the humans who live and work there, and their personal and cultural investments in the environment,
- their ability to contribute important knowledge about Bering Sea natural and social system dynamics, and
- scientific issues of importance to Bering Sea communities and their survival.

Implementing ideas from Bering Sea community liaisons, the committee drafted an outline of the social science plan, which is available for community comment on the ARCUS web site: www.arcus.org/bering/hbest/index.html.

For more information, see the ARCUS web site: www.arcus.org/bering, or contact George Hunt regarding BEST (949-499-7048; fax 949-824-2181; glhunt@uci.edu) or Ben Fitzhugh regarding the social sciences plan (206-543-9604; fax 206-543-3285; fitzhugh@u.washington.edu).

Arden Bement Becomes Twelfth NSF Director

On 24 November 2004, Arden L. Bement, Jr., became the twelfth director of NSF. Bement had been NSF's acting director since February 2004 (see *Witness* Spring 2004). President Bush nominated him for the permanent position in September 2004, and the Senate confirmed Bement on 20 November. The NSF director's term is for six years.

While he was acting NSF director, Bement continued to direct the National Institute of Standards and Technology (NIST), an agency of the Department of Commerce. He was appointed NIST director in 2001. His appointment as permanent NSF director coincides with his resignation as director of NIST.

Bement holds an engineer of metallurgy degree from the Colorado School of Mines, a master's degree in metallurgical engineering from the University of Idaho, a doctorate degree in metallurgical engineering from the University of Michigan, honorary doctorate degrees in engineering from Cleveland State University and the Colorado School of Mines, and an honorary doctorate degree in science from Case Western Reserve University.

Bement began his career as a research associate at General Electric (1954–65). Subsequent positions included manager, Fuels and Materials Department and the Metallurgy Research Department, Battelle Northwest Laboratories (1965–70); professor of nuclear materials, Massachusetts Institute of Technology (1970–76); director, Office of Materials Science, Defense Advanced Research Projects Agency (DARPA; 1976–79); deputy under secretary of defense for research and engineering (1979–80); and vice president of technical resources and of science and technology for TRW Inc. (1980–92).

In 1992, Bement joined Purdue University as the David A. Ross Distinguished Professor of Nuclear Engineering and head of the School of Nuclear Engineering. He also held appointments at Purdue in the schools of Materials Engineering and Electrical and Computer Engineering, as well as in the Krannert School of Management. He was director of the Midwest Superconductivity Consortium and the Consortium for the Intelligent Management of the Electrical Power Grid.

Bement served as head of NIST's Visiting Committee on Advanced Technology, the agency's primary private-sector policy adviser; as head of the advisory committee for NIST's Advanced Technology Program; and on the Board of Overseers for the Malcolm Baldrige National Quality Award.

He also served on the National Science Board (NSB) from 1989–95; chaired the Commission for Engineering and Technical Studies and the National Materials Advisory Board of the National Research Council; was a member of the Space Station Utilization Advisory Subcommittee and the Commercialization and Technology Advisory Committee for the National Aeronautics and Space Administration (NASA); and consulted for the Department of Energy's Argonne National Laboratory and the Idaho National Engineering and Environmental Laboratory.

Bement is a member of the U.S. National Academy of Engineering; has been a director of Keithley Instruments Inc. and the Lord Corp.; and was a member of the Science and Technology Advisory Committee for the Howmet Corporation, a division of ALCOA.

For more information, see the NSF web site: www.nsf.gov.

Bement on the International Polar Year (IPY)

We are especially pleased at this new opportunity, offered by IPY, to advance fundamental science alongside the mission activities of our fellow agencies. While our Office of Polar Programs would naturally take the NSF lead, a number of NSF directorates—Bio- and Geosciences, Education and Human Resources, Engineering, and Social and Behavioral Sciences—also have potential roles. Some particular areas that could serve as science foci at NSF for the International Polar Year [include]:

We have already joined with a number of our fellow agencies in the broadest effort to date to understand the Arctic, called SEARCH, the Study of Environmental Arctic Change. We are also enthusiastic about the interest on the part of the Arctic nations and the international community in transforming SEARCH into a truly international effort, under a new name: The International Study of Arctic Change.

I'll also mention the importance of studying the Arctic Ocean, its ecosystems, and the geophysics beneath. All of these are largely unexplored, yet their study will offer insight into areas ranging from life in extreme conditions to territorial claims.

Another proposed NSF focus for IPY science—in potential partnership with NASA, USGS, and other agencies—is the large ice sheets, both north and south. While we know enough to recognize that we cannot yet model their behavior, their dynamics and fate are of direct consequence to human beings around the globe.

Another high priority will be to focus genomics technology on life in the extreme conditions of polar regions. This is an area of potential collaboration with the Department of Energy. Genomic tools are coming on-line that can sample organisms directly in the natural environment and help to trace complex environmental relationships. More polar scientists need training in these technologies.

Other areas ripe for exploration in IPY include extending observations at the polar Long-term Ecological Research Sites into the winter season and performing research on arctic peoples. Additional activities could include establishing systems to record and share data around the world, exploring the Arctic Ocean's Gakkel Ridge, along with ecosystem changes in the Bering Sea.

A lasting legacy of IPY will be a portrait of the "state of the poles"—a benchmark of the atmosphere, oceans, land, and ecosystems at both ends of the globe for future studies.

—excerpted from remarks made by Dr. Bement at the International Polar Year Implementation Workshop, 8 July 2004 (see page 26). For the complete text, see www.nsf.gov/od/lpa/forum/bement/alb040708_intpolar.htm.

NSF Stresses Environmental Education, Cyberinfrastructure

In its 2003 report *Complex Environmental Systems: Synthesis for Earth, Life and Society in the 21st Century,* the NSF Advisory Committee for Environmental Research and Education (AC-ERE) stressed the need to build workforce and institutional capacity to provide quality environmental education that "is based on the natural, engineering, and social sciences, utilizes current educational technology, and prepares students for a broad array of careers." The committee anticipates that within the next few years scientists and engineers—and increasingly the general public—will be called upon to understand complex environmental systems, use advanced information technologies, and interpret results for a wide array of interested groups. At all levels, innovative approaches to education about the environment are needed to train individuals to undertake interdisciplinary, collaborative, and synthesis activities. The committee expressed special concern about the need to broaden participation in careers in environmental science and engineering. For more information and a copy of the report, see the ERE web site: www.nsf.gov/geo/ere/ereweb/index.cfm.

To begin to respond to these needs, NSF is again offering a "venture fund" for Innovation in Environmental Science and Engineering Education (EdEn) in FY 2005. Providing an internal source of matching funds for proposals that address education and training priorities in the environmental sciences, the EdEn venture fund is not a program that can be applied to directly. Proposals to existing solicitations or supplement requests should be sent to the cognizant NSF program officers, who may then enter proposals into the EdEn venture fund competition if they address EdEn venture fund priorities and review well in their respective competitions. The EdEn venture fund provides 50/50 matching funds with the cognizant program up to $75,000 for one year only.

As an example, the Alaska Lake Ice and Snow Observatory Network (ALISON) project (see page 29) received EdEn venture fund support through its proposal to the Arctic Research and Education Program in the Office of Polar Programs.

The research and education communities should be aware of this internal funding opportunity in order to address EdEn priorities in proposals to programs throughout the foundation. The EdEn venture fund will support activities that promote the education of students and the public in environmental areas, broadly defined, as well as address the special concerns outlined in the AC-ERE report. Projects supported by the venture fund must:

- enhance preparation and encourage participation of underrepresented groups in environmental education, and/or
- relate to one or more of the topical areas outlined in the AC-ERE report, and/or
- address the impact of interdisciplinarity, complexity, and collaboration on environmental education.

Some examples of appropriate activities are:

- research on the effectiveness of the environment as a teaching tool for spatial and temporal learning or for introducing complex and interdisciplinary topics into the curriculum;
- projects that enhance training and professional development of K–12 teachers;
- outreach activities, including international efforts and meetings, that utilize or encourage innovative approaches to collaboration and partnerships; and
- cross-over activities that provide environmental research experiences for educators and environmental education experiences for researchers.

For more information, contact Renée Crain in the Office of Polar Programs (703-292-8029; fax 703-292-9082; rcrain@nsf.gov) or Dave Campbell, Director's Office Staff Associate for the Environment (703-292-7981; fax 703-292-9232; dcampbel@nsf.gov).

Cyberinfrastructure and Sensors

The Arctic Sciences Section of the NSF Office of Polar Programs (OPP) includes a new emphasis area in Arctic Cyberinfrastructure and Sensors (CIS). CIS will fund research to enable development of both sensors and links in an arctic-wide network of multidisciplinary, integrated sensors, connecting to potential users via the Internet. CIS will support the research required to create new, more capable sensors of physical, biological, or chemical variables in the ocean, ice, and air, as well as the methodologies to enable such measurements to be made from fixed arrays or autonomous platforms. CIS will focus on arctic-specific issues: for example, methodologies for data transmission from under an ice pack as opposed to data transmission protocols in general.

The CIS emphasis area is closely tied to the Arctic Research Support and Logistics (RSL) Program (see pages 4–7). As a rule of thumb, CIS should receive proposals addressing research in the development of novel sensors or instruments. Conversely, proposals for long-term observations in the Arctic using more established means should be submitted to the RSL Program. Because development efforts may be a part of proposals to the other Arctic Section programs, such proposals will be jointly reviewed and may be jointly funded.

