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Native Observations Capture Impacts of Sea Ice Changes

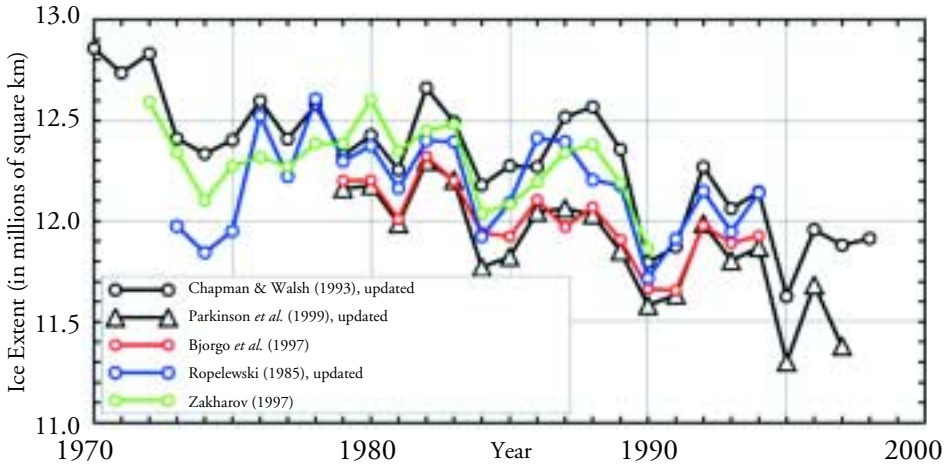
by Henry P. Huntington

Many signs of change in the arctic environment have been identified through scientific research. Familiar examples include a thinning of sea ice, earlier growing seasons on land, and rising temperatures in permafrost. Other signs of change have been observed by indigenous residents of the Arctic, who report changes in sea-ice characteristics, a greater frequency of extreme weather, and declines in the availability or body condition of some marine mammals.

Caleb Pungowiyi, a Yup'ik Eskimo from Western Alaska, expressed his concerns about changes involving arctic marine mammals and the environment in a November 1998 letter to the Marine Mammal Commission. Pungowiyi is a Special Advisor on Native Affairs to the Commission, an independent federal agency providing policy and program guidance to Congress and the Executive Branch on marine mammal conservation. Pungowiyi noted that the Native community had observed:

- in many areas, the sea ice has been of relatively poor quality in recent years;
- over the past 30 years or so, Bering Sea ice has become thinner, and it has been forming later and disintegrating or melting earlier; and
- there are more broken ice floes.

These changes affect the marine mammal species upon which Native communities rely for subsistence. For example, walrus calf production in poor ice years has been low. There also is growing concern that ringed seals, which depend upon stable ice conditions to successfully rear their young and are principal prey for polar bears, may decline in population due to poor ice conditions.



Several studies have documented a decrease in the extent of sea ice in the northern hemisphere over the past 25 years (Vinnikov et al. *1999[1]).*

With these concerns in mind, the Marine Mammal Commission brought together a roughly equal number of scientists and knowledgeable representatives of Alaska Native communities for a workshop on *Impacts of Changes in Sea Ice and Other Environmental Parameters in the Arctic*. Support for this workshop also came from the University of Alaska's North Pacific Marine Research Initiative, the National Marine Fisheries Service, and the National Oceanic and Atmospheric Administration's Office of Oceanic and Atmospheric Research.

The purposes of the workshop, held in February 2000 in Girdwood, Alaska were:

- to review, from both traditional knowledge and scientific perspectives, how changes in sea ice and other environmental parameters may be affecting arctic living resources and the indigenous cultures and practices that depend upon those resources;
- to identify possible measures that can be taken to mitigate the impacts of realized and anticipated changes; and
- to develop a document that provides a compelling blueprint for action by legislators, conservationists, arctic residents, and others.

The combination of multidisciplinary science and traditional knowledge

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provided a strong basis for addressing the challenges posed by environmental change in the Arctic, and the effects that these changes may have had, and in some cases are having, on marine mammals and the Alaska Native way of life.

Workshop participants recognized that the effects of environmental change are already being seen in northern Alaska and that further attention is warranted to assess and minimize the likely severity of future impacts. Although the workshop focused largely on the Alaskan Arctic, its implications are international in scope, because all arctic regions face similar challenges related to environmental change.

Several of the changes documented by scientists have been reported before (*e.g.*, warming of permafrost, thinning of pack ice in the Arctic Ocean, melting of glaciers, rising sea level). Changes observed by Elders and Native hunters, however, have not generally been widely reported. Examples of such observations presented at the workshop included shifts in marine mammal distributions and changes in the characteristics of sea ice and its formation. In Alaska, for example:

- more humpback whales are seen at Gambell in the Bering Sea;
- bowhead whales are seen near Deering in Kotzebue Sound;
- fewer bearded seals are seen near Deering;
- populations of some bird species (*e.g.*, oldsquaws, sandpipers) have declined in some areas;
- multi-year ice floes no longer drift south through the Bering Strait to St. Lawrence Island in the fall;
- at Barrow, break up of sea ice is much earlier than it used to be, occurring now in June rather than July; and
- sea water freezes only from the top rather than also on the bottom as it used to. (Bottom-forming ice brings sediments and nutrients to the surface when it breaks free and floats.)

Physical effects have been observed as well:

- sandy beaches are disappearing on St. Lawrence Island, as erosion increases because there are more storms and less sea ice to protect shorelines in the fall.

Observations of this kind make clear the need for careful cataloguing of Native knowledge of the local environment and the changes that are occurring in it. Linking otherwise isolated bits of information from different communities and over time can help identify significant trends and stimulate further research into the causes of the observed changes.

With this in mind, the workshop's recommendations include several concerning the need for more collaborative research, built on true partnerships between coastal communities and researchers. In particular, workshop participants recommended development of a formal plan involving residents of coastal communities:

- to systematically record observations of selected physical and biological parameters (*e.g.*, ice conditions, temperature, wind speed and direction); and
- to conduct beach surveys to count, identify, and collect samples from stranded or beach-cast marine mammals, sea birds, and fish.

Results of such local monitoring programs would include greater community involvement in climate-change research, improved monitoring, and enhanced quantity and quality of data collected. For example:

- Community-based monitors can track events that cannot be monitored by remote field stations (*e.g.*, migrations, strandings).
- Traditional knowledge, drawing on observations of phenomena over time periods far longer than those for which scientific records are available, can help identify trends and illuminate causal relationships among environmental parameters.
- Such understanding of environmental and ecological interactions can help to create and test hypotheses regarding the likely impacts of climate change.
- Local involvement in monitoring provides another avenue for identifying community concerns and involving local residents in decisions affecting the future of their communities.

Other workshop recommendations addressed research needs, policy, communication, and educational initiatives for all groups, including students, educators, and decisionmakers. The participants recommended using ongoing local and regional research programs to inform and excite students and others, and to encourage more Native students to pursue science careers.

The workshop report will contain the conclusions and recommendations of the workshop, a summary of the discussions held by break-out groups during the workshop, and background papers describing various aspects of environmental change in the Arctic. The report is expected to be completed and available by mid-2000.

For more information, contact Robert H. Mattlin, Assistant Scientific Program Director for the Marine Mammal Commission in Bethesda, MD (301/504-0087; fax 301/504-0099; rmattlin@mmc.gov). ■

Walrus feed on the seafloor of the shallow continental shelf. They rest, mate, and give birth on sea ice. If the pack ice retreats beyond the edge of the continental shelf, as it has done in some recent years, the walrus must either swim great distances to reach their feeding grounds or find haulouts on land, either of which stresses the animals. (Photo © Bill Hess, Running Dog Publications).

Henry P. Huntington is owner of Huntington Consulting. He works on a number of topics related to arctic research and policy.

References

1. Vinnikov, K.Y., A. Robock, R.J. Stouffer, J.E. Walsh, C.L. Parkinson, D.J. Cavalieri, J.F.B. Mitchell, D. Garrett, and V.F. Zakharov. 1999. Global Warming and Northern Hemisphere Sea Ice Extent. *Science* 286:1934–1936.

ARCSS Committee Encourages Information Exchange

The Arctic System Science (ARCSS) Committee (AC) provides guidance on behalf of the arctic research community to the ARCSS Program to ensure its long-term relevance and viability in light of new results and science priorities. The AC is pursuing various activities to identify new initiatives and advance integration (see *Witness* Spring/Autumn 1999).

The AC is planning for an ARCSS-wide All-Hands meeting in late 2001, with goals including identification of ARCSS research opportunities that will address questions about system interactions through interdisciplinary modeling efforts and active involvement of young investigators.

Working with Rudy Dichtl, who recently replaced Matt Cross as the Data Manager at the ARCSS Data Coordination Center (ADCC) at the National Snow and Ice Data Center, the AC helped to develop a user survey to evaluate the past data management of ADCC and ARCSS and to gather suggestions for improvements. The survey is available at http://arcss.colorado.edu/questionnaire.

The AC oversaw publication of a new brochure, *Understanding Global Change in the Arctic* (see Publications, page 27), designed to assist researchers in education and outreach efforts by introducing a broad general audience to the ARCSS Program and the significance of global change in the region.

For more information on the ARCSS Program, see the ARCSS web site (http://www.nsf.gov/od/opp/arctic/system.htm) or contact Program Director Mike Ledbetter (703/292-8029; fax 703/282-9082; mledbett@nsf.gov) or AC Chair Jack Kruse (413/367-2240; fax 413/367-0092; jkruse@geo.umass.edu). ■

SEARCH Gains Interagency and International Recognition

The Study of Environmental Arctic Change (SEARCH) proposes to establish an organized research program investigating the suite of changes documented in the Arctic over the past decade that coincide with the increasing Arctic Oscillation (AO) index, but that also coincide with increasing human use of the Arctic's resources (see *Witness* Spring/Autumn 1999). An understanding of these potentially interrelated changes, collectively known as *Onami*, and their implications will require a coordinated program of:

- long-term observations,
- modeling,
- process studies, and
- assessment of probable ecological and social impacts.

Increasingly, SEARCH is being recognized in the larger community of climate-oriented research and U.S. funding agencies. SEARCH was included as "ready for immediate attention" in the most recent revision (Fall/Winter 1999) of the *U.S. Arctic Research Plan* of the Interagency Arctic Research Policy Committee (IARPC).

An Interagency Working Group on SEARCH (IWGS) was established and tasked in March 2000. The National Oceanic and Atmospheric Administration (NOAA) chairs the working group. Other agencies represented include NSF, the National Aeronautics and Space Administration, the Environmental Protection Agency, and Departments of Defense and Energy.

During the next several months, the IWGS plans to develop an interagency plan for the conduct of SEARCH activities, with the following tentative timeline:

- An implementation plan for Fiscal Year (FY) 2001, including plans for collaborative projects investigating ocean fluxes (see page 21) and improved modeling of ocean/atmosphere interactions, was sent to IARPC at the end of June 2000;
- A summary of agency budget requests to support SEARCH activities in FY 2002 will be prepared for the Office of Management and Budget by December 2000;
- The interagency SEARCH science plan and a proposed coordinated interagency budget request for FY 2003 is expected to be completed by February 2001.

In addition, the U.S. component of the Climate Variability and Predictability (CLIVAR) program has endorsed SEARCH as the arctic component of its effort. CLIVAR is an interdisciplinary research program within the World Climate Research Programme (WCRP) focusing on the variability and predictability of the slowly varying components of the climate system (see http://www.soc.soton.ac.uk/CLIVAR). CLIVAR investigates physical processes in the climate system that occur on seasonal, interannual, decadal, and centennial time scales.

A joint working group will oversee the SEARCH-CLIVAR collaboration. Because SEARCH plans to include social and ecological aspects of arctic change that are outside of the usual domain of CLIVAR, organizational decisions about the collaboration remain to be made.

SEARCH has also garnered international support. Many of the key observations must be made outside the United States, or in waters best reached from other countries, necessitating international cooperation. Thus far, the following international programs are discussing collaborative arrangements with SEARCH:

- the Arctic Climate System Study (ACSYS; see http://www.npolar.no/acsys/impplan/index.htm) and the Climate and Cryosphere Project (CLIC; http://www.npolar.no/acsys/CLIC/clic_may2.pdf), which are both part of the WCRP (see *Witness* Spring/Autumn 1999 and http://www.wmo.ch/web/wcrp/wcrp-home.html); and
- the Variability of Exchanges in Northern Seas Project (VEINS; http://www.ifm.uni-hamburg.de/~veins/), funded by the European Union.

For more information, see the SEARCH web site (http://psc.apl.washington.edu/search), or contact Jamie Morison in Seattle, WA (206/543-1394; fax 206/616-3142; morison@apl.washington.edu). ■

OAII Researchers Visit USCGC *Healy* and Plan Research

Arctic oceanographers converged on the inner harbor of Baltimore in March 2000 to visit the Coast Guard's new research icebreaker, the USCGC *Healy* (see page 24 and *Witness* Spring/Autumn 1999). The visitors included colleagues from the University-National Oceanographic Laboratory System (UNOLS) and the Arctic Icebreaker Coordinating Committee (AICC), both directly involved in the development of the *Healy*'s scientific capabilities, and personnel from NSF and the Office of Naval Research (ONR), and ARCSS Ocean-Atmosphere-Ice Interactions (OAII) scientists.

Shelf Basin Interactions (SBI)

Forty SBI Phase I principal investigators (PIs), co-PIs, postdoctoral and graduate students, and NSF and ONR science managers met in Baltimore to discuss initial results from SBI Phase I studies. A portion of the meeting held on the *Healy* included tours of the impressive new arctic research platform and scientific presentations in a poster session organized by the AICC (see page 24). Participants shared information about shelf-basin processes in the Western Arctic Ocean, including:

- water-mass transport and characteristics,
- biogeochemical characteristics in water and sediments,
- higher and lower biological populations and dynamics, and
- modeling results of interdisciplinary data sets.

Research results include:

- evidence for significant recent changes in the Pacific and Atlantic inflows into the Arctic Ocean;
- recent ecological changes in Pacific Waters entering the Arctic; and
- evidence for major temperature changes during the Holocene in the Western Arctic.

A summary of the presentations and abstracts is available on the SBI web site (http://utk-biogw.bio.utk.edu/sbi.nsf).

Participants also discussed the draft SBI Phase II implementation plan for field work to begin in Spring 2002.

In late March 2000, the SBI Science Steering Committee met to finalize the SBI Phase II implementation plan which will form the basis for an NSF Announcement of Opportunity expected in January 2001. Results of this meeting include:

- restructuring of the cross-disciplinary SBI objectives under three headings—Input to the Bering Strait Region, Transformations in the Research Box, and Output to the Arctic Basin;
- focusing the program into a defined study area on the outer shelf-slope of the Chukchi and Beaufort seas, with set transect lines for survey and process-type studies;
- designation of mooring instrumentation, and survey and process data requirements;
- further development of goals for an international pan-arctic meeting to be held 7–9 November 2000 near Atlanta, Georgia;
- development of a field plan including intense seasonal field sampling in 2002 and 2004, and more limited seasonal sampling in 2003 and 2005 on select transects; and
- recommendations for the SBI Phase II Announcement of Opportunity.

For more information, see the SBI web site (http://utk-biogw.bio.utk.edu/sbi.nsf), or contact SBI co-chairs Jackie Grebmeier at the SBI Project Office in Knoxville, TN (865/974-2592; fax 865/974-3067; jgreb@utkux.utk.edu) and Terry Whitledge in Fairbanks, AK (907/474-7229; fax 907/474-5863; whitledge@ims.uaf.edu).

Surface Heat Budget of the Arctic Ocean Program (SHEBA)

During the SHEBA Field Experiment in 1997–98, researchers gathered a year-long data set that documents key climate-forming processes in a column extending from the upper halocline in the Arctic Ocean to the top of the arctic atmosphere (see *Witness* Autumn 1998). A summary of initial data and results from the Field Experiment was published in the 12 October 1999 issue of *EOS* ("Year on Ice Gives Climate Insights," v. 80, No. 41). SHEBA data sets are available on the web site maintained by the Joint Office for Science Support (JOSS) (http://www.joss.ucar.edu/cgi-bin/codiac/ds_proj? SHEBA). JOSS is coordinating the collection and exchange of field data. The National Snow and Ice Data Center (see *Witness* Autumn 1996) will continue to archive SHEBA data as part of ARCSS Data Coordination.

The *Journal of Geophysical Research—Oceans* will publish a special volume emphasizing SHEBA studies. Researchers are encouraged to submit both observational and theoretical papers. For more information, contact Don Perovich in Hanover, NH (603/646-4255; fax 603/646-4644; perovich@crrel.usace.army.mil).

In April 2000, SHEBA and the National Atmospheric and Space Administration (NASA) held a joint workshop in Boulder, Colorado on the Arctic Cloud Experiment conducted by the NASA FIRE (First ISCCP Regional Experiment) program in collaboration with the SHEBA Field Experiment (see *Witness* August 1994). The workshop included:

- presentation of results from SHEBA Phase II,
- working group sessions on key processes that affect the heat budget and climate of the Arctic Ocean, and
- planning for interdisciplinary research during Phase III.

For more information, see http://eosweb.larc.nasa.gov/ACEDOCS/workshop/.

The SHEBA Project is nearing the end of Phase II (1997–2000) and looks ahead to its third and final phase (2000–02). Phase III of SHEBA will focus on modeling, synthesis, and integration of SHEBA data sets to elucidate arctic climate feedbacks and develop improved formulations for arctic processes in global climate models (see http://www.nsf.gov/cgi-bin/getpub?nsf0019). Phase III projects are underway in Summer 2000.

For more information, see the SHEBA web site (http://sheba.apl.washington.edu), or contact Richard Moritz at the SHEBA Project Office in Seattle, WA (206/543-8023; fax 206/543-3521; dickm@apl.washington.edu).

For more information about OAII, see the OAII web site (http://arcss-oaii.hpl.umces.edu), or contact Lou Codispoti or Jane Hawkey at the University of Maryland's Horn Point Lab (410/221-8479; fax 410/221-8390; codispot@hpl.umces.edu, hawkey@hpl.umces.edu).

LAII Prepares for the 2000 Field Season

The ARCSS Land-Atmosphere-Ice Interactions (LAII) Program, initiated in 1991, currently funds studies in two principal thematic areas:

- **Arctic Transitions in the Land-Atmosphere System** (ATLAS) is a coordinated program to examine the geographical patterns and controls over climate-land surface exchange, and to develop scenarios of future change in the Arctic (see *Witness* Autumn 1998). Eleven projects were funded in 1998–99; eight are conducting fieldwork in 2000.
- The **International Tundra Experiment** (ITEX). ITEX is a collaboration among investigators from nine countries to examine the effects of increased summer temperature on tundra vegetation (see *Witness* Spring/Autumn 1999). ITEX researchers in North America have integrated their research projects into a collaborative program known as the North American Tundra Experiment (NATEX), which now includes investigators from the United States and Canada. Five NATEX projects are conducting fieldwork in 2000.

In addition to these thematic research programs, several research projects are funded to investigate a range of topics pertinent to LAII goals, including:

- the role of climate factors on carbon and nutrient uptake by tundra root systems;
- carbon storage and the history of peat formation in drained thaw-lake basins;
- comparison of factors controlling carbon flux from acidic *vs.* non-acidic types of tundra;
- impacts of anthropogenic disturbance on tundra land-cover; and
- factors influencing permafrost conditions and spatial variability.

ITEX Plans

ITEX continues to expand in North America as well as in the European Union and Russia, although the three regions have very different working conditions, political constraints, and potential funding opportunities. ITEX will hold its 10th annual workshop *From Decade to Millennium* in Sweden, 22–25 September 2000 (see page 27) and a synthesis workshop in early 2001 to analyze ITEX data on changes in community composition.

For more information about the 2001 meeting, contact Marilyn Walker in Fairbanks, AK (907/474-2424; fax 907/474-6251; mwalker@lter.uaf.edu). For more information about ITEX, contact ITEX Chair Philip Wookey in Uppsala, Sweden (+46/18471-2521; fax +46/1855-5920; philip_andrew.wookey@natgeog.uu.se) or Gabrielle Stockmann at the Secretariat in Copenhagen, Denmark (+45/3288-0118; fax +45/3288-0101; gs@dpc.dk).

LAII Science Workshop

The annual LAII Science Workshop convened in Seattle, Washington in February 2000 with 100 researchers, graduate students, NSF managers, logistics providers, and data-management personnel in attendance. Participants:

- communicated research results;
- discussed future synthesis activities;
- planned to address the NSF Biocomplexity in the Environment initiative (see *Witness* Spring/Autumn 1999);
- met with personnel from VECO Polar Resources, the new arctic logistics contractor, to plan the 2000 field season;
- interacted with a new data-management team including Rudy Dichtl, the new ARCSS Data Manager at the National Snow and Ice Data Center (NSIDC); and Jim Moore, Dick Dirks, and Greg Stossmeister from the Joint Office for Science Support (JOSS) at the University Center for Atmospheric Research. JOSS supports the ongoing data-collection and data-exchange efforts of ATLAS, while NSIDC is responsible for data archiving and long-term access.

The LAII Science Steering Committee has four new members: Brad Griffith (University of Alaska Fairbanks), Gary Kofinas (Dartmouth College), Andrea Lloyd (Middlebury College), and Gus Shaver (Marine Biological Laboratory).

For more information, see the LAII web site (http://www.laii.uaf.edu/), or contact Patricia A. Anderson at the LAII Science Management Office in Fairbanks, AK (907/474-5415; fax 907/474-6722; patricia@gi.alaska.edu). ■

In March 2000, ATLAS researchers Matthew Sturm, Jon Holmgren, Glen Liston (above), and Ken Tape completed a 350-mile transect across the North Slope of Alaska from Ivotuk to Barrow, Alaska. Their field report reads, in part: "The purpose of the traverse was to test the hypothesis that there are regional patterns of snow characteristics, like depth and density, on the Arctic Slope, and that these patterns take the form of broad east-west bands controlled by the topography. We also wanted to test whether the patterns of snow distribution we had observed in our Kuparuk Basin traverses (1994–1997) could be applied further to the west. Preliminary examination of the data... suggests that the Kuparuk patterns are repeated in remarkable detail in the west, and that these patterns are indeed controlled by the interaction of storms with the regional geography. This is good news, because it means that extrapolation of our snow results across the entire Arctic Slope is possible" (photo by Matthew Sturm).

PARCS Projects Facilitate Synthesis and Dating

An understanding of the past behavior of the Earth's climate system is essential to understanding present and possible future conditions. For this reason, in 1999, NSF consolidated support for such research in the Paleoenvironmental Arctic Sciences (PARCS) initiative within the Earth Systems History (ESH) Program (see *Witness* Spring/Autumn 1999).

The PARCS Steering Committee (SC) met for the first time in October 1999. Its goal is to support the broad-based U.S. arctic paleoenvironmental community by:

- providing data-management services,
- facilitating scientific activities through the funding of small workshops;
- providing access to Accelerator Mass Spectrometry (AMS) radiocarbon preparation and dating services; and
- developing future research priorities via science meetings.

PARCS research includes a broad range of Quaternary paleoenvironmental projects in the Arctic and subarctic, including studies of modern processes and calibrations that are paleoenvironmentally oriented. The 1999 PARCS document, *The Arctic Paleosciences in the Context of Global Change Research,* describes current research directions. PARCS research is funded or co-funded by ESH, ARCSS, and the Arctic Natural Sciences Program (see page 11). The SC intends, however, to serve arctic paleoenvironmental researchers in the U.S. community and their international collaborators, regardless of their source of funding.

PARCS is committed to promoting synthesis of arctic proxy data and data-model comparisons (*e.g.*, BIOME 6000, Circum-Arctic PaleoEnvironments [CAPE] and its *Paleoenvironmental Atlas,* the Paleoclimate Modeling Intercomparison Project, the PARCS database). PARCS researchers are obligated to archive their data with the PARCS database; other researchers can also do so and benefit from data archives stored there. The data manager (Matt Duvall, University of Washington) is available to assist with:

- archiving data sets; and
- creating synthetic and value-added data sets for use in modeling, data-model comparisons, and other research.

PARCS-funded projects have access, through ESH, to the AMS-radiocarbon preparation facility at the University of Colorado and to the leading AMS-dating laboratories; these features reduce turnaround time and costs for PARCS investigators. For more information, contact Scott Lehman (303/492-8980; fax 303/492-6388; lehmans@spot.colorado.edu).

In June 2000, PARCS researchers attended a CAPE meeting in Iceland on understanding the role of arctic sea ice in the arctic and global climate systems.

For more informaton, see the PARCS web site (http://www.ngdc.noaa.gov/paleo/parcs/index.html), or contact SC co-chairs Mary Edwards in Trondheim, Norway (+47/7359-1915; fax +47/7359-1878; mary.edwards@svt.ntnu.no) and Mike Retelle in Lewiston, ME (207/786-6155; fax 207/786-8334; mretelle@bates.edu).

RAISE Sponsors Arctic Coastal Dynamics Workshop

In November 1999, a project funded by the Russian-American Initiative on Shelf-Land Environments (RAISE) brought 45 participants from Canada, Germany, Russia, and the U.S. to Woods Hole, Massachusetts for a workshop on Arctic Coastal Dynamics (ACD).

The RAISE program was initiated in 1995 to facilitate collaborative research between Russian and American scientists on processes and events in terrestrial, shelf, and ocean environments in northern Eurasia (see *Witness* Spring/Autumn 1999). The ACD workshop convened under the auspices of the International Permafrost Association's (IPA) Coastal and Offshore Permafrost Working Group.

The 200,000-km coastal margin of the Arctic Ocean is the dynamic interface between permafrost-rich terrestrial ecosystems and shallow continental shelves, which comprise 30% of the area of the Arctic Ocean and approximately 20% of the world's continental shelf area. These highly variable coastlines are key components of the arctic system and sites of most human activity that occurs at high latitudes. Little is known, however, about sediment sources and transport rates along the arctic coastline, such as relative amounts of sediment derived from coastal erosion vs. river discharge. Such data are necessary for interpreting geological history and predicting the response of arctic coasts and shelves to changes in climate and sea level.

While local and regional studies have provided insight into high-latitude sediment budgets, no attempts have been made to synthesize and expand investigations to encompass the Arctic. As a first step, researchers met to develop international standards for mapping and measuring high-latitude coasts and their dynamics. Participants:

- developed a classification system for high-latitude coasts based on morphology and materials, and identified specific regions for prototype mapping;
- enumerated the primary forcing parameters for coastal change in the Arctic;
- agreed upon methods for estimating and mapping volumes of ground-ice;
- proposed tools and techniques for long-term monitoring, including direct involvement of local communities.

Progress from the ACD workshop was presented at the Laptev Sea conference in Russia in November 1999, the AGU Fall 1999 Meeting in the U.S., and the International Arctic Science Committee (IASC) meeting in April 2000 (see page 20).

The ACD Program has been accepted as an official IASC-IPA activity. IASC will fund an invited workshop in Fall 2000 to develop a science and implementation plan. For more information on the ACD Program, see the ACD web site (http://www.awi-potsdam.de/www-pot/geo/acd.html).

For more information on RAISE, contact Vladimir Romanovsky in Fairbanks, AK (907/474-7459; fax 907/474-7290; ffver@uaf.edu).

Workshop on Whaling Compares Past with Present

Traditionally, whale hunting has been a major subsistence activity for coastal Native societies of the Western Arctic, and it remains a primary focus today along the coasts of Alaska and Chukotka. Natives of this region have systematically used baleen whales (principally bowheads and grays) for at least the past millennium and probably much of the preceding millennium.

In March 2000, the ARCSS and Arctic Social Sciences programs jointly sponsored a workshop in Anchorage, Alaska on *Native Whaling in the Western Arctic: Development, Spread, and Responses to Changing Environments.* Twenty social and natural scientists from Canada, England, Russia, Switzerland, and the United States, as well as representatives from the Native communities of Barrow, Gambell, Little Diomede, Point Hope, and Wales, discussed prehistoric and historic whaling and responses to environmental change.

Numerous participants stressed the importance of integrating traditional knowledge with scientific data during workshop sessions focused on:

- Environmental Change and Whaling over the Past Two Millennia,
- Bowhead Whales and their Predation,
- Prehistoric and Historic Whale Hunting, and
- Contemporary Whaling Patterns.

Discussions of environmental change and whaling covered recent trends in atmospheric circulation and associated implications for sea-ice extent and temperature anomalies (see pages 1 and 3) of immediate concern to contemporary Eskimo whalers facing environmental uncertainty and changes. In the longer term, a retrospective comparison of the 2000-year record of Bering Sea storms with the history of Eskimo cultures shows that periods of increased storminess have corresponded with expansion of whaling activity at sites along the Alaskan coast and perhaps also with the rise of major Eskimo cultures.

Three important and interrelated perspectives underlie a developing understanding of the nature of bowhead whales, their predation, and the consequent evolution of Native whaling societies:

- the influence of environmental conditions on access to whales (*e.g.*, wind speed and direction, fast-ice patterns in the spring);
- the archaeological record (*e.g.,* whale biology, artifact technologies); and
- the Native whalers themselves. Contemporary whalers from Diomede and Wales discussed issues of environmental change and marine pollution related to resource extraction and tourism.

James Savelle (McGill University) measures a bowhead whale skull at the Pingasugruk site, north of Wainwright, Alaska; the morphometric measures indicate that Eskimo whalers preferentially targeted juvenile whales when hunting (photo by Allen McCartney).

Sessions on prehistoric whaling patterns focused on whalers' selection of species and size characteristics over time on both sides of the Bering Strait. This history is relevant today as modern communities respond to quotas imposed by the International Whaling Commission. Additionally, the proximity of Wales to Siberia was shown to be pivotal in the arrival and spread of whaling traditions in Alaska.

Discussion of contemporary whaling focused on several dimensions of traditional whaling societies including:

- the sheer survival of the whaling tradition, expressed in interviews with village elders from Gambell and Little Diomede;
- changes in community social organization, reflected, for example, in changes in the nature of the *qalgi* (community houses) in Iñupiat communities; and
- changes in traditional economic systems related to whaling on the north coast of Alaska.

Maggie Ahmaogak, Executive Director of the Alaska Eskimo Whaling Commission (AEWC), stressed the role of the AEWC in the preservation of Native whaling in the ten communities that it represents.

Two important overarching issues emerged from the workshop:

- natural scientists should communicate their findings to Native communities in ways that aid the development of solutions to local environmental concerns; and
- natural and social scientists should assist the communities with gathering scientific and historic information related to the development of Native whaling in the western Alaskan Arctic.

According to participants, these two concerns are key to achieving a more comprehensive understanding of Native Eskimo whaling societies and their responses to environmental changes.

For more information, contact John Dixon in Fayetteville, AR (501/575-5808; fax 501/575-2642; jcdixon@comp.uark.edu), Allen McCartney in Fayetteville, AR (501/575-6374; fax 501/575-6595; apm@comp.uark.edu), or Roger Harritt in Anchorage, AK (907/257-2704; fax 907/257-2707; anrkh@uaa.alaska.edu).

An Introduction to the Arctic Social Sciences Program

The multidisciplinary and interdisciplinary Arctic Social Sciences Program encompasses all social sciences research supported by NSF.

Arctic societies have experienced numerous transformations and transitions over the millennia. The Arctic Social Sciences Program supports research that documents and analyzes the dynamic cultures, economies, and technologies of northern populations. From studies of ancient worlds (through archaeology and physical anthropology) to investigations of contemporary and rapidly shifting arctic societies (through sociology and political science), arctic social scientists compare how different communities shape and are shaped by their environment.

Currently the Arctic Social Sciences Program supports about 40 research projects. Several noteworthy projects supported by the Arctic Social Sciences Program are highlighted on this and the following two pages.

For more information, see the Arctic Social Sciences Program web site (http://www.nsf.gov/od/opp/arctic/social.htm) or contact Program Manager Fae Korsmo in Arlington, VA (703/292-8029; fax 703/282-9082; fkorsmo@nsf.gov). ■

Project Documents Inuit Knowledge of Climate Change

Inuit people have lived in the arctic environment for more than 1000 years, observing and passing on knowledge about the region's climate. To explore the value of this information in the context of arctic climate change, the Arctic Social Sciences Program is funding work on Inuit knowledge of climate and climate change in the eastern Canadian Arctic.

The principal investigators for this multi-year project are Roger Barry, Director of the National Snow and Ice Data Center, and geography Ph.D. student Shari Fox of the Cooperative Institute for Research in Environmental Sciences, both at the University of Colorado at Boulder. Barry brings substantial knowledge of the physical environment and climate in the eastern Canadian Arctic; Fox approaches the work with a background in both human and physical geography, as well as several years of working with Inuit people. Together, they will document Inuit climate knowledge through interviews, participant observation, and content analysis of archived oral histories.

Weather is generally the principal determining factor of daily activity for the Inuit; for this reason, it is perhaps the most closely observed of all natural phenomena. Residents of the Arctic have developed an acute awareness of climate and weather processes, variability, and change. Climate change and its impacts have become an urgent concern for Inuit communities. Reports from the 1996 Inuit Circumpolar Conference[1] and research by Fox document Inuit observations of environmental changes including:

- changes in the timing of seasonal cycles and seasonal characteristics,
- poor vegetation growth,
- changes in air temperature,
- changes in the timing of sea-ice breakup and freeze-up,
- more rain events in winter,
- increasing winds and storm frequency,
- changes in sea-ice distribution, and
- discoloration of sea ice.

Community input into the design and implementation of the research is an important aspect of this project. In Spring and Summer 2000, preliminary meetings and interviews in the four communities participating in the project—Igloolik, Iqaluit, Baker Lake, and Clyde River, all in the territory of Nunavut in the eastern Canadian Arctic—are helping to establish local needs and objectives for the research.

During several extended visits in both summer and winter, researchers anticipate:

- interviewing Inuit hunters, Elders, and other community members;
- spending time with Inuit at hunting camps and traveling on sea ice, which will provide valuable opportunities to discuss weather in context;
- using photography and video to help document Inuit understanding of weather phenomena and changes through time; and
- using maps, aerial photos, satellite imagery, and map overlays as a basis for discussion, and to document observed changes in sea-ice distribution and characteristics, as well as snow cover.

Inuit knowledge of temperature, sea-ice distribution, and extreme weather events can be cross-referenced and calibrated with records from weather stations and satellites. For instance, Jacobs *et al.* (1974)[2] noted that ice conditions in 1972, an unusually cold year, "were the worst in living memory of the Eskimo [sic] population of Broughton Island." Anomalous mild climate events in the early 1950s also offer important opportunities to explore the extent to which Inuit climate knowledge may be able to confirm instrumental climate data, and augment contemporary understanding of these events and subsequent impacts. Furthermore, maps compiled by hunters and Elders pre-dating scientific observations may be able to extend the sea-ice record.

This project will contribute to a greater understanding of how arctic climate has changed through time and affected the environment. It will also provide a model for cooperation that may be applicable in interactions with indigenous populations throughout the circumarctic region and in wider research topics.

For more information, contact Roger Barry in Boulder, CO (303/492-5488; fax 303/492-2468; rbarry@kryos.colorado.edu) or Shari Fox (303/492-6115; fax 303/492-2468; sfox@kryos.colorado.edu). ■

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2. Jacobs, J.D., R.G. Barry, R.S. Bradley, and R.L. Weaver. 1974. Studies of climate and ice conditions in eastern Baffin Island, 1971–73. Occasional paper 9, Institute for Arctic and Alpine Research, University of Colorado, Boulder. 78 pp.

Genetic Analysis Investigates Aleut Prehistory

The archaeological record of the Aleutian Islands is marked by an abrupt transition in the shapes of the early inhabitants' skulls. The earliest people had long, narrow crania typical of temperate-climate populations. Approximately 1000 years ago, however, these were replaced by broader, shorter, and rounder crania more typical of contemporary North American arctic populations.

This abrupt morphological shift was first described by Ales Hrdlicka of the National Museum of Natural History, a pioneer of American physical anthropology. Hrdlicka attributed this transition to a population-replacement event, while his student William Laughlin argued for population genetic continuity across the transition to more rounded skulls.

Molecular techniques are now being used to distinguish between these hypotheses. Dennis O'Rourke and Geoffrey Hayes, anthropological geneticists at the University of Utah, are examining patterns of genetic variation in remains that were recovered by Hrdlicka and his students in the late 1930s from the Chaluka midden at Nikolski on Umnak Island, two caves on Kagamil Island, and a third cave on Ship Rock Island. Permission to collect and analyze these materials has been granted by the Aleut Corporation, the Aleutian and Pribilof Islands Association, and the Chaluka Corporation. To date, O'Rourke and Hayes have retrieved mitochondrial DNA (mtDNA) samples from remains of 35 individuals.

The mitochondrial DNAs of Native Americans separate primarily into four haplogroups, or lineages, defined by a specific set of genetic markers in four regions of the mtDNA. Although initial sample sizes in the Aleutian study are small, O'Rourke and Hayes' preliminary comparisons found no substantial differences in haplogroup frequencies in pre- and post-transition populations or between sites. These early results suggest that the morphological transition in skull shape was not due to a population replacement.

By the end of 2002, more than 150 prehistoric samples will have been analyzed in four ways:

- determination of haplogroup frequencies;
- high-resolution sequencing of a highly variable segment of the mtDNA;
- direct dating by ^{14}C accelerator mass spectroscopy; and
- stable isotope analyses of carbon and nitrogen to characterize the diets of the individuals (see article this page).

This molecular analysis is funded by the Arctic Social Sciences Program as part of a larger investigation, in which Michael Crawford and Dixie West (University of Kansas) are conducting genetic analyses of modern Aleut communities and archaeological remains from the region, respectively (see *Witness* Spring/Autumn 1999).

For more information, contact Dennis O'Rourke and Geoffrey Hayes in Salt Lake City, UT (801/581-6251; fax 801/581-6252; orourke@anthro.utah.edu, hayes@anthro.utah.edu). ■

Stable Isotopes Reveal Early Diets

Some archaeological evidence indicates that the Classic Thule who inhabited the northwest coast of Hudson Bay during the latter part of the Medieval Warm Period (*ca.* AD 900–1350) actively hunted bowhead whales (*Balaena mysticetus*) in crews of four to eight men from open sea driftwood and seal-skin umiaks, armed with lances and toggling harpoons—an extraordinary enterprise, given the size of the whales. Other investigators argue that the Classic Thule scavenged, rather than hunted, the enormous bowheads, which were secondary to caribou and seal in economic importance.

In either case, the Classic Thule who used whales were followed by Modified Thule—defined in part by the apparent absence of whaling—but the timing of this transition is thus far poorly defined. Archaeological evidence suggests that the Medieval Warm Period freed sea lanes in the central Canadian Archipelago from year-round ice, opening rich eastern feeding grounds to migrating bowheads. The subsequent Neo-Boreal cooling may have restricted bowhead migration routes and led to the end of open sea whaling by AD 1200.

Assessing the importance of whales in Classic Thule diets on the basis of artifacts alone is problematic. Assemblages of animal bone at Thule residential sites are biased toward easily transported small prey. While bowhead skeletal elements often comprised the superstructure of winter houses, their prevalence is not a reliable reflection of predation intensity or the importance of whales in Thule diets.

The Arctic Social Sciences Program has funded research to use stable and radioisotope chemistry of human and faunal skeletal remains to examine the role of bowhead whales in eastern arctic diets. Joan Coltrain (University of Utah) is working closely with the Canadian Museum of Civilization and with the consent of the Inuit Heritage Trust and other First Nations groups to examine remains of humans and their prey from Kamarvik, Silimuit, and Native Point. Kamarvik and Silimuit, on the northwest shore of Hudson Bay, are believed to have been occupied by Classic Thule foragers. The Sadlermuit people of Native Point, on the southern coast of Southampton Island, appear to have relied primarily on ringed seals.

Stable isotope analysis is ideally suited to address issues of diet in the eastern Arctic for the following reasons:

- stable carbon isotope ratios record the role of terrestrial *vs.* marine foods in sampled diets, indicating, for example, the relative importance of caribou *vs.* marine resources; and
- stable nitrogen isotope ratios in the remains of a predator record whether it consumed herbivores (*e.g.,* bowhead whales) or carnivores (*e.g.,* seals).

Although work is not complete, initial results are consistent with the argument that the Classic Thule actively hunted bowhead whales.

For more information, contact Joan Coltrain in Salt Lake City, UT (801/585-6444; fax 801/581-6252; coltrain@anthro.utah.edu). ■

Gender Roles Shed Light on Ancient Subsistence Cultures

The woman quickly butchered the seal her husband had deposited on the boulder-strewn shore. Her young daughter observed attentively. Deft slices from two different-sized uluus separated the hide and, in turn, transformed the hindquarters, forequarters, rib cage and other sections into neat packets of meat which were placed in plastic sacks. As the woman finished her task, the daughter began hauling the meat homeward up a steep slope. The woman's eldest son arrived to retrieve the hide. Remaining packets were quickly distributed to those who wanted them. A middle-aged man selected a "bag of ribs for frying," and the final packet was given to a small boy with explicit instructions about who should receive the meat.

Daily events such as those described above are being documented as part of a multi-year, international research project funded by the Arctic Social Sciences Program on Gender Dynamics and Subsistence Systems in Circumpolar Societies: An Ethnoarchaeological Interpretation.

This project grew directly from work by Robert Jarvenpa and Hetty Jo Brumbach (both at the State University of New York-Albany) with Chipewyan (*Dene*) communities in central subarctic Canada, conducted between 1979–92. Observations of hunting, fishing, and collecting activities in these communities proved useful for modeling the roles and relationships of men and women in the archaeological past.

In collaboration with Chipewyan consultants, Jarvenpa and Brumbach mapped and inventoried a network of historical archaeological sites representing:

- hunting encampments,
- multi-family winter settlements, and
- trading outpost communities of the 1890s–1950s.

They also collected life histories and conducted formal task-differentiation interviews to identify the social, spatial, temporal, and material dimensions of specific economic tasks. The texts from these interviews demonstrated:

- the complexity of the interdependent economic roles of women and men;
- the movements of men and women upon the landscape; and
- their uses of tools, facilities, and structures.

This empirical and systematic means of modeling past activities of men and women can clarify and resolve interpretation of archaeological records, in which women's activities often have been portrayed as invisible or hard to assess.

The research now sponsored by the Arctic Social Sciences Program expands the framework developed with the Chipewyan to a comparative sample of societies representing several other major biogeographic zones and cultural-linguistic traditions in the circumpolar world:

- Finnish Saami,
- Alaskan Iñupiaq, and
- Siberian Khanty.

The 1999 field season began in Kultima, a community of reindeer-herding Saami in the mountainous Enontekiö district of northwestern Finland. Jukka Pennanen (University of Oulu) served as the expert on-site collaborator, with graduate assistants Riitta-Marja Leinonen (University of Oulu) and Scott Williams (State University of New York-Albany).

Much of the Kultima fieldwork focused on management of reindeer, the predominant subsistence and economic resource for this community; significant information was also retrieved on fishing, ptarmigan and hare hunting, arctic farming and cattle management, and craft production, and the use of other resources.

Heavy dependence on reindeer has generated a rather complex architectural landscape of fences, corrals, and specialized outbuildings. As an example, one family-household maintains approximately 36 different kinds of outdoor storage and processing facilities in addition to a large reindeer corral shared with other families.

Many of these facilities are prime loci of women's activities and planning, including specialized craft workshops maintained by women to diversify their household economies. Such increasing economic specialization is likely to elevate the archaeological visibility of women, as the facilities associated with women's spheres of performance tend to be concentrated near residential bases.

The 1999 field season was completed in Inalik, an Iñupiaq Eskimo community on Little Diomede Island in Alaska's Bering Strait. The expert on-site collaborator was Carol Zane Jolles (Indiana University-Purdue University-Indianapolis) with research assistance from Inalik resident Anthony Soolook and Inalik student interns Stanley Milligrock, Josh Menadelook, and Sheena Ozenna. Some interview sessions and participant observation focused on auklets, auklet eggs, and wild greens which were prominent in the summer food quest. Other sessions concentrated on walrus, seals, whales, and other resources that are important in other seasons.

Ethnoarchaeological mapping at Inalik documented an elaborate system of subterranean and semi-subterranean storage chambers constructed of stones and boulders from the adjacent ocean shore. These multi-family "meat holes" (*uua'* or *kaluwak*) are essential for keeping supplies of frozen and fermented meat, seal oil, eggs, greens, and other food items. The meat holes, which include several distinct types, figure prominently in the storage, processing, and food management phases of the hunting economy and, as such, are important sites of female domestic authority within the community.

The Summer 2000 field season will be conducted among Trom'Agan Khanty communities in western Russian Siberia, with Elena Michaelovna Glavatskaia (Urals State University) serving as the expert on-site collaborator.

When information from all four societies is available for detailed case comparison and analysis, Jarvenpa, Brumbach, and their collaborators will strive to link variations in subsistence and resource management for major sectors of the Circumpolar North with:

- types or degrees of differentiation in female and male economic roles, and
- types of archaeologically visible signatures or "gendered landscapes."

The investigators also hope that the resulting documents will be relevant to the participating communities for cultural education, local history, and resource planning.

For more information, contact Robert Jarvenpa and Hetty Jo Brumbach in Albany, NY (518/442-4703 or 442-4453; fax 518/442-5710; jarvenpa@cas.albany.edu or brumbach@cnsvax.albany.edu).

An Introduction to the Arctic Natural Sciences Program

The multidisciplinary Arctic Natural Sciences (ANS) Program supports research in the atmospheric sciences, biological sciences, earth sciences, glaciology, and oceanography.

In addition to providing core support for disciplinary research in the Arctic, ANS coordinates arctic research with the NSF Directorates for Geosciences and Biological Sciences. The program also helps facilitate multidisciplinary, cross-disciplinary, and polar projects funded by the Office of Polar Programs (OPP).

In April 2000, Neil Swanberg joined the OPP staff as a Program Manager in Arctic Natural Sciences (ANS). He shares management of ANS with Jane Dionne, who has been with ANS since 1998. Swanberg earned a B.S. in Zoology from the University of California, Davis and a Ph.D. in Biological Oceanography from the Woods Hole Oceanographic Institution-Massachusetts Institute of Technology joint program. He has held positions at Dartmouth College, Lamont-Doherty Earth Observatory, Woods Hole, and the University of Bergen and served as a rotator in the Polar Biology and Medicine program at OPP. Most recently he was the Deputy Executive Director of the International Geosphere-Biosphere Program.

Several noteworthy projects supported by the ANS Program are highlighted on this and the following two pages.

For more information, see http://www.nsf.gov/od/opp/arctic/natural.htm or contact Swanberg or Dionne in Arlington, VA (703/292-8029; fax 703/282-9082; nswanber@nsf.gov; jdionne@nsf.gov).

Arctic Marine Microbes are Efficient Despite Cold

Most organic particles sinking from the upper ocean are remineralized to CO_2 by benthic microbial communities. The small fraction of the particle flux that escapes remineralization is buried as organic carbon in sediments. In temperate sediments, seasonally low temperatures frequently correlate with decreased microbial activity. Until recently, microbial processes in the deep and polar oceans were also assumed to be hampered by low temperatures or combined effects of temperature and substrate.

Results from recent studies now suggest that polar microbial communities function efficiently at low temperatures. The specific means by which they maintain their activities under conditions that inhibit their temperate counterparts, however, have yet to be investigated.

These processes are likely to be important in the global carbon cycle because:

- burial of organic carbon in sediments ultimately affects atmospheric levels of both O_2 and CO_2; and
- permanently cold conditions characterize the majority of ocean sediments.

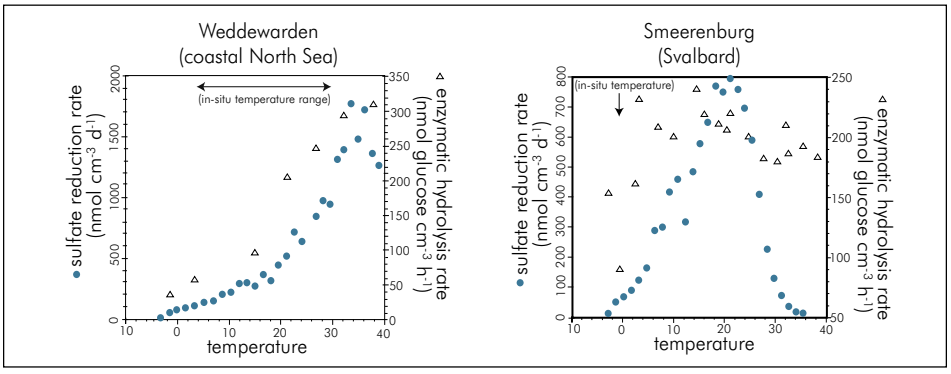
A team of scientists from the University of North Carolina-Chapel Hill and the Max-Planck Institute for Marine Microbiology (Bremen, Germany) is investigating the regulation and efficiency of organic carbon cycling by microbial communities in permanently cold arctic sediments. Their work is sponsored by the Arctic Natural Sciences Program and the Max-Planck Society. The team is focusing on the relationships among:

- rates of the initial and terminal steps of organic carbon remineralization;
- the composition and size of the microbial community;
- activities and distributions of individual members of the community; and
- temperature responses of the microbial community as a whole and of individual species within the community.

Preliminary research aboard the R/V *Jan Mayen* in September/October 1995 determined that carbon remineralization rates in the permanently cold fjords of western Svalbard were comparable to rates measured in more temperate sediments. A survey of microbial abundance and diversity, conducted at that time, collected the first psychrophilic (cold-loving) sulfate-reducing bacteria.

The first full field season in July 1999 took advantage of the research facilities in Ny-Ålesund (see *Witness* Autumn 1998), with shipboard activities conducted aboard the M/V *Farm*. Temperature responses of the initial and terminal steps in carbon cycling—extracellular enzymatic hydrolysis and sulfate reduction (in anoxic sediments), respectively—were investigated in sediment slurries. The 2000 field season will be based out of facilities at University Courses on Svalbard (UNIS) in Longyearbyen (see *Witness* Spring/Autumn 1999). Work in 2001 will focus on physiology and population distributions of specific microbes.

For information, contact Carol Arnosti in Chapel Hill, NC (919/962-5754; fax 919/962-1254; arnosti@marine.unc.edu).



Microbial communities from Smeerenburg Fjord exhibit rates of both sulfate reduction and enzymatic hydrolysis that reach maximum levels at much lower temperatures than observed in samples from more temperate environments. The adaptations and mechanisms yielding this temperature response will be studied in detail in specific organisms (figures by Carol Arnosti).

Team Explores Effects of Arctic Sunrise on Ozone

Between 1 February and 10 May 2000, more than 30 scientists from North America, Europe, and Japan conducted experiments at Alert (82.5°N, 62.3°W) in Nunavut, Canada aimed at understanding how ozone (O_3), which is highly photochemically reactive, is destroyed at the time of polar sunrise.

Because the sun does not rise above the horizon at Alert between late October and early March, chemical and physical processes can be studied in the extended absence, and then in the presence, of solar radiation. ALERT2000 builds on a series of Polar Sunrise Experiments conducted at the Canadian Forces Station at Alert during the past 15 years.

During the past century, ozone concentrations in the lower atmosphere (troposphere) have roughly tripled. Much of this increase is from anthropogenic sources, involving production in the troposphere when nitrogen dioxide (NO_2) breaks down in the presence of solar radiation, a process known as photolysis.

At ground level, ozone is toxic; at the same time, it provides a cleansing mechanism for the removal of other atmospheric pollutants. In the troposphere as a whole, it functions as a greenhouse gas. In the upper atmosphere (stratosphere), the ozone layer absorbs potentially harmful UV radiation.

At Alert in the 1980s, Environment Canada scientists Jan Bottenheim and Len Barrie found that ozone from ground level to roughly 400 m is destroyed after polar sunrise in March. Often for several days in a row, and especially during the month of April, the air in the marine boundary layer (from above the Arctic Ocean surface to around 400 m) is devoid of ozone.

Subsequent investigations confirmed that bromine atoms, which rapidly react with and destroy ozone, are involved. Bromine in the arctic boundary layer is most likely derived from sea salt. Researchers are now asking how sea-salt bromine gets into the gas phase in a form that can react efficiently with ozone.

New evidence from experiments at Alert and at Summit, Greenland suggests that:

- the snowpack is highly reactive when irradiated by sunlight, and
- this previously unrecognized site of photochemical reactions may significantly impact atmospheric concentrations of some gases.

For example, in two independent studies, by Brian Ridley (National Center for Atmospheric Research) at Alert and by Richard Honrath (Michigan Technological University) at Summit, reactive nitrogen oxides appeared to be produced in the snowpack, probably under the influence of sunlight. Paul Shepson (Purdue University) also reported production of formaldehyde in the snowpack at both locations.

Because pollutants removed from the atmosphere by snow may remain near the surface, exposed to sunlight, these observations indicate a need for improved understanding of the fate of chemical species in snow-covered regions. The atmospheric scientists, meteorologists, and snow physicists of the ALERT2000 team worked at two sites—one 6 km inland from the Arctic Ocean coastline and the other at an ice camp approximately 5 km offshore (see photo).

At the ice camp, the researchers are studying the ozone-depletion phenomenon by measuring ozone and bromine radicals. They are also studying the chemistry of gas phase mercury. Previous studies have indicated that mercury is consumed in the Arctic Ocean boundary layer, possibly by the same bromine radicals, implying that the Arctic Ocean could be a significant sink for this toxic metal.

The studies over land focus on air-snow interactions and the role played by sunlight in these processes. Snow physicists will describe the physical characteristics of the snowpack, including such critical parameters as snow density, surface area, and the depth to which sunlight penetrates the snow. Micrometeorological experiments are also under way to delineate the flux of many chemicals in and out of the snowpack.

This research addresses the following questions:

- How do gases partition between the snow and air?
- How are gases removed from the atmosphere during precipitation? and
- How might photochemistry in the air, ice, and snow affect the chemical composition of the lower atmosphere?

ALERT2000 will contribute to understanding factors that influence ozone on a global scale. Preliminary results are promising; a larger campaign is contemplated for the Arctic Ocean surface in 2004–05.

ALERT2000 is funded largely by Environment Canada; additional contributions come from the NSF Arctic Natural Sciences Program, France, and Italy. The Canadian Forces, especially the Defense Research Establishment Atlantic, contribute substantial logistical support.

For more information, see the ALERT-2000 web site (http://ARQM.tor.ec.gc.ca/ALERT2000), or contact Paul Shepson in West Lafayette, IN (765/494-7441; fax 765/494-0239; pshepson@purdue.edu) or Jan Bottenheim in Toronto, ON (416/739-4838; fax 416/739-5704; jan.bottenheim@ec.gc.ca). ■

The ALERT2000 studies are investigating how bromine (from sea salt) that occurs in the snowpack may be reacting in the presence of sunlight to destroy ozone and incorporate mercury into the arctic ecosystem (photo by Jan Bottenheim).

New AUV Project will Access Arctic Seafloor Sites

Geological and geophysical exploration of the deep seafloor is a difficult task anywhere in the world, and until recently, it has been completely unthinkable in the ice-covered Arctic Basin.

The Autonomous Polar Geophysical Explorer (APOGEE) project, funded by the Arctic Natural Sciences Program, is now using robotic instrumentation to open the arctic seafloor to scientific exploration. Recent advances in autonomous underwater vehicle (AUV) technology make it possible for swimming robots, working from icebreakers, to carry geophysical instruments to the seafloor in the Arctic Basin and back.

Principal investigators at the Woods Hole Oceanographic Institution and Lamont-Doherty Earth Observatory are working with researchers at the Bluefin Robotics Company. The fundamental technical challenges facing the APOGEE project are to design an AUV that can:

- home to and be recovered from a dock suspended from the stern of an icebreaker, and
- occupy seafloor sites for long periods of time to make geophysical measurements.

Both of these mission requirements call for significant advances over current designs, as all AUVs in operation today are strictly water-column instruments that must be deployed and recovered in ice-free water.

The prototype vehicle will carry a three-component broadband seismometer, with the scientific objective of making seismic measurements on the Gakkel Ridge. Seismic data will help determine the subsurface structure of the ridge, which is actually a rift valley 4–5 km deep running across the east side of the Arctic Basin. The rift is believed to constitute the largest outcropping of primitive mantle material anywhere on Earth. Testing this hypothesis is an appropriate starting place for the APOGEE program.

Initial sea tests for the prototype vehicle are scheduled for deep water off Bermuda in December 2000. If these tests are successful, the first science mission to the Arctic Basin could be as early as August 2001.

The ultimate goal for the APOGEE program is to provide a reliable autonomous research platform to explore and investigate the deep seafloor beneath any ice-covered body of water on Earth or elsewhere. An animated video describing the project can be seen on the APOGEE web site (http://obslab.whoi.edu/research/arctic/apogee.html). VCR tapes are also available upon request.

For more information, contact Rob Sohn in Woods Hole, MA (508/289-3616; fax 508/457-2150; rsohn@whoi.edu).

Bering Sea Frontal Zone Supports Complex Trophic Webs

Over most of the Bering Sea shelf, productivity declines during the summer due to nutrient depletion by the spring phytoplankton bloom. Solar heating of the surface water stratifies the water column, isolating more nutrient-rich waters in the cooler, deeper layer. From the shoreline to a frontal zone near the 50 m depth contour, however, waters remain well mixed even in the warmer summer months. This frontal zone is an area of high biological productivity.

Stephan Zeeman (University of New England) and colleagues have hypothesized that the frontal zone was responsible for prolonging production through the summer by allowing the transfer of nutrient-rich water from the bottom water layer of the shelf into the surface waters adjacent to the front. The result would be a stimulation of phytoplankton growth in the area, followed by enhanced growth of zooplankton due to the increased food availability. That, in turn, would support top-level predators that feed on the zooplankton.

Funded by the Arctic Natural Sciences Program, the Inner Front Project focuses on physical-biological interactions of a few key elements in the trophic web: nutrients, phytoplankton production, euphausiid zooplankton, and short-tailed shearwaters whose preferred food is euphausiids. The Inner Front Project collaborates with investigators in the National Oceanic and Atmospheric Administration's Southeast Bering Sea Carrying Capacity Program (see *Witness* Spring 1998). The combined data sets allow an unprecedented look at trophic dynamics in the region.

In 1997, the first year of the study, anomalous conditions prevailed throughout the area:

- sea-surface temperatures were 2°C above normal;
- the frontal zone itself was not well established;
- an enormous bloom (encompassing approximately 400,000 km^2) of the coccolithophore *Emiliania huxleyi,* which had never been documented in the Bering Sea, lowered euphausiid densities relative to previous years;
- shearwater populations declined by approximately 10%;
- marine mammal distributions were altered (*e.g.,* right whales were seen for the first time in decades); and
- the Bristol Bay sockeye salmon run was about half the predicted size.

Although conditions normalized in subsequent years, the *E. huxleyi* population has persisted, and the impact of this change is not yet fully understood. Preliminary work done during Summer 1999 provides some evidence that microzooplankton are feeding on the new arrivals.

Investigators also saw evidence of one mechanism by which the front injects nutrients into the surface waters. At the front, waves along the thermocline pushed lobes of the deeper water toward the surface, resupplying nutrients to the depleted upper layer of water.

For more information, contact Stephan Zeeman in Biddeford, ME (207/283-0170 ext. 2410; fax 207/282-6379; szeeman@mailbox.une.edu).

Logistics Survey Responses will Update Advice to NSF

Arctic research support and logistics capabilities in the U.S. have improved substantially in the last few years. The NSF Office of Polar Programs (OPP) now has a specific budget for arctic logistics and an Arctic Research Support and Logistics program manager. Efforts are underway to better support research and increase international collaborations in many parts of the Arctic (see pages 20–23). The USCGC *Healy* has successfully completed trials and will soon commence research operations (see page 24). VECO Polar Resources is in its first year of providing arctic logistics support, and major improvements at Toolik Field Station have increased year-round access and science capabilities (see article this page). Research support provided since 1997 by the Barrow Arctic Science Consortium (see *Witness* Spring/Autumn 1999) is facilitating field investigations on Alaska's North Slope.

The arctic research community continues to identify support needs in light of recent improvements and emerging science priorities. The Research Support and Logistics Working Group (RSLWG; see *Witness* Spring/Autumn 1999) initiated an on-line survey in February 2000 and held a "town meeting" in Washington, DC in May 2000 to gather information about logistics needs. This process represents one of several opportunities for investigators to have input into ongoing improvements of the federal arctic research infrastructure.

One of the ten questions in the survey (see http://www.arcus.org/rslwg) asks what researchers consider to be essential research support. Most of the 100 survey responses received thus far emphasize the need for field communications and access to remote locations. Respondents also affirm the value of data compilation and coordination. Individual survey responses and a summary are posted on the ARCUS web site.

The RSLWG will use this information to update the 1997 report, *Logistics Recommendations for an Improved U.S. Arctic Research Capability,* by:

- considering science needs requiring innovative research support and logistics, and
- identifying new science opportunities made possible by the expanded support.

Following publication of the 1997 report (see http://www.arcus.org/Logistics), Congress appropriated $22 million for arctic logistics in FY 1999 and $25 million in FY 2000. Many of the 1997 recommendations are being implemented with these funds.

The draft update is expected to be available for community review in Spring 2001 and published later in the year. The updated recommendations are intended for use by all agencies with research interests in the Arctic.

The RSLWG is supported by NSF to expand upon the work of ARCUS' former Logistics Working Group, which was sponsored by the U.S. Arctic Research Commission (see page 19) and NSF.

For more information, see the ARCUS web site, or contact RSLWG co-chairs Peter Schlosser (845/365-8707; fax 845/365-8155; peters@ldeo.columbia.edu) and Terry Tucker (603/646-4268; fax 603/646-4644; wtucker@crrel.usace.army.mil). ■

Toolik Field Station Upgrades Labs

In October 1999, the Toolik Field Station (TFS) received delivery of four new modular laboratories, and the equipment to support associated communications and power upgrades. The NSF Office of Polar Programs (OPP) provided funding for the upgrades, recommended in the report *Toolik Field Station: The Second 20 Years,* which was published by ARCUS in 1996 on behalf of the arctic research community.

The new modules are 24 feet wide and 60 feet long. They replace house trailers less than half that size, some over 35 years old, which had been converted to laboratories. The new labs feature fume hoods, computer work areas, field sample preparation and processing areas, bench space, and chemical preparation areas.

Fiber-optic cable has been brought in to Toolik Field Station; design and installation of the local area network will be completed in Summer 2000. The fiber-optic line replaces the VHF radio/microwave-based telephone communication system that has served the labs since the early 1990s. This upgrade became possible when Kanas Telecom, Inc. completed installation of a fiber-optic line paralleling the Trans-Alaska Pipeline from Prudhoe Bay to Valdez (photo by Mike Abels).

Related upgrades include:

- a fiber-optic line to the Station (see photo);
- delivery of 3000 cubic yards of gravel to support new laboratory module pads and improve the Station's road surfaces;
- installation of four new generators (50 and 80 kilowatts) in a sound-attenuated enclosure;
- replacement of the electric cable tray distribution; and
- delivery of a Caterpillar-wheeled integrated tool carrier with forks, bucket, and snowblade.

Because of increased power requirements for the new labs, the existing cable tray and electric distribution wire were resized. The cable tray now includes conduits that will support future expansions for telephone and Internet access.

Some of the installation had not been completed when VECO Polar Resources (VPR) replaced the Polar Ice Coring Office (PICO) as NSF's arctic logistics provider in December 1999. Tasks that remain to be completed by VPR during the 2000 field season include:

- installation and splicing of phone lines, fiber-optic cables, and electric lines throughout camp, with plans for installation of a local area network;
- construction and installation of ramps, steps, and decks for the new labs; and
- installation of upgraded exterior water supply and holding tanks.

For more information, contact Mike Abels in Fairbanks, AK (907/474-5063; fax 907/474-5513; fnmaa@uaf.edu). ■

OPP will Support Innovations in Arctic Instrumentation

The NSF Office of Polar Programs (OPP) solicited proposals in January 2000 for the Polar Instrumentation and Technology Development Program (http://www.nsf.gov/cgi-bin/getpub?nsf0025). This program will support the development of unique techniques and instruments for research and innovative technological solutions to the problems of infrastructure or research support in remote and extreme polar environments.

OPP will fund concept and engineering development through field testing of novel technologies that permit low-risk, environmentally friendly observations of remote regions with limited or no direct access. Application of the technologies will be funded through other mechanisms.

The initiative aims to:

- improve observations over broad temporal and spatial scales;
- reduce the footprint of research in environmentally sensitive areas;
- ensure safer access to regions that are currently inaccessible or inhospitable; and
- foster development of efficient, flexible technologies to enhance support of research in polar regions.

As much as $3 million is available for eight awards ($500,000/year maximum), which will be announced in August and September 2000. 54 proposals representing 48 projects have been submitted for a total of $38.4 million over one to five years.

For more information, contact Program Coordinator Simon Stephenson in Arlington, VA (703/292-8029; fax 703/282-9082; sstephen@nsf.gov).

OPP Funds Improvements For Long-Term Observatories

The Office of Polar Programs (OPP) has funded the first round of awards for the new Long-Term Observatory (LTO) Program. OPP's Arctic Research Support and Logistics Program administers the new initiative, addressing the need to improve the observational infrastructure in the Arctic (see *Witness* Spring/Autumn 1999). The LTO Program is a direct response to recommendations developed at the *Opportunities in Arctic Research* workshop in September 1998 (see *Witness* Autumn 1998).

The LTO Program Solicitation issued in March 1999 (see http://www.nsf.gov/cgi-bin/getpub?nsf99101) invited proposals for the development and use of:

- environmental observatories,
- remote/autonomous instruments, and
- sample repositories.

From a pool of 73 proposals requesting $102 million for 53 projects, OPP anticipates distributing $19.5 million for 15 proposals to support 12 projects. This total includes co-funding from the Division of Atmospheric Sciences, Division of Environmental Biology, and the Arctic System Science (ARCSS) Program. Not all of the awards have been made yet.

OPP anticipates repeating the LTO solicitation, with some modifications, in FY 2002, if current budget levels continue.

For more information, contact Simon Stephenson in Arlington, VA (703/292-8029; fax 703/282-9082; sstephen@nsf.gov).

Funded Projects 1999

An Arctic Environmental Observatory in Bering Strait—Lee Cooper (University of Tennessee) and Louis Codispoti (University of Maryland) *$1.9 million*

A Hydrological Observing System for the Pan-Arctic Landmass (Arctic Rims)—Charles Vorosmarty (University of New Hampshire), Mark Serreze (University of Colorado), and David Bromwich (Ohio State University) *$1.5 million*

Creating a 47-Year Public Record of Sea-Ice Draft in the Arctic Ocean—Andrew Rothrock (University of Washington) and Walter Tucker (Cold Regions Research and Engineering Laboratory) *$1.3 million*

Development of a High Spectral Resolution Lidar for Long-Term Unattended Measurement of Arctic Clouds and Aerosols—Edwin Eloranta (University of Wisconsin) *$0.9 million*

Long-Term Observations of the Arctic Upper Atmosphere Using the Kodiak, Alaska SuperDARN Radar—William Bristow (University of Alaska) *$0.7 million*

Long-Term Wind and Temperature Measurements in the Arctic Mesosphere and Lower-Thermosphere—Scott Palo (University of Colorado) *$0.7 million, co-funded by the Division of Atmospheric Sciences*

Science Coordination Office for Summit Greenland Environmental Observatory—Roger Bales (University of Arizona) and Jack Dibb (University of New Hampshire) *$0.5 million*

Traditional Knowledge in a Changing Arctic: Gathering, Preservation, and Sharing of the Yup'ik "Way of Being"—Mark John (Calista Elders Council) *$1.0 million*

An Arctic Archival Observatory—Joseph Cook (University of Alaska) *$1.1 million, co-funded by the Division of Environmental Biology & Division of Biological Infrastructure*

Applications of Aerosondes to Long-Term Measurements of the Atmosphere and Sea-Ice Surface in the Beaufort/Chukchi Sector of the Arctic Ocean—Judith Curry (University of Colorado) *$4.0 million*

North Pole Station: A Distributed Long-Term Environmental Observatory—James Morison (University of Washington) and Kelly Falkner (Oregon State University) *$3.7 million, co-funded by the Arctic System Science (ARCSS) Program*

NSF Plans Infrastructure to Support Biological Research

Recognizing that a significant investment in infrastructure is necessary to support studies on ecological systems and to integrate environmental research from molecular to global scales, NSF is preparing to establish an integrated network of ten major environmental observatories across the country.

Individual observatories within the planned National Ecological Observatory Network (NEON) will provide resources to support research at local and regional scales. The network as a whole will share a common interdisciplinary research infrastructure, common protocols, and an advanced computational network to support observations, synthesis, and analysis at all scales. NEON is envisioned as a national research platform available, both physically and electronically, to all scientists with pertinent interests. It will include a substantial education and outreach component.

The ultimate structure of NEON will be a function of community input, NSF goals, and funding constraints. In 1999 and early 2000, NSF convened three advisory workshops to outline:

- general structure and goals,
- interdisciplinary capabilities and conceptual breadth of the network, and
- instrumentation and other technological needs of the NEON observatories.

Reports from the second and third workshops are available at http://www.sdsc.edu/NEON. A fourth advisory workshop on network management issues will convene later in 2000.

NEON observatories will be distributed across the United States in functionally important habitats, rare habitats, transition zones (ecotones), and along major environmental gradients. Such an array is intended to enhance the study of themes in environmental biology of national and international importance, including the structure and dynamics of populations, communities, ecosystems, and landscapes; biodiversity; global change; and anthropogenic influences.

NSF will select NEON sites on the basis of competitive proposals from consortia of existing ecological and environmental research facilities in a region (*e.g.*, field stations, marine laboratories, long-term ecological research sites). The array of observational stations, complementary facilities, and services that can be established under the auspices of one observatory will be as important as the distribution and integration of the observatories in the network as a whole. Connections to advanced computational facilities and environmental networks maintained by other federal agencies will be encouraged, as will liaisons with similar activities that are being developed in other countries.

NSF has proposed to launch each observatory with $10 million and to sustain each with a $1.25 million annual operating budget for at least 30 years, depending upon the excellence of its service to the community and the quality of science enabled by that service.

For more information, see http://www.archbold-station.org/abs/neon/index.html, or contact Scott Collins at the NSF Division of Environmental Biology in Arlington, VA (703/306-1479; fax 703/306-0367; scollins@nsf.gov). ■

NSF Inaugurates Automated North Pole Observatory

In April 2000, an international scientific team deployed a set of drifting buoys from the North Pole to begin recording data for the first long-term environmental observatory in the Arctic Ocean. No camp on the arctic ice pack can be permanent or stationary, so the environmental observatory at the North Pole is designed to consist of automated instruments moored on the ocean floor and on drifting buoys deployed from the Pole at regular intervals.

To support this long-term presence, NSF has funded the North Pole Environmental Observatory project for five years (see page 15). Jamie Morison (University of Washington) is the principal investigator. Researchers from Oregon State University, the Pacific Marine Environmental Laboratory, the Japan Marine Science and Technology Center, and Canada's Met-Ocean Corporation also traveled to the Pole to launch the automated instruments.

The buoys launched in April 2000 are the first set in a series that will be launched over the course of several seasons. The buoys are expected to drift with the ice pack from the Pole to the Greenland Sea measuring atmospheric pressure, temperature, wind, solar radiation, water temperature, salinity, ice temperature profiles, and ice thickness. Coverage will be enhanced in subsequent years by instruments anchored to the sea floor. The new U.S. Coast Guard Cutter *Healy* (see page 24) also is expected to assist in deploying buoys. The Japanese and Canadian groups are contributing in-kind support, including instrumentation and some logistics assistance, to the project. Ultimately, NSF intends that instruments deployed from the North Pole automated observatory will serve a broad range of sciences.

The long-term scientific record at the North Pole will allow more comprehensive monitoring of the Arctic in order to understand its role in the regulation of global climate. Observations have shown that the Arctic Ocean has, in recent years, sustained a rapid thinning of sea ice (see *Witness* Spring/Autumn 1999) and shifts in ocean circulation (see *Witness* Autumn 1998). These changes appear to be related to a pattern of change in the atmospheric circulation of the Northern Hemisphere (see page 3), which is roughly centered at the Pole. Even with the use of submarines (see *Witness* Spring 1998) and icebreakers (see *Witness* Autumn 1998), it has proven difficult to obtain long-term measurements of temperature and other variables at the Pole.

For more information, see the project's web site (http://psc.apl.washington.edu/northpole), or contact Jamie Morison in Seattle, WA (206/543-1394; fax 206/616-3142; morison@apl.washington.edu). ■

Houses Approves Small Increases for NSF Budget

This article has been abstracted from information on the FY 2001 federal appropriations process developed by the American Association for the Advancement of Science (AAAS) Office of Science and Policy Programs and the American Institute of Physics (AIP) Office of Science Policy.

When introducing his FY 2001 budget request in February, President Clinton made NSF the centerpiece of his Research and Development (R&D) budget, which placed a strong emphasis on achieving a better balance among science and engineering disciplines. Because NSF is the only R&D funding agency responsible for the entire range of science and engineering disciplines, with a particular emphasis on fundamental research and non-life sciences disciplines, the budget request singled out NSF for an unprecedented $675 million or 17.3% increase in its total budget to $4.6 billion. The requested increase was spread across the breadth of NSF's research portfolio, with special attention to the agency's leading role in several multi-agency initiatives.

Congress has chosen to allocate $17 billion less than the President for discretionary spending in the federal budget while increasing defense spending more, limiting Congressional budgets for domestic programs such as NSF. On 21 June, the House of Representatives approved an FY 2001 VA-HUD appropriations bill (HR 4635) that would provide mostly level funding for R&D programs in the federal independent agencies, including NSF, that are covered by the bill.

The House would provide a total NSF budget of $4.0 billion, $526 million less than the President's request, but still $149 million or 3.8% more than FY 2000. Research and Related Activities (R&RA) would total $3.1 billion, up 5.4% over FY 2000, but well below the requested 19.7% increase. The full House approved HR 4635 after making several amendments, including one that reduced the budget for the Office of Polar Programs to $264.5 million, an $18 million cut from the budget proposed by the House Appropriations Committee.

Although the appropriation is less than the Administration's request, the House bill generally follows NSF's stated priorities on distribution of the funds among the research directorates. The Computer and Information Science and Engineering directorate would receive $439 million, an increase of 13.1%. The Biological Sciences directorate would receive $450 million, an increase of 8.6%, while programs in the mathematical and physical sciences, engineering, earth sciences, and social sciences would receive increases between 6 and 8%.

The only program within R&RA to decline from FY 2000 levels would be Integrative Activities, which would fall 32.5% from $129 million to $87 million. The Major Research Equipment account, which funds construction of large-scale scientific facilities, would receive $77 million, far less than the $139 million request. The House bill includes full funding of $13.5 million for continued construction of the new South Pole Station, but would save money by withholding funding for the requested new start of the National Ecological Observatory Network (see page 16).

NSF's Education and Human Resources programs would receive $694 million, slightly below FY 2000 levels and well below the $729 million request. Although the House would provide the full requested amounts for Educational System Reform, the Experimental Program to Stimulate Competitive Research (EPSCoR), and other EHR programs, the bill reduced the funding for Undergraduate Education and Graduate Education.

As of press time, the Senate had not yet drafted its version of the VA-HUD appropriations bill. This process began with a hearing before the Senate Committee on Health, Education, Labor, and Pensions, chaired by James Jeffords (R-VT), on 12 July.

Before the appropriations process is over, final funding levels for VA-HUD bill programs are expected to be higher than levels proposed by the House. Although it is probable that additional funds will be found for NSF programs, especially if the Senate VA-HUD bill proposes higher funding levels, it appears unlikely that Congress will agree to the President's full requested increases.

For more information, see the AAAS web site (http://www.aaas.org/spp/R&D), the AIP web site (http://www.aip.org/gov), or the U.S. Congress web site (http://thomas.loc.gov). ■

GPS Becomes Ten Times More Accurate

In May 2000, the U.S. military stopped scrambling signals from the 24 Global Positioning System (GPS) satellites, allowing civilian users to access the worldwide navigational system accurately without resorting to expensive techniques to correct the signal.

The previous deliberate degradation of the signals in the interest of national security had limited the resolution of the system to approximately 100 meters, which is not accurate enough for most scientific purposes. More precise GPS readings for users not cleared by the Department of Defense required installation of fixed and roving receivers, labor-intensive averaging of readings over time, or both.

The decision not to scramble the GPS signals will increase the resolution of the civilian system to approximately 9 meters. The improved resolution is likely to be of substantial benefit to members of the arctic research community. Access to accurate GPS information and inexpensive receivers is expected to simplify many aspects of data collection in the field, improve personnel safety at remote locations, and streamline the increasingly widespread use of Geographic Information Systems (GIS) to collect and manage data.

For more information, see the Interagency GPS Executive Board web site (http://www.igeb.gov). ■

Arctic Council Meets in Alaska to Review Progress

Senior officials from the eight arctic nations, representatives from four arctic indigenous organizations, and accredited observers convened in Fairbanks, Alaska in April 2000 for the biannual Arctic Council Senior Arctic Officials (SAO) Meeting. More than 150 delegates actively discussed and debated cooperative measures to promote environmental protection and sustainable development in the arctic region. Chief David Salmon, Second Traditional Chief of Interior Alaska Athabascans from the Gwich'in village of Chalkyitsik, opened the meeting, urging delegates to work together with indigenous people of the Arctic to address threats to the arctic environment.

The Arctic Council is a high-level intergovernmental forum established in 1996. The eight arctic nations are Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden, and the U.S. The four arctic indigenous organizations that have Permanent Participants (PP) status are the Aleut International Association, the Inuit Circumpolar Conference, the Russian Association of Indigenous Peoples of the North, and the Saami Council. The Gwich'in Tribal Council has applied to become the fifth PP of the Council.

Chairs from each of the Council's working groups reported on progress they have made on tasks assigned at the Arctic Council Ministerial Meeting held in Iqaluit, Canada in September 1998.

Environmental Protection

Four of the Council's five working groups address environmental issues such as contaminants, conservation of living resources, prevention of marine pollution, and environmental emergencies. Delegates reviewed options for organizing and implementing an action plan to eliminate pollution of the Arctic. The Arctic Council Action Plan (ACAP) is a key initiative that will outline possible national, regional, and global actions to reduce emissions and clean up contaminants (*e.g.,* heavy metals, persistent organic pollutants, radioactivity, chemicals that deplete the ozone layer). The ACAP Working Group, chaired by Per Døvle, Deputy Director of the Norwegian Pollution Control Authority, met in late June 2000 in Oslo, Norway to further discuss implementation. The Senior Officials are inquiring whether their respective governments are interested in leading any one of 11 possible ACAP projects that the Council has endorsed.

Delegates heard a progress report on the Arctic Climate Impact Assessment (ACIA), including a request that Council members nominate experts from their countries to serve as authors for the project, which aims to examine comprehensively the effects of global climate change and increased ultraviolet radiation on the arctic region and its inhabitants (see page 21).

Representatives of the Council's Arctic Monitoring and Assessment Program (AMAP) and the U.S. Environmental Protection Agency reported on the Council's multilateral program to identify and remediate PCB-contaminated sites in the Russian Federation. At the end of June 2000, the Council expects to receive results from Phase I of the project, which is identifying contaminated sites. The United States has offered to fund a sizeable part of Phase II, which will assess the feasibility of remediating contaminated sites and refitting facilities that produce PCBs. If approved by the Council in October 2000, Phase II could be complete by the next Senior Arctic Officials meeting in Fall 2002. Phase III is intended to be a pilot project to refit a production facility.

Sustainable Development

The Arctic Council's Sustainable Development Working Group (SDWG) heard progress reports on initiatives to:

- improve the health and well-being of arctic children and youth (led by Canada),
- assess prospects for circumpolar applications of telemedicine (led by the U.S.),
- manage regional fisheries (led by the Saami Council), and
- promote cultural- and eco-tourism in the Arctic (led by the U.S. and State of Alaska).

The SDWG also heard presentations on health and social welfare issues such as:

- emerging infectious diseases,
- the health and environment of arctic indigenous people, and
- a survey of living conditions in the Arctic.

Canada introduced an initiative on capacity building which it proposed should be an organizing theme for the work of the Council. Quoting from a United Nations Development Program report, Canada described capacity building as "the sum of efforts needed to nurture, enhance, and utilize the skills and capabilities of people and institutions at all levels—national, regional, and international—so they can better progress toward sustainable development."

Norway reported on projects directly related to sustainable development and of interest to the Council, including the feasibility of opening a Northern Sea Route and international workshops it had recently held addressing reindeer herding and husbandry, the use and conservation of living arctic marine resources, and production of oil and gas in the Arctic.

Public Awareness, Education, and Outreach

Delegates were updated on developments to establish a circumpolar University of the Arctic (see *Witness* Spring/Autumn 1999). They also discussed a Canadian initiative to bring an arctic voice to the international gathering that will mark the 10th anniversary of the 1992 Rio de Janeiro Conference on the Environment.

The Arctic Council exercised its Internet capabilities by broadcasting a live panel discussion on *Contaminants and Human Health*. Public television and radio also aired the taped discussion, and copies will be available to download from the Internet. Delegates were briefed on the Arctic Council web site, the Arctic Environmental Data Directory, and a possible Arctic Council magazine.

The next SAO and Ministerial Meetings will take place on 10–13 October 2000 in Barrow, Alaska. Finland has offered to chair the Council when the U.S. chairmanship expires in October 2000.

For more information, see the Arctic Council web site (http://arctic-council.usgs.gov), or contact Tracy Hall at the Arctic Council Secretariat in Washington, DC (202/647-4972; fax 202/647-1106; hallta@state.gov). ■

President Names Three Members to the USARC

In January 2000, President Clinton reappointed George Newton as Chair of the U.S. Arctic Research Commission (USARC). Newton, who has been a member of the Commission since 1989 and Chair since 1996, is recognized for conceiving and negotiating the establishment of the Science Ice Expedition (SCICEX) program (see *Witness* Spring/Autumn 1999). He is Director of Research and Evaluation at Management Support Technology, Inc. in Fairfax, Virginia.

The President also has appointed Jackie Grebmeier and Jim Llewellyn to the Commission. Grebmeier is a specialist in polar biological oceanography at the University of Tennessee in Knoxville. She has served on advisory committees for the National Research Council, National Academy of Sciences, and NSF. She is currently a project co-leader for joint Russian-U.S. ecosystem studies in the Bering and Chukchi seas (see page 4).

Llewellyn is an attorney with BellSouth Corporation practicing regulatory law. He has served as Chief Counsel in the Office of former Senator Sam Nunn (D-GA) and as Senior Assistant Attorney General for the State of Georgia.

Other Commission members are: Richard Glenn (Department of Energy Management, North Slope Borough, Barrow, AK), John Hobbie (Marine Biological Laboratory, Woods Hole, MA), Walter Parker (Parker Associates, Anchorage, AK), and Jack Roderick (Anchorage, AK).

The next edition of the Commission's *Report on Goals and Objectives for Arctic Research* is being prepared during Spring and Summer 2000 for publication in January 2001. Input from the arctic research community is welcomed. The 1999 Report can be found on the USARC web site.

For more information, see the USARC web site (http://www.uaa.alaska.edu/enri/arc_web/archome.htm), or contact USARC Executive Director Garry Brass in Arlington, VA (800-AURORAB or 703/525-0111; fax 703/525-0114; g.brass@arctic.gov).

Polar Research Board Begins Four New Studies

The Polar Research Board (PRB) has four new studies underway. First, the PRB is reviewing NASA's strategy for providing derived, geophysical data sets (*e.g.,* Polar Pathfinder) to the polar science community. The study's goals are to:

- summarize the strategy, scope, and quality of NASA's polar geophysical data;
- suggest ways to make these and future data sets more useful to researchers; and
- consider how well the products are reaching the appropriate communities.

The committee is chaired by John Walsh (University of Illinois). It is expected to complete its work by December 2000.

At the request of the *Exxon Valdez* Oil Spill Trustee Council, the PRB is forming a committee to provide independent scientific guidance about a comprehensive plan for a long-term, interdisciplinary research and monitoring program in the northern Gulf of Alaska. The committee will:

- review research and monitoring activities in the region since the oil spill;
- convene one or more information-gathering meetings in Alaska where researchers and the public can convey their perspectives on what the research and monitoring plan should accomplish;
- review the general strategy proposed in the draft Science Program (which includes information on the social and political context, mission, approach, and scientific background); and ultimately,
- review the draft Research and Monitoring Plan, including the scope, structure, and quality of the proposed approach.

The committee will also address broader issues related to overall effectiveness of the Trustee Council's program and plan for guiding continued efforts to understand biological change in the Gulf of Alaska.

A third study will explore the science and policy implications of abrupt climate change, as distinct from gradual global warming. Clear guidance is lacking to steer the myriad current research efforts pertaining to abrupt change and to better blend science and policy needs. This study will:

- describe what is known about abrupt climate change from paleoclimate proxies, historical observations, and numerical modeling (*e.g.,* patterns and magnitudes of possible changes, mechanisms, forcing thresholds, probabilities); and
- explore the critical knowledge gaps concerning the potential for abrupt climate changes, including those aspects of change that are of greatest potential importance to society and economies.

Based on this information, the committee will outline a research strategy to fill the critical knowledge gaps. The study will be chaired by PRB member Richard Alley (Pennsylvania State University).

The PRB will soon begin work on a fourth study, requested by Congress, to understand the cumulative environmental impacts of oil and gas exploration, development, and production on Alaska's North Slope. This two-year effort will:

- review existing information;
- assess known and probable cumulative impacts; and
- attempt to describe possible cumulative effects.

Nominations for the committee closed 15 May 2000.

For more information, see the PRB web site (http://national-academies.org/prb), or contact PRB Executive Director Chris Elfring in Washington, DC (202/334-3479; fax 202/334-1477; celfring@nas. edu).

Canadian Polar Commission Raises Profile of the Arctic

The Canadian Polar Commission (CPC) was created by an act of Parliament in 1991 to serve as Canada's lead agency in the development and dissemination of polar knowledge. The CPC (see *Witness* Spring/Autumn 1999) maintains working relationships with governments, universities, research institutes, industry, aboriginal organizations, and non-governmental groups throughout Canada.

At the international level, the CPC represents Canada on the International Arctic Science Committee (see article this page and *Witness* Autumn 1998) and the Scientific Committee on Antarctic Research. While not itself engaged in polar study, the CPC has responsibility for:

- monitoring, promoting, and disseminating knowledge of the polar regions;
- contributing to public awareness of the importance of polar science to Canada;
- enhancing Canada's international profile as a circumpolar nation; and
- developing recommendations to government on polar science policy.

In Spring 1999, the seven-member board of the CPC met to redefine the organization's mission and values, and to develop, in consultation with staff, a three-year strategic plan, including:

- building a higher profile in Canada for polar knowledge at the community, regional, national, and international levels;
- finding fresh and innovative ways to promote polar science; and
- collaborating effectively with public- and private-sector partners.

Toward these ends, the Commission approved several initiatives, including the Canadian Polar Information Network (CPIN), an on-line source of arctic and Antarctic data and information. Newly established, the CPIN (http://www.polarcom.gc.ca/cpin/default.htm) features:

- the Polar Science Forum, an interactive communications and information resource;
- a registry of Canadian polar researchers; and
- links to sources of data and information throughout Canada and the circum-arctic region (*e.g.,* Arctic Environmental Data Directory, Antarctic Master Directory, Global Change Master Directory).

An important step in the creation of a robust polar information infrastructure in Canada, CPIN will, in the near future, include a metadata search and filing facility and a GIS-based data display tool.

To enhance its capacity for monitoring and reporting, the Commission also introduced *Arctic and Antarctic Research in Canada,* a series of publications that will profile polar research sectors while helping to identify key issues and trends relevant to the development of public policy. More comprehensive reports on a wide range of cross-cutting issues, including:

- traditional knowledge,
- funding,
- logistics and infrastructure,
- licensing, and
- data management

will also be by published by the CPC as part of the series, while a regular state-of-polar-science report will synthesize information periodically. The Commission will complement this work in 2000 by identifying a suite of polar science indicators that can be compiled and tracked over time as a broad measure of Canada's commitment to building polar knowledge.

For more information, see the CPC web site (http://www.polarcom.gc.ca), or contact Alan Saunders in Ottawa, ON (888/POLAR01; fax 613/943-8607; saunders@polarcom.gc.ca).

IASC Hosts Arctic Science Summit

More than 200 scientists and science administrators from several arctic science organizations attended the second Arctic Science Summit Week (ASSW) in April 2000 in Cambridge, UK. The International Arctic Science Committee (IASC, see *Witness* Autumn 1998) initiated ASSW to provide opportunities for coordination, collaboration, and complementarity in all areas of arctic science. ASSW comprises meetings of arctic research organizations, a Joint Science Day on a topical issue, and related workshops.

A major poster session preceded the Joint Science Day on *Impacts of Climate Change in the Arctic,* which was attended by the local science community and media as well as meeting participants. The Joint Science Day brought the Arctic Climate Impact Assessment (ACIA, see page 21), to the attention of the general arctic science community.

The following organizations held their annual meetings as part of ASSW:

- the IASC Council, Regional Board, and Executive Committee;
- the ACIA Steering Committee;
- the Arctic Ocean Sciences Board;
- the European Polar Board;
- the Forum of Arctic Research Operators (see *Witness* Spring/Autumn 1999);
- the Nansen Arctic Drilling Program (see *Witness* Spring 1998); and
- the Nordic Polar Research Group.

Workshops were convened on:

- a comprehensive geophysical mapping project covering the Arctic Ocean Basin and surrounding areas (see page 22);
- sustained monitoring of arctic fluxes that connect the Arctic Ocean to lower latitudes (see page 21); and
- arctic carbon cycling, organized by the Feedbacks and Arctic Terrestrial Ecosystems (FATE) project group.

Associated receptions, including one at the Scott Polar Research Institute, offered opportunities for informal discussions. The Local Organizing Committee for ASSW 2000 was headed by the British Antarctic Survey and sponsored by the Natural Environment Research Council and the Polar Regions Section of the Foreign and Commonwealth Office.

A number of reports based on the discussions at ASSW are now in development. The next ASSW will be held in Iqaluit, Canada in late April 2001.

For more information, see the IASC web site (http://www.iasc.no), or contact IASC Executive Secretary Odd Rogne in Oslo, Norway (+47/2324-1602; fax +47/2324-1601; iasc@iasc.no).

Arctic Council Prepares Arctic Climate Impact Assessment

The international Arctic Climate Impact Assessment (ACIA) project is about to commence under the auspices of two working groups of the Arctic Council (see page 18 and *Witness* Spring/Autumn 1999) and the International Arctic Science Committee (IASC, see page 20). The goal of the ACIA is to evaluate and synthesize knowledge on climate variability, climate change, increased ultraviolet radiation, and their consequences. The aim is to provide useful and reliable information to the governments, organizations, and peoples of the Arctic on policy options to meet such changes. The ACIA will examine possible future impacts on:

- the environment and its living resources,
- human health, and
- infrastructure.

Three major volumes will be completed by 2004; they are:

- a peer-reviewed scientific volume,
- a synthesis document summarizing results, and
- a policy document providing recommendations for coping and adapting.

Broad participation of experts from many different disciplines and countries is anticipated. Authors will be guided by an Assessment Steering Committee (ASC) with representatives from:

- the Arctic Council's Arctic Monitoring and Assessment Program, and Conservation of Arctic Fauna and Flora;
- IASC; and
- indigenous peoples of the Arctic.

The United States is the lead country for this effort; representatives from NSF and the National Oeanographic and Atmospheric Administration (NOAA) will also be members of the ASC. Its chairman is Robert Corell (United States); the Vice-Chair is Pål Prestrud (Norway). An ACIA Secretariat has been established at the International Arctic Research Center of the University of Alaska Fairbanks and funded by NSF and NOAA. Additional contributions are expected from other arctic countries.

Close ties will be maintained with the group conducting a similar regional assessment as part of the Intergovernmental Panel on Climate Change (see *Witness* Autumn 1998 and Autumn 1997), but the ACIA expects to provide considerably more detail on the expected impacts in the Arctic. The means by which it arrives at its conclusions is intended to be transparent, with credible and rigorous review and clear statement of the degrees of uncertainty in the conclusions.

For more information, contact Gunter Weller, Interim Executive Director of the ACIA Secretariat in Fairbanks, AK (907/474-7371; fax 907/474-6722; gunter@gi.alaska.edu). ■

Initiative Will Coordinate Measurement of Ocean Fluxes

As part of the Arctic Science Summit Week in April 2000 (see page 20), the Arctic Ocean Science Board and International Arctic Science Committee held a meeting on a joint initiative to measure climatically important oceanic exchanges between the Arctic and subarctic seas. The objectives of the Arctic/Subarctic Ocean Fluxes (ASOF) meeting were to discuss:

- critical measurements needed to understand the role of high-latitude oceans in decadal climate variability, and
- ways of achieving the coordinated long-term funding required to implement a system of such measurements across all the main gateways to and from the Arctic Ocean over a period of a decade or more.

The approximately 50 meeting participants confirmed that an urgent research focus is warranted on both these issues, in view of the observational and modeling evidence that appears to link variability in these fluxes to abrupt changes in the strength of the thermohaline circulation (THC) in the North Atlantic.

For example, the paleoclimate record from ocean sediments suggests that previous episodes of THC slowdown or shutdown have coincided with periods when ice and freshwater were more widespread than they are today and may have occurred rapidly, in only a few decades. Advanced coupled climate models appear to conclude that greenhouse gas forcing may lead to a dramatic reduction in the strength of the THC in the Atlantic, while contemporary ocean circulation models appear to confirm that an increase in the southward flux of ice and freshwater through Fram Strait may be able, in a few years, to reduce the intensity of the THC in the North Atlantic.

At present, however, researchers lack direct measurements of oceanic heat and freshwater fluxes needed to develop and test these models. Model improvement depends upon obtaining these measurements simultaneously at all arctic gateways and over a period long enough to capture variability. Participants identified sites where these fluxes might best be measured and proposed appropriate methodologies, including the use of new techniques for working in difficult sub-ice locations.

The first measurements of oceanic exchanges between the Arctic Ocean and subarctic seas were made in the Bering Strait (North Pacific) and Fram Strait (North Atlantic) in the mid-1960s or 1970s, and observations in the 1990s have documented significant changes in heat flux toward the Arctic Ocean (see *Witness* Spring 1998) and in freshwater/ice flux from the Arctic. While several programs involving researchers from the European Community, Norway, United Kingdom, the United States, and Canada now plan extended flux studies, the ASOF joint initiative is a significant step toward achieving a coordinated long-term system of such measurements across the Arctic.

The ASOF science planning group is chaired by Olav Orheim, Director of the Norwegian Polar Institute. The next planning meeting will take place during the Sverdrup Symposium in Tromsø, Norway, 22–23 September 2000 (see page 27).

For more information, contact Bob Dickson in Suffolk, UK (+44/1502-524-282; fax +44/1502-513-865; r.r.dickson@cefas.co.uk). ■

International Effort Generates Chart of the Arctic Ocean

Since late 1997, bathymetric specialists from the eight arctic countries have been working to compile all available bathymetric data north of 64°N into a coherent, state-of-the-art, publicly available digital database and a comprehensive relief map of the Arctic Basin seabed and adjacent land areas.

The International Bathymetric Chart of the Arctic Ocean (IBCAO) project has:

- assembled original depth observations and information extracted from published maps;
- constructed a grid that defines depth and elevation throughout the region at a resolution of 2.5 km;
- included the elevations of surrounding land masses, so that marine and terrestrial relief north of 64°N is described in one seamless grid—the Beta Grid;
- distributed the Beta Grid, soliciting feedback and recommendations of additional relevant data sets; and
- used the Beta Grid to construct a provisional shaded relief map, which has also been released to the community, to facilitate visualization of the contents of the grid and enable comparisons with existing maps.

Besides providing important corrections to older maps, the new products feature increased detail and resolution in both deep and shallow areas.

The Beta Grid, provisional map, and associated documentation are available from the IBCAO web site (http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html), which is maintained by the U.S. National Geophysical Data Center.

The IBCAO project has been overseen by an Editorial Board of bathymetric specialists from Canada, Denmark, Germany, Iceland, Norway, Russia, Sweden, and the United States, as well as three international organizations that have interests in arctic mapping and research—the International Hydrographic Organization (IHO), the Intergovernmental Oceanographic Commission (IOC), and the International Arctic Science Committee (see page 20).

The IBCAO project has received funding and in-kind support from IASC, IOC, Stockholm University, the Swedish Polar Secretariat, the Swedish Polar Committee, the Swedish Ymer Foundation, the U.S. Office of Naval Research, and the U.S. National Geophysical Data Center. These ad hoc contributions have supplemented the voluntary efforts and in-kind contributions of Editorial Board members, their associates, and home institutions.

For more information, contact Ron Macnab at the Geological Survey of Canada in Dartmouth NS, Canada (902/426-5687; fax 902/426-6152; macnab@agc.bio.ns.ca). ■

TUNDRA Studies Arctic Feedbacks in Russian Watershed

Tundra Degradation in the Russian Arctic (TUNDRA) is an interdisciplinary research project studying the effects of global change, industrial pollution, and the public perception of environmental degradation in the East-European Russian Arctic. The research is funded for three years (1998–2000) by the IVth Framework Environment and Climate Programme of the European Commission (EC).

TUNDRA is designed to assess processes originating in the Arctic that feed back to the global climate system, particularly changes in greenhouse gas emissions and freshwater runoff. Investigators in multiple disciplines from Denmark, Finland, the Netherlands, Russia, and the United Kingdom are studying:

- present climate and its natural variability, using a regional climate model and analyses of past climate variability;
- arctic feedbacks to global warming, including treeline dynamics, soil and peat carbon dynamics, methane fluxes, changes in freshwater runoff, albedo changes; and
- regional impacts of global change such as land and water pollution, permafrost melting, and human responses.

Pollution specialists and social anthropologists also are assessing how pollution may be affecting ecosystem function and residents' perceptions and how human attitudes in turn affect environmental legislation and its implementation.

The study area selected for the project is the 100,000-km^2 Usa River basin west of the Ural Mountains (see figure). The Usa River flows into the Pechora River and the Barents Sea. The watershed encompasses arctic and alpine treelines, extensive lowland tundra, and the southern limits of permafrost. The Usa Basin has also sustained a range of human impacts, from almost uninhabited to densely populated regions, from indigenous economies to Russian industrialization, and from clean to polluted areas. The main industrial centers in the area are Vorkuta and Usinsk.

A closely related project, Permafrost in the Usa Basin (PERUSA), is studying possible future permafrost degradation and its effect on infrastructure. PERUSA is funded by the International Association for Cooperation with Scientists from the former Soviet Union Programme (INTAS; see http://www.intas.be) of the EC.

The Usa Basin is located in the East-European Russian Arctic (map by K. Mikkola, modified by S. Mitchell).

For more information, see the TUNDRA web site (http://www.urova.fi/home/arktinen/tundra/tundra.htm), or contact Peter Kuhry in Rovaniemi, Finland (+358/16 3412755; fax +358/16 3412777; pkuhry@levi.urova.fi). ■

Circumpolar Social Science Ph.D.s will Meet in Alaska

The Circumpolar Arctic Social Science (CASS) Ph.D. Network, now in its fifth year, will hold an international field course in Alaska in August 2000. The theme of the course is *Northern Communities and the Global Economy: New approaches to community resource management and use*. The goal of CASS is to prepare the next generation of international arctic social scientists to work collaboratively across national and disciplinary boundaries on pressing circumpolar research topics. CASS also provides Ph.D. students in social sciences with a sophisticated understanding of cultural, social, and ethical issues essential for effective arctic research.

Eighteen Ph.D. students and six senior faculty are expected to participate in the Alaska field course. Countries represented will include Canada, Denmark (including Greenland), Finland, Iceland, Japan, Norway, Russia, Sweden, and the United States. From 5–20 August 2000, participants will:

- participate in a workshop on building an international arctic social sciences research network in Anchorage;
- experience the Old Minto Cultural Heritage Camp in interior Alaska; and
- interact with faculty and students at the University of Alaska Fairbanks.

In addition, plans are underway for participants to visit Red Dog Mine in northwest Alaska and Prudhoe Bay on the North Slope.

Since 1996, CASS has brought students and faculty from arctic nations together for a multi-week field course in northern locations, enabling them to present research topics, theories, methods, and findings to others and create a personal and professional network. CASS seeks to develop a cadre of younger social scientists with:

- an appreciation of the importance of interdisciplinary research;
- an understanding of the nuances of international and cross-cultural collaborations; and
- a broad understanding of diverse theoretical and methodological approaches across scientific disciplines.

Ph.D. students from eight countries visited a First Nations museum in Northern Quebec in September 1999 (photo provided by Rick Caulfield).

Moreover, increased interest on the part of indigenous peoples and other northern residents in research about their communities requires that Ph.D. students become familiar with emerging issues related to:

- indigenous knowledge systems,
- ethics of research involving communities,
- intellectual property rights, and
- local perceptions of research priorities.

The focus and location of previous field courses are as follows:

- 1996—*Diversity and Local Communities* in South Greenland;
- 1997—*Mega-projects and Local Participation in Development* in northeast Quebec (policy and research issues, and the history surrounding the James Bay and Northern Quebec Agreement);
- 1998—*Security in the Arctic* in northern Norway, Svalbard, and Russia (Kola Peninsula); and
- 1999—*Political Autonomy and Economic Development in the Arctic* in Quebec and Nunavik.

Funding for the field courses has come largely from the Nordic Council of Ministers, the Nordic Academy for Advanced Study, Canada's Social Sciences and Humanities Research Council, and individual universities.

For more information, contact Richard Caulfield in Fairbanks, AK (907/474-5573; fax 907/474-6325; ffrac@uaf.edu) or Phyllis Morrow (907/474-6608; fax 907/474-7453; ffpm@uaf.edu). ■

U.S. and Norway Plan for Joint Research

As two of the eight arctic nations, Norway and the United States are major participants in circumarctic research. In August 1999, the two countries co-sponsored a workshop organized by the Norwegian Research Council, Norwegian Polar Institute, and ARCUS (see *Witness* Spring/Autumn 1999). Working groups were organized around studies in:

- upper atmosphere,
- lower atmosphere,
- oceanography and geophysics,
- paleoclimatology, and
- biology.

In addition, participants discussed multidisciplinary research questions appropriate for broadened cooperation in Svalbard, including:

- How will climate change be mediated, and what will be the effect on carbon cycles?
- How will climatic changes interact with stratospheric ozone dynamics and ultraviolet radiation?
- How can we use the synergistic co-location of powerful observational facilities of upper atmospheric processes on Svalbard to study how these processes affect consumer, business, and defense satellite communications?

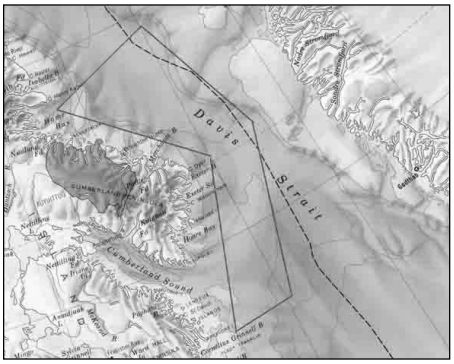
Workshop participants and the wider arctic research community have reviewed the draft report from the workshop. ARCUS will publish *Opportunities for Collaboration between the United States and Norway in Arctic Research* later this summer.

For more information, contact ARCUS. ■

USCGC *Healy* Trials Proceed to Cold Waters in Baffin Bay

The U.S. Coast Guard Cutter *Healy,* delivered to the Coast Guard in November 1999 (see *Witness* Spring/Autumn 1999), successfully completed warm water tests and trials off Puerto Rico in February 2000. Most science systems performed well; for the most part, trouble occurred in systems that were expected to need longer periods for adjustments.

The *Healy* underwent ice trials and cold-water science-systems testing in Baffin Bay in April, May, and June 2000. The Coast Guard worked closely with Canada, Denmark, and Greenland on these tests. Members of the Arctic Icebreaker Coordinating Committee (AICC) oversaw all testing of science systems and, in addition to the test reports, are contributing to an executive report. After completion of testing, the *Healy* will arrive at her home port of Seattle in August 2000.



Science-system testing and ice trials for the USCGC Healy *are underway in Baffin Bay in April, May, and June 2000 (figure provided by Terry Tucker).*

AICC Advocates Science Support

As researchers anticipate the availability of the USCGC *Healy* in 2001 (see article this page), the committee charged with overseeing support for its science operations continues its advocacy for productive collaboration between university researchers and U.S. Coast Guard (USCG) officers and crew members.

The Arctic Icebreaker Coordinating Committee (AICC) was established in 1996 by the USCG, NSF, and the University-National Oceanographic Laboratory System (UNOLS; see page 25) to support scientists who wish to conduct research aboard the USCG icebreakers that are available to the academic community—specifically, the USCGC *Polar Star, Polar Sea,* and *Healy* (see *Witness* Spring 1997).

One of the goals of the AICC is to ensure that the quality of science support on arctic marine science missions aboard USCG icebreakers equals that available on the large vessels administered by UNOLS; the USCG enthusiastically supports this goal. To this end, in March 2000 the AICC circulated an informal letter to the arctic research community, recommending that one or more of the 27 institutions that operate UNOLS vessels (see table page 23) provide companion support for the pre-cruise, technical, and operational aspects of missions beginning in 2001 and 2002 (see http://www.unols.org/aicc/healyuse.pdf). The AICC recommended that the user community consider submitting proposals to NSF to provide appropriate companion support, such as:

- facilitating frequent direct interactions among scientists and USCG personnel to assure that scientific requirements for operational and technical support will be met; and
- assisting the USCG with training, operation, and maintenance of specific science systems (*e.g.,* CTD, coring systems, science data network, SeaBeam, Acoustic Doppler Current Profiler).

Such assistance could be funded as a cooperative agreement, which could be modified as cruise needs become clearer. The AICC noted that the NSF Division of Ocean Sciences Research Ship Operations Program (see http://www.nsf.gov/pubs/2000/nsf0039/nsf0039.pdf) also may be appropriate for this purpose. Proposals to this program are due 15 October.

For more information, see the full text of AICC's letter of 1 March 2000 in the ArcticInfo archive on the ARCUS web site (http://www.arcus.org/arcticinfo/fr_search.html), or contact Jim Swift (see article this page). ■

Science planning for use of the *Healy* is well underway, following Internet solicitation of user ideas and community planning and information meetings in October 1999 during the NSF Ocean-Atmosphere-Ice Interactions All-Hands meeting in Virginia Beach (see *Witness* Spring/Autumn 1999), the AGU 1999 Fall Meeting, and the 2000 Ocean Sciences meeting. These audiences were principally concerned with the planning and scheduling process, science equipment, and technical support. Their feedback is being used to update information for prospective users.

An abridged version of the five-year rolling plan for use of U.S. arctic icebreakers is available at http://www.unols.org/aicc/healyuse.pdf. Additional information will be available later this year on the University-National Oceanographic Laboratory System (UNOLS, see page 25) new web site (http://www.unols.org) including:

- planning ideas;
- proposals submitted, funded, and scheduled; and
- accompanying information about logistics and user contacts.

The AICC will continue to help the arctic research community with coordination and long-term planning. For example, last year the AICC alerted the community that the *Healy* might work in the Eastern Arctic in Summer 2001, with Western Arctic work possible for Spring 2001. Important details remain to be worked out, but progress is being made on this important planning issue.

Proposals to use the *Healy* must be submitted to NSF—which is likely to be the primary science funding agency—no later than 15 February of the year prior to the sea work. In late summer of that year, proposals that are likely to be funded, and any that were successfully reviewed from earlier years, will be examined by a group comprised of Coast Guard and funding agency representatives. That group will determine the *Healy's* science sea schedule for the year ahead.

For more information, see the *Healy* web site (http://www.uscg.mil/pacarea/healy), or contact AICC Chair Jim Swift in La Jolla, CA (858/534-3387; fax 858/534-7383; jswift@ucsd.edu). ■

High-Latitude Research Requires New Mid-Sized Vessels

While moored instrumentation, drifting buoys, and remote sensing are increasingly important in oceanographic research, investigators continue to require access to ocean-going research vessels. The U.S. oceanographic community has benefited from a fleet of research vessels operated by academic institutions through the University-National Oceanographic Laboratory System (UNOLS). Established in 1971, the UNOLS fleet is currently composed of 29 vessels (see box) available to all researchers; UNOLS coordinates schedules for optimal use. NSF, the leading federal agency involved with the fleet, provides much of the operating and maintenance support for UNOLS vessels.

The UNOLS Fleet Improvement Committee (FIC) is leading interagency efforts to determine the fleet composition appropriate to meeting future research needs. The most serious future shortfall in available vessels is likely to be in the intermediate size class (30–60 meters long). While remote technologies now accomplish part of the research that had been conducted aboard the largest vessels, the demand for intermediate ships is growing as attention to coastal issues increases. These intermediate-sized vessels are aging and, in many cases, need to be replaced.

The R/V *Alpha Helix,* for instance, is the oldest vessel in the U.S. academic fleet. Now 35 years old and overdue for retirement, the *Alpha Helix* is the only UNOLS vessel assigned to Alaskan waters, which comprise more than half of the total U.S. coastal area.

The *Alpha Helix* has supported researchers from many institutions and agencies, investigating topics such as:

- the ecosystems of the southeast Bering Sea and Gulf of Alaska,
- physical and biological responses of the Bering and Chukchi seas to natural variability,
- nearshore oceanography of the Chukchi and Beaufort seas,
- ocean dynamics and biological regimes in the Pribilof Islands area, and
- interactions among marine mammals, birds, and fisheries.

The FIC is placing a high priority on an *Alpha Helix* replacement; the Science Mission Requirements statement notes that a replacement vessel should be of intermediate size, capable of fisheries research as well as oceanographic studies, and moderately ice-strengthened (not an icebreaker) for early spring/late fall Bering Sea work. Such a vessel is needed to support increasing agency and academic work on high-latitude issues such as interactions between the endangered Steller sea lion and pollock of the Bering Sea, which is the largest single-species fishery in North America.

A Memorandum of Understanding has been signed between the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and the Woods Hole Oceanographic Institution with the intent of enhancing opportunities for researchers at both institutions to conduct high latitude research. As a first step, the two organizations will cooperate to design an intermediate-sized research vessel meeting the FIC specifications that might also serve other locales as intermediate ships are replaced.

For more information about UNOLS and its research vessels, see the UNOLS web site (http://www.unols.org). For more information about the *Alpha Helix*, contact Vera Alexander in Fairbanks, AK (907/474-6824; fax 907/474-7386; vera@sfos.uaf. edu). ■

UNOLS Research Vessels

(see http://www.unols.org/fic/planning/fltplan.htm)

Ship	*Operating Institution*	*Owner*	*Length(m)*	*Built/Refit*
	Class I & II			
Knorr	Woods Hole Oceanographic Institution	Navy	85	1970/89
Melville	Scripps Institution of Oceanography	Navy	85	1969/90
Maurice Ewing	Lamont-Doherty Earth Observatory	NSF	73	1983/90
Thomas G. Thompson	University of Washington	Navy	84	1991
Roger Revelle	Scripps Institution of Oceanography	Navy	85	1996
Atlantis	Woods Hole Oceanographic Institution	Navy	84	1997
	Class III & IV			
Alpha Helix	University of Alaska	NSF	41	1966
Cape Henlopen	University of Delaware	U. Delaware	37	1976
Gyre	Texas A&M University (TAMU)	TAMU	55	1973/80
Point Sur	Moss Landing Marine Laboratories	NSF	41	1981
Cape Hatteras	Duke University/University of North Carolina	NSF	41	1981
Robert G. Sproul	Scripps Institution of Oceanography	SIO	38	1981/85
Pelican	Louisiana Universities Marine Consortium	LUMCON	32	1985
Longhorn	University of Texas	U. Texas	32	1971/86
Edwin Link	Harbor Branch Oceanographic Institution (HBOI)	HBOI	52	1982/88
Sea Diver	Harbor Branch Oceanographic Institution	HBOI	35	1959/92
Endeavor	University of Rhode Island	NSF	56	1977/93
Weatherbird II	Bermuda Biological Station for Research (BBSR)	BBSR	35	1981/93
Wecoma	Oregon State University	NSF	56	1976/94
Oceanus	Woods Hole Oceanographic Institution	NSF	54	1976/94
Seward Johnson	Harbor Branch Oceanographic Institution	HBOI	63	1984/94
New Horizon	Scripps Institution of Oceanography (SIO)	SIO	52	1978/96
	Class IV			
Laurentian	University of Michigan	U. Mich.	24	1974
Blue Fin	University System of Georgia	U. Georgia	22	1972/75
Clifford A. Barnes	University of Washington	NSF	20	1966/84
Urraca	Smithsonian Tropical Research Institute (STRI)	STRI	33	1986/94
Blue Heron	University of Minnesota	U. Minn.	26	1985/98
*F.G. Walton Smith**	University of Miami	U. Miami	29	2000

The Ronald H. Brown *also participates in the UNOLS scheduling process, although she is not a UNOLS vessel. She was built in 1996 (83 m), and is owned and operated by the NOAA Office of Marine and Aviation Operations.*

** In 2000,* F.G. Walton Smith *is expected to replace* Calanus*, built in 1971 (23 m). Both vessels are owned and operated by the University of Miami.*

U.S. Global Change Assessment Open for Comment

A draft report presenting a major assessment of how global change may affect different regions and sectors in the United States in the next 100 years is available for public comment until 11 August. The draft synthesis report of the U.S. National Assessment, *Climate Change Impacts on the United States, the Potential Consequences of Climate Variability and Change,* was prepared under the auspices of the U.S. Global Change Research Program (USGCRP; see *Witness* Autumn 1998).

The USCGRP began the assessment process with a series of 20 regional and sectoral workshops in 1997–98 about climate change impacts with contributions from both stakeholders and scientists. The five sectors examined in the assessment were Water, Agriculture, Human Health, Forests, and Coastal Areas and Marine Resources. The regional and sector teams are publishing separate reports of their analyses, many of which are still continuing.

To prepare a national-level synthesis of the key findings of the regional and sectoral studies and the relevant scientific literature, the USGCRP established the 14-member National Assessment Synthesis Team (NAST), chaired by Anthony Janetos of the World Resources Institute, Thomas Karl of the National Oceanic and Atmospheric Administration's National Climatic Data Center, and Jerry Melillo of The Ecosystems Center of the Marine Biological Laboratory at Woods Hole.

The NAST developed the National Assessment report and oversaw three previous rounds of extensive expert review of the draft. The National Assessment draws on three tools to evaluate potential climate change impacts:

- state-of-the-art climate models to generate climate change scenarios,
- historical climate records to evaluate sensitivities of particular regions and sectors to climate variability and extremes, and
- "what if" analyses, which ask how, and how much, the climate would have to change to produce major impacts on specific regions or sectors.

The Assessment, which is intended for a general audience, has two parts:

- the Overview, a 150-page summary of the findings, and
- the Foundation, a longer, more thoroughly referenced document.

Both parts, and information on offering comments on the draft, are available at http://www.gcrio.org/NationalAssessment. The report will be revised in light of the comments received from the public and then forwarded by the NAST to the federal agencies, Congress, and the President.

For more information, see the National Assessment Coordination Office web site (http://www.nacc.usgcrp.gov), or contact Executive Director Mike MacCracken in Washington, DC (202/314-2230; fax 202/488-8681; mmaccrac@usgcrp.gov)

Alaska Rural Systemic Initiative Assesses First Five Years

As the Alaska Rural Systemic Initiative (AKRSI) approaches the end of its first five-year funding period, it is assessing its achievements and applying for funding to pursue a new set of initiatives. At a statewide meeting in Kodiak, Alaska in April 2000, AKRSI distributed *Guidelines for Respecting Cultural Knowledge,* adopted in February 2000 by the Assembly of Alaska Native Educators, to Elders, educators, and organizations from Alaska and Canada. The document is available at http://www.ankn.uaf.edu/standards/CulturalDoc.html.

The guidelines address issues concerning the documentation, representation, and use of traditional cultural knowledge, with special attention to academic settings. By minimizing the potential for misuse and misunderstanding, the authors and contributors are offering encouragement and support for educators and facilitating mutual respect and beneficial exchanges.

AKRSI was funded in September 1995 by the NSF Educational System Reform Programs and the Annenberg Rural Challenge (see *Witness* Autumn 1997). Since then, the organization has brought people together from throughout the State to:

- systematically document the knowledge systems of Alaska Native people; and
- develop educational policies and practices that effectively integrate Native and Western knowledge through a renewed educational system.

AKRSI's success can be seen on individual and community levels:

- science and math test scores in the 20 Alaskan rural school districts working with AKRSI initiatives have improved (Kushman and Barnhardt, 1999);
- indigenous peoples worldwide have adapted and applied cultural standards;
- organizations in Alaska have used the curriculum themes based on Native values to develop educational units.

NSF funding for AKRSI ends in August 2000. Annenberg no longer provides funding. Co-directors Frank Hill (Alaska Federation of Natives), Ray Barnhardt, and Oscar Kawagley (both University of Alaska Fairbanks) have submitted a proposal to NSF for another five-year grant to:

- further develop indigenous curriculum, building upon the units and resources developed thus far; and
- involve tribal colleges to help bridge regional communication, promote curriculum distribution, and establish a more centralized method of cultural documentation.

For more information, contact Sean Topkok in Fairbanks, AK (907/474-5897; fax 907/474-5615; fncst@uaf.edu, sean@arcus.org).

References

Kushman, J.W. and R. Barnhardt. *Study of Alaska Rural Systemic Reform Final Report.* 1999. Online at http://www.ankn.uaf.edu/reform.

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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

August 23-26 12th Inuit Studies Conference. University of Aberdeen, Scotland, UK. Contact Conference Organiser Mark Nuttall in Aberdeen (m.nuttall@abdn.ac.uk; inuitstudies@abdn.ac.uk; http://www.abdn.ac.uk/conference/inuitstudies).

September 13-15 The Arctic Regional Climate Model Intercomparison Project. Fairbanks, AK. Contact Project Coordinator Eric Girard in Boulder, CO (girard@terra.colorado.edu; http://cires.colorado.edu/lynch/workshop/).

September 17-22 The Fifth Boreal Forest of the World Conference. Moscow, Russia. Contact Taiga Rescue Network in Jokkmokk, Sweden (+46/9712-2057; fax +46/9711-7039; taiga@ajtte.com; http://www.snf.se/TRN).

September 21-23 H.U. Sverdrup Symposium: The Role of Ocean/Sea Ice/Atmosphere Interaction in Polar and Sub-polar Climate. Tromsø, Norway. Contact Anne Kibsgaard in Tromsø (+47/7775-0616; fax +47/7775-0501; anne.kibsgaard@npolar.no; http://www.npolar.no/).

September 21-23 Fourth International Symposium on Permafrost Engineering. Lanzhou, China. Contact Zhu Yuanlin (zhuy1@ns.lzb.ac.cn) or Niu Fujun (niufujun@ns.lzbac.cn) in Lanzhou (+86/931-884-1490; fax +86/931-882-1894).

September 21-24 51st AAAS Arctic Science Conference. Whitehorse, YT, Canada. Contact the Yukon Science Institute in Whitehorse (ysi@taiga.net) or Peter G. Johnson in Ottawa, ON (613/562-5800 ext. 1061; fax 613/562-5145; peterj@aix1.uottawa.ca; http://www.Taiga.net/arctic2000/).

September 22-25 10th ITEX Workshop: From Decade to Millennium. Abisko Research Station, Swedish Lapland. Contact Ulf Molau in Göteborg, Sweden (+46/31773-2665; fax +46/31773-2677; itex@systbot.gu.se; http://www.systbot.gu.se/research/ITEX/meeting.html).

October 3-5 2nd Meeting of the International Ice Charting Working Group (IICWG). Reykjavik, Iceland. Contact Thor Edward Jakobsson in Iceland (thor@vedur.is; http://nsidc.org/NOAA/IICWG/index.html).

October 4-6 Polar Research from the Last to the Next Millennium: American Polar Society Symposium 2000. University of Colorado Boulder. Contact Ernest Angino in Lawrence, KS (rockdoc@cjnetworks.com; http://www-nsidc.colorado.edu/aps2000).

November 2-4 North Meets North: The First Meeting of NRF (Northern Research Forum). Akureyri, Iceland. Contact the NRF Secretariