Witness the ARCTIC

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# Closing the Gap Between Scientific Research and Education

*By Renée Crain*

*Students at Salisbury Community School in Vermont present posters on arctic hydrology and climate change. Their teacher, Amy Clapp (center), participated in the Teachers and Researchers Exploring and Collaborating (TREC) program in 2004 and 2005, working with Robert "Max" Holmes (far right) studying the water chemistry of large arctic rivers. Drawing on her TREC experiences in Russia, Canada, and Alaska and with feedback from Holmes, Clapp created a month-long unit for her students on the interactions between arctic rivers and climate change, which culminated in this school-wide presentation. The students later traveled with Clapp and Holmes to Burlington where they presented their posters to participants at the Vermont Science Teachers Association Annual Meeting. Photo courtesy of Amy Clapp.*

Continued leadership in scientific and technological innovation is increasingly critical to maintaining U.S. prosperity in a rapidly changing global community. Concerns about this issue led to the recent congressionally requested report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* which outlines actions that federal policy-makers should take to enhance the science and technology enterprise so that the U.S. can successfully compete, prosper, and be secure in the 21st century. The first recommendation of the report is vast improvement of K–12 science and mathematics education to increase America's talent pool (Committee on Prospering in the Global Economy of the 21st Century 2006). There is evidence that the achievement of U.S. students in science, technology, engineering, and math (STEM) is slipping behind their international peers. For instance, U.S. students performed below average in both math and science in the 2003 Programme for International Student Assessment—a survey that measures math, science, and reading literacy of 15-year-olds, primarily in industrialized nations (National Science Board 2006).

One way to address issues of scientific leadership and STEM education is through the integration of scientific research and education. As the funding source for approximately 20% of all federally supported basic research conducted by U.S. colleges and universities, the National Science Foundation (NSF) funds scientists working on the cutting-edge of science and engineering and fosters integration of research and education in several ways. On a foundation-wide level, NSF has identified the integration of research and education as one of three core strategies that guide the entire agency in establishing priorities, identifying opportunities, and designing new programs (NSF 2000). In addition, NSF evaluates all proposals on two criteria as part of the merit review—intellectual merit and broader impacts. The broader impacts criterion requires that proposed projects have value beyond the immediate science field. These broader impacts can include developments in infrastructure for research or education, increasing diversity in science and engineering, broad dissemination of the research results, or significant teaching or training opportunities. Many of the broader impacts with societal relevance can be achieved through the inte-

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gration of research and education; joining together research and education assures that the findings and methods of research are quickly and effectively communicated in a broader context and to a larger audience (NSF GPRA Strategic Plan 2000).

The Arctic, one of the most extreme environments on Earth, provides an excellent setting in which to promote research and education connections. The region is undergoing profound environmental and socioeconomic changes, and research conducted in the Arctic is at the leading edge of scientific inquiry. Beginning in 1999, the Office of Polar Programs (OPP) Arctic Sciences Section increased its emphasis on stimulating innovative education projects with a budget designated specifically for Arctic Research and Education. This funding ($300,000 in FY 2004) supports activities that bridge research and education; most commonly, awards are made as supplements to funded grants and agreements or as small grants for pilot projects. The majority of the 63 awards made to-date are funded in partnership with other Directorates at NSF and other agencies. Proposals to this funding source may include formal or informal education or outreach for students K–12 and higher or to the broader public.

Examples of activities that link arctic research and education include teacher enhancement programs, visiting scientist and journalist programs, and efforts to directly incorporate arctic communities into research projects.

Enhancement experiences for teachers aim to develop scientific knowledge and inquiry-based teaching practices through participation in field research and related professional development opportunities, such as peer mentoring. From 1992–2005, OPP and the Directorate for Education and Human Resources (EHR) co-sponsored Teachers Experiencing Antarctica and the Arctic (TEA), a program enabling K–12 teachers to participate in polar research expeditions. Thirty-nine teachers worked on arctic research projects through TEA sponsorship. See *Witness* Spring 2003 or http://tea.armadaproject.org/. In response to requests from researchers who wanted to host teachers in the field, OPP funded ARCUS and VECO Polar Resources (VPR; see page 11) to continue and expand the K–12 teacher research experiences that proved so valuable in TEA. Since 2004, Teachers and Researchers Exploring and Collaborating (TREC) has supported the participation of 26 teachers in arctic field projects; the 2006 TREC season is underway with several field expeditions already complete and teachers currently in the field. This program uses online and live video and audio conferencing technologies to bring the research experience to hundreds of classroom and public audiences worldwide. See page 3 or www.arcus.org/trec.

The Alaska Lake Ice and Snow Observatory Network (ALISON) brings K–12 students, science and math teachers, and researchers at the University of Alaska Fairbanks (UAF) together to learn about the variability of lake ice, snow, and conductive heat flow in Alaska. Each year, Martin Jeffries, Research Professor in the Department of Geology and Geophysics, and other scientists at UAF train teachers and students in rural and urban Alaska to regularly collect data on snow and lake ice. The data, often collected from areas where it is not feasible for scientists to travel on a regular basis, are integral to the research, and the teachers and students who participate are research partners both doing and learning about the science. See *Witness* Winter 2004/2005 or www.gi.alaska.edu/alison/index.html.

Involving local communities in science is another way to increase the impact of a project. For example, Robert "Max" Holmes of the Woods Hole Research Center is expanding a collaboration that started in 2003 with one student living beside the Lena River in Zhigansk, Russia, who assisted with sampling, to include communities and schools at five other sites along major arctic rivers in Russia, Canada, and Alaska. In his Student-PARTNERS project (www.whrc.org/studentpartners), Holmes is working with arctic residents to collect year-round samples from these rivers, and students, teachers, and communities are becoming integral partners in the research.

Supporting visiting scientific experts to share their knowledge with communities and schools is another way to improve research and education connections on the local level. One such program, funded by NSF, is ARCUS' Arctic Visiting Speakers' Series, which supports researchers and other arctic experts to travel and speak in communities where they might not otherwise connect. The program provides a cost effective way for K–12, graduate and undergraduate, and public audiences to learn about important arctic issues. Since 2000, the first year of the program, 49 speakers have participated in over 130 different engagements worldwide. See *Witness* Spring 2002 or www.arcus.org/arctic_speaker/index.html.

Journalist immersion programs allow reporters to observe and participate in the process of science by working with investigators and graduate students conducting research. This type of program also benefits participating researchers who gain an understanding of the influences that shape the way science is reported to the public. For example, the Science Journalism Program at the Marine Biological Laboratory (MBL) entrains science journalists in the process of arctic research. Part of a larger program at MBL, up to five journalists travel to Alaska each year to spend time at Toolik Field Station and other field research sites learning about the Arctic and engaging with arctic researchers. With this background in scientific research, the 225 journalists who have participated in the program since 1985 are able to contribute to the informal science education of their audiences more effectively. See page 26 or www.mbl.edu/inside/what/news/sci_journal/index.html.

The funding increases in the President's 2007 budget request to support the recently announced American Competitiveness Initiative recognize NSF's leadership role in supporting the nation's capabilities in science, technology, engineering, and mathematics (Domestic Policy Council, Office of Science and Technology Policy 2006). In March 2007, the International Polar Year (IPY) will begin, and education and outreach will be a significant part of the IPY effort and legacy. The OPP and EHR directorates are working together during IPY to support integration of NSF-funded research with education to contribute to the development of the next generation of scientists and engineers. Proposals to a joint OPP-EHR special solicitation for IPY were received 1 May 2006; under the education emphasis area, proposals could

address formal science education experiences for K–12 teachers and undergraduate or graduate students, informal science education for the broader public, and coordination and communication for IPY education projects. See www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf06534. OPP plans to continue this emphasis of linking research with education beyond IPY 2007–2008 and to measure the outcomes of these investments to inform future plans. These measures are a first step in "rising above the gathering storm."

For more information, see the Arctic Research and Education website: www.nsf.gov/funding/pgm_summ.jsp?pims_id=13448&org=ARC, or contact Renée Crain (rcrain@nsf.gov; 703-292-8029).

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*Photo above right: As part of an oceanography lab, high school students in Virginia conduct a sediment settling rate experiment. Through the TREC program, their teacher, Steve Marshall, participated in a June 2005 expedition to the Arctic Ocean aboard the U.S. Coast Guard Cutter* Healy. *While on board, Marshall worked with scientists conducting sediment core research and collected samples that his students used in this and other experiments. Knowing that they were working with "real" sediment from the Arctic considerably increased student interest in the class. Photo courtesy of Steve Marshall.*

## Advancing Science Education Through Teacher Research Experiences in the Arctic

After a nationwide search, eight teachers have been selected to take part in the 2006 Teachers and Researchers Exploring and Collaborating (TREC; see *Witness* Winter 2004/2005) program, which pairs K–12 teachers with researchers to improve science education through arctic field experiences and Internet connections to classrooms and the public. TREC teachers work side-by-side with scientists during the spring and summer on field projects investigating topics such as tundra ecology, marine biology, atmospheric chemistry, and climate change.

The first 2006 expedition began in early May—Samantha Dassler-Barlow, a middle school science teacher from North Carolina, and Patricia Janes, an editor for Scholastic Inc., joined Lee Cooper, a professor at the University of Tennessee, on board the U.S. Coast Guard Cutter *Healy*. They spent five weeks on this icebreaker investigating ecological changes in the Bering Sea that are occurring as the climate warms.

Other TREC field projects and locations this spring and summer include investigation of prehistoric human-environment interactions in the Kuril Islands of Russia; atmospheric chemistry on the Greenland Ice Sheet; ancient dinosaur ecosystems on Alaska's North Slope; climate change in Svalbard, Norway; and two tundra ecology projects at Toolik Field Station in Alaska.

Extensive planning is necessary to ensure that the teachers are fully prepared and able to effectively communicate their experiences to classroom and public audiences. Before departing for the field, TREC provides an intensive orientation consisting of several webmeetings with all teacher and researcher participants, as well as a face-to-face workshop. Through these interactions, teachers learn about safety in the field, journaling, using technologies for communicating via the Internet, and public outreach. Each teacher also spends considerable time planning how to convey their experiences and the knowledge they gain to their students—these ideas are incorporated into an education plan that the teachers will implement in the year following their field expedition.

While teachers are in the field, TREC's outreach elements leverage the appeal of the Arctic to audiences of all ages around the world. Teachers and researchers communicate their experiences through the Virtual Base Camp, a section of the TREC website allowing participants to share their daily activities in an online journal and photo gallery and answer questions from students and the public. During live calls from the field, participants use Horizon Wimba, a software platform customized for TREC, that enables live audio web-conferencing, online presentations, Internet touring, application sharing, polling, and private and public text chat.

To complement the field experience, TREC has built a sustained learning environment for teachers and researchers and supports integration of research experiences and inquiry-based approaches into classroom curriculum through online seminars, an e-mail listserve, and teacher peer groups. As a result of their time in the field together, teachers and researchers continue to collaborate and discuss current science issues, content, and technology resources long after they return.

For more information, see www.arcus.org/TREC or contact Janet Warburton at ARCUS (warburton@arcus.org; 907-474-1600).

# Study Explores Social Effects of TB in Southwest Alaska

A project funded by the NSF Arctic Social Sciences program entitled White Plague: A Historical Ethnography of Tuberculosis Among Yup'ik Peoples of Southwestern Alaska examines the social effects of tuberculosis (TB). This disease was endemic in the Alaska Native population during the 19th century. Due to increasingly sustained contact with outsiders, by the mid 20th century it had reached epidemic proportions, devastating many rural communities. In the 1930s, one out of three Alaska Natives died of TB. In southwestern Alaska, Yup'ik people had one of the highest reported incidence and prevalence rates in the world. By the 1950s, it was estimated that one out of every thirty indigenous Alaskans was in a tuberculosis sanatorium, most located outside of Alaska in the Seattle/Tacoma area, remaining there for two or more years. Until the mid to late 1950s there were not enough TB beds in Alaska to treat all the patients; people often had to wait several years to be admitted. At this time, the Alaska Native death rate for TB was about 673 out of 100,000 compared to about 18 out of 100,000 for whites in the U.S.

By the mid 1950s, a massive public health campaign against TB in Alaska was well underway, and within two decades dramatic improvement occurred in both morbidity and mortality rates with the introduction of intensive control efforts, including chemotherapy, quarantine measures, and surveillance. By the 1970s, tuberculosis was no longer the primary cause of death among Alaska Natives. Even after over 40 years of public health intervention, however, tuberculosis remains a significant and serious chronic health problem among Alaska Natives. In 2000, the active case rate in Alaska was 17.2 out of 100,000, which was the highest rate in the U.S. The majority of these cases were among the indigenous population. Each year since 2000, the incidence rate has fallen, but in Alaska the case rates remain substantially higher than in the U.S. population at large.

Although it is widely known that TB ravaged rural Alaska communities throughout the 20th century, little attention has been given to the social suffering experienced by individuals, kin, and communities as a result of the disease. The ways indigenous people responded in their everyday lives to the desolate circumstances and public health interventions have largely gone unexplored. Linda Green, an anthropologist at the University of Arizona, leads the Alaska-based research team collecting oral histories from community members in three villages—Hooper Bay, Chevak, and Nunapichuk—in the Yukon-Kuskokwim Delta and interviewing public health and medical practitioners who provided services to those with TB. In all three communities, the research team has been enthusiastically supported by the tribal councils, mayor and city council offices, schools, elders, and community members.

One objective of Green's research is to examine the complex relationship between Alaskan Natives and modern western medicine from the perspective of indigenous people in rural areas. Documenting these encounters with TB and western medicine provides information on the social transformations that have affected Alaska Native well-being over the 20th century and how these transformations continue to affect people and their communities today. Another project objective is to investigate how medical ideologies and practices developed at the territorial (later state) and federal levels. The study examines how western notions of modernity, progress, and the indigenous "other" influenced public health and medical ideologies and interventions with regard to TB and Alaska Natives. Crucial to such an explication is an understanding of how the forces and structures of western scientific knowledge and public health policy contributed to a transformation of the ways that Alaska Native people lived and died.

After data analysis is complete, Green will write a historical ethnography focusing on how processes of modernity—specifically, changing public health and medical policies and practices—influenced a reworking of Alaska Native identity, social relations, and social organization. Collaborative local history projects and a museum exhibit now in the planning stages will focus on the many-faceted role of TB in the lives of Yup'ik people in the 20th century.

Understanding lessons of the past as well as present patterns of social development through the lens of TB is important to the well-being of arctic and sub-arctic residents, in both health policy development and health care delivery. This exploration of TB and control of the disease gives insight into the ways in which diseases are both biological and social entities and the unacknowledged consequences of health care policies and practices on peoples' lives.

Green worked as a public health nurse and TB consultant for the state of Alaska in the late 1970s and early 1980s. Since then, she has worked as a social-cultural anthropologist in rural Guatemala examining the effects of political and structural violence on the Mayan Indian population.

For more information, contact Linda Green (lbgreen@email.arizona.edu; 520-621-6291).

*In July 2005, Elders in Hooper Bay shared stories and memories of how the TB epidemics affected them, their families, and the community. Photo by Ole Lake.*

# Project Reveals Saami Prehistory in Coastal Sweden

The Saami (also spelled "Sámi") number approximately 80,000 people living in Norway, Sweden, Finland, and the Kola Peninsula in Russia. Studies of Saami DNA suggest their ancestral population separated long ago from other European populations. The Saami, or Lappish, language consists of nine dialects belonging to the Finno-Ugric language family.

In Sweden, Saami land-use rights have been restricted to reindeer ownership as a result of government policies, and herding has *de facto* become a key symbol of Saami identity. Lapland as an administrative region has served as a means for preserving a nomadic herding lifestyle and separating the Saami from Swedish settlers. These policies depict Saami territory in Sweden as limited to the northernmost and interior regions of the country.

With support from the NSF Arctic Social Sciences Program, Noel Broadbent of the Smithsonian Institution Arctic Studies Center (see *Witness* Spring 1998) initiated a three-year project in 2004 pursuing the archaeological evidence of Saami settlement and land-use in coastal Sweden. The Search for a Past is one of the first projects to pursue the Saami past outside of Lapland. The primary area of investigation has been in coastal Västerbotten, about 800 km north of Stockholm (see map). In the summer of 2005, Saami sites were also investigated at Hornslandet in coastal Hälsingland, which is only 300 km north of Stockholm.

The sites are characterized by hut complexes situated in outer coastal areas, especially on peninsulas or islands. The huts are generally oval in shape, 4 m by 5 m in size, with low cobble walls and central hearths. The huts radiocarbon date to A.D. 800–1300, the Viking Period, although some date to as early as A.D. 400. Bone material shows them to have been used by seal hunters, but there are also bones of sheep, goats, birds, and small game. The dwellings often cluster in groups of three to five structures and are very similar in appearance to the so-called "Stalo" huts from the Swedish mountain regions where the Saami hunted reindeer. The Grundskatan site in Västerbotten consists of 50 features including dwellings, cairns (manmade piles of stone) for storage, stone alignments (reindeer, sheep, or goat enclosures), livestock sheds, and circular ritual features. Some small grave cairns with cremations have also been documented nearby.

The major breakthrough in arguing the case for Saami coastal settlement came though an unexpected find in one of the huts at Grundskatan—a deposition of animal bones under a small cairn built into the corner of a dwelling. All the buried bones, which were from a single adult brown bear, had been cut up and ritually buried in accordance with Saami bear ceremonialism. The bear bones radiocarbon dated to approximately A.D. 870. This ritual bear burial shows that the people who had occupied these huts were unquestionably Saami.

The distribution of metal artifacts in Upper Norrland from the Late Iron Age (A.D. 400–1100) corresponds with waterways and eskers (gravel ridges deposited by water flowing under glaciers), which reflect both trade routes and settlement areas in the interior and on the coast. It is hardly a coincidence that the two main rivers in Västerbotten have Saami names—Skellefte and Ume. There are some 25 registered metal artifacts from coastal Västerbotten. Half of these finds have direct parallels to artifacts found at Saami sacrificial sites in Upper Norrland's interior. The finds of sheep and goat bones, as well as livestock sheds and corrals, suggest that the coastal Saami had combined seal hunting with husbandry. Mercantile interest in seal oil may have been an important factor behind intensified seal hunting during the Viking Period.

Saami coastal sealing and trading in Sweden came to an end in the first half of the 14th century. A number of forces converged at this time: aggressive Swedish agrarian expansion, church and state domination, Black Death, and the onset of the Little Ice Age. It is likely that changed ice conditions made traditional sealing more difficult. In response to all the forces of change, Saami dependencies on domesticated reindeer increased after the 14th century in the interior and mountain regions.

In Norway and the Kola Peninsula, Saami territory still extends along thousands of kilometers of northern coasts. According to the Icelandic and Norwegian sagas from the 1100–1200s, the Saami lived as far south as Hadeland in Norway, 20 km northwest of Oslo. The Saami or their ancestors were known to have formerly occupied nearly the whole of Finland and were even as far south as the Western Dvina (Daugava) River in Latvia. This project is helping to demonstrate that the Saami once lived from the mountains to the coasts in Sweden and much farther south than historical records have suggested. Archaeological research is helping the Saami know their ancient pasts and to better assert their indigenous identities and rights today.

For more information, see www.mnh2.si.edu/arctic/features/saami/index.html, or contact Noel D. Broadbent (broadben@si.edu; 202-633-1904).


*The Search for a Past project is investigating archaeological evidence of Saami settlement in coastal Sweden. The highlighted rectangle indicates the overall research area and red stars mark individual sites.*

# ARCSS Investigators Contribute to Synthesis Efforts

The Arctic System Science (ARCSS) Program focuses on understanding the fundamental characteristics, dynamics, and controlling principles of the arctic system through support of key field research and integration and synthesis of knowledge from past and ongoing studies.

ARCSS funding currently supports a number of organized research efforts: Synthesis of Arctic System Science (SASS; see below), Study of the Northern Alaska Coastal System (SNACS; see page 8), Freshwater Integration (FWI; see page 8), Western Arctic Shelf-Basin Interactions (SBI; see page 9), Human Dimensions of the Arctic System (HARC; see *Witness* Winter 2004/2005), and Paleoenvironmental Arctic Sciences (PARCS; see page 7). In addition to the explicit focus on synthesis supported by the new SASS funding, each of these efforts is pursuing synthesis and integration within and among its component projects, as well as with the larger ARCSS and arctic research communities.

### Seattle Meetings

Three groups of ARCSS investigators met in March 2006 in Seattle, Washington. Researchers supported by SNACS and SASS funding met both separately and together to share information on project plans and discuss overarching themes and linkages between projects and approaches for synthesis. The associated meeting of the ARCSS Committee (AC) included an open session with presentations covering community science activities and discussions on science goals and questions, key unknowns, and future priorities and activities, including those of the ARCSS Communities of Practice. The AC made tentative plans to convene an All-Hands Workshop in 2007. Josh Schimel of the University of California, Santa Barbara, assumed the chair of the AC and Jonathan Overpeck rotated to the position of past chair. Additional information about ARCSS activities will be announced through the ARCSS website and listserve.

For more information or to subscribe to the ARCSS listserve, see: www.arcus.org/ARCSS, or contact Josh Schimel (schimel@lifesci.ucsb.edu; 805-893-7688), Neil Swanberg (nswanber@nsf.gov; 703-292-8029), or Helen Wiggins (helen@arcus.org; 907-474-1600).

# New ARCSS Projects Pursue System-scale Synthesis

The need for an integrated understanding of the arctic system has increased as the pace of arctic change has accelerated. The field research and analysis and integration activities that began with the start of the ARCSS Program in 1989 provide a robust foundation for a major synthesis effort. Following on the 2003 and 2004 ARCSS workshops on synthesis (see *Witness* Winter 2004/2005), NSF issued an ARCSS solicitation in November 2004 for proposals on synthesis, focused explicitly on questions that link multiple system components and processes across a range of temporal and spatial scales. In response, NSF received 76 proposals for 34 separate projects totaling $25 million and was able to fund nine major projects with 22 awards totalling $7.037 million over three years:

- Synthesis of Arctic System Carbon Cycle Research Through Model-Data Fusion Studies Using Atmospheric Inversion and Process-Based Approaches. A. D. McGuire (University of Alaska Fairbanks [UAF]), J. Melillo (Marine Biological Laboratory [MBL]), Q. Zhuang (MBL), M. Follows (Massachusetts Institute of Technology [MIT]) *$1,179,591.*
- Sunlight and the Arctic Atmosphere-Ice-Ocean System. D. Perovich (Cold Regions Research and Engineering Laboratory [CRREL]), B. Light (University of Washington [UW]), H. Eicken (UAF) *$1,142,867.*
- Greening of the Arctic: Synthesis and Models to Examine the Effects of Climate, Sea Ice, and Terrain on Circumpolar Vegetation Change. D. A. Walker (UAF), H. Epstein (University of Virginia) *$888,368.*
- A Synthesis of Rapid Meltwater and Ice Discharge Changes: Large Forcings from the Ice with Impacts on Global Sea Level and North Atlantic Freshwater Budgets. M. Fahnestock (University of New Hampshire [UNH]), M. Truffer (UAF), R. Alley (Pennsylvania State University [PSU]), J. Box (Ohio State University [OSU]), S. Das (Woods Hole Oceanographic Institution [WHOI]), I. Joughin (UW) *$878,230.*
- Heterogeneity and Resilience of Human-*Rangifer* Systems: A Circumpolar Social-Ecological Synthesis. G. Kofinas (UAF) *$750,296.*
- Humans and Hydrology at High Latitudes. R. Lammers (UNH), D. White (UAF) *$657,025.*
- A Heat Budget Analysis of the Arctic Climate System. M. Serreze (University of Colorado [CU]), M. Steele (UW) *$641,545.*
- Arctic Surface Air Temperatures for the Past 100 Years: Analysis and Reconstruction of an Integrated Data Set for Arctic System Science. I. Rigor (UW) *$533,128.*
- Synthesis of Modes of Ocean-Ice-Atmosphere Covariability in the Arctic System from Multivariate Century-Scale Observations. M. Miles (Environmental Systems Analysis Research Center), M. Serreze (CU) *$366,319.*

The Synthesis of Arctic System Science (SASS) investigators have held two online meetings to begin discussing approaches for synthesis and integration among SASS projects; the March 2006 meeting in Seattle advanced this planning and collaboration. In December 2005, ARCSS issued a second SASS solicitation (available at www.nsf.gov/pubs/2006/nsf06523/nsf06523.htm). Proposals were due 24 March 2006. NSF anticipates making five to ten awards totalling $7 million over three years.

For more information, see the SASS website: www.arcus.org/ARCSS/SASS, or contact Neil Swanberg (nswanber@nsf.gov; 703-292-8029), or Helen Wiggins (helen@arcus.org; 907-474-1600).

# PARCS Synthesizes Records to Describe Past Climates

The Paleoenvironmental Arctic Sciences (PARCS; 1999–2005) program straddled two NSF programs, Arctic System Science (ARCSS) and Earth System History (ESH), to coordinate research efforts aimed at understanding paleoenvironmental changes in the Arctic and how they relate to the arctic system and Earth systems in general. The program supported a data management office that coordinated with the National Oceanic and Atmospheric Administration (NOAA) Paleoclimatology program to maintain a web-based data archive and interactive presentations of PARCS syntheses. This includes georeferenced databases and maps, as specified by the ESH 2003 science plan for the Arctic (www.ncdc.noaa.gov/paleo/parcs/syntheses.html). PARCS synthesis results and ongoing related research concentrate on three major topical areas.

**High-resolution climate variability.** Recent results based on the synthesis of a 600-year record have demonstrated that high-resolution (annual to decadal) proxy climate records from the Arctic preserve a signature of summer temperature that is related to both global mean temperature and the Arctic Oscillation. The study is based on an analysis of 144 sites and shows multiple modes of variability. A manuscript reporting these findings is in preparation. To continue this research, a group of investigators recently received funding through the ARCSS Program to develop and synthesize high-resolution proxy climate records from 30 lakes across the North American Arctic. This project will nearly triple the number of high-resolution, 2,000-year-long proxy climate records currently available and will enhance the understanding of the magnitude and mechanisms of arctic temperature variability.

**Holocene thermal maximum.** During the early to middle Holocene, much of the Arctic experienced temperatures that were warmer than present, probably due to a summer anomaly 10,000–12,000 years ago; summer temperatures were generally 1–2°C warmer than today. Describing the pattern of the Holocene thermal maximum (HTM) provides clues to the processes that modulate the effects of radiative forcing and the impacts of warmer conditions on the arctic system. A major international synthesis of paleoenvironmental records from 140 sites in the western Arctic (0–180° W; Kaufman et al. 2004) provided clear evidence for an HTM episode at 120 of the sites (figure 1). Alaska and northwest Canada experienced the HTM around 9,000–11,000 years ago, while warming in northeast Canada lagged by about 4,000 years, probably in part because of the chilling effects of the lingering Laurentide Ice Sheet. This spatial asymmetry is similar to the pattern of warming seen in the Arctic over the past several decades, suggesting a preferred mode of variability in the atmospheric circulation that generates a recurrent pattern of warming under positive radiative forcing. A parallel synthesis effort is underway for the eastern Arctic, and all of the data compiled by the HTM groups will be available through the PARCS data archive.

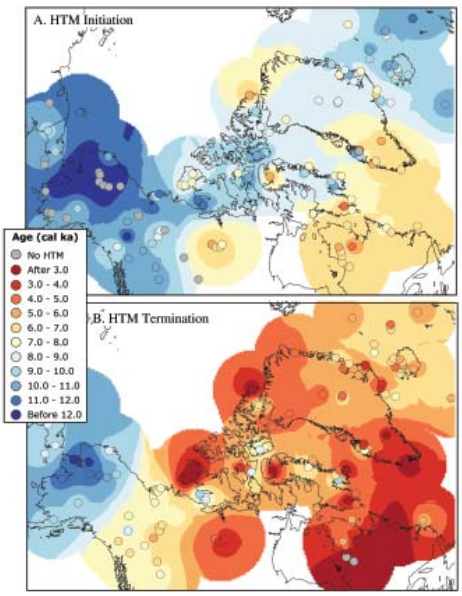


*Figure 1. Spatio-temporal pattern of the Holocene thermal maximum (HTM) in the western Arctic. A. Initiation and B. termination of the HTM. Gray dots indicate equivocal evidence for the HTM. Dot colors indicate bracketing ages of the HTM, which are contoured using the same color scheme. From Kaufman et al. 2004.*

**Last interglaciation.** In the fall of 2002, PARCS hosted a meeting of the Circumarctic Paleoenvironments (CAPE) initiative, an International Geosphere-Biosphere Programme - Past Global Changes (IGBP-PAGES) project, to summarize the state of knowledge pertaining to the last interglaciation (LIG; 125,000–130,000 years ago). This synthesis showed that LIG warming was strongest over the North Atlantic and Eurasia (figure 2). Sea level was also considerably higher, and the size of the Greenland Ice Sheet was reduced.

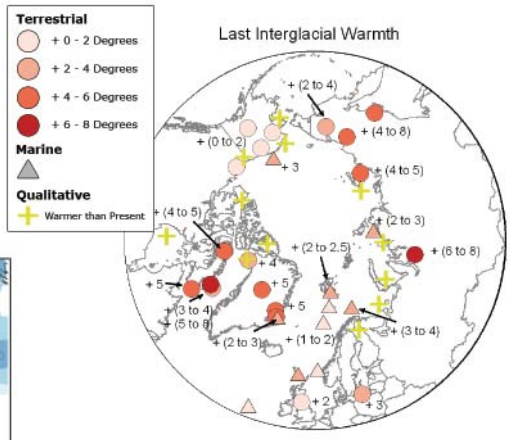


*Figure 2. Maximum summer temperature (differences relative to present) during the last interglaciation derived from paleotemperature proxies (CAPE in press).*

Although funding to support the PARCS office and science steering committee expired 31 October 2005, the ARCSS Program still supports the data management function of several synthesis projects. Members of the arctic paleosciences community are encouraged to work with other ARCSS researchers to form new Communities of Practice to integrate paleosciences into other Arctic System Science research initiatives.

For more information, see the PARCS website: www.ncdc.noaa.gov/paleo/parcs, or contact Darrell Kaufman (darrell.kaufman@nau.edu; 928-523-7192), Glen MacDonald (macdonal@geog.ucla.edu; 310-825-2568), or Matt Duvall (matt@consulair.com; 207-795-5097).

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# FWI Working Groups Begin Synthesis

Since 2002, the ARCSS Program has funded 22 projects to answer key questions associated with the arctic hydrological cycle from a multidisciplinary perspective under the Freshwater Integration study (FWI; see *Witness* Spring 2004). A primary goal of FWI is the synthesis and integration of available data and modeling studies to reveal processes, linkages, and causes of variability in the arctic terrestrial, atmosphere, and upper-ocean hydrologic cycle. The FWI investigators have begun a formal synthesis and integration effort, using a team-based approach, to achieve synthesis within projects, between projects, and with the greater arctic research community.

Following community discussions, including sessions at the 2004 FWI All-Hands meeting in Woods Hole, Massachusetts, two working groups are leading the FWI synthesis and integration activities. The Budgeteers working group is quantifying stocks and fluxes, comparing and evaluating budgets, and identifying gaps in data; working group chairs are Mark Serreze, University of Colorado at Boulder (atmosphere subgroup), Richard Lammers, University of New Hampshire (land), and Craig Lee, University of Colorado at Boulder (ocean). The Budgeteers group has a paper in review at *Journal of Geophysical Research–Oceans*.

The Changes and Attributions working group is documenting changes to the arctic hydrologic cycle, working to understand the source of the changes, and developing predictive simulations of feedbacks to the Earth and human systems. Working group chairs are Marika Holland, National Center for Atmospheric Research (global processes), Jennifer Francis, Rutgers University (atmosphere), Craig Lee, University of Colorado (ocean), Max Holmes, Woods Hole Research Center (land), and Dan White, University of Alaska Fairbanks (impacts). The Changes and Attributions group is compiling an online table of observed and projected changes and impacts (see http://arcticchamp.sr.unh.edu/synthesis/WorkingGroups/Changes/index.shtml). The table includes annotated bibliographies, summaries, figures, and data sets for each cluster of variables (land, atmosphere, ocean), and community contributions and discussion are welcome. An article planned for *Eos* will highlight progress in the FWI strategy for synthesis.

In addition to its support for FWI synthesis efforts, the Community-Wide Hydrological Analysis and Monitoring Program (Arctic-CHAMP) Science Management Office (SMO) has coordinated and facilitated several other FWI activities, including:

- annual FWI All-Hands meetings,
- assisting FWI investigators to organize three special sessions on arctic hydrology at the 2004 and 2005 American Geophysical Union (AGU) meetings and a press conference on Arctic Climate Change and the Intensifying Hydrologic Cycle at the 2004 meeting,
- organizing an August 2005 FWI workshop on hydrologic responses to degrading permafrost, attended by 31 scientists from four nations, and
- planning for an FWI All-Hands synthesis workshop in 2007 as well as a second, international workshop during the International Polar Year 2007–2008.

For more information, see the Arctic-CHAMP website: http://arcticchamp.sr.unh.edu, or contact Jonathan Pundsack (jonathan.pundsack@unh.edu; 603-862-0552).

# SNACS Commences Field Work on Northern Alaska Coast

In 2004, the ARCSS Program funded six projects under the Study of the Northern Alaska Coastal System (SNACS; see *Witness* Winter 2004/2005) to investigate coastal processes with the larger goal of understanding how interactions and linkages in all arctic coastal regions affect arctic and global systems. Most of the SNACS field work is located near Barrow, Alaska, to enable a high degree of collaboration and coordination among the projects.

The SNACS winter field work culminated in a large experiment at an open lead off-shore of Barrow in March 2005. About 30 scientists affiliated with multiple projects and institutions gathered data on the transfer of chemicals and water vapor from the ocean to the air and land. The collaborators also built an ice road to access the lead that was later successfully used by several whaling crews. Participating groups included:

- two SNACS projects, led by Matthew Sturm and Rob Rhew;
- several projects affiliated with the international, multidisciplinary Ocean-Atmosphere-Sea Ice-Snowpack (OASIS) program (see *Witness* Spring 2003); and
- a project using a remotely operated Aerosonde aircraft to observe the atmosphere and sea ice surface, funded by Arctic Research Support and Logistics (see pages 10–14) .

The experiments resulted in a session with 50 abstracts at the 2005 American Geophysical Union (AGU) fall meeting.

All six of the SNACS projects worked in the Barrow area in late summer 2005, enabling sharing of helicopter and ground transport and exchange of information within the SNACS group and with other research projects working in the area.

SNACS investigators participated in the March 2006 ARCSS meetings in Seattle, Washington (see page 6), to discuss approaches to larger scale synthesis and integration. Tom Douglas of the Cold Regions Research and Engineering Lab in Alaska has agreed to act as the SNACS synthesis coordinator.

For more information, see the SNACS website: www.arcus.org/arcss/snacs, or contact Tom Douglas (Thomas.A.Douglas@erdc.usace.army.mil; 907-353-9555), Neil Swanberg (nswanber@nsf.gov; 703-292-8029), or Helen Wiggins (helen@arcus.org; 907-474-1600).

# SBI Plans for Synthesis and Modeling Phase

The Western Arctic Shelf-Basin Interactions (SBI) project is a multi-year, interdisciplinary effort to investigate the impact of climate change on the physical and biological linkages between the arctic shelves and adjacent ocean basins. This program is supported by the ARCSS Program and the Office of Naval Research (ONR). The SBI project (see *Witness* Spring 2003) is progressing in three phases over ten years:

- Phase I (1998–2001; 31 principal investigators [PIs], 18 projects): retrospective analysis and synthesis, opportunistic field investigations, and modeling;
- Phase II (2002–2006; 40 PIs, 14 projects): field program in the Bering Strait region and over the outer shelf and slope in the Chukchi and Beaufort Seas, complemented by biophysical modeling; and
- Phase III (2007–2009): synthesis and integration of data into conceptual and numerical models to improve understanding of the arctic system and capability of predicting climate change impacts on shelf-basin interactions.

Currently in its final year, the major goals of Phase II are to investigate:

- physical modifications of North Pacific and other waters on the Chukchi shelf and slope, and exchanges of these waters across the shelf and slope; and
- biogeochemical modifications of North Pacific and other waters over the Chukchi and Beaufort shelf and slope areas, with an emphasis on carbon, nutrients, and key organisms that represent a suite of trophic levels.

In addition, Phase II included comparative studies over the wide Chukchi and narrow Beaufort shelves and adjacent slopes to facilitate extrapolation and integration of the western Amerasian Arctic into a pan-arctic perspective.

In December 2005, *Deep Sea Research II* published the first special issue on SBI project results; 23 papers presented an overview of the project and its results to date. Several additional special volumes are anticipated in the future.

Current plans for SBI Phase III (2007–2009) activities include:

- development of pan-arctic models suitable for simulating scenarios of the impacts of climate change on shelf-basin interactions, and
- aggregation of SBI results with datasets from other projects to produce new composite datasets that will contribute to regional and pan-arctic environmental change assessments.

The SBI Advisory Committee and ARCSS Committee are collaborating in developing plans for SBI Phase III. A series of face-to-face and virtual meetings have provided opportunities for comment on these plans, as did an open meeting at the February 2006 Ocean Sciences meeting in Honolulu, Hawaii. The committees hope that NSF will be able to release an announcement of opportunity that includes SBI Phase III objectives in 2006.

For more information, see the SBI website: http://sbi.utk.edu, or contact Jackie Grebmeier (jgrebmei@utk.edu; 865-974-2592).

# Workshop Aims To Improve US/Russian Collaboration

The Russian-American Initiative for Land-Shelf Environments (RAISE) facilitates collaborative research between Russian and American scientists working to understand processes and events in terrestrial, shelf, and ocean environments in northern Eurasia within the context of global environmental change. Created in 1995, RAISE is supported by the ARCSS Program and the Russian Federation for Basic Research (see *Witness* Autumn 2001).

In June 2005, the RAISE Science Management Office sponsored a workshop exploring the challenges that need to be met in order to improve the capacity of U.S. and Russian scientists to work together on arctic research problems. Participants included a cross-section of U.S. and Russian field scientists, agency and Russian Academy representatives, and representatives of VECO Polar Resources (see page 11) and the Civilian Research and Development Foundation (see www.crdf.org).

A number of existing challenges for scientists planning field research in the Russian Arctic were identified, including:

- logistics,
- import and export regulations for samples and equipment,
- permitting,
- funding for Russian collaborators, and
- the lack of many high-level agreements between the U.S. and Russia supporting joint research efforts.

It was also noted that successful collaborations are often the result of existing personal relationships between U.S. and Russian scientists that date back to the Soviet era. In other cases, Russian émigrés living in the U.S. take lead roles in field programs because of their Russian language skills and knowledge of government permitting requirements.

Recommendations to improve collaborative research opportunities included increasing research funding and training support for emerging scientists proposing to work in the Russian Arctic and identifying information resources that are relevant to those initiating new collaborations. Databases, such as the International Arctic Science Committee's International Science Initiative in the Russian Arctic, that provide names and contact information for scientists working on projects in this region were recognized as useful resources. Participants also noted the importance of communicating the need for collaborative research to policy makers and the public.

A workshop report and a news feature for *Eos* describing selected recommendations are planned.

For more information, see the RAISE website: http://arctic.bio.utk.edu/RAISE/index.html, or contact Lee Cooper (lcooper1@utk.edu, 865-974-2990).

# Study Outlines Plans for Arctic Observing Network

Many of the efforts underway to advance understanding of the Arctic call for improved observational capabilities. To guide these improvements, the NSF Office of Polar Programs (OPP) sponsored a two-year National Academies study to outline the potential scope, composition, and implementation strategy for an arctic observing network (AON; see *Witness* Winter 2004/2005). The 18-member study committee, which was overseen by the Polar Research Board (PRB; see page 22), released its report, *Toward an Integrated Arctic Observing Network*, in May 2006 (http://fermat.nap.edu/catalog/11607.html).

To conduct its work, the study committee hosted meetings in Washington, D.C., Anchorage, Alaska, and Copenhagen, Denmark, between October 2004 and September 2005. The committee:

- developed an overarching philosophy and conceptual foundation for an international AON,
- reviewed the purposes and extent of existing and planned global observing systems and platforms,
- highlighted critical spatial, temporal, or disciplinary gaps,
- identified key variables of importance to the Arctic,
- described the infrastructure and approach needed to create a comprehensive AON,
- addressed the need for sound data and information management and access, and
- recommended ways to coordinate implementation and operation of an AON in an international setting.

The study concludes that an integrated, complete, dynamic, and multidisciplinary environmental observing network will improve society's understanding of and ability to respond to ongoing systemic changes in the Arctic and its capability to anticipate, predict, and respond to future change both in the Arctic and around the globe. The data flowing from an AON could contribute to a wide range of programs and activities, including research studies, decision-support tools, and integrated environmental assessments that help decision makers understand what is happening and, as appropriate, adopt adaptation and mitigation measures. Because many potential components of the AON already exist or are being planned, and because of the projected surge of activity during the International Polar Year (IPY) 2007–2008, there is an immediate opportunity for major progress.

## Key Recommendations

The report makes two overarching recommendations:

1. The AON should be initiated using existing activities and with the flexibility and resources to expand and improve to satisfy current and future scientific and operational needs. In its initial phase, the AON should monitor selected key variables consistently across the arctic system.
2. Work to design and implement an internationally coordinated AON should begin immediately to take advantage of a unique window of opportunity created by IPY.

In a third, multifaceted recommendation, the report outlines four essential functions of the AON that would operate in parallel, build on existing resources, and serve the interests of all participants:

1. observing system development (which includes assessing complete coverage, system design and optimization, technology development, and sensor and observer deployment);
2. data acquisition (which includes maintaining existing observational capabilities and filling critical gaps);
3. data management, integration, access, and dissemination; and
4. network maintenance and sustainability (which includes network and observation sustainability, personnel development, coordination and integration regionally and globally, and communication).

The report includes recommendations on steps toward these four essential functions.

Building the AON will require international cooperation and support. Because some areas of the Arctic have more developed monitoring and information systems than others, it will be critical to engage all arctic nations from the outset. During the IPY, there will be a burst of new and intensive internationally coordinated monitoring for a two-year period that will help jump-start the AON. In addition, emerging activities including

- the Global Earth Observation System of Systems (GEOSS; see www.epa.gov/geoss/index.html),
- the interagency Study of Environmental Arctic Change (SEARCH; see page 17),
- the International Study of Arctic Change (ISAC; see page 17), and
- the Arctic Council's proposed consortium for Coordination of Observation and Monitoring of the Arctic for Assessment and Research (COMAAR; www.ans.kiruna.se/meetings/comaar/info.htm)

will provide timely opportunities to enhance and better coordinate the AON through access to international partners and capabilities.

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

## NSF Seeks Observing Network Proposals

In February 2006, the NSF Office of Polar Programs (OPP) and Directorate for Education and Human Resources (EHR) released a program solicitation in anticipation of the International Polar Year 2007–2008. The research emphasis areas in the solicitation are:

- ice sheet history and dynamics;
- biological adaptations at the cellular and genomic level to life in extreme cold and prolonged darkness; and
- the arctic observing network.

The solicitation is available at www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf06534; proposals were due 1 May 2006. Information on the emphasis areas for education can be found on pages 2–3.

# NSF Arctic Logistics Contract Awarded to VECO USA

In February 2004, NSF solicited proposals for research support and logistics providers for the Office of Polar Programs (OPP) Arctic Sciences Section. In February 2005, the contract was re-awarded to VECO USA. VECO USA has been the arctic logistics contractor since 1999 (see *Witness* Winter 2000/2001) when the OPP Arctic Section established the Arctic Research Support and Logistics Program. The new contract has an estimated value of $93 million over seven years, which includes three contract years plus up to four one-year awards based on performance. The prior contract was a three-year contract with two one-year extensions.

Three companies—VECO USA, Polar Field Services, and SRI International—collectively known as VECO Polar Resources (VPR) provide logistics support. VECO USA is responsible for program management, including procurement, subcontract management, and accounting support. VECO USA also provides expertise in construction management, engineering, and information technology. Polar Field Services is responsible for research support, planning, and construction oversight through interactions with the research community and OPP. SRI International provides information technology and telecommunication services.

The OPP Arctic Section funds 100–120 field projects in the Arctic each year, amounting to approximately 600 people in the field at 90 different field sites. VPR supports these projects by providing pre-proposal consultations, logistics and operational plans, risk assessments, transport, communications, safety training, telemedicine, construction, maintenance, and field camp operation and personnel. Field sites can vary from small, remote field camps, to remote instrumentation locations, to ice camps on the Arctic Ocean, to established field sites such as Summit Station in Greenland.

Highlights of VPR support in 2005 include:

- coordination of air support, fuel, and user days for the North Pole Environmental Observatory spring campaign to retrieve and redeploy buoys and moorings and conduct conductivity temperature depth (CTD) and hydrographic surveys from a sea ice camp near the North Pole (http://psc.apl.washington.edu/northpole/index.html);
- staging of a field camp on King Island and base camp at Cape Woolley to support a group documenting the traditional ecological knowledge of the King Island community (see *Witness* Winter 2004/2005; http://oregonstate.edu/dept/anthropology/faculty/kingston/king_island/king_island.htm);
- infrastructure upgrades in support of research at the Barrow Environmental Observatory, including installation of a power system, boardwalks and trails, an automated tram system, and control structures for carbon flux experiments (http://gcrg.sdsu.edu/);
- provision of air support and field camp for undergraduate students and their instructors participating in a high arctic field course at Thule Air Base (http://depts.washington.edu/icylands/); and
- coordination of an intensive sampling campaign measuring tracers of the six largest rivers that drain the watershed of the Arctic Ocean—support included maintenance of contracts required to complete sampling in Russia, Alaska, and Canada, coordination of supply and sample shipments, and travel assistance (http://ecosystems.mbl.edu/partners/).

VPR support in 2006 is well underway. The contractor is currently consulting with the National Renewable Energy Laboratory to install a proof-of-concept renewable energy power system at Summit Station (see *Witness* Winter 2004/2005). The wind/solar hybrid system will tie into and augment the station's existing generators. This is the second stage of a long-term project to reduce emissions at Summit Station, a prime site for "clean air" investigations focusing on snow and atmospheric chemistry research. VPR is concurrently pursuing a number of other emissions-reducing strategies, one of which involves the test of several custom-built electric snowmobiles.

The 12-week Go North! dogsled expedition through the Arctic National Wildlife Refuge began in February. VPR provided fixed-wing charters, expedition food and fuel, camping equipment, and trail resupply throughout the trip (http://polarhusky.com/home.asp).

Other plans for 2006 include supporting the test of a deep ice sheet coring drill designed by Ice Coring and Drilling Services at the University of Wisconsin. The drill is designed to obtain high quality ice cores continuously from the surface to a depth of at least 3,800 m. VPR pre-staged equipment and infrastructure at the test site near Summit Station and is supporting the drill team and around-the-clock drilling activities from May through July. (www.ssec.wisc.edu/icds/projects/waiscores.html).

During late spring and summer 2006, the logistics contractor also plans to coordinate a large helicopter and fixed-wing campaign in support of the second field season of the St. Elias Erosion/Tectonics Project, a multidisciplinary study to address the evolution of the St. Elias Mountains (www.geol.vt.edu/profs/js/js-alaska1.html).

Throughout the spring and summer, VPR is again working with ARCUS to provide logistics support for participants in the Teachers and Researchers Exploring and Collaborating (TREC) program (see page 3 or www.arcus.org/TREC/index.php).

In collaboration with the Institute of Arctic Biology at the University of Alaska Fairbanks, VPR will also continue to contribute to infrastructure upgrades at Toolik Field Station, including installation of a new power module, continuation of science support building design and construction, and completion of a shower module expansion (see *Witness* Winter 2004/2005). VPR will also support the station's efforts as it moves into year-round operations.

For more information, see the VPR website: www.vecopolar.com, or contact Jill Ferris (jill@polarfield.com; 303-984-1450), or Simon Stephenson (sstephen@nsf.gov; 703-292-7435).

# Aging Polar Icebreaker Fleet Becomes NSF Responsibility

In a major change to the long-standing relationship beween NSF and the U.S. Coast Guard (USCG), the FY 2006 federal budget (see page 21) shifts responsibility for the U.S. polar icebreaker fleet from the USCG to NSF. The USCG owns and operates three polar icebreakers that are almost entirely used to support NSF programs in the Antarctic and Arctic (see table). Past USCG budgets included funds for crews, maintenance, training, and other support to ensure the ships were ready for operations but lacked funding to deploy icebreakers solely for USCG mission responsibilities. Until 2005, NSF reimbursed the USCG for the incremental costs of icebreaker use through an interagency agreement. In 2004, these incremental costs totaled about $12 million. Similar arrangements between NSF and the USCG have been in place since 1965, when the polar icebreaking mission transferred from the Navy to the USCG.

The highest priority mission of the two older and larger icebreakers, the *Polar Sea* and *Polar Star*, is the annual Operation Deep Freeze (DF), which supports operations at the three U.S. Antarctic stations by escorting supply ships to McMurdo Station, the U.S. Antarctic Program (USAP) logistics hub. This mission requires the deployment of one or two icebreakers for approximately 130 days per year from November to March. Depending on ice conditions, the vessels work singly or in tandem to break a channel through what is normally about 15–20 nautical miles (35 km) of ice.

For the past several years, as the almost 30-year-old *Polars* faced significant maintenance issues, severe ice conditions in McMurdo Sound have required the use of two icebreakers to channel through up to 80 nautical miles (148 km) of ice. Repairs prevented *Polar Star* from participating in DF 2003, and the newer arctic research icebreaker USCGC *Healy* (see *Witness* Spring/Autumn 1999) assisted the *Polar Sea*. The *Polar Sea* was unable to participate in DF 2005, however, because it was pulled from service as mission incapable in early 2005; two of its three engines have been condemned. The ship is expected to be out of service until at least November 2006. Estimates of engine repair costs range up to $10 million. The *Polar Star* successfully supported DF 2005 with the assistance of a 29-year-old conventionally powered Russian icebreaker, the *Krasin*, chartered by NSF at a cost of $4.13 million.

*Table at right: Characteristics of the U.S. polar icebreakers and ice-strengthened polar research vessels. Abbreviations: UAF: University of Alaska Fairbanks; ARRV: Alaska Region Research Vessel (see* Witness *Spring 2004); ECO: Edison Chouest Offshore, Inc.; RPSC: Raytheon Polar Services Company; SBI: Shelf-Basins Interactions Program (see page 9).*

### Congressional Action

The FY 2006 transfer of responsibility for the icebreakers was accompanied by a $48 million budget moved from the USCG to NSF; according to the relevant congressional report (HRept 109-118), the transfer gives "NSF…flexibility to pursue alternatives to current operations," such as chartering icebreakers, and NSF is specifically directed "to immediately begin a concurrent pursuit of alternative, more economical icebreaking solutions for 2006 and beyond." The report also acknowledges that "burdening NSF with the responsibility for maintenance and long-term modernization costs of the Coast Guard icebreaking fleet would irresponsibly jeopardize the nation's primary source of funding for critical basic scientific research."

Under this arrangement, the USCG continues to operate and maintain the ships, which it estimates will cost $55–$75 million annually for the next several years. NSF and the USCG signed a $54 million Memorandum of Understanding in August 2005 to cover icebreaker operations in FY 2006, including engine repairs to the *Polar Sea* and use of the *Healy*. The proposed FY 2007 budget continues to assign funding responsibility for the polar icebreakers to NSF and includes $57 million to operate and maintain the polar icebreaker fleet.

For DF 2006, NSF chartered the *Krasin* for an estimated $9 million, with the expectation that the Russian ship would be able to perform the mission alone. The *Krasin* developed propeller problems in January, however, and the *Polar Star*, which had been on standby in Seattle, was called in to assist. Following completion of DF 2006, plans call for the *Polar Star* to be put in caretaker status for an indefinite period, with its crew reduced from 135 to about 35 personnel. The short-term repairs to the *Polar Sea* are expected to sustain its operations for another two to three years, and current plans call for the *Polar Sea* to participate in DF 2007.

NSF is gathering advice from several sources, including the National Academies and the OPP Advisory Committee, on alternatives for icebreaking operations in future years (see facing page).

For more information, see the NSF website: www.nsf.gov/news/news_summ.jsp?cntn_id=101833&org=NSF&from=news, or contact Simon Stephenson (sstephen@nsf.gov; 703-292-8029).

| Polar Icebreakers | Owner/Operator | Year Commissioned, Home Port, Comments |
|---|---|---|
| *Healy* 128 m | USCG/USCG | 1999, Seattle. Intended for arctic research; assisted with DF 2003. |
| *Polar Sea* 122 m | USCG/USCG | 1978, Seattle. Out of service until November 2006. Expected to be available for DF 2007. |
| *Polar Star* 122 m | USCG/USCG | 1976, Seattle. Will go into caretaker status after DF 2006. |
| **Ice-strengthened Polar Research Vessels** | | |
| *Alpha Helix* 41 m | NSF/UAF | 1966, Seward. Works in coastal Alaska; replacement planned (ARRV). |
| *Nathaniel B. Palmer* 94 m | ECO/RPSC | 1992, New Orleans. Works mostly in Antarctica; supported SBI in 2003; replacement planned. |
| *Laurence M. Gould*, 76 m | ECO/RPSC | 1997, New Orleans. Works in Antarctica. |

# Committees Analyze Options for Icebreaker Operations

Two committees are advising NSF on its options for meeting future polar icebreaking needs:

- the National Academies' Committee on Assessment of U.S. Coast Guard (USCG) Polar Icebreaker Roles and Future Needs, and
- the Office of Polar Programs (OPP) Advisory Committee's Subcommittee on U.S. Antarctic Program (USAP) Resupply.

### National Academies Study

In April 2005 at the request of Congress, the USCG funded the National Academies' Polar Research Board and Transportation Research Board to undertake an assessment of USCG polar icebreaker roles and future needs in supporting U.S. operations in the Antarctic and Arctic, including:

- scenarios for continuing those operations and analysis of alternative approaches;
- the changes in roles and missions of polar icebreakers in support of national priorities in the polar regions; and
- potential changes in the roles of USCG icebreakers that may develop due to environmental change in the Arctic, such as might occur with increased marine operations in the Northern Sea Route and the Northwest Passage (see page 25).

The 15-member study committee, which includes experts in national defense, commercial shipping, ship design, science management, marine safety and environmental protection, icebreaker operations, climate change, and arctic and Antarctic science, released an interim report in December 2005 and will deliver a final report in summer 2006.

The interim report, which highlights the most urgent and time dependent issues in the committee's charge, finds that the *Polar Sea* and *Polar Star* are near the end of their operational design service lives. Both ships are inefficient to operate as their maintenance needs increase and their technological systems become more and more obsolete. These conditions are increasing the risk of operational failure and are placing national programs and missions at risk. A short-term solution is needed to provide a bridge from the current situation to a long-term solution to this problem; implementation of a long-term solution is expected to require at least four to eight years.

The report provides five major interim recommendations:

- the U.S. should reliably control (by ownership or other means) at least one heavy icebreaker that is available and capable of breaking a channel into McMurdo Station;
- the U.S. should maintain dedicated year-round icebreaker capability for the Arctic to support national security interests as well as science;
- in the short term, the required maintenance should be performed to make at least one Polar Class ship mission capable over the next four to eight years;
- in the short term, the management of the U.S. polar icebreakers should reside with the USCG, and it should have the appropriate operational and maintenance budget to fulfill USCG missions that require icebreaking; and
- in the short term, NSF should revert to being a user and should continue to negotiate financial agreements to pay for icebreaker services when USCG ships are employed.

The study's final report will focus on providing direction for meeting the nation's long-term icebreaking needs for the next several decades. The study committee will investigate the mix of icebreaking capabilities and numbers of ships needed, explore options for acquring those capabilities, and compare a wide range of models for managing and operating the ships.

Following completion of the study, the Office of Science and Technology Policy has indicated that it plans to produce a Presidential Directive on national polar icebreaker needs, including size and structure of the fleet.

The committee's interim report is available at www.nap.edu/catalog/11525.html. For more information, see the National Academies' Current Projects website: http://www8.nationalacademies.org/cp/ (search for icebreakers) or contact study director Maria Uhle (muhle@nas.edu; 202-334-3531).

### OPP Advisory Committee Report

In early 2005, the OPP Advisory Committee (OAC) asked a subcommittee to examine issues and develop recommendations related to effective long-term resupply of the U.S. Antarctic Program, including appropriate icebreaker support.

Like the National Academies icebreaker committee, the OAC subcommittee's August 2005 report finds that the *Polar Sea* and *Polar Star* are near the end of their design service lives. The report recommends that NSF develop a comprehensive systems approach to Antarctic icebreaking. In the near term, this includes commercial sources, backed up by the USCG vessels. In the longer term, a new icebreaker may be needed, and NSF should examine commercial business models for procurement and/or operations of that vessel. The report also recommends that the USAP develop the means to continue science support in the event of a failed future Deep Freeze mission.

In response to the report's longer term recommendations, the OAC recommended that NSF begin to define the characteristics of its icebreaking requirements; according to material presented at the October 2005 OAC meeting, these characteristics are beginning to emerge:

- a vessel capable of performing the USAP break-in and escort without requiring refueling from McMurdo;
- a commercially manned vessel; and
- a vessel under a long-term charter, for only the period of the mission.

NSF is also considering whether it would be desirable for such a vessel to be available to work with the *Healy* in the Arctic when not engaged in the Antarctic, or to engage in other commercial activities when not under charter to NSF. OPP expects to issue a Request for Expressions of Interest from industry regarding icebreaking in the coming year. OPP will also explore the potential for international collaboration as an option for obtaining icebreaker support.

The report is available at: www.nsf.gov/od/opp/opp_advisory/final_report/oac_resupply_report_081205_rpt.pdf. For more information, see the OAC website: www.nsf.gov/od/opp/advisory.jsp.

# New Arctic Marine Laboratory Opens in Ny-Ålesund

In June 2005, a new arctic marine laboratory began operations in Ny-Ålesund, the international base for research in natural sciences in Svalbard. Built by Kings Bay AS, the Norwegian public corporation that owns and runs Ny-Ålesund, the international laboratory is adjacent to Kongsfjorden, an open fjord with a mixture of boreal and arctic flora and fauna, strong environmental gradients due to large tidewater glaciers, and relatively abundant marine mammal and seabird populations (Hop et al. 2002, Svendsen et al. 2002). The development of the lab was recommended by participants at a joint Norway/U.S. workshop in 1999 (ARCUS 2000).

The new lab has extensive capabilities for experimental studies of aquatic organisms, including facilities for controlled temperature and salinity, ambient seawater and photoperiod, long-term holding and acclimation, diving facilities with a decompression tank, special labs for ecotoxicology and isotopic studies, and classroom and office space. Its location on the shore of Kongsfjorden will facilitate combined field and lab research projects.

The total cost of the two story, 600 $m^2$ lab is approximately NOK 33 million (about $5 million USD); funding came from the Norwegian government and ConocoPhillips (about $1 million USD).

A Marine Lab Project Group, led by the Norwegian Polar Institute (NPI), planned and oversaw development of the lab, which is available for rent to its members and others as space allows. The rental consortium that has made ten-year agreements for use of the laboratory includes:

- Alfred Wegener Institute (Germany)
- Chinese Arctic and Antarctic Administration (see page 24)
- Italian National Research Council
- Korea Polar Research Institute
- Norwegian Polar Institute
- National Science Foundation (U.S.)
- Scottish Association for Marine Science
- University Centre in Svalbard (UNIS)

Under the terms of the lab's user access plan, each of these members is committed to a minimum annual rent of the lab (NOK 150,000 [about $23,000 USD]), which entitles each to 150–375 user-days per year, depending on the season. Other institutions can rent the lab for a rate about 50% higher per user-day. These costs do not include room and board or transportation, which need to be arranged separately with Kings Bay AS. The consortium members are represented by the Marine Lab Advisory Group, currently led by Haakon Hop of NPI, which acts as an advisory body for scientific issues related to the use and running of the lab.

In July 2005, the Svalbard Research Experience for Undergraduates (REU) marine program (led by Ross Powell, Northern Illinois University, and Julie Brigham-Grette, Univerity of Massachusetts Amherst) took two U.S. undergraduates to the lab for a pilot program investigating glacial sedimentation processes relevant to understanding climate records preserved in marine and lacustrine basins. Studies focused on sediment transport and deposition in Kongsfjorden by polythermal tidewater glaciers, icebergs, meltwater streams, and marine currents. Students sampled glaciers and icebergs for debris concentrations, collected seawater samples for suspended sediment concentrations, performed conductivity temperature depth (CTD) casts to define water column structure, conducted bathymetric profiling using GPS control, collected fjord sediment samples with small box-cores and short gravity cores, and performed initial sample processing in the new marine lab.

Field-related research in Kongsfjorden can take advantage of several long-term data sets. Significant observational time-series from the Kongsfjorden area include historical and recent databases on oceanography (from 1905), meteorology (from 1911), tide gauge measurements (from 1974), hardbottom benthos (photographic series from 1980), marine mammals (from 1981), seabirds (from 1988), CTD measurements (from 1993), zooplankton (from 1995), stable isotopes and lipids (from 1996), and ice concentration and snow and ice thickness (from 2003, occasionally from 1997). Currently, there is no coordinated data collection system for Kongsfjorden, but routine state variables are measured regularly by several institutions.

Networks involved in marine research in Svalbard include:

- Arctic Marine Ecosystem Research Network (ARCTOS), a consortium of Norwegian scientists studying arctic marine productivity and ecology, led by Paul Wassmann of the University of Tromsø (see www.nfh.uit.no/arctos); and
- Kongsfjorden and Hornsund, which are designated as European Marine Biodiversity Sites (EMBS; see www.iopan.gda.pl/projects/biodaff/).

For more information on the Arctic Marine Laboratory, see the King's Bay website: www.kingsbay.no, or contact Kjersti Dale (forskning@kingsbay.no; +47-7902-7252), or Haakon Hop (haakon.hop@npolar.no; +47-7775-0522).

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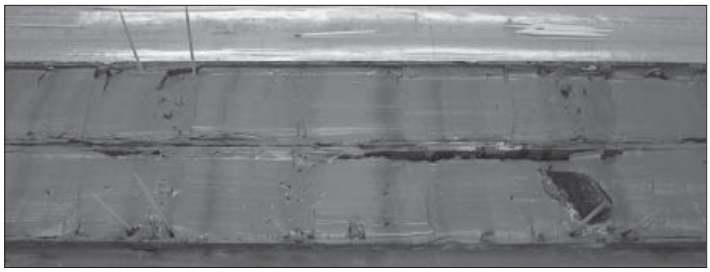
Svendsen, H. et al. 2002. The physical environment of Kongsfjorden-Krossfjorden, an Arctic fjord system in Svalbard. *Polar Research* 21: 133–166.


*In the new arctic marine lab, Ryan Cumpston, a senior at Northern Illinois University, wraps up sediment trap and gravity core samples from Kongsfjord. Photo by J. Brigham-Grette.*

# Marine Sediment Chronicles History of Hubbard Glacier

In response to warming in the Arctic, the melt rate of Alaskan coastal glaciers has accelerated, resulting in a reduction in thickness and length of most glaciers and contributing substantially to global sea level rise. Tidewater glaciers, however, seem to behave anomalously, thickening over the past 20 years while those adjacent to them on land have thinned and retreated. Glaciers with tidewater termini differ from those with terrestrial termini because contact with a water body at the terminus affects ablation rate through iceberg calving. Behavior of these cliff-calving glaciers is primarily related to water depth at the terminus. Presently, at least ten large Alaskan tidewater glaciers terminate in shallow water and are slowly advancing into the sea—their terminus positions appear insensitive to climate forcing. It appears that the melt rate and release of freshwater from Alaskan glaciers are accelerating, in spite of terminus dynamics. Accurately quantifying discharge from the large cliff-calving glaciers is difficult, however, because they end in marine bays and fjords.

In a project funded by the NSF Arctic Natural Sciences Program, Establishing Marine Varve Thickness as a Proxy for Annual Climate Variability and PDO Oscillations, Ellen Cowan (Appalachian State University), John Jaeger (University of Florida), Ross Powell (Northern Illinois University), and their students are using the marine sediment record at Hubbard Glacier to develop proxies for meltwater and iceberg discharge that can be correlated with local meteorological forcing. Hubbard Glacier, the largest tidewater glacier in North America, makes an ideal study site because of the 50+ year record of local climatology in the town of Yakutat located 30 miles away.



One goal of this project is to analyze the past 20 years of the glacimarine sediment record in Disenchantment Bay, the proglacial basin of the glacier, to quantify the response of the glacifluvial system and iceberg discharge to Pacific climate variability, such as the Pacific Decadal Oscillation (PDO). The PDO is positively correlated with air temperature and freshwater discharge into the Gulf of Alaska and may be recorded in the marine sediment record.

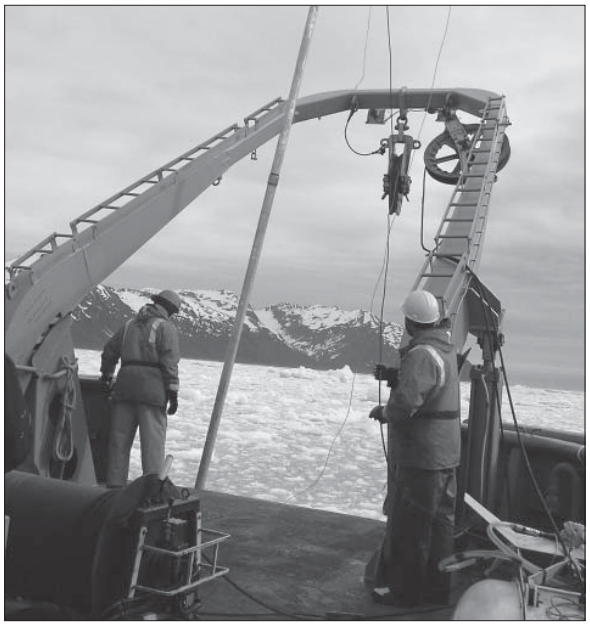
During a research cruise aboard the R/V *Alpha Helix* in June 2004, the team collected piston cores and multicores to quantify the annual sediment deposition from glacial meltwater. Annual layers, or varves, are identified by a coarse/fine grain couplet, which includes an iceberg-rafted diamicton (unsorted admixture of pebbles, sand, and mud) followed by laminated mud encasing lenses of debris. A sheet of diamicton is deposited across the floor of Disenchantment Bay each winter/spring when the meltwater system is shut down and iceberg rafting is intensified by onshore winds and the absence of sea ice. Iceberg rafting continues during the summer months but the debris is diluted by glacifluvial mud.

The team also collected 298 km of high-resolution seismic reflection profiles using a Huntec Deep-Tow system to increase spatial coverage and correlation of annual sediment layers. The acoustic contrast between the coarser-grained diamicton and the fine-grained meltwater muds within each varve can be detected in more proximal areas (<10 km from the glacier) where the annual varve thickness averages more than 30 cm per year.

The cores are currently being analyzed for their sedimentological and physical characteristics, and radiochemical techniques are being employed to establish varve thickness and chronology. Once analysis is complete, the sediment record will be directly compared with the nearby instrumental and ice core records of precipitation, temperature, and snowfall accumulation. The resulting high resolution proxy record of meltwater discharge can then be used to better understand the connection between rapid melting of Alaskan glaciers and decadal trends in arctic warming.

To communicate their results and experiences at Hubbard Glacier to general audiences, Cowan, Jaeger, and Powell have produced a photographic display for the McKinney Geological Teaching Museum on the campus of Appalachian State University.

For more information, contact Ellen Cowan (cowanea@appstate.edu; 828-262-2260), John Jaeger (jaeger@geology.ufl.edu; 352-846-1381), or Ross Powell (ross@geol.niu.edu; 815-753-7952).



*Left: Researchers aboard the R/V* Alpha Helix *collect piston cores from Disenchantment Bay in southeast Alaska. The marine sediment collected here will be used to develop proxies for meltwater and iceberg discharge from Hubbard Glacier. Top: Split piston core showing a glacimarine varve. Iceberg-rafted diamictons are shown between sets of closely spaced toothpicks. The laminated mud deposited by meltwater during summer months occurs between them.* Most *of the cores collected during the cruise were 6 m in length and 7.6 cm in diameter. Photos courtesy of Ellen Cowan.*

# Siberian Specimen Inaugurates Study of Paleogenomics

Until recently, the prospect of recovering more than a tiny fraction of the complete DNA pattern of an extinct species with available methods seemed remote. Recently published research, however, partly supported by the Arctic Natural Sciences Program (Poinar et al. 2006) shows that "paleogenomics"—the study of the total genetic material of ancient organisms, including extinct species—is now a reality, with more comprehensive results than ever before.

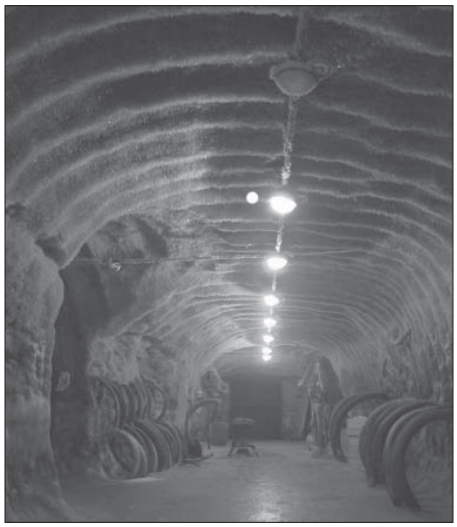
Using new methods, Hendrik Poinar of McMaster University, Ross MacPhee of the American Museum of Natural History, and colleagues were able to recover and identify an extraordinary amount of endogenous DNA from a well preserved jaw belonging to a woolly mammoth (*Mammuthus primigenius*) that died near Lake Taimyr in northern Siberia 28,000 years ago. For most of the time since its discovery in 1999, the fossil had been kept at -10°C in a manmade "ice cave" in the town of Khatanga; this may account for its exceptional preservation, which allowed the investigators to collect the most sequence information recovered for any extinct species. The previous record was 27,000 bp (base pairs of nucleotide sequence) of nuclear DNA for the extinct cave bear *Ursus spelaeus* (Noonan et al. 2005). With the new techniques, including a novel high-throughput sequencing method, the mammoth jaw sample yielded 13 million bp alignable to a verified modern African elephant sequence.

Virtually all of the endogenous DNA from the Taimyr specimen was nuclear. Overall, it was found that woolly mammoth and African elephant sequences differ by less than 1.5%; Asian elephant sequences should differ even less. These results represent only about 0.5% of the whole genome of *M. primigenius*, which is estimated to be roughly 2.8 billion bp. Given the high rate of sequence recovery now achievable, however, the researchers estimate that as little as one year will be needed to acquire and verify most or all of the coding regions of the woolly mammoth's genome.

Characterization of the complete genetic material of this (or any other) extinct species is likely to contribute considerably to answering long-standing questions in molecular evolution and extinction studies. A study of comparative elephantid genomics including Pleistocene species would allow investigators to ask, for example, to what degree and in what specific ways did woolly mammoths differ genetically from any of the species of living elephants? How did certain functional genes differ, such as those controlling hair growth or fat deposition, which made life possible for woollies living at high latitudes? Do mutation rates vary among species? When did phylogenetic splits occur?

Why did mammoths disappear everywhere in their enormous range, which ultimately extended over large portions of three continents, while other elephants managed to survive in tropical Africa and Asia? Paleontological investigations have shown that the final extinction of *M. primigenius* was actually a very recent phenomenon, occurring less than 4,000 years ago in their last outposts, small islands in the East Siberian and Bering Seas. On mainlands, however, woolly mammoths seem to have disappeared earlier, perhaps 9,000–10,000 years ago.

The team was also able to identify DNA sequences attributable to a wide range of other organisms associated with the mammoth sample. In addition to a small amount of sequence indicating contamination by human handling, as expected, there was substantial genetic evidence for the presence of a variety of bacteria, viruses, and plants. The DNA from most of these sources represent secondary associations which probably came about after the animal died. The fact that sequence information can now be quickly recovered for practically any DNA present in a sample, however, means that the study of these associations can be taken to a new level. For example, during the past century a number of so-called partial "permafrost mummies" of woolly mammoths, woolly rhinos, horses, and other ice age mammals have been recovered in Siberia and Alaska. Most are highly incomplete, but some retain gut tissues together with their contents. Although plant macrofossils and pollen in gut contents can provide information regarding what the animals were eating, unrepresented taxa will obviously be missed. Ancient DNA can help with this problem because certain groups of plants can be recognized on the basis of distinctive sequences in their chloroplast DNA, which may be preserved even when plant tissues are not. This kind of information can contribute to the long-running controversy regarding the arctic Pleistocene environment: highly productive grasslands or low-diversity tundra?



*The "ice cave" in Khatanga, where specimens are stored in optimal conditions for preservation. The facility is excavated into permafrost and maintains an average temperature of -10°C. Man-made "ice caves" can be found in a number of arctic settlements in Russia. The caves were excavated with tunnel boring machines, which are used for a variety of purposes (e.g., subway tunnels, underground pipelines). Although it is sometimes said that the tunnels were used in Soviet times to hide weapons, in fact they mostly seem to have served very ordinary functions like cold storage. The Khatanga tunnel system, for example, is used to hold fish and reindeer carcasses throughout the year for local consumption, in addition to mammoth bones. Photo by Clare Flemming.*

For more information, contact Ross MacPhee (macphee@amnh.org; 212-769-5480), or Hendrik Poinar (poinarh@mcmaster.ca; 905-525-9140, ext. 26331).

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# SEARCH Community Updates Implementation Priorities

The overall goal of the Study of Environmental Arctic Change (SEARCH) is to understand the nature, extent, and future development of the system-scale changes presently observed in the Arctic. Currently more than 40 SEARCH projects have been implemented, with contributions from several U.S. funding agencies, including NSF, the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA), among others. Recent developments, including the creation of the International Study of Arctic Change (ISAC) as the international program of which SEARCH will be a part of and the upcoming International Polar Year (IPY) 2007–2008, offer opportunities for accelerated implementation of SEARCH.

### SEARCH Implementation Workshop

In recognition of these opportunities, the SEARCH Science Steering Committee (SSC) organized a SEARCH Implementation Workshop to update the 2003 *SEARCH Implementation Strategy* and to align implementation priorities with evolving thinking in the SEARCH and ISAC communities, as well as the arctic community at large. The main goal of the workshop was to provide recommendations for prioritized implementation of SEARCH during the period of the IPY, with a view beyond this near-term time line.

Held 23–25 May 2005 at the National Conference Center in Lansdowne, Virginia, the SEARCH Implementation Workshop was attended by over 80 scientists, including members of the SEARCH SSC, the SEARCH Panels (Observing Change, Understanding Change, and Responding to Change), the Interagency Program Management Committee (IPMC), and the wider research community.

The workshop was organized to include a combination of plenary discussions and breakout sessions. Breakout sessions alternated between the panel-focused themes (Observing, Understanding, and Responding) and smaller working groups organized around several specific topical areas (e.g., terrestrial ecosystems, distributed marine observations, human dimensions, etc.) that were identified by the SEARCH SSC as requiring specific attention.

The workshop report, *Study of Environmental Arctic Change: Plans for Implementation During the International Polar Year and Beyond* was released in November 2005. The activities and priorities within the report draw from a number of sources and community discussions, including the initial *SEARCH Science Plan* and *SEARCH Implementation Strategy*; white papers prepared by SEARCH implementation panels; community input received in response to the white papers posted online; and discussions during and after the workshop.

The priorities detailed in this report are guided by the need to understand the complex of pan-arctic change. Workshop participants identified the following set of scientific questions that lie at the heart of the SEARCH program:

1. Is the arctic system moving to a new state?
2. To what extent is the arctic system predictable (i.e., what are the potential accuracies and/or uncertainties in predictions of relevant arctic variables over different timescales)?
3. To what extent can recent and ongoing climate changes in the Arctic be attributed to anthropogenic forcing, rather than to natural modes of variability?
4. What is the direction and relative importance of system feedbacks?
5. How are terrestrial and marine ecosystems and ecosystem services (i.e., processes by which the environment produces resources that support human life) affected by environmental change and its interaction with human activities?
6. How do cultural and socioeconomic systems interact with arctic environmental change?
7. What are the most consequential links between the arctic and the Earth systems?

To address these science questions, recommendations for implementation were developed for Observing Change: Identified Needs, Existing Programs, and Priorities; Understanding Change: Analysis, Synthesis, and Modeling; Responding to Change: Developing Adaptive Responses; SEARCH Data Management Strategy; and Education and Outreach.

The final report is available at: www.arcus.org/search/meetings/2005/siw/report.php. The report was referenced in the IPY NSF Program Solicitation released in February 2006 for the Arctic Observing Network emphasis area (see page 10). Proposals were due 1 May.

### SEARCH SSC Meeting

The SEARCH SSC met in Fairbanks, Alaska, in late November 2005 to share information about IPMC activities, updates on SEARCH activities, and information on related national and international programs. The SSC discussed issues related to SEARCH implementation, including agency plans, coordination with international activities, further development of a searchable online SEARCH project inventory, data management activities, and a potential State of the Arctic Conference for spring 2008. To complement the SEARCH panel structure, the SSC is working to establish three standing working groups to address issues of data management, paleoenvironmental studies, and education and outreach.

### International Activities

Planning for the International Study of Arctic Change (ISAC) continues. The two bodies overseeing ISAC, the Arctic Ocean Sciences Board and International Arctic Science Committee (IASC), are working together to finalize appointment of a Scientific Steering Group and establish an International Program Office to provide support for the activities of ISAC and serve the organizational needs of the program. Michael Tjernström of Sweden and Grete K. Hovelsrud of Norway have been appointed as ISAC co-chairs, and IASC distributed a call for applications for the ISAC Executive Director position with a closing date of 28 April.

For more information, see: www.arcus.org/search, or contact Peter Schlosser (schlosser@ldeo.columbia.edu; 845-365-8707), Neil Swanberg (nswanber@nsf.gov; 703-292-8029), or Helen Wiggins (helen@arcus.org; 907-474-1600).

# BEST Plans for Implementation and Cooperation

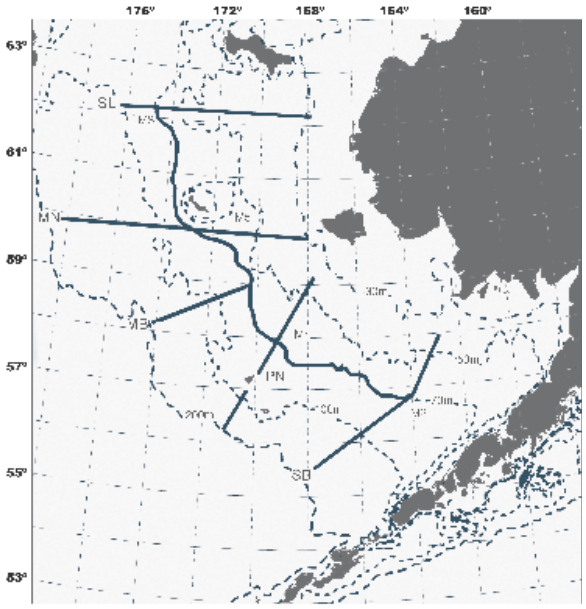
The Arctic Sciences Section has been working with the arctic research community and residents of the Arctic to develop a comprehensive approach to basic research in the Bering Sea. The Arctic Research Opportunities Program Solicitation released in September 2005 included a section requesting proposals addressing the goals of the Bering Sea Ecosystem Study (BEST; see *Witness* Winter 2004/2005); proposals were due 16 December 2005.

The 2004 BEST science plan identifies questions important for understanding how climate variability could influence the ecosystems of the eastern Bering Sea and their ability to sustain goods and services required by people. Social scientists have developed a draft parallel science plan, *Sustaining the Bering Ecosystem: A Social Sciences Plan*, which outlines a community-based research program focused on the residents of Bering Sea communities and their need to understand how climate variability will affect their future. These two plans have been integrated into a single program to study the ecosystem as a whole, including the social implications of climate change and roles of people in the system.

In May 2005, 132 people from 12 nations, both scientists and residents, reviewed a draft of the integrated BEST implementation plan at an open workshop during the Global Ocean Ecosystem Dynamics (GLOBEC) Symposium on Climate Variability and Sub-arctic Marine Ecosystems. The BEST Science Steering Committee revised the document in response to these comments, and a final implementation plan is now available.

Under the auspices of the Study of Environmental Arctic Change (SEARCH; see page 17), the BEST program will support integrated, interdisciplinary studies of eastern Bering Sea marine ecosystems. The BEST field program is expected to begin in spring 2007 and continue through 2009.

To improve understanding of the variables and processes shaping all aspects of the Bering Sea, from physical forcing (atmosphere and ocean) to food web responses (including fish, seabirds, marine mammals, and humans), fundamental research in the physical, natural, and social sciences, appropriate for funding by NSF, will be linked to studies funded by other agencies with interests in the region. The BEST program will be closely coordinated and integrated with the new National Oceanic and Atmospheric Administration (NOAA) Fisheries North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) and Loss of Sea Ice (LOSC) programs. NPCREP and LOSC will be making physical and biological oceanographic observations in support of ecosystem and fisheries oceanography investigations in the eastern Bering Sea during the same time frame as that anticipated for the BEST field program (figure).




*The BEST field program is designed to leverage an extensive array of oceanographic measurements that will be made by other programs in the next few years. These observational programs will be supported by NOAA's North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) program and by the North Pacific Research Board (NPRB). At present, it is expected that the Pacific Marine Environmental Laboratory will have at least four biophysical moorings located along the 70 m isobath. These mooring data could be supplemented with standardized stations along five survey lines extending from the inner domain to the continental slope possibly connected by a section along the 70 m isobath that could be occupied by BEST cruises. Figure courtesy of P. Stabeno (NOAA).*

BEST is also a partner in a consortium of agencies and institutions concerned about the Bering Sea ecosystem. Partners in the Climate Change and Bering Sea Ecosystem consortium include: BEST, NOAA (Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory), the North Pacific Research Board, the Alaska Ocean Observing System, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the U.S. Arctic Research Commission, and the University of Alaska Fairbanks. Members of the consortium met in July 2005 and will meet again in July 2006 to identify important gaps in their research coverage and devise a strategy to use their collective resources effectively.

In addition, BEST is the U.S. component of a new regional GLOBEC program, Ecosystems of Sub-Arctic Seas (ESSAS), which will initiate collaborative studies of the sub-arctic seas, including cooperative ecological research of the eastern, western, and basin areas of the Bering Sea by Japan, Russia, and the U.S. A draft of the ESSAS implementation plan was also reviewed during the May GLOBEC symposium. Over 50 papers were submitted by symposium participants for inclusion in a special volume of *Progress in Oceanography.*

A June 2006 workshop, held in St. Petersburg, Russia, and sponsored by the North Pacific Marine Science Organization (PICES) and GLOBEC, identified mechanisms and fluxes particularly sensitive to climate variability and was the beginning of the ESSAS program's efforts to compare responses to climate variability in the Bering Sea, the Sea of Okhotsk/Oyashio region, the Newfoundland/Labrador shelf, and the Barents Sea.

For more information on BEST, including the science and implementation plans, see the ARCUS website: www.arcus.org/Bering, or contact George Hunt (geohunt2@u.washington.edu; 206-221-6118), or Ben Fitzhugh (fitzhugh@u.washington.edu; 206-543-9604). For more information on ESSAS, see the GLOBEC website: www.pml.ac.uk/globec/structure/regional/essas/essas.htm, or contact Ken Drinkwater (kendrink@ims.no; +47-5523-6990).

# Stephenson Replaces Pyle as Head of OPP Arctic Section

In April 2006, the NSF Office of Polar Programs (OPP) announced the appointment of Simon Stephenson as the new Section Head for Arctic Sciences, replacing the founding head of the section, Thomas E. Pyle, who retired in August 2005. Stephenson is appointed for an initial period of two years.

Stephenson has 28 years experience in polar research. His first 11 years were as a glacier geophysicist with the British Antarctic Survey and then with a team based at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center working on the dynamics of West Antarctic ice streams. In 1989, Stephenson joined OPP as the Research Support Manager for the Antarctic Program, and in 1999 he moved to the Arctic Section to lead the establishment of NSF's new Research Support and Logistics Program for the Arctic (see pages 10–14). The program has improved the capacity and capability of facilities throughout the Arctic used by U.S. researchers supported by NSF, often through international partnerships with other nations involved in arctic research. Stephenson also served as the program officer for the Arctic Long-term Observations program.

Stephenson graduated from the University of Liverpool in 1978 and earned a Master of Philosophy in Glacier Geophysics from the Council for National Academic Awards, UK, in 1984.

### Pyle Retires After Decade at OPP

NSF recruited Tom Pyle to join OPP in 1995 as it reorganized the office to include a specific section for arctic research in addition to its longstanding programs supporting science in Antarctica.

Pyle grew up in Brooklyn, New York, and earned his B.A. in geology from Columbia University and M.S. and Ph.D. in oceanography from Texas A&M. After three years on the faculty of the University of South Florida, he moved to the Stennis Space Center to manage the Marine Geology and Geophysics Program for the Office of Naval Research (ONR). In 1981, Pyle joined the National Oceanic and Atmospheric Administration (NOAA), where he served as deputy director of the National Ocean Survey and chief scientist of the National Ocean Service, managing the scientific operations of the NOAA fleet.

In 1985, Pyle moved to the Joint Oceanographic Institutions (JOI), where he served as vice president, manager of the program office for the Nansen Arctic Drilling Program, and principal investigator for the international Ocean Drilling Program (see *Witness* Winter 2004/2005).

While the search for Pyle's replacement was underway, Michael Van Woert served as interim head of the Arctic Sciences Section. Van Woert became executive officer of OPP in 2005. Van Woert earned his B.S. in physics from the University of California, Davis, and Ph.D. from Scripps Institution of Oceanography. After ten years in industry, during which he made several trips to Antarctica, Van Woert became program manager for the Physical Oceanography program at NASA in 1993.

In 1994, he joined ONR, where he managed the High Latitude Dynamics program. His arctic responsibilities at ONR included the Science Ice Exercises (SCICEX; see page 22) and Surface Heat Budget of the Arctic Ocean (SHEBA) programs (see *Witness* Autumn 2001). In 1997, Van Woert moved to NOAA to become chief scientist of the National Ice Center, where he managed a group focused on improving operational sea ice products for navigation and research.

For more information, see the OPP website: www.nsf.gov/dir/index.jsp?org=OPP, or contact Simon Stephenson (sstephen@nsf.gov; 703-292-8029) or Michael Van Woert (mvanwoer@nsf.gov; 703-292-8030).

### New ARCSS Associate Manager

Janet Intrieri joined OPP in October 2005 as the Arctic System Science (ARCSS) Associate Program Manager on an Interagency Detail assignment from NOAA. Intrieri has been an atmospheric research scientist since 1985 at the NOAA Environmental Technology Laboratory in Boulder, Colorado, which recently became part of the new NOAA Earth System Research Laboratory. Intrieri earned her B.S. in meteorology from Penn State, M.S. in atmospheric sciences from Colorado State, and M.S. and Ph.D. in aerospace engineering from the University of Colorado. Intrieri specializes in lidar remote sensing of the atmosphere. She was a principal investigator on the SHEBA project.

For more information, see the ARCSS website: www.nsf.gov/funding/pgm_summ.jsp?pims_id=13426&org=ARC, or contact Janet Intrieri (jintrier@nsf.gov; 703-292-4426).

### Olsen New Deputy Director of NSF

Kathie L. Olsen became deputy director of NSF in August 2005. She joined NSF from the Office of Science and Technology Policy (OSTP), where she was the associate director and deputy director for science. Prior to the OSTP post, she served at NASA as chief scientist (1999–2002) and acting associate administrator for the new Enterprise in Biological and Physical Research (2000–2002). Olsen's positions prior to NASA include senior staff associate for the Science and Technology Centers in the NSF Office of Integrative Activities, Brookings Institution legislative fellow, NSF detail in the office of Senator Conrad Burns of Montana, and acting deputy director for the NSF Division of Integrative Biology and Neuroscience.

Olsen earned a B.S. in biology and psychology from Chatham College in Pittsburgh, Pennsylvania, and a Ph.D. in neuroscience from the University of California Irvine. She was a postdoctoral fellow in the Department of Neuroscience at Children's Hospital of Harvard Medical School. Subsequently at SUNY-Stony Brook she was both a research scientist at the Long Island Research Institute and assistant professor in the Department of Psychiatry and Behavioral Science at the medical school. Her research on neural and genetic mechanisms underlying development and expression of behavior was supported by the National Institutes of Health.

Olsen replaces Joseph Bordogna, who resigned in June 2005 after serving as deputy director since 1996.

For more information, see the NSF website: www.nsf.gov/od/.

# NSF-wide Programs Support Varied Research Efforts

Three NSF-wide programs recently made awards of interest to the arctic research community.

### New Polar Ice Sheet Center

In April 2005, NSF announced awards for the two successful proposals in the 2003 Science and Technology Centers (STC) competition, one of which has a polar focus. The Center for Remote Sensing of Ice Sheets (CReSIS) at the University of Kansas (KU) will develop models and technology to improve understanding of the mass balance of polar ice sheets and its impact on sea level. The center will receive $19 million over five years, with a possible five year renewal. The CReSIS proposal builds on the Polar Radar for Ice Sheet Measurements (PRISM) project, funded by NSF and NASA since 2001. KU professor Prasad Gogineni heads the CReSIS STC, which includes 13 other institutions, four outside the U.S., as partners.

The STC program supports long-term scientific and technological research and education activities, with an emphasis on knowledge transfer; centers may receive up to $4 million annually for up to ten years. Administered by the NSF Office of Integrative Activities, the program has had five competitions (in 1989, 1991, 1998, 2000, and 2003), awarding a total of 38 centers in a variety of research areas. NSF received 164 pre-proposals in the 2003 competition. The announcement of a future competition is under consideration and is a decision for the FY 2008 NSF budget.

For more information, see the CReSIS STC website: www.cresis.ku.edu/, the NSF website: www.nsf.gov/od/oia/programs/stc/, or contact Margaret E. M. Tolbert in the Office of Integrative Activities (mtolbert@nsf.gov; 703-292-8040).

### Endangered Languages Project

At least half of the world's 6,000–7,000 currently used human languages are considered endangered; about 300 have fewer than 100 native speakers. To address this intellectual crisis, NSF and the National Endowment for the Humanities (NEH) are collaborating to fund projects to improve knowledge of endangered languages. The Smithsonian Institution National Museum of Natural History also participates in the Documenting Endangered Languages (DEL) project as a research host to appropriate projects but does not provide funding.

The first DEL awards, totaling $4.4 million, were announced in May 2005; 26 institutional awards for up to 3 years and 13 fellowships for 6–12 months will support digital documentation projects on more than 70 endangered languages. Five projects will document some of the more than 200 endangered northern languages:

- Continuing Tlingit Language Documentation. Keri Edwards, Sealaska Heritage Institute. *$266,224.*
- Documentation of the Endangered Eastern Khanty Dialects. Andrei Filtchenko, Rice University. *Fellowship*.
- Developing a Northern Indigenous Languages Archive: Yup'ik Pilot Project. Gary Holton, University of Alaska Fairbanks (UAF). *$39,186.*
- Pedagogical Grammar of Gwich'in. Kathy Sikorski, UAF. *$103,947.*
- Lower Tanana Dictionary and Literacy. Siri Tuttle, UAF. *$109,772.*

Proposals for the next round of this program are due 15 September 2006. Assuming funds are available, NSF and NEH expect to continue the program for another four years, with approximately $2 million available each year to support 6–10 standard grants and 12 fellowships.

For more information, see the NSF website: www.nsf.gov/funding/pgm_summ.jsp?pims_id=12816, or contact Anna Kertulla (akerttul@nsf.gov; 703-292-7432).

### Revamped International Programs

The office supporting NSF international activities recently implemented several changes to its programs. The NSF International Division, previously housed in the Social, Behavioral, and Economics Sciences Directorate, was renamed the Office of International Science and Engineering (OISE) in January 2002 and placed in the director's office in June 2004. A recently formed OISE Advisory Committee held its first meeting in June 2005. The new portfolio of OISE activities includes:

**Planning Visits and Workshops:** a new solicitation for planning efforts that may lead to innovative international projects (NSF 04-035; due dates vary).

**Global Scientists and Engineers:** designed to provide international experience for U.S. students and early-career investigators, this set of activities includes:

- Developing Global Scientists and Engineers (NSF 04-036; due 15 September and 15 February).
- Research Experience for Undergraduates (NSF 05-592; due 17 August).
- East Asia and Pacific Summer Institutes for U.S. Graduate Students (NSF 05-617; due 12 December).
- Pan-American Advanced Studies Institutes (NSF 03-506; due 15 January).
- International Research Fellowships (NSF 05-599; due 12 September).

**Partnerships for International Research and Education (PIRE):** a one-time solicitation for long-term international research and educational activities. Proposals were due in March 2005.

NSF received 174 PIRE proposals and funded 12, including the U.S.-Russia-Japan Partnership in Research and Education in Volcanology, which will receive $2.2 million over five years. John Eichelberger of UAF is the project's principal investigator, with collaborators from the Institute of Volcanology and Seismology in Petropavlovsk-Kamchatsky, Russia, and the University of Tokyo, Japan. The project involves students from all three countries in comparing the evolution of three important lateral blast eruptions, two in Kamchatka and Mt. St. Helens in the U.S., over the past 50 years.

OISE hopes to be able to offer the PIRE solicitation again in the near future. In partnership with NSF's research directorates, OISE will also continue to support international collaboration across NSF's programs. Researchers may include an international dimension in their proposals or request supplementary funding to active awards.

For more information, see the NSF website: www.nsf.gov/div/index.jsp?org=OISE, or contact Edward Murdy (emurdy@nsf.gov; 703-292-8711).

# 1.8% Increase Returns 2006 NSF Budget to 2004 Level

In November 2005, President Bush signed the fiscal year (FY) 2006 Science, State, Justice, Commerce, and Related Agencies Appropriations Act, which includes the NSF budget. The final NSF budget is $5.58 billion, a 1.8% increase over FY 2005 after a mandated 1.28% rescission. Because the FY 2005 budget reflected a decrease of 1.9%, the FY 2006 budget essentially returns the agency to FY 2004 funding levels, without accounting for inflation. In real terms, the FY 2006 budget is lower than in any of the last three years, and far below the $8.5 billion authorized in 2002 in a plan to double the NSF budget by 2007 (see *Witness* Spring 2002).

Funding for NSF's Research and Related Activities (R&RA) account increased by $96.6 million (2.3%) to $4.3 billion. The largest R&RA increase is $44.3 million (15.9%) to Polar Programs, partially covering a transfer of $48 million in Coast Guard costs for icebreakers to the NSF budget (see page 12).

The Education and Human Resources (EHR) budget was cut 5.6% ($46.85 million) to $797 million, bringing NSF support for education down to FY 2000 levels in real terms. One bright spot in EHR was $99 million (a $5 million increase) for the Experimental Program to Stimulate Competitive Research (EPSCoR).

The Major Research Equipment and Facilities Construction (MREFC) account increased by 15.6% ($25.74 million) to $191 million to fund four ongoing projects (the Scientific Ocean Drilling Vessel [see *Witness* Winter 2004/2005], Atacama Large Millimeter Array, EarthScope, and IceCube Neutrino Observatory).

### FY 2007 Budget Request

On February 6, President Bush released his proposed budget for FY 2007, including increases for some science and engineering programs as part of the American Competitiveness Initiative, a response to growing concerns about the state of U.S. innovation (see page 1). Three agencies (NSF, the Department of Energy Office of Science, and the National Institute of Standards and Technology Laboratories) would receive substantial budget increases.

The request proposes a $439 million (7.9%) increase for the overall NSF budget to $6.0 billion in 2007. NSF's R&RA account would total $4.7 billion, a 7.7% increase. Most research directorates would increase 5–9% after several years of flat or declining funding, but the budgets of several directorates, including Mathematical and Physical Sciences; Geosciences; Biological Sciences; and Social, Behavioral and Economic Sciences, would remain below 2004 levels in real terms. The new Office of Cyberinfrastructure, a recent spin-off from the Computer and Information Science and Engineering directorate, would see its funding climb 44% to $182 million.

The Office of Polar Programs (OPP) would receive $438 million, a boost of $48.76 million (12.5%), largely for International Polar Year (IPY) 2007–2008 research and associated logistics costs. The Arctic Sciences section request includes increases of $8.3 million for IPY research activities, $8 million to provide logistics in support of IPY, and $1.46 million for the Bering Ecosystem Study (BEST; see page 18). The Antarctic Sciences section would receive an increase of $8.5 million for IPY research and $9 million for IPY logistics.

The OPP request also includes $57 million to operate and maintain the polar icebreaker fleet. The OPP budget no longer includes funding for the U.S. Arctic Research Commission (USARC; see page 22), which is now a separate account in R&RA, with a budget of $1.45 million, an increase of $280,000 (23.5%) over FY 2006.

The EHR budget would increase 2.5%, a 20% decrease from 2004 in real terms. The EHR request includes $2 million in FY 2007 for IPY education activities. Over the next two years, EHR plans an internal reorganization that will;

- merge the Elementary, Secondary and Informal Education Division and the Research, Evaluation and Communication Division into a new Division of Research on Learning in Formal and Informal Settings,
- move the Math and Science Partnership program to the Division of Undergraduate Education, and
- combine the Instructional Materials Development, Teacher Professional Continuum, and Centers for Learning and Teaching programs to create a new Discovery Research K–12 program.

The MREFC account would increase 26%, from $191 million to $240 million, including $12 million for the National Ecological Observatory Network (NEON; see *Witness* Spring 2000), $13.5 million for the Ocean Observatories Initiative, and $56 million for the Alaska Region Research Vessel (ARRV; see *Witness* Spring 2004).

Final results of the budget process will not be known until after Congress considers the FY 2007 budget request in the coming months. For more information, see the NSF Budget Division website: www.nsf.gov/about/budget.

### Appropriations Reorganized

In February 2005, the House Appropriations Committee reorganized the 13 appropriations subcommittees responsible for individual appropriations bills. The major change, which was also ratified by the Senate, was the elimination of the Veterans Affairs-Housing and Urban Development (VA-HUD) and Independent Agencies subcommittee, which had been responsible for funding NSF, the National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA), among others. The new House subcommittee overseeing NSF appropriations is the Science, State, Justice, and Commerce subcommittee, chaired by Frank Wolf (R-VA); in the Senate, the relevant subcommittee is Commerce, Justice, and Science, chaired by Richard Shelby (R-AL). The new subcommittee structures in the two chambers (10 in the House, 12 in the Senate) do not correspond precisely, which may lead to difficulties in future conferences.

For more information, see the Library of Congress legislative information website: http://thomas.loc.gov, the American Association for the Advancement of Science website: www.aaas.org/spp/rd, or the American Institute of Physics website: www.aip.org/gov/budginfo.html.

# PRB Provides Expertise for Many Purposes

The Polar Research Board (PRB), a unit of the National Academies, was established in 1958. Unique in its coverage of both arctic and Antarctic science, the PRB strives to make research in the polar regions more productive and responsive to the needs of the U.S.; maintain U.S. awareness of and representation in international science programs; and enhance understanding of issues in polar regions.

The PRB program has two elements: a study element and a core element. Examples of recent projects under the Board's oversight as part of its study element include the Arctic Observing Network study (see page 10) and the assessment of Coast Guard polar icebreaker roles and needs (see page 13). A new study is underway to consider the environmental and scientific stewardship responsibilities related to exploration of subglacial lake environments in Antarctica.

Under its core element, the PRB serves as a source of information and assistance to federal agencies, Congress, and others in the polar community and serves as the U.S. National Committee for the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (ICSU) and as the U.S. National Committee for the International Arctic Science Committee (IASC).

Also under its core element, the Board continues to facilitate planning for International Polar Year (IPY) 2007–2008:

- working with numerous agencies, groups, universities, and the international community to move IPY from concept to implementation;
- ensuring that the U.S. polar research community participates in critical planning activities and opportunities for international cooperation; and
- developing selected outreach opportunities that will happen during 2007–2008.

For more information on the PRB, see: www.dels.nas.edu/prb/, or contact Chris Elfring (celfring@nas.edu; 202-334-3479). For more information on the U.S. National Committee for IPY, see: www.us-ipy.org/, or contact Chris Elfring or Maria Uhle (muhle@nas.edu; 202-334-3531).



# John Farrell Takes Helm as Executive Director of USARC

John W. Farrell has been appointed the executive director of the U.S. Arctic Research Commission (USARC) and joins its Arlington, Virginia, headquarters in June, replacing Garrett Brass.

Farrell brings to the Commission a broad background in science, research, and management. Prior to his current position as Associate Dean of Research and Administration at the University of Rhode Island Graduate School of Oceanography, he served as program director at the Joint Oceanographic Institutions where he managed the international Ocean Drilling Program (ODP) and the NSF-supported U.S. Science Support Program. He played a pivotal role in planning and implementing the Integrated Ocean Drilling Program (IODP), the successor to the ODP. He also participated in the highly successful IODP Arctic Coring Expedition (ACEX), conducted in the summer of 2004 atop the Lomonosov Ridge near the North Pole (see *Witness* Winter 2004/2005). Farrell has spent more than 10 months at sea as a research scientist on expeditions to all major ocean basins and has published more than 35 peer-reviewed papers. Farrell is a geology graduate of Franklin and Marshall College and earned his M.S. degree and Ph.D. in geological sciences from Brown University.

Brass, who led the Commission staff from 1995 to early 2006, considers the Science Ice Exercises (SCICEX; see *Witness* Autumn 2001) program one of the most important accomplishments of his tenure at the USARC and offers this summary of its significance:

"In January 1993, the USARC worked with several Navy commands and civilian research agencies to allow civilian scientists to conduct research aboard U.S. Navy fast attack nuclear submarines under the sea ice in the Arctic Ocean. The results from the six SCICEX cruises from 1993 to 1999 were outstanding; the data base on Arctic Ocean hydrography more than doubled and the data base on marine bathymetry in the Arctic increased roughly tenfold. SCICEX data on changes in the thickness of arctic sea ice, the penetration of warm Atlantic water into the Arctic Ocean, chemical and biological activity in the Arctic, the glacial age history of the Arctic Basin, global climate change, and many other subjects have caused revolutions in our understanding.

Now that the Cold War has ended and with it the dedicated SCICEX cruises, the program continues to prepare for short (five- to ten-day) data collection exercises known as "opportunity" cruises, but scientists no longer ride along and specialized instruments like Seafloor Characterization And Mapping Pods (SCAMP) are idle. The likeliest platforms to replace the Arctic Ocean survey function of the SCICEX submarine cruises are autonomous underwater vehicles (AUVs), but existing platforms don't have the endurance to conduct SCICEX style surveys and there are many other hurdles to cross before they can assume the submarine's survey mission. The SCICEX program was a brilliant success. We are still exploring opportunities for the next phase."

For more information, see www.arctic.gov, or contact George Newton (703-525-0111).

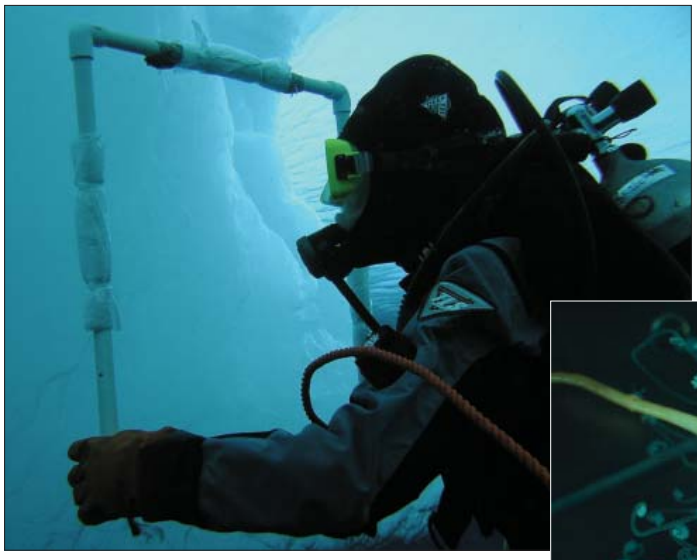
# Exploration of Arctic Canada Basin Finds New Species

In June and July 2005, an international team of 24 scientists from the U.S., China, and Russia collaborated to explore the depths of the Canada Basin under the auspices of the Census of Marine Life (COML) Arctic Ocean Biodiversity (ArcOD) project. Operating from the U.S. Coast Guard icebreaker *Healy* and funded by the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean Exploration, the team examined the biota of the sea ice, water column, and seafloor in this ice-dominated ecosystem with a variety of techniques. At 14 stations, they used divers, high definition video platforms, a specially designed remotely operated vehicle (ROV), ice coring, plankton nets, and bottom cores and trawls to retrieve material and images from depths sometimes greater than 3,000 m.

The new tools gave the investigators the first comprehensive look at the deep arctic seafloor, water column, and sea ice habitats in the Canada Basin, revealing unexpectedly high densities and diversity of animals. Among the thousands of specimens collected, at least seven previously unknown species were found by the team: four soft-bodied zooplankton species and three benthic polychaete worms.

Rolf Gradinger of the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks (UAF) was chief scientist on the voyage; other institutions represented on the team included California State University Monterey Bay, Harbor Branch Oceanographic Institution, NOAA, Texas A&M University Corpus Christi, University of Hawaii, Western Washington University, Zoological Institute, P.P. Shirshov Institute of Oceanology, and Polar Research Institute of China (see page 24).

The 2005 cruise was the third in a series by this research team—in 2002 to the Canada Basin on the Canadian Coast Guard icebreaker *Louis S. St-Laurent,* and in 2004 to the Bering and Chukchi Seas on the Russian research vessel *Professor Khromov*, funded by the NOAA Arctic Research Office and Ocean Exploration. The ArcOD team is currently working on proposals for research to be conducted during the International Polar Year 2007–2008.



*Left: Diver Katrin Iken deploys a quadrat to count under-ice amphipods (sand fleas) in the Canada Basin. Photo by S. Harper, UAF/NOAA. Below: An unidentified cnidarian polyp collected from the deep Canada Basin with the manipulator arm of an ROV. The specimen was attached to a second species of cnidarian. Photo by B. Bluhm and K. Iken, UAF/NOAA.*

The ArcOD project also supports an Arctic Marine Taxonomic Center (AMTC) to provide taxonomic training and expertise, examine already collected materials in detail, and organize data from past (mostly Russian) arctic expeditions and literature and distribute it electronically. AMTC program responsibilities are shared by two branches of the Russian Academy of Sciences, the Zoological Institute in St. Petersburg and the Shirshov Institute in Moscow.

### The Census of Marine Life

The international Census of Marine Life (COML) program involves investigators from more than 70 nations. COML seeks to assess and explain the diversity, distribution, and abundance of life in the oceans by answering three big questions:

- What did live in the oceans? Three History of Marine Animal Populations centers work to extend time series by gathering and integrating historical and archival data on marine biota.
- What lives in the oceans now? Fourteen field projects, including ArcOD, estimate abundance and distribution of marine species in every ocean realm and zone.
- What will live in the oceans? Three Future of Marine Animal Populations centers work to improve statistical design, data exchange and model interface, model development, data syntheses, and prediction.

All the data on species, location, and abundance from COML investigations, as well as data from many other sources, will be available through an online Ocean Biogeographic Information System, where they can be integrated with environmental data, maps, and model outputs.

An international Science Steering Committee and Secretariat, based at the Consortium for Oceanographic Research and Education, oversee the COML, which began in 2000 and is planned to continue until 2010, with a total cost estimated at $1 billion. Projects are funded by both private foundations and governmental sponsors; in the U.S., these include NSF, NOAA, the National Oceanographic Partnership Program, and the Office of Naval Research. The Alfred P. Sloan Foundation is the largest private sponsor of COML.

For more information on the Canada Basin expedition, see: www.oceanexplorer.noaa.gov/explorations/05arctic, or contact Jeremy Potter (Jeremy.Potter@noaa.gov; 301-713-9444, ext. 136). For more information on the ArcOD project, see: www.sfos.uaf.edu/research/arcdiv/, or contact Rolf Gradinger (rgradinger@ims.uaf.edu; 907-474-7407). For more information on the Census of Marine Life, see: www.coml.org, or contact Ron O'Dor (rodor@COREocean.org; 202-332-0063, ext. 239).

# China Increases Polar Research Budget as IPY Nears

China is making major commitments to polar research in support of the International Polar Year 2007–2008, including:

- increasing its annual budget for polar science (approximately $6.5 million) by $1.2 million in 2006, and
- allocating an additional $60 million over the next three years to improve infrastructure and capabilities supporting polar research.

China opened its first arctic research station in Ny-Ålesund in 2003, plans to start establishment of its third station in Antarctica by 2008, and is in the process of refurbishing its research icebreaker *Xuelong*.

Chinese efforts in polar research are led by two complementary organizations within the State Oceanic Administration: the Chinese Arctic and Antarctic Administration and the Polar Research Institute of China (PRIC). The Chinese Arctic and Antarctic Administration is the government department in Beijing responsible for planning and coordinating Chinese polar research and expeditions and supporting international cooperation. The PRIC in Shanghai was established in 1989 and has three basic tasks:

- conduct polar scientific research, including upper atmospheric physics, glaciology, biology, and oceanography;
- provide transportation and logistical support to the Chinese National Antarctic/Arctic Research Expeditions (CHINARE), including running the *Xuelong* and the polar stations; and
- supply informational support to polar science, including publishing a journal (*Chinese Journal of Polar Science*) and providing data management, library, and archive services.

### Future Plans

During Arctic Science Summit Week 2005, hosted by the Chinese Arctic and Antarctic Administration, PRIC Director Zhang Zhanhai gave an overview of future arctic research in China. Overall aims include:

- developing and coordinating national programs;
- developing new technologies, equipment, and logistical capabilities;
- improving observatories and carrying out long-term monitoring work in the Arctic Ocean and Ny-Ålesund;
- enhancing international collaboration in arctic research;
- cultivating the next generation of polar scientists, experts, and logistic managers; and
- ensuring data collection and sharing.

The 167 m R/V *Xuelong* is in the process of being refurbished to become a modern research platform supporting new instrumentation, including:

- a hull-based acoustic ice monitoring system,
- arctic ice buoys,
- under-ice moorings with automated data transmission,
- an unmanned aerial vehicle for remote sensing (6 hours endurance, range of 100 km), and
- high frequency ground wave radar.

When the reconstruction is completed in August 2006, laboratory space will have increased to 300 $m^2$ and the ship will accommodate two helicopters.

Zhang also outlined plans for the Arctic Change and Tele-Impact on Mid-Latitudes (ARCTIML, 2006–2010) project, a major new Chinese effort to further understanding of arctic change and its response and feedback to global climate by addressing the impact of arctic change on mid-latitudes. The multidisciplinary CHINARE–2003 expedition to the Chukchi Sea and Canadian Basin laid the foundation for ARCTIML. Initially, two ARCTIML cruises are planned. A cruise aboard R/V *Xuelong* is planned for 2008–2009, during IPY, starting from China through the Bering Strait to the North Pole, continuing through the Atlantic Ocean to Antarctica. The R/V *Xuelong* can go through 1.2 m ice; therefore, this cruise will require cooperation with an additional icebreaker.

China encourages international cooperation in ARCTIML and in polar activities, and hopes to work with other countries and international organizations and programs on joint cruises and field work as well as opportunities for sharing resources such as facilities, vessels, and station data.

For more information, see the PRIC website: www.pric.gov.cn, or contact Zhang Zhanhai (zhangzhanhai@pric.gov.cn; +86-21-685-07533). ■

## Nations Launch Asian Forum for Polar Sciences

At a Council of Managers of National Antarctic Programs (COMNAP) meeting in 2003, the Asian nations involved in COMNAP discussed the increasing need for a regional group to facilitate practical cooperation among Asian neighbor countries in polar research and logistics. Directors of national polar research institutes from China, Japan, and Korea met in May 2004 to develop a framework for an Asian Forum for Polar Sciences (AFOPS). In September 2004, AFOPS was officially inaugurated. India and Malaysia are now members as well.

Korea is serving as the chair country for a two-year term, and Kim Yeadong of the Korea Polar Research Institute (KOPRI) is AFOPS chairman. The AFOPS Secretariat is established at KOPRI. Member countries have representatives for each of the five AFOPS working groups: Earth science, life science, planetary science, engineering and logistics, and public relations and data management.

Representatives of AFOPS met at the 2005 Arctic Science Summit Week, which may become a regular AFOPS venue. AFOPS will make efforts to develop and support cooperative programs on polar research, convene joint symposia and workshops for polar sciences, support Asian countries in developing their national polar programs, and produce joint publications on polar sciences.

For more information, see the AFOPS website: www.afops.org/. ■

# Assessment to Evaluate Impacts of Arctic Marine Activity

The Arctic Council is an intergovernmental forum that addresses environmental protection and sustainable development issues and challenges faced by arctic governments and people (see *Witness* Winter 2004/2005). Council deliberations are conducted at the ministerial level between the eight arctic states and permanent participants (representing arctic indigenous groups). Between these meetings, which occur every two years, the chair of the Council, currently Russia, leads the Senior Arctic Officials in the work of the Council. Five expert working groups focus on issues such as monitoring, assessing, and preventing pollution in the Arctic, climate change, biodiversity conservation and sustainable use, emergency preparedness and prevention, and living conditions of arctic residents.

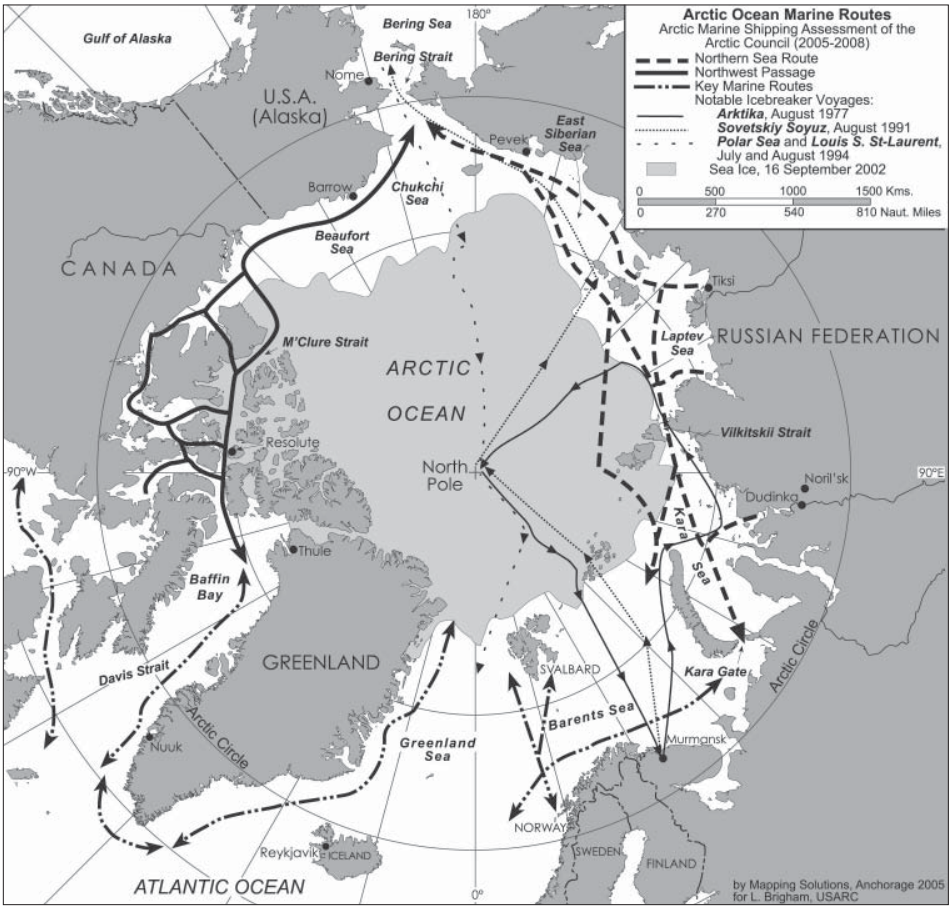
The Protection of the Arctic Marine Environment (PAME) working group was established by arctic ministers in 1993 to address policy, pollution prevention, and control measures related to protection of the arctic marine environment from land and sea-based activities. In 2004, the ministers requested that the PAME working group conduct a comprehensive Arctic Marine Shipping Assessment (AMSA).

The three-year assessment began in February 2005 and is a direct follow-up to the Council's 2004 Arctic Marine Strategic Plan and Arctic Climate Impact Assessment (ACIA). In particular, ACIA Key Finding #6, stating that "reduced sea ice is very likely to increase marine transport and access to resources," guided the evolution of AMSA. Most observers of the Arctic believe it highly plausible that sea ice reductions will hasten increased marine access throughout the Arctic Ocean and likely lengthen the navigation season in all regions.

The assessment is under the general guidance of three lead countries: Canada, Finland, and the U.S. As part of the initial work of AMSA, surveys have been sent to each of the arctic states requesting all arctic shipping data for 2004. Ship types that are part of the assessment include tankers, bulk carriers, container ships, tug-barge combinations, fishing vessels, ferries, cruise ships, research vessels, icebreakers, and offshore supply vessels. Integration of the 2004 data will produce a historic "picture" of levels of marine activity in the Arctic Ocean at the beginning of the 21st century. Analyses will be conducted to determine the social, environmental, and economic impact of shipping today. Evaluation of the impacts of arctic shipping on large marine ecosystems will be included in AMSA as well. In the second phase of AMSA, projected and plausible levels of shipping for 2020 and 2050 will be determined based on scenarios of the future, derived from ACIA sea ice and climate information and regional arctic economic analyses. The impacts of these future marine activity levels will also be determined.

AMSA should yield key findings that will be relevant to the arctic states, permanent participants, all arctic stakeholders, and the global maritime community. Once the findings are available, PAME will work with the Senior Arctic Officials to develop recommendations for consideration by the Arctic Council ministers. A final report will be presented at the 6th Arctic Council Ministerial Meeting, which will be held in Norway in autumn 2008.

For more information, see the PAME website: www.pame.is, or contact Lawson Brigham at the U.S. Arctic Research Commission (usarc@acsalaska.net; 907-271-4576).




*This map indicates key marine routes in the Arctic Ocean and coastal sub-arctic that will be reviewed as part of the Arctic Marine Shipping Assessment. Three polar icebreaker voyages in the central Arctic Ocean are illustrated: the first surface ship voyage to the North Pole by the Soviet nuclear icebreaker* Arktika *in August 1977; the tourist voyage by the Soviet nuclear icebreaker* Sovetskiy Soyuz *in August 1991; and the historic scientific transect by the polar icebreakers* Polar Sea *(USA) and* Louis S. St-Laurent *(Canada) in summer 1994. The icebreakers* Healy *(USA) and* Oden *(Sweden) conducted a similar scientific crossing of the Arctic Ocean in 2005. Also shown is the minimum extent of arctic sea ice on 16 September 2002 derived from satellite passive microwave observations. Notable for this date are large, ice-free areas north of the Russian Arctic coastal seas; a historic ice edge retreat in the Beaufort Sea; and an ice edge well north of Svalbard. Map courtesy of Lawson Brigham.*

# Online Workshop Focuses on IPY 2007–2008 Education

The International Polar Year (IPY) 2007–2008 is an opportunity to build on inherent interest in polar regions and engage audiences of all ages in science. As IPY approaches, a series of workshops are defining strategies for education efforts.

The most recent of these was the IPY Integrated Collaborative Education Planning Workshop, which was sponsored by NSF and the National Oceanic and Atmospheric Administration (NOAA) and held online over two weeks in March 2006 with more than 240 participants. Organized by the College of Exploration in cooperation with the Cooperative Institute for Research in Environmental Sciences (CIRES), the workshop aimed to:

- build on the prior planning for IPY outreach and education efforts, such as the 2004 Bridging the Poles workshop (see www.ldeo.columbia.edu/res/pi/polar_workshop/) and the 2005 Poles Together workshop (see http://cires.colorado.edu/news/archives/2005/ipy.html);
- engage, expand, and inform the emerging community of researchers, educators, media specialists, and exhibit experts involved in IPY activities;
- foster cooperation, communication, and collaboration throughout this community to deliver IPY educational programs; and
- define a set of key messages about the polar regions to enhance polar literacy.

Twelve breakout sessions covered an array of topics, including formal and informal education, international collaboration, serving diverse audiences, field experiences, and educational technology and digital media. Workshop presentations and discussions remain available on the website, which will serve as an ongoing forum for communication as programs move into implementation. A section of resources on polar education includes a variety of materials such as lesson plans, maps, and videos and remains open for submissions.

For more information, see the workshop website: www.coexploration.org/ipy/ice, or contact Renée Crain (rcrain@nsf.gov; 703-292-8029).

# Journalists Gain Intensive Field and Lab Experience

The Marine Biological Laboratory (MBL) in Woods Hole, Massachusetts, is an international center for research, education, and training in biology. A private marine laboratory, the MBL supports a year-round staff of more than 275 scientists and support-staff working in fields such as cell and developmental biology, ecology, microbiology, molecular evolution, global infectious disease, neurobiology, and sensory physiology. Each summer, an additional 1,400 scientists and advanced students from around the world come to the MBL to study the diverse and abundant marine organisms found in the waters of Cape Cod. The laboratory's educational program, consisting of six major summer courses and approximately twelve special topics courses throughout the year, plays a significant role in training the world's experimental biologists.

The MBL Science Journalism Program completed its 20th year in 2005, providing fellowships to print and broadcast journalists and editors to study basic environmental and biomedical science at the laboratory. During a week-long residency in June, approximately 15–20 fellows participate in one of two hands-on mini laboratory courses, each designed specifically for non-scientists. One course features research techniques currently in use by ecosystems ecologists both in the field and in the laboratory, and the other course explores techniques used in biomedical research. Later in the summer, five fellows are selected to travel with John Hobbie, co-director of the Ecosystems Center at the MBL, and other scientists to Toolik Field Station in Alaska to learn more about environmental research.

*Journalists in the MBL's Science Journalism Program survey the view of the Sagavanirktok River from Slope Mountain, looking south toward the Brooks Range. From left, Hannah Hoag, freelance writer; Jeff Tollefson of the* Congressional Quarterly, *and Mike Stark of the* Billings Gazette. *Photo by John Hobbie.*

At Toolik, journalists take part in fieldwork and laboratory analysis, learning firsthand about arctic ecology and the impacts of environmental change. Although not a requirement of the fellowship, many articles inspired by these interactions have been written about the Arctic and the research conducted there. The fellowships provide participating journalists with a background and understanding of science that will pay off later in their environmental reporting. Since the program began, 225 journalists have participated.

The MBL Science Journalism Program is supported by the NSF Office of Polar Programs, the American Society for Biochemistry and Molecular Biology, the American Society for Cell Biology, the Howard Hughes Medical Institute, the National Aeronautics and Space Administration, The New York Times Company Foundation, and the Waksman Foundation for Microbiology. The deadline to apply for participation in the June laboratory courses is typically early March.

For more information, visit the MBL website: www.mbl.edu, or contact Pamela Clapp Hinkle (pclapp@mbl.edu, 508-289-7423).

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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 a cooperative agreement with NSF, grants from the National Park Service, and 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

**June 24–29, 2006** European Science Foundation–Japan Society for the Promotion of Science (ESF-JSPS) Frontier Science Conference Series for Young Researchers on Climate Change. Nynäshamn, Sweden. For more information, see www.esf.org/esfjsps/06214.

**July 10–13, 2006** Inuit Circumpolar Conference General Assembly. Barrow, Alaska. For more information, contact Art Conrad Ivanoff (artcivanoff@hotmail.com).

**August 7–9, 2006** Asian Permafrost Conference. Lanshou, China. For more information, see www.casnw.net/permafrost/index.html.

**August 12–18, 2006** Coastal Zone Canada 2006 Conference and Youth Forum: Arctic Change and Coastal Communities. Tuktoyaktuk, Northwest Territories. For more information, see www.czca-azcc.org.

**September 11–12, 2006** Symposium on North Atlantic Climate and Ecosystems: A Current Threat? Reykjavik, Iceland. For more information, see www.hafro.is/symposium.

**September 12–14, 2006** 2006 Alaska Park Science Symposium. Denali National Park and Preserve, Alaska. For more information, see www.nps.gov/akso/Symposium.

**September 17–23, 2006** International Ice Drilling Technology Workshop. Sheperdstown, West Virginia. For more information, see www.idt-workshop.unh.edu.

**October 5–8, 2006** 4th Northern Research Forum Open Meeting: The Borderless North. Oulu and Tornio, Finland, and Haparanda and Luleå, Sweden. For more information, see http://thule.oulu.fi/nrf2006.

**November 9–12, 2006** Earth System Science Partnerships (ESSP) Open Science Conference on Global Environmental Change: Regional Challenges. Beijing, China. For more information, see www.essp.org/essp/ESSP2006/.

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

## Publications

Ahlenius, Hugo, Kathrine Johnsen, and Christian Nellemann, eds. 2005. *Vital Arctic Graphics: People and Global Heritage on Our Last Wild Shores.* United Nations Environment Programme (UNEP)/GRID-Arendal. 43 pages. ISBN 82-7701-033-8. $20.00 USD. See the UNEP/GRID-Arendal website (www.vitalgraphics.net/arctic.cfm).

Fienup-Riordan, Ann. 2005. *Ciuliamta Akluit/Things of Our Ancestors.* University of Washington Press. 448 pages. ISBN: 0-295-98471-6. $25.00 USD. Contact the University of Washington Press (www.washington.edu/uwpress/search/books/FIETHI.html).

Krupnik, Igor, Rachel Mason, and Tonia W. Horton, eds. 2004. *Northern Ethnographic Landscapes: Perspectives from Circumpolar Nations.* Contribution to *Circumpolar Anthropology* Series, Volume 6. Arctic Studies Center, Smithsonian Institution. 416 pages. ISBN 0-9673429-7-X. $22.50 USD. Contact the University of Alaska Press (888-252-6657; www.uaf.edu/uapress).

Polar Research Board. 2006. *Toward an Integrated Arctic Observing Network*. National Academies Press. 128 pages. ISBN 0-309-10052-6. $37.35 USD. Contact National Academies Press (888-624-8373; www.nap.edu/catalog/11607.html).

Polar Research Board, Transportation Research Board. 2005. *Polar Icebreaker Roles and U.S. Future Needs: A Preliminary Assessment.* National Academies Press. 52 pages. ISBN 0-309-10069-0. $16.20 USD. Contact National Academies Press (888-624-8373; www.nap.edu/catalog/11525.html).

Revkin, Andrew. 2006. *The North Pole Was Here: Puzzles and Perils at the Top of the World.* Kingfisher. 128 pages. ISBN 0-753-45993-0. $15.95 USD. See the Houghton Mifflin Company website (www.houghtonmifflinbooks.com).

University Corporation for Atmospheric Research (UCAR) Joint Office of Science Support (JOSS). 2005. *Arctic Transitions in the Land-Atmosphere System (ATLAS) Project: Seward Peninsula Site CDs.* Contact JOSS (303-497-8987, ivocd@joss.ucar.edu) or see the project website (www.joss.ucar.edu/atlas/).

## A Note From the ARCUS President

The approach of the International Polar Year (IPY) in 2007–2008 offers a good opportunity to reflect on the development of arctic research, which has undergone enormous changes in the past few decades. As recently as 1980, the U.S., although it is one of the eight arctic nations, did not have an arctic policy or a framework for such a policy's implementation—in stark contrast to the Antarctic, for which the U.S. has had an explicit working policy since 1959. This fact seems astonishing when we reflect on the strategic priorities of the Cold War.

In the early 1980s, a small group of us wrote a white paper outlining arctic problems of national interest (Hickok et al. 1981). These included national security, natural resources, protecting the environment, and preserving the cultures of the native populations of the Arctic. Addressing these issues required detailed knowledge, which we did not have, of the Arctic's environment, geology, seas, climate, and people. In 1981, the American Association for the Advancement of Science (AAAS) published this paper, and the AAAS Council issued a resolution urging the U.S. and Alaska "to articulate rigorous arctic science policies."

Around this time, the Polar Research Board (see page 22) established an Arctic Research Policy Committee that made recommendations toward developing a policy-guided, comprehensive plan for arctic research. These recommendations provided the basis for the enactment of the Arctic Research and Policy Act of 1984 (ARPA).

Although ARPA represented enormous legal progress, it did not immediately change the climate for arctic research. Many factors have since played a role in assuring a vital U.S. arctic research effort. Not the least of these was the evolution of ARCUS into a neutral, competent advocate for arctic research—a community of scientists from research and educational institutions working together to develop and coordinate research efforts with appropriate agencies, to disseminate results, and to increase public awareness.

The prescient legislators who introduced ARPA recognized the major issues mandating a strong arctic effort at that time. Today, were we to list the reasons for promoting arctic research, our list would be very similar. The big difference is the now widespread public recognition of the global importance of the Arctic. ARCUS has had a leading role in communicating this information—positioning the U.S. arctic research community to provide an outstanding contribution to IPY and reach an informed and receptive audience.

—Vera Alexander

### Reference

Hickok, D. M., G. Weller, T. N. Davis, V. Alexander, and R. Elsner. 1981. *United States Arctic Science Policy.* AAAS (Alaska Division). 62 pages.

### Inside



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