In addition to the arctic-specific CIS area, OPP is also participating in the recent solicitation for the Sensors and Sensor Networks program, released in November 2004. This multidisciplinary research activity seeks to advance fundamental knowledge in new technologies for sensors and sensor networks, and in the use of sensor data in control and decision-making across a broad range of potential applications. The proposed research must apply engineering principles to address the needs of future sensing systems, while advancing engineering knowledge.

NSF anticipates making approximately 40 awards, with anticipated funding of $20 million from the Directorate for Engineering and up to $3 million additionally from other NSF Directorates and Offices. The deadline for proposals is 3 March 2005. The complete solicitation (NSF 05-526) is available at www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05526&org=NSF.

For more information, see the NSF OPP web site: www.nsf.gov/dir/index.jsp?org=OPP, or contact Dennis Conlon (703-292-4658; fax 703-292-9082; dconlon@nsf.gov).

OPP Updates: New Arctic Solicitation, Post-docs, Guidelines

In October 2004, the Arctic Sciences Section of the NSF Office of Polar Programs (OPP) released an updated program solicitation for proposals to conduct research in the Arctic. The solicitation describes opportunities in

- Arctic Natural Sciences (see page 11),
- Arctic Social Sciences (see pages 12–13),
- Arctic System Science (see pages 8–10),
- Arctic Research Support and Logistics (see pages 4–7),
- Arctic Cyberinfrastructure and Sensors (see page 17), and
- Arctic Research and Education.

The solicitation also announced a single annual target date for proposals to all Arctic Sciences Section programs. Holding two annual competitions arbitrarily divided proposals competing for funding in a single fiscal year. The 2005 deadline was 24 January. Community interest in the timing of the deadline has led ARCUS to develop an online survey of the arctic research community to determine the best timing for an annual deadline in future years. Survey details will be forthcoming on ArcticInfo.

See the complete solicitation (NSF 05-514) at www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05514.

Polar Research Fellowships

In March 2004, the NSF Office of Polar Programs (OPP) solicited the first applications for Postdoctoral Fellowships in Polar Regions Research. This new program offers support for training and research on any aspect of scientific study of the Antarctic and/or the Arctic for a continuous period of up to 3 years. OPP received 22 applications by the June deadline.

Winners of the 2004 competition are:

Gregory A. Balco (Ph.D. 2004, University of Washington), who will work with Howard Conway at the University of Washington on glaciology and glacial geology of west Antarctica;

Nate A. Bickford (Ph.D. 2004, Arkansas State University), who will work with Brenda Norcross at the University of Alaska Fairbanks on habitat use and life history of fish in the eastern Bering Sea;

Bradley A. Buckley (Ph.D. 2003, Arizona State University), who will work at Stanford University with George Somero on the genomics of Antarctic notothenioids, a cold-tolerant group of perch-like fish;

Brook Nunn (Ph.D. 2004, University of Washington), who will work with David Goodlett at the University of Washington on the effects of iron supply on the size, composition, and bioavailability of dissolved organic carbon from *Phaeocystis antarctica,* a colonial haptophyte alga;

Matthew D. Wallenstein (Ph.D. 2004, Duke University), who will work with Josh Schimel at the University of California, Santa Barbara, on the seasonal variability of the soil microbial communities responsible for decomposition of the arctic tundra carbon pool; and

Kenia Whitehead (Ph.D. 2002, University of Washington), who will work with Nitin Baliga at the Institute of Systems Biology in Seattle, Washington, and Ferran Garcia-Pichel at Arizona State University on global patterns of gene expression and regulation in response to UV radiation and low temperature stress.

OPP anticipates hosting workshops, beginning in FY 2005, for fellows and their sponsoring scientists to

- promote the development of skills,
- facilitate connections among fellows as developing scientists and as members of the polar research and education communities,
- provide opportunities to meet NSF program officers and support staff, and
- enable participants to contribute to the development of the postdoctoral fellowship program.

The deadline for applications to the 2005 postdoctoral fellowship competition is 2 March 2005. Travel grants are available for applicants to travel to a potential host institution; grants may be submitted at any time but at least three months prior to the proposed travel.

For more information, see the complete program solicitation (NSF 04-566) at www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf04566, or contact Kathleen Flint (703-292-4426; kflint@nsf.gov) or Bernard Lettau (703-292-8030; blettau@nsf.gov).

New Research Guidelines

Because field research in the Arctic is often conducted near settlements, in areas used for subsistence harvests by local residents, or in habitat used by threatened or endangered species, it has the potential to disrupt subsistence activities or disturb federally protected species. A new set of guidelines on these issues has been developed and is available for comment. It is intended to help researchers make appropriate contacts in arctic communities and plan fieldwork in a manner that reduces potential disruptions.

The new *Guidelines for Improved Cooperation between Arctic Researchers and Northern Communities*, drafted by the Arctic Sciences Section and the Barrow Arctic Science Consortium, with input from the Alaska Eskimo Whaling Commission, North Slope Borough Department of Wildlife Management, and the Alaska Native Science Commission, have been available for community review and feedback since August 2004. The document has received many reviewer comments and will be revised in spring 2005.

The draft *Guidelines* contain:

- maps depicting areas of high use for subsistence activities,
- information about protected species,
- migration routes of some key subsistence use species,
- contact information for relevant organizations, and
- a timeline and a checklist for developing research plans.

This information should be used by researchers to improve communication with northern communities and plan research activities in keeping with the *Principles for Conduct of Research in the Arctic* (www.nsf.gov/od/opp/arctic/conduct.jsp). In addition, the *Guidelines* are intended to raise awareness of federally protected species in northern Alaska and provide information to help researchers comply with federal laws.

For more information, a copy of the *Guidelines*, or to comment on the document, see the ARCUS web site: www.arcus.org/guidelines, or contact Renée Crain (703-292-8029; rcrain@nsf.gov).

NSF Budget Down 1.9%, First Cut Since 1996

The NSF budget for FY 2005 was included in the consolidated appropriations bill drafted and approved by both Houses of Congress on 20 November 2004 and signed by the president on 8 December (P.L. 108-447). The bill cut NSF's budget by 1.9% ($105 million), bringing the new NSF budget down to $5.472 billion from its FY 2004 level of $5.577 billion. The Bush Administration had requested a 3.0% increase for NSF. This budget is far short of the $7.4 billion FY 2005 authorization signed into law in 2002 as part of a plan to double the NSF budget by FY 2007 (see *Witness* Spring 2002).

Funding for NSF's Research and Related Activities (R&RA) account declines by 0.7% ($30.8 million), from $4.251 to $4.220 billion. Most research directorates were cut from 1.5–2.0%. The Office of Polar Programs was given a budget of $347.2 million, an increase of 1.5% ($5.1 million).

The Major Research Equipment and Facilities Construction (MREFC) budget increased by 12.1% ($18.7 million). The IceCube Neutrino Detector in Antarctica received $47.6 million, considerably more than the $33.4 million requested, but the Scientific Ocean Drilling vessel (see page 24) received only $14.9 million of the $40.9 million requested. The MREFC budget requested $12 million to start the proposed National Ecological Observatory Network (NEON), but the final budget includes only $6 million in the R&RA account for NEON planning and design.

Education and Human Resources (EHR) funding declines 10.4% ($97.6 million). Congress moved funding for the Math and Science Partnerships back to its traditional home in EHR instead of the NSF proposal to move it to the R&RA account, but cut its funding from $140 million down to $80 million.

The final FY 2005 appropriation is likely to lead to far lower success rates in FY 2005 grant competitions. Even with the requested 3% increase, NSF had estimated that the overall success rate would dip to 23% in FY 2005. Among some directorates, the odds would be even lower. The Engineering Directorate expected to fund only 15% of its research grant applications, while Biological Sciences would fund fewer than one in five (19%).

The Bush Administration will release its FY 2006 budget request on 7 February 2005. For more information on the NSF FY 2005 and 2006 budgets, see the NSF Budget Division web site: www.nsf.gov/about/budget. For more information on federal support for research, see the American Association for the Advancement of Science web site: www.aaas.org/spp/rd or the American Institute of Physics web site: www.aip.org/gov/budginfo.html.

Two New Reports from U.S. Arctic Research Commission

The U.S. Arctic Research Commission (USARC) recently published two reports of interest to the U.S. and international polar community.

Climate Change, Permafrost, and Impacts on Civil Infrastructure reports the findings of a task force chartered by the USARC to identify key issues and research needs to better understand global change impacts on permafrost in the Arctic and linkages to natural and human systems. The task force of eight was composed of university scientists and engineers, a former USARC commissioner, and the USARC deputy executive director. The major topics addressed include:

- permafrost and its role in the Arctic,
- future climate change and current research initiatives,
- impacts on infrastructure in Alaska and the circumpolar north, and
- specific recommendations to federal agencies, the State of Alaska, and the National Research Council.

This publication is the first stage of a long-term USARC effort to enhance permafrost research and ensure permafrost studies are adequately addressed in all global carbon dioxide and arctic systems programs.

Advancing Oil Spill Response in Ice-Covered Waters was developed and published in collaboration with the Prince William Sound Oil Spill Recovery Institute (OSRI; see www.pws-osri.org). In anticipation of increasing navigational access to northern waters in the upcoming decades, this report identifies key programs and research and development projects that will improve the ability to respond to oil spills in ice-covered waters. The report grew out of the broad range of oil spill-related topics presented at the 2000 Alaska Clean Seas International Oil and Ice Workshop in Anchorage, Alaska. It identifies seven priority program areas:

- dispersants in ice;
- oil deflection or redirection in a broken ice field;
- remote sensing of oil under, in, among, or on top of ice;
- transferring viscous products with ice;
- chemical herders;
- capabilities of existing mechanical recovery systems; and
- simulants.

Additionally, the Commission held its 74th meeting 18–19 January 2005 in Ballston, Virginia, to discuss updates on programs and research projects affecting the U.S. Arctic and recommendations from these reports.

These reports are available on the USARC web site: www.arctic.gov. For more information, contact Garry Brass (703-525-0111; g.brass@arctic.gov).

Polar Research Board Advises Evolving Science Programs

The mission of the Polar Research Board (PRB), which is a unit of the National Academies, is to "promote excellence in polar science and advise government and the science community on issues relevant to the Arctic, Antarctic, and cold regions in general." The PRB has a variety of responsibilities, such as planning for the International Polar Year 2007–2008 (see page 26), and helping U.S. scientists engage in international activities through U.S. Committees to the International Arctic Science Committee (IASC; see page 27) and the Scientific Committee on Antarctic Research (SCAR). The main responsibility of the Board, composed of about 14 volunteer members with diverse scientific backgrounds (see box), is the design and oversight of focused studies that provide concrete advice to federal and state agencies and others with cold region interests. Each study is conducted by a specially appointed ad hoc committee, also volunteers, who gather information, deliberate, and write consensus reports with recommendations.

In recent years, the National Academies overall, and the PRB in particular, has come to play a special role in helping in the design and oversight of new or evolving science programs. By drawing on existing expertise, PRB committees can help program planners learn how other research programs handle the common tasks of requests for proposals, data management, and science advisory functions and set up sound mechanisms for operation. The Board increasingly uses a variety of outreach approaches to help new science programs identify research priorities that meet their missions and serve the needs of relevant communities. Two recent examples of this type of work have directly served northern regions.

First is the report *Elements of a Science Plan for the North Pacific Research Board* (NRC 2004), sponsored by the North Pacific Research Board (NPRB). The NPRB is custodian to 20% of the interest earned from the Environmental Improvement and Restoration Fund; in 1997, Congress dedicated these funds to research in the North Pacific Ocean, the Bering Sea, and the Arctic Ocean. Knowing that careful advance planning could increase the value of its work over time, the NPRB sought assistance to design a framework for a science plan that would help in administration and distribution of the research funds. As part of its work, the committee visited communities along the coast of Alaska and talked with residents to gain a sense of their needs for the applications of scientific research. The committee's report to the NPRB provided advice on management issues ranging from the proposal process to data management, guidance on the elements needed in a successful science plan, and specific recommendations of research themes addressing

- ecosystem states and variability;
- human impacts on the marine environment;
- economic, social, and management research; and
- forecasting and responding to environmental change.

A second report of this type is *Developing a Research and Restoration Plan for Arctic-Yukon-Kuskokwim (Western Alaska) Salmon* (2004), sponsored by the Alaska Department of Fish and Game. This committee was asked to guide expansion of a research program to improve understanding of the causes of recent declines in salmon populations in western Alaska. It, too, visited coastal communities to interact with stakeholders and resource managers. It outlined elements of a research and restoration plan for the region, including thoughts on the focus of the program, strategies for developing research themes, synthesis of prior research, and integration of the study plan with existing programs. It provided a comprehensive list of questions identified as important to stakeholders and suggestions for implementing the program.

These two reports illustrate the role of the Board in providing direct science planning advice; PRB reports, however, can address different kinds of issues and be of use to varied audiences. National Academies reports are available at www.nap.edu.

For more information, see the PRB, web site: www.national-academies.org/prb, or contact Chris Elfring (202-334-3426; fax 202-334-1477; celfring@nas.edu).

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Arctic Council Ministers Discuss Policy, Future Projects

At the fourth biennial Ministerial Meeting of the Arctic Council (see *Witness* Spring 2004) in Reykjavik, Iceland, on 24 November 2004, Iceland's Foreign Minister, David Oddson, welcomed ministers from the eight member countries of the Arctic Council and delegates of the six permanent participants that represent arctic indigenous organizations. Undersecretary of State for Global Affairs Paula J. Dobriansky led the U.S. delegation. The foreign ministers of Russia, Sweden, Finland, and Norway, the Environment Minister of Canada, and the Greenland Home Rule Minister of Finance also participated.

Presentation of the completed Arctic Climate Impact Assessment (ACIA; see page 1) and curiosity about the resulting policy recommendations attracted considerable media attention. Ministers signed the Reykjavik Declaration—which includes language on climate change in the Arctic—and approved an ACIA policy document, which is available under "What's New" on the Arctic Council web site at www.arctic-council.org. The policy document in response to the ACIA includes consensus recommendations on mitigation, adaptation, research, monitoring, and outreach.

Iceland organized the first comprehensive assessment of human conditions in the Arctic by social science experts. Oran Young of the University of the Arctic (see *Witness* Spring 2004) co-directed *The Arctic Human Development Report* with Níels Einarsson of the Stefansson Arctic Institute in Iceland. Several U.S. experts from the University of Alaska served as lead chapter authors. The report is available through the Stefansson Arctic Institute at www.svs.is. Ministers welcomed the report and directed the Council's five working groups to consider appropriate follow-up actions.

The Arctic Council's working groups reported to the ministers on a growing number of activities and outlined new strategic visions for the Council's work in marine conservation, biodiversity monitoring, and sustainable development. Ministers confirmed that the Arctic Council will provide political support for the International Polar Year (IPY; see page 26) in the Arctic and decided that the Arctic Council will develop proposals to the IPY Joint Committee. The U.S. volunteered to facilitate submission of a proposal on human health in the Arctic. Sweden will facilitate a proposal on observations and monitoring.

To reinforce the importance Iceland and the Arctic Council attach to scientific cooperation in the Arctic, Iceland also hosted Arctic Science Summit Week 2004 (see page 27), a conference on information technology, and a meeting of ministers of education and science. Kathie Olsen of the Office of Science and Technology Policy led the U.S. delegation to the latter meeting.

> "U.S. participation in the Arctic Council continues to grow along with the work. New energy and expertise is coming from the University of Alaska system, from a younger generation of Alaska natives, and wider engagement with those active in arctic science organizations. On behalf of the Department of State, I salute your contributions. They are making a difference for arctic residents and the Arctic Council."
>
> Sarah K. Brandel, U.S. Senior Arctic Official

Looking Ahead

Iceland passed the Arctic Council chair's gavel to Russian Foreign Minister Sergey Lavrov, who outlined Russia's priorities for the 2004–06 period. He noted that Russia will help assure timely completion of

- the Arctic Monitoring and Assessment Program (AMAP) Assessment of Oil and Gas Development in the Arctic,
- the work on shipping and transportation infrastructure by the Sustainable Development (SDWG) and Protection of the Arctic Marine Environment (PAME) working groups, and
- clean up under the Arctic Council Action Plan on Pollution (ACAP) of ecological "hot spots" identified by the Barents Euro-Arctic Council (see www.beac.st).

Russia plans to introduce a new focus on the prevention and management of emergencies to the Arctic Council by engaging other nations in Arctic Rescue, a program headed by the federal agency EMERCOM. Russia will chair the Emergency, Preparedness, and Response (EPPR) and Sustainable Development working groups. The chairman of the Senior Arctic Officials will be Ambassador Vitaly Churkin of the Russian Ministry of Foreign Affairs. Norway's Minister of Foreign Affairs announced Norway's willingness to assume the chair in 2006.

The U.S. will chair two of the Arctic Council's working groups during the upcoming Russian chairmanship:

- John Calder of the National Oceanic and Atmospheric Administration (NOAA) will chair AMAP and in this capacity oversee the completion of the Assessments of Oil and Gas Development and Acidification; and
- Robert Dyer of the Environmental Protection Agency (EPA) will continue as chair of ACAP.

Kenton Wohl of the U.S. Fish and Wildlife Service completed his successful two-year chairmanship of the Conservation of Arctic Flora and Fauna (CAFF) working group and passed the lead to Sweden.

Ministers approved the pilot phase of a Project Support Initiative (PSI) that will assist the council with project preparation and provide a mechanism for non-grant funding. ACAP is to work with the Initiative during the pilot phase. The Nordic Environment Finance Corporation (NEFCO) is to manage the PSI. Norway announced a substantial contribution to help start the PSI at the Ministerial Meeting.

The U.S. Department of State sponsored a workshop in January 2005 to consider the implications of climate variability, as described in the ACIA, for a number of foreign policy issues, including the availability and potential for exploitation of energy, fisheries, and other resources, access to new sea routes, new claims under the 1982 United Nations Convention on Law of the Sea (see *Witness* Spring 2004), and national security.

For more information, see the Arctic Council web site: www.arctic-council.org, or contact Sarah Brandel (202-647-3264; fax 202-647-4353; brandelsk@state.gov).

Canadian Commission Promotes Polar Studies

Established in 1991, the Canadian Polar Commission (CPC) is Canada's lead advisory agency for polar research issues and is responsible for monitoring, promoting, and disseminating polar knowledge. The Commission has been active on several fronts to facilitate greater cooperation between Canadian researchers and the international research community.

The CPC leads Canada's preparations for the International Polar Year 2007–2008 (IPY; see page 26), including the establishment of Canada's IPY Steering Committee (see box). As part of this effort, the Commission, with funding from Foreign Affairs Canada, held open sessions in northern communities including Whitehorse, Yellowknife, Kuujjuaq, Iqaluit, and Happy Valley-Goose Bay. Throughout summer 2004, these meetings

- elicited suggestions from the public and northern scholars regarding IPY planning and Canada's role, and
- gathered ideas for pan-Canadian and pan-northern projects.

The Commission also met with the United States Arctic Research Commission (USARC; see page 19) and the Arctic Institute of North America (AINA; see *Witness* Spring 2004) in Calgary, Alberta, in spring 2004 to discuss polar research issues of common interest and strategies to increase AINA's funding and profile.

In March 2004, the CPC and the Canadian Mission to the European Union jointly hosted a two-day Canada-EU Symposium in Brussels entitled "Environmental Assessment, Climate Change Research and Policy Implications in the Arctic." The symposium brought 50 climate change researchers and decision makers together to discuss arctic research issues, concerns, and opportunities in an effort to stimulate research initiatives between Canadian and EU scientists. In conjunction with the symposium, the United Nations Environment Programme (UNEP) and the European Environment Agency (EEA) released a joint report, *Arctic Environment: European Perspectives*, aimed at promoting discussion on European policy actions related to the Arctic. The report is available at: http://reports.eea.eu.int/environmental_issue_report_2004_38/en.

The Commission was also one of the organizers of the third Northern Research Forum (NRF), "The Resilient North—Human Responses to Global Change," along with the NRF Secretariat, the Government of the Northwest Territories, the City of Yellowknife, Aurora College, and the community of Rae-Edzo. During September 2004, 144 participants from nine countries met in Yellowknife to address issues that are challenging northerners' ability to adapt to change. An ongoing activity of the University of the Arctic (UArctic; see *Witness* Spring 2003), the Forum convenes biannually to stimulate discussion among members of the research community and northern stakeholders to address the problems and opportunities facing circumpolar peoples in the context of social and environmental change and economic globalization.

In September 2003, the CPC and the Canadian Committee for Antarctic Research (CCAR) held an international workshop at the University of Alberta to develop a framework for a Canadian Antarctic Research Program (CARP). "Polar Connections" was a follow-up to the CPC's paper, *Antarctic Science and Bipolar Linkages: A Strategy for Canada* (2002), which makes recommendations and outlines how Canada should go about increasing its research activities in Antarctica.

Additionally, the CPC maintains the Canadian Polar Information Network (CPIN), which is designed to make polar data and information more readily available to the Canadian public. This communication network, which includes interactive workshops and on-line discussion groups, continues to expand and is extensively used by government agencies, international groups, and non-government organizations.

For more information, see the CPC web site: www.polarcom.gc.ca, or contact John Bennett (613-943-8605; fax 613-943-8607; bennettj@polarcom.gc.ca).

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Thirteen Draft Science Plans to be Reviewed at ICARP II

The Second International Conference for Arctic Research Planning (ICARP II; see *Witness* Spring 2004) is scheduled for 10–13 November 2005 in Copenhagen, Denmark. ICARP II will guide international cooperation in the Arctic over the next 10–15 years by complementing ongoing research programs and planned initiatives, such as the International Polar Year (see page 26).

In preparation for ICARP II, over 120 scientists are contributing to the development of 13 draft research plans addressing a range of pan-arctic themes, including:

- sustainable development and arctic economies,
- indigenous peoples and change in the Arctic,
- arctic coastal processes,
- deep central basin of the Arctic Ocean,
- Arctic Ocean margins and gateways,
- arctic shelf seas,
- terrestrial cryosphere and hydrologic systems,
- terrestrial biosphere and biodiversity,
- simulating and understanding past, present, and future patterns of change,
- science in the public interest,
- vulnerability, resilience, and rapid change,
- enabling research infrastructure, and
- resources and funding to enable research.

By June 2005, the working groups will deliver the draft research plans, which will be widely circulated and then serve as the basis for discussion during ICARP II. An integrated comprehensive plan for arctic research over the next decade will also be offered for discussion.

For more information, see the ICARP II web site: www.icarp.dk, or contact Patrick Webber (517-355-1284; fax 517-432-2150; webber@msu.edu).

Program Supplies Wide Array of Long-term Buoy Data

The International Arctic Buoy Programme (IABP) maintains a network of drifting buoys throughout the central Arctic Ocean to provide meteorological and oceanographic data for real-time operational requirements and research purposes, including support to the World Climate Research Programme (WCRP) and the World Weather Watch Programme (WWW). Beginning as the Arctic Ocean Buoy Programme in 1978, the IABP was developed as a cooperative effort and is funded and managed by its participants (see box), who provide equipment, services, and program coordination, as well as funding.

Thirty-six operational buoys populate the array, which collects data on air temperature, surface pressure, and ice drift. Buoys transmit data over the ARGOS satellite communication system to be collected and quality controlled by the Polar Science Center (PSC) of the Applied Physics Laboratory, University of Washington, for use by the research community. The data are also available in near-real time over the Global Telecommunication System for use in operational modeling and forecasting.

In addition to data management and IABP coordination responsibilities, the PSC maintains the IABP web site: http://iabp.apl.washington.edu. Here, several data sets on sea level pressure, surface air temperature, ice motion, and other geophysical variables are available to the public. Also available from this site is a free CD-ROM containing buoy data and derived products from 1979 through 1999, a temperature and salinity data set from drifting buoys deployed between 1985 and 1994, GIF files graphically depicting gridded products, and a surface air temperature data set that combines data from buoys, manned drifting stations, and meteorological land stations.

The PSC portion of the IABP is funded by the U.S. Interagency Buoy Program (USIABP) and managed by the National Ice Center (NIC). The USIABP represents several U.S. entities (see box). The NIC also collaborates with Canada under the auspices of the North American Ice Service to offer a common suite of ice products and ice-related services and information to North American and international users.

For more information, see the IABP web site: http://iabp.apl.washington.edu, or contact Ignatius Rigor (206-685-2571; ignatius@apl.washington.edu).

International Arctic Buoy Programme Participants

- Alfred Wegener Institute for Polar and Marine Research—Germany
- Arctic and Antarctic Research Institute—Russia
- Chinese Arctic and Antarctic Agency
- Christian Michelsen Research—Norway
- International Arctic Research Center at the University of Alaska, Fairbanks—United States and Japan
- Japan Marine Science and Technology Center
- Marine Environmental Data Service—Canada
- Meteorological Service of Environment Canada
- National Ice Center—United States
- Naval Meteorology and Oceanography Command—United States
- Naval Oceanographic Office—United States
- Norwegian Meteorological Institute
- Norwegian Polar Institute
- Pacific Marine Environmental Laboratory—United States
- Polar Science Center, Applied Physics Laboratory, University of Washington—United States
- Service Argos—France and United States
- U.K. Meteorological Office
- United States Army, Cold Regions Research and Engineering Laboratory
- U.S. Interagency Buoy Program—including the International Arctic Research Center at the University of Alaska, Fairbanks; National Aeronautics and Space Administration; National Ice Center; National Oceanic and Atmospheric Administration; National Science Foundation; and Office of Naval Research
- Woods Hole Oceanographic Institution—United States
- World Climate Research Programme (WCRP)—International

Cooperating Nations Foster Ocean Drilling Programs

More than 30 years of scientific ocean drilling have explored the earth's geological history in increasing detail. The first effort to recover records from the global seafloor by deep ocean coring and downhole logging was the Deep Sea Drilling Project (DSDP, 1968–1983). The DSDP began as a U.S. program but quickly evolved into an international effort with five nations (France, West Germany, Japan, U.K., and U.S.S.R.) partnering in funding and decision-making through the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). As the DSDP drillship *Glomar Challenger* reached the end of its useful life, the DSDP evolved into the Ocean Drilling Program (ODP, 1985–2003) with the commissioning of the *JOIDES Resolution*. Twenty-three nations contributed to the ODP, with more than half of the funding from the U.S.

Integrated Ocean Drilling Program

A new international ocean drilling program began on 1 October 2003. The Integrated Ocean Drilling Program (IODP) is co-led by NSF and the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT), each of which will contribute about $500 million to IODP over its ten-year span. Significant scientific and financial participation is also provided by the European Consortium for Ocean Research Drilling (ECORD) and China.

More than 600 scientists contributed to the development of the IODP initial science plan, available on the IODP web site (www.iodp.org), which identifies three areas of initial emphasis: the deep biosphere and sub-seafloor ocean, the processes and effects of environmental change, and solid earth cycles and geodynamics.

Like DSDP and ODP, IODP expeditions are proposal-driven and planned after extensive scientific and safety review. The IODP differs from its predecessors, however, in using three types of drilling vessels, each provided by an IODP partner:

- a heavy riser vessel for drilling deep sedimentary and crustal holes, contributed by Japan;
- a lighter riserless vessel to provide widely distributed arrays of high resolution cores to address climate, environmental, and observatory objectives, contributed by the U.S.; and
- occasional use of mission-specific platforms, contributed by ECORD, for projects that cannot be undertaken by the two primary vessels.

Japan, led by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), constructed a new platform for IODP, the *Chikyu*, a 210 m long riser vessel launched in 2002. The riser, a metal tube extending from the seafloor to the vessel, contains a device to prevent blow-out, which allows for drilling in areas with hydrocarbon potential. It uses drilling mud rather than seawater as a drilling fluid, which is advantageous in unstable holes or areas with slow penetration. A riser vessel can drill deep into the crust at both passive and convergent margins. Riser technology will allow long-term expeditions in areas previously inaccessible to scientific ocean drilling. The *Chikyu* eventually will have a 12 km drill string for coring in water depths up to 4 km. Still undergoing outfitting and testing, she will begin expeditions in 2007.

The U.S.—through the alliance of the Joint Oceanographic Institutions (JOI), Lamont-Doherty Earth Observatory of Columbia University, and Texas A&M University—operates a riserless drillship for IODP. For the first phase of IODP, it will be the same vessel used in ODP—the *JOIDES Resolution*, which will conduct five expeditions in 2004–2005 before an approximate year-long hiatus in drilling. During this time, a vessel (the *Resolution* or a similar vessel) will be converted to meet the long-term needs of IODP. Riserless expeditions will resume on the upgraded ship in mid-2006. Riserless drilling is effective in moderate to deep water and allows sampling in most of the world's oceans.

Fourteen European countries comprise the ECORD, which operates mission-specific expeditions to carry out high-priority research that cannot be served by the other platforms, particularly in shallow waters and ice-covered regions. The Arctic Coring Expedition (ACEX; see page 25) is the first IODP mission-specific platform operation. The ACEX is operated by the ECORD Science Operator (ESO), in cooperation with the Swedish Polar Research Secretariat (SPRS). The next mission-specific expedition will work in the Tahiti/Great Barrier Reef area in 2005.

The IODP held a town meeting in December 2004 in association with the American Geophysical Union (AGU) fall meeting in San Francisco.

For more information, see the IODP web site: www.iodp.org, or contact Nancy Light (202-465-7500; fax 202-955-8363; nlight@iodp.org).

Arctic Programs and Plans

Since the early 1990s, the Nansen Arctic Drilling (NAD) Program has led the development of plans to study the Arctic's geological evolution and past environmental change. NAD is an international research effort funded by contributions from member nations; JOI serves as the NAD secretariat.

Several reports (see References) outline key scientific questions requiring at least a decade of dedicated arctic scientific drilling and a long-term funding commitment. NAD is supporting the development of a proposal to drill in the Chukchi borderland region. For more information, contact Bernard Coakley, chair of NAD (907-474-7565; fax: 907-474-5163; bernard.coakley@gi.alaska.edu).

The European Polar Board has begun planning for a new research icebreaker with a deep-drilling capability that would contribute to IODP. The science plan for this effort is available at www.ecord.org/about/j/AB-science.pdf. For more information, contact Jörn Thiede (jthiede@awi-bremerhaven.de).

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International Team Cores Lomonosov Ridge Sediments

The sediments from the top of the Lomonosov Ridge contain a climate record dating back more than 50 million years. The paleosciences community has been interested in drilling in this area for a number of years to gather direct evidence of past climate fluctuations, but were unable to arrange commitments to meet the daunting logistical challenges. Among other difficulties, drilling operations would require a ship to hold its position in the moving ice sheets of the Arctic Ocean at a point only 250 km from the North Pole, while drilling into a ridge that is 800 m below sea level at its shallowest point. In 2003, however, the new Integrated Ocean Drilling Program (IODP; see page 24) implemented a multiple drilling platform approach, including mission-specific platforms for areas inaccessible to other drillships. In the first project under this new approach, the European Consortium for Ocean Research Drilling (ECORD; the IODP partner providing mission-specific platforms) devised a plan to drill the Lomonosov Ridge.

In August 2004, three icebreakers met at the ice edge northwest of Franz Josef Land to begin this project, known as the Arctic Coring Expedition (ACEX). The $12.5 million ACEX expedition involved over 200 people, including scientists, technicians, crew, and educators (see page 30), and recovered hundreds of meters of core from the seafloor. The 34 ACEX investigators on- and off-shore represent 27 institutions (seven U.S. institutions, seven Japanese, five U.K., two French, and one each from Sweden, Norway, the Netherlands, Russia, Italy, and Germany). The ACEX project was funded by NSF, ECORD, the Japanese Ministry of Education, Culture, Sports and Technology, and the Chinese Ministry of Science and Technology.

At the drill site, temperatures hovered between 0° and -11°C, and ice floes of 1–3 m blanketed over 90% of the ocean surface. The ice drifted at speeds of up to 0.3 knots and changed direction with little warning. Specially converted for this expedition, the Swedish coring icebreaker *Vidar Viking* undertook the drilling, suspending over 1600 m of core pipe through the water column and into the underlying sediments. The two other icebreakers, the Russian nuclear vessel *Sovetskiy Soyuz* and the Swedish diesel-electric *Oden*, protected *Viking* by circling "upstream" in the ice, breaking the floes into pieces too small to dislodge her from within a 40 m radius from a fixed position.

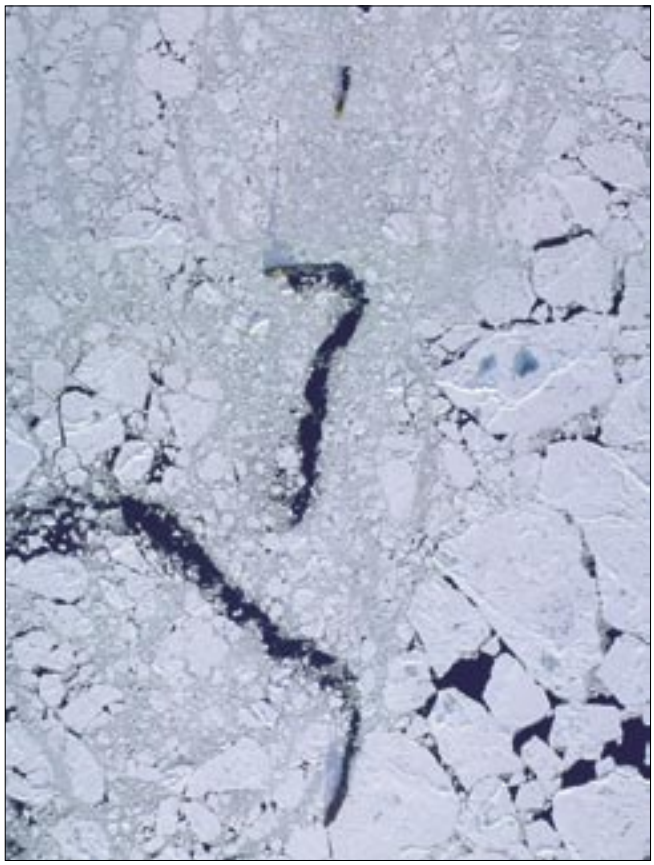
Despite thick and pervasive ice cover, the fleet and ice management teams successfully enabled the coring crew to recover cores from three holes that extended as deep as 430 m beneath the seafloor, in water depths as great as 1300 m. Ice conditions became unmanageable only twice, forcing the fleet to retrieve the pipe and move away until conditions improved.

Early results reveal that the upper sediments indicate the presence of sea ice in the Arctic Ocean over at least the past 15 million years. In older underlying cores, dark organic-rich sediments contain abundant remains of plants and algae, including diatoms, silicoflagellates, and dinoflagellate cysts. These sediments are about 45 to 50 million years old and indicate an environment characterized by ice-free, warmer surface ocean waters. Within these sediments, a zone contained massive concentrations of megaspores of the hydropterid fern *Azolla*, which resembles duckweed. Similar findings, dated to 49.3 million years ago, have been reported from many sites in the higher latitudes of the northern hemisphere and suggest a widespread freshwater environment in the region at that time.

Still deeper, the team found direct evidence that the North Pole was unequivocally ice-free and much warmer 55 million years ago during an episode of global warming. These deep sediments contain microfossils of marine plants, algae, and animals consistent with subtropical, shallow seas, as well as a mass extinction event. Geologists refer to this interval as the "Paleocene–Eocene Thermal Maximum." This brief period of extreme warmth coincided with massive input of carbon to sea and air that has been attributed to the dissociation of large deposits of gas hydrates (frozen methane within the seabed). This discovery indicates that the arctic surface ocean was warmer, somewhere around 20°C, whereas today it is usually no warmer than -1.5°C and generally covered by ice at least 1 m thick.

The cores have been transferred to a repository at the University of Bremen, Germany, where the science team will study them in detail.

For more information, see the ACEX web site: www.iodp.de, or contact Kate Moran (401-874-6421; kate.moran@uri.edu) or John Farrell (401-874-6561; jfarrell@gso.uri.edu).



Drillsite overview from 3300 m, showing the coring ship Vidar Viking *on station (at the top of the picture). Below,* Oden *keeps the waters clear of ice floes, and at the bottom, the* Sovetskiy Soyuz *breaks up the larger floes moving towards the coring site. Photo by Per Frejvall.*

Impetus Builds for International Polar Year 2007–2008

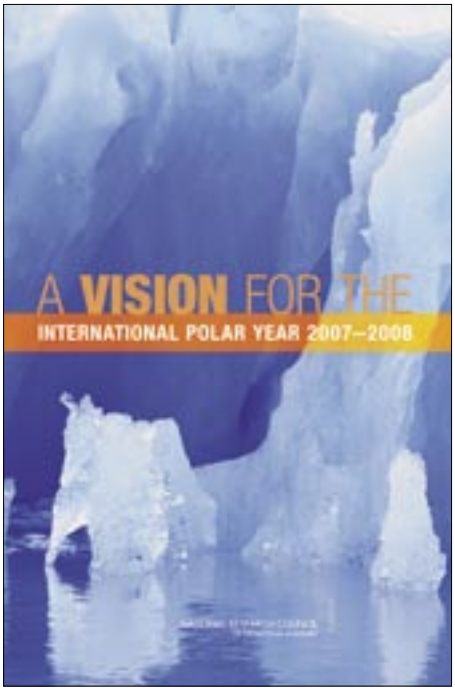
The International Polar Year (IPY) 2007–2008 will be an internationally coordinated campaign of polar observations, research, and analysis designed to further understanding of physical and social processes in the polar regions, examine their globally-connected role in the climate system, and establish research infrastructure for the future (see *Witness* Spring 2004). Building on and enhancing existing relevant initiatives, the IPY will stimulate new and innovative observations and research, as well as attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues. The official period of the IPY will be from March 2007 through March 2009 to allow observations during all seasons and the possibility of two summer field seasons in both the Arctic and the Antarctic.

International Efforts

The International Council for Science (ICSU) formed an International Planning Group in May 2003 to establish the characteristics defining the Polar Year and produce an initial Outline Science Plan as well as recommendations for an implementation strategy, including outreach and education elements. The Planning Group completed its work in September 2004 and was succeeded by an IPY Joint Committee (JC) and an International Programme Office established by the ICSU and the World Meteorological Organization (WMO). The Joint Committee will be responsible for scientific planning, coordination, guidance, and oversight of the IPY. In conjunction with the WMO, the International Programme Office will support the IPY JC. Nearly 20 nations have formally declared the intent to participate by forming national committees, and several more have contributed as points of contact.

U.S. Efforts

In the summer of 2003, the National Academies' Polar Research Board (PRB; see page 20) established the U.S. National Committee for the International Polar Year to outline a framework for U.S. participation in IPY. The committee authored a report, *A Vision for the International Polar Year 2007–2008* (NRC, 2004), that identified five scientific challenges for the IPY:



The U.S. National Committee released A Vision for the International Polar Year 2007–2008 *in October 2004. The report presents an overview of potential science themes, enabling technologies, and public outreach activities for IPY 2007–2008.*

- assess large-scale environmental and social change in the polar regions, with questions looking at both the physical and human dimensions of change and its impact;
- conduct scientific exploration of polar regions to answer important geological, climatological, glaciological, and biological questions;
- create internationally coordinated observing networks in the polar regions to better describe the environmental state;
- increase understanding of human-environment dynamics in a region where the connections are intimate and where the impacts of change are clear; and
- create new connections between science and the public using these regions that are inherently intriguing.

This report is now available in hardcopy from the National Academy Press and in PDF format at http://books.nap.edu/catalog/11013.html.

To further IPY planning, the PRB also organized a two-day workshop in July 2004 in Washington, D.C., aimed at furthering IPY discussions between the National Academy of Sciences and U.S. federal agencies. The workshop, attended by 47 agency representatives and scientists, focused on how the U.S. might address the scientific challenges outlined above and develop a suite of coordinated scientific activities consistent with international interests. Agencies represented included:

- The National Academies,
- National Science Foundation,
- Department of Homeland Security/ U.S. Coast Guard,
- Department of Energy,
- Environmental Protection Agency,
- Department of Interior/U.S. Geological Survey,
- Department of Defense/Arctic Submarine Lab,
- National Oceanic and Atmospheric Administration,
- State Department,
- Smithsonian Institution,
- National Aeronautics and Space Administration,
- National Institutes of Health,
- Office of Science and Technology Policy, and
- the Department of Defense/Office of Naval Research.

The workshop was organized around three main sessions:

- opening agency remarks in the context of current understanding of international interests,
- discussion on possible U.S. and international IPY science and technology initiatives, and
- discussion of IPY implementation and next steps.

Print copies of the workshop report are available from the National Academy Press, and PDF copies are available at http://us-ipy.org/download/ipy_workshop.pdf.

For more information, see the U.S. National Committee for the IPY web site: http://us-ipy.org, the ICSU web site: www.ipy.org, or contact Chris Elfring (202-334-3479; fax 202-334-1477; celfring@nas.edu).

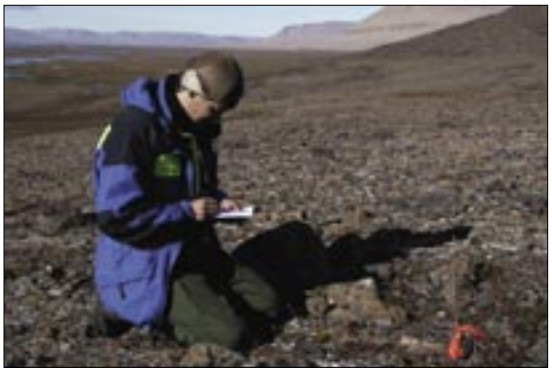
International Effort Launches Arctic Biodiversity Initiative

A growing research topic in ecosystems ecology investigates the relationship between biodiversity and ecosystem function, motivated in part by the rapid increase in rates of global species extinctions associated with human activities, as well as by the importance of vegetation in global biogeochemical cycling and radiation balance. Most experimental investigations of these relationships have focused on temperate ecosystems, often in an agricultural context or in artificial environments. In arctic ecosystems, however, the relationships between biodiversity and function remain largely unknown; arctic systems are often described as "simple" due to low species richness within selected taxa. In some arctic species, however, climatic variation or geographic isolation have resulted in significant genetic variation within species.

To advance understanding of the causes and consequences of changing biodiversity in arctic and alpine terrestrial ecosystems, the International Arctic Science Committee (IASC) added the Circum-Arctic Terrestrial Biodiversity (CAT-B) initiative to its project catalog in 2003. The broad goal of the CAT-B initiative is to quantify and understand the role of biodiversity in arctic and alpine ecosystems and to evaluate threats to biodiversity. Through the formation of a multinational, circumarctic, integrated, and standardized research network, CAT-B will aim to:

- identify relevant drivers of change across contrasting regional/local settings;
- develop monitoring strategies;
- conduct a variety of intra- and inter-site experiments and meta-analyses;
- predict the potential impact of changes in biodiversity on ecosystem function and feedback processes; and
- provide products to user groups such as global change modelers, the remote sensing research community, educators, industry, local communities, conservation organizations, and planners.

The CAT-B initiative builds on the results of several international programs in tundra ecology, including the International Tundra Experiment (ITEX), which began in 1990 (see *Witness* Winter 2000/2001), and the Arctic Biodiversity theme of the IASC Feedbacks on Arctic Terrestrial Ecosystems (D-FATE) project, which began in 1995 (see *Witness* Spring 2003).



Martin Westberg, a lichenologist at Lund University, Sweden, records species diversity at Croker Bay on Devon Island during the Tundra Northwest Expedition 1999. Photograph by Ulf Molau.

At CAT-B sites, investigators plan to quantify the relationship between plant diversity and net primary productivity (NPP) of experimental plots, as well as the chemical composition of both living plant tissues and detritus on a species- and tissue-specific basis. Quantifying the relationships between NPP, resource quantity and quality for other trophic levels in the system (herbivores and decomposers), and other key ecosystem processes (such as soil respiration, net ecosystem production, nutrient mineralization, and methane flux) provides the basic information for understanding system responses to change. Against this background of within- and between-site variations in biodiversity-NPP relationships, experimental and monitoring work at each site could include:

- manipulation of biodiversity (e.g., removal/addition of specific plant, herbivore, or soil microbial taxa);
- imposition of a suite of physical, chemical, or biological disturbance regimes; and
- manipulation of climatic drivers (such as snow depth, insolation, or air temperature), atmospheric chemistry (CO_2 concentrations, deposition of airborne nitrogen and sulfur-containing pollutants), and fluxes of UV-B radiation.

The CAT-B initiative has held two international meetings in Uppsala, Sweden, in November 2003 and May 2004 with a total of 38 participants from 12 countries (including all of the arctic nations) to develop a set of coordinated research proposals capable of attracting national and international funding. Participants agreed that CAT-B should embrace all levels in the hierarchy of biological diversity, from genes to ecosystems, but identified food webs, functional groups of organisms, and trophic cascades as the key themes for initial development. These themes form the basis of research proposals to the European Science Foundation (ESF) and the European Union (EU) Marie Curie Actions; in due course CAT-B plans for parallel projects to be launched in North America. The plans, composition, and activities of CAT-B will continue to evolve and expand to reflect changing research priorities and developing links with user groups.

The next CAT-B meeting is tentatively planned for 4–6 May 2005 in Stirling, Scotland, U.K. For more information, see the IASC web site: www.iasc.no, or contact CAT-B coordinator Philip Wookey (+44-1786-467804; fax +44-1786-467843; philip.wookey@stir.ac.uk).

Arctic Science Summit Week 2005 in China

Arctic Science Summit Week (ASSW) is an annual event organized by the major international arctic research organizations, led by the International Arctic Science Committee (IASC). The seventh ASSW will be held 17–24 April 2005 in Kunming, in the Yunnan province of China, hosted by the Chinese Arctic and Antarctic Administration.

Each ASSW includes the annual meetings of the participating organizations, as well as a Project Day and a Science Day, which bring issues of general interest to the participants. For more information, see the IASC web site: www.iasc.no, or the ASSW 2005 web site: www.chinare.gov.cn/artic/index.htm.

CIRES Infrastructure Facilitates Science Education

The Cooperative Institute for Research in Environmental Sciences (CIRES; see *Witness* Winter 2000/2001) is jointly sponsored by the University of Colorado at Boulder and NOAA's Office of Oceanic and Atmospheric Research. With organizational support from the University and major financial support from NOAA, institute scientists collaborate in research programs aimed at understanding basic and applied problems in the physics and chemistry of the atmosphere, cryosphere, oceans, and solid earth.

The CIRES K–12 Education and Public Outreach Program complements the institute's research efforts, using them as a resource to educate people about the earth and environmental science issues. Combining rigorous science with innovative teaching practices, ongoing projects include:

- classroom and prospective teacher professional development,
- volunteer opportunities for scientists,
- education components for research projects,
- district partnerships, and
- research mentors for high school students.

CIRES Outreach also hosts workshops and classes promoting science in the classroom. At the 2003 and 2004 AGU meetings, Sandra Laursen and Lesley Smith, outreach scientists from CIRES, led workshops focused on scientific inquiry in the classroom. Aimed at scientists interested in contributing to K–12 activities, the workshops illustrated how scientists' understanding of scientific inquiry can benefit schoolchildren, and provided participants with an introduction to national standards for inquiry-based science education and hands-on examples of how inquiry might look in the classroom. CIRES Outreach will continue to offer this workshop through support from an NSF Geoscience Education award.

For more information on CIRES Outreach, see: http://cires.colorado.edu/~k12, or contact Susan Buhr (303-492-5657; sbuhr@cires.colorado.edu), or Sandra Laursen (303-492-5431; sandra.laursen@colorado.edu).

From Toolik to Svalbard, Teachers Experience Field Research

"I don't think I have ever seen my three classes so motivated and enthusiastic about a unit. I have enjoyed every minute of teaching it. I don't know if it is because they are connected to my experience in Siberia last year, just ready to learn this stuff, or if my excitement is contagious."

—Amy Clapp
2004 TREC Teacher

In Teachers and Researchers Exploring and Collaborating (TREC; see *Witness* Spring 2004), K–12 teachers participate in arctic field projects, working closely with researchers to improve science education through experiences in scientific inquiry. TREC builds on the scientific and cultural opportunities of the Arctic to link research and education through topics that naturally engage students and the wider public. In addition to arctic field research experiences, TREC supports teacher professional development and a sustained community of teachers, scientists, and the public through workshops, Internet seminars, an e-mail listserve, and teacher peer groups.

In summer 2004, the first season of TREC, arctic field projects included:

- Snow Photochemistry—Summit, Greenland;
- Biogeochemical Fluxes in the Largest Arctic Rivers—Lena River, Siberia;
- Arctic System Science Shelf-Basin Interactions—USCGC *Healy*, Arctic Ocean;
- Models for the Arctic Tundra—Toolik Field Station, Alaska;
- Diversity in Tundra Ecosystems—Toolik Field Station, Alaska;
- Organic Pollutants and Dissolved Organic Matter—Toolik Field Station, Alaska;
- Macroinvertebrate Survey—Caribou Poker Creek, Alaska;
- Biocomplexity of Frost-Boil Ecosystems—Prince Patrick Island, Canada;
- CO_2 Flux in the Alaskan Arctic—North Slope, Alaska; and
- Holocene Climate Change—Svalbard, Norway.

While in the field, teachers and researchers communicated extensively with their colleagues, communities, and approximately 500 students of all ages in over 20 classrooms, using a variety of tools including satellite phones, online journals, and interactive "webinars" (web-based seminars). Researchers interacted with students during visits to schools before and after the field experience. The online outreach elements of the project also conveyed these experiences to a broad audience far beyond the classrooms of the TREC teachers. The web site "Virtual Base Camp" has been viewed over 250,000 times by visitors sharing information and interacting with teachers, researchers, and students. Viewers accessed a total of 1,100 journal entries describing daily activities and project details along with more than 1,300 accompanying photos. Additionally, media coverage about TREC projects reached an extensive national and international audience. Teachers and researchers are now collaborating to develop classroom activities and curriculum.

Plans are underway for the 2005 season. Ninety teachers, from schools with a wide range of demographics, responded to the nationwide search. Successful applicants will be paired with scientists for arctic fieldwork. This season, classrooms and the general public are again encouraged to participate "virtually" through online message boards, photo albums, Internet "webinar" presentations, and online learning and teaching resources.

Funding for TREC is provided by the NSF Office of Polar Programs, and administered by ARCUS with logistical support from VECO Polar Resources.

For more information, see the TREC web site: www.arcus.org/trec, or contact Helen Wiggins at ARCUS (907-474-1600; fax 907-474-1604; helen@arcus.org).

Students Fill Gaps in Lake Ice Observations

Lake ice is a sensitive indicator of climate variability and change. The duration of the ice cover, defined by freeze-up in the autumn and break-up in the spring, has been declining on northern lakes and rivers since at least the mid-19th century (Magnuson et al., 2000), but data in Alaska on the spatial and temporal variability of lake ice duration and other measures, including ice thickness and conductive heat flow, are relatively sparse. Ice thickness represents the integrated effects of air temperature and precipitation on ice growth during the course of the winter; the conductive heat flow through the ice and snow as ice grows dominates the winter surface energy balance. At a time when other components of the cryosphere such as snow, glaciers, sea ice, and permafrost are undergoing rapid change, the lack of detailed data on lake ice is a significant gap in knowledge.

Across Alaska, K–12 teachers and students are helping improve that situation by participating in the Alaska Lake Ice and Snow Observatory Network (ALISON). In winter 2003–04, over 200 students and their teachers measured ice thickness and the depth, density, and temperature of the snow on the ice. They derived the conductive heat flow at frozen lakes and ponds at ten different locations in Alaska and provided their data to university researchers.

Designed to engage K–12 students and teachers as scientists, ALISON partners participants with a scientist, Martin Jeffries of the University of Alaska Fairbanks, and a science educator, Delena Norris-Tull of the University of Montana Western, to

- support teacher professional development and student learning in a local context through the study of snow and ice—abundant and familiar materials; and
- create scientifically valuable data documenting the lake ice and conductive heat flow variability in Alaska, which can be used for evaluating the performance of numerical models of past, contemporary, and future lake ice and heat flow variability.

Jeffries has been investigating the growth, thickness, conductive heat flow, and duration of the ice cover on ponds near Poker Flat Research Range in central Alaska each winter since 1999–2000. When teachers Marge Porter (Somers High School, Somers, CT) and Shannon Graham (Washington School for the Deaf, Vancouver, WA) joined the project, as part of the Teachers Experiencing the Arctic and Antarctic Program (TEA; see *Witness* Spring 2003), they encouraged Jeffries to add a science education component with teachers and students making lake ice and snow measurements in other Alaska climate zones.

The first ALISON study sites in winter 2002–03 were launched at Barrow, Nome, Shageluk, Wasilla, Fairbanks, and Amos Lakes. In winter 2003–04 Healy, Mentasta, Minto, Seward, and Wales joined the project. Plans for winter 2004–05 include additional observatories at Huslia, Willow, Sterling, and Kenai.

Jeffries and Norris-Tull visit each location in the fall to provide equipment, initial setup, and training in making measurements and entering data into spreadsheets that calculate snow density, temperature gradient, thermal conductivity, and conductive heat flow.

Throughout the year, the students' data are forwarded regularly to the University for quality assessment and control before the results are posted on the ALISON web site (www.gi.alaska.edu/alison). Here, the data are displayed graphically, and Excel files are available to download for educational purposes. ALISON results are shared freely so that anyone can compare the ice thickness; depth, density, and temperature of the snow on the ice; and the heat flow through the ice and snow on frozen lakes and ponds throughout Alaska.

At the end of the school year, ALISON culminates in a five-day professional development workshop for participating teachers in Fairbanks. This provides an opportunity for the teachers to meet and share the results of their research experience and how they transferred it to the classroom. Participants discuss science and mathematics standards and work together to develop standards-based classroom materials and activities.

Home-school participants take snow density and depth measurements on the ice at Aurora Pond in Fairbanks. This particular group has been making measurements since winter 2001–02. Photo by Martin Jeffries.

Cheryl Abbott (Wasilla High School) and Marc Swanson (Seward Elementary School) collaborated to develop hands-on activities and materials for a heat and energy unit, which forms part one of the *ALISON Activities Booklet: Using Lake Ice to Understand Heat Conduction, Translating Thermal Conductivity into the Classroom*. Together with Todd Hindman (Anvil City Science Academy, Nome), Abbott and Swanson were awarded a 2004 Toyota Tapestry Grant for *Project Sikuvik: The Science of Lake Ice and Snow* (Sikuvik is Iñupiaq for "ice time").

ALISON is supported by NSF (see page 17), the International Arctic Research Center, and the University of Alaska Natural Resources Fund.

For more information, see the ALISON web site: www.gi.alaska.edu/alison, or contact Martin Jeffries (907-474-5257; martin.jeffries@gi.alaska.edu), or Delena Norris-Tull (406-683-7043; d_norris@umwestern.edu).

Reference

Magnuson, J. J. et al. (2000) Historical trends in lake and river ice cover in the northern hemisphere. *Science* 289:1743-1746.

Arctic Research Thrives in ARMADA Classrooms

As Kathy Couchon's seventh grade students hammer hand-made corers into the sediment of Rhode Island's Narrow River, they excitedly ask, "Is this what you did in the Arctic, Mrs. Couchon?" "Well, not quite," she responds.

In August and September of 2004, Kathy participated in the six-week Arctic Coring Expedition (ACEX; see page 25) as an ARMADA Master Teacher. Funded by NSF, the ARMADA project provides K–12 teachers the opportunity to participate actively in research projects in ocean, polar, and environmental science. Master Teachers transfer their research experiences, including scientific data, methodologies, and technology, into their classrooms. Master Teachers also serve as mentors to colleagues in their home school district who are new to teaching science. They work together to integrate the research experience into the classroom and identify related standards-based resources and curricula.

Kathy quickly took what she learned on the icebreaker *Oden* to her classroom at Narragansett Pier Middle School (Narragansett, RI). Her science curriculum now includes coring, where the students examine sediment cores to determine what the layering signifies in the life of a salt marsh. The students photograph the cores while looking for soil type, color, and grain size—the same procedure used onboard the *Oden* during the expedition. David Smith, a microbiologist at URI's Graduate School of Oceanography (GSO) and member of the ACEX scientific party, continues his involvement with the ARMADA Project by working with Kathy and her students to conduct microbe research using student-built "Winogradsky" columns and comparing their student research with his deep ocean bacteria research. John Farrell, a GSO scientist, also contributed to Kathy's experience through serving as her host research scientist aboard the *Oden*. He made sure that Kathy actively participated in the research activities and that she understood and appreciated the scientific research enterprise that develops in a field setting. John's efforts were supported by the NSF Paleoclimate Program in the Division of Atmospheric Sciences.

In summer 2004, other ARMADA Project Master Teachers also participated in northern expeditions and are sharing their experiences with their students and mentoring new teachers in their school districts. Expeditions included:

- Steve Schmidt of Newman High School (Wausau, WI) joined the scientific party aboard the USCGC *Healy* for the Western Arctic Shelf-Basin Interactions project (SBI; see *Witness* Spring 2003), an interdisciplinary program investigating the impact of global change on physical, biological, and geochemical processes over the Chukchi and Beaufort Sea shelf basin region in the Western Arctic Ocean.
- Linda Hoffman (Palms Middle School, Los Angeles, CA) and Katie Roberts (Hingham Middle School, Hingham, MA) each spent four weeks aboard the NOAA ship *McArthur II* in the waters of western Canada, Gulf of Alaska, Aleutian Islands, and Bering Sea as part of the Structure of Populations, Levels of Abundance, and Status of Humpback whales (SPLASH) project. They focused on locating, collecting data on, and understanding the distribution of humpback whales.
- Leesa Wingo (South Anchorage High School, Anchorage, AK) worked with the U.S. Geological Survey and National Park Service in Glacier Bay to study the physical-biological coupling at frontal zones in Glacier Bay National Park.

Narragansett Pier Middle School students, Denny Tierney and Nicholas Marasco, take part in a coring expedition at a site in Rhode Island. Their teacher, Kathy Couchon, has engaged her students in coring since she returned from the six-week Arctic Coring Expedition (ACEX) in September 2004. The students analyzed their salt marsh cores in November 2004, at the same time the ACEX scientific party was analyzing the arctic cores in Bremen, Germany. Photo by Kathy Couchon.

The ARMADA Project is funded by the NSF Education and Human Resources Directorate through the Teacher Enhancement Program and is administered by the University of Rhode Island Office of Marine Programs based at GSO.

For more information, see the ARMADA web site: www.armadaproject.org, or contact Jill Johnen, ARMADA Project Science Director (401-874-6211; jjohnen@gso.uri.edu) or Andrea Kecskes, ARMADA Project Coordinator (401-874-6524; akecskes@gso.uri.edu).

New Web Site Highlights Alaska Science

Alaska Science Outreach, an independently produced service of AlaskaWriter LLC, has launched a new web site featuring outreach about Alaska-related science at www.alaskascienceoutreach.com. The web site serves as a portal to public domain stories produced by scientists and research institutions and offers original Alaska science news items and features for distribution. Posting of press releases, small features, and links is free. The site is currently seeking regular contributors to submit original stories or reprints appropriate for wider distribution.

For more information, see the Alaska Science Outreach web site: www.alaskascienceoutreach.com, or contact Sonya Senkowsky (907-830-7355; fax 801-751-4911; editor@alaskascienceoutreach.com).

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ARCUS is a nonprofit organization consisting of institutions organized and operated for educational, professional, or scientific purposes. Established by its member institutions in 1988 with the primary mission of strengthening arctic research, ARCUS activities are funded through cooperative agreements with NSF and the National Park Service, a Memorandum of Understanding with the Alaska Federation of Natives, and by membership dues.

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wit·ness (wit nis) *n.* **1.a.** One who has heard or seen something. **b.** One who furnishes evidence. **2.** Anything that serves as evidence; a sign. **3.** An attestation to a fact, statement, or event. —*v. tr.* **1.** To be present at or have personal knowledge of. **2.** To provide or serve as evidence of. **3.** To testify to; bear witness. —*intr.* To furnish or serve as evidence; testify. [Middle English *witnes(se),* Old English *witnes*, witness, knowledge, from *wit,* knowledge, wit.]

Calendar

February 28–March 2 Sea Ice Mass Budget of the Arctic (SIMBA) Workshop: Bridging Regional to Global Scales. Seattle, Washington. For more information, see www.iarc.uaf.edu/workshops/SIMBA_2005/index.php

March 13–18 5th Gordon Research Conference on Polar Marine Science. Ventura, California. For more information, see www.grc.org/programs/2005/polar.htm

April 11–15 Climate and Cryosphere (CliC) First Science Conference. Beijing, China. For more information, see www.clic2005.org

April 17–24 Arctic Science Summit Week. Kunming, China. For more information, see www.chinare.gov.cn/artic/index.htm

April 22–23 Pacific Arctic Group (PAG) Symposium: Circulation and Ecology of the Pacific Arctic Shelves and Connection to Deep Basins. Kunming, China. For more information, see www.iasc.no

May 16–20 GLOBEC Symposium: Climate Variability and Sub-Arctic Marine Ecosystems. Victoria, British Columbia. For more information, see www.globec.org

May 19–20 ARCUS 17th Annual Meeting and Arctic Forum 2005. Washington, D.C. For more information, see www.arcus.org/annual_meetings/2005/index.html

May 31–June 3 3rd Russian Conference on Geocryology. Moscow State University, Russia. For more information, see www.geol.msu.ru/deps/cryology/fe.htm

June 10–14 Evolution 2005 Conference. University of Alaska Fairbanks. For more information see www.evolution05.uaf.edu

June 12–16 2nd European Conference on Permafrost. Potsdam, Germany. For more information, see www.awi-potsdam.de/EUCOP

June 15–17 Rapid Landscape Change and Human Response in the Arctic and Sub-Arctic. Whitehorse, Canada. For more information, see www.taiga.net/rapidchange

For more events, check the Calendar on the ARCUS web site (www.arcus.org/ARCUS/Calendar/index.html).

Publications

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Ulvevadet, Birgitte, and Konstantin Klokov. 2004. *Family-Based Reindeer Herding and Hunting Economies, and the Status and Management of Wild Reindeer/Caribou Populations*. Centre for Saami Studies, University of Tromsø. 170 pages. Contact Birgitte Ulvevadet (birgitte.ulvevadet@sami.uit.no; www.sami.uit.no/srh).

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A Note From the ARCUS President

I hope that, since I am writing this message on New Year's Eve, I will be forgiven for a somewhat retrospective and perhaps even maudlin perspective. I am excited and encouraged by the progress and potential of arctic research and the recognition of an ever-growing need for ARCUS involvement to advocate and facilitate in support of the research community.

Over the past decades, there has been a big change in interest and support for research in northern regions. I will give a subarctic example. In the 1970s, the National Science Foundation developed a program called Research Addressing National Needs (RANN). The University of Alaska responded with a proposal for a comprehensive study of Prince William Sound, including the watersheds and social aspects. It was well-reviewed but not funded. Why? Because the opinion was that it did not address a national need. The region was considered far too remote and of limited pragmatic interest (this was, of course, before the Trans-Alaska oil pipeline). As a result, there were virtually no baseline data about the area when the *Exxon Valdez* tanker hit Bligh Reef in 1989.

We are better off now. The Arctic is increasingly recognized as important in global climate change (see page 1). Other issues in the region, such as subsistence needs, the prospect of increased development, and the potential for ice-free navigation, raise provocative research questions.

In response to the need for more information about the Arctic, the scientific community and agencies are developing well conceived, prescient programs:

- The interagency Study of Environmental Arctic Change (SEARCH) forms the foundation of the International Study of Arctic Change (ISAC), which has the potential to become the signature circumarctic program (see page 15).
- The international Census of Marine Life includes a field project on Arctic Ocean Diversity (see www.coml.org).
- New national and international research efforts in the subarctic seas are moving ahead (see page 15).

All this is happening as the 2007–2008 International Polar Year approaches (see page 26). Clearly, the arctic research community is larger and more active than ever before; its needs for effective networking, outreach, and coordination will continue to grow; and the role of ARCUS in serving that community will continue to expand.

—Vera Alexander

Vera Alexander is a biological oceanographer who has worked in high latitudes since 1962. She was dean of the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks from 1989 to 2004, when she became the Provost's Special Assistant for Fisheries and Ocean Policy. A long-time member of the ARCUS Board of Directors, she was elected president in 2003. She also serves on the U.S. Marine Mammal Commission and North Pacific Marine Science Organization (PICES), among others.

Inside

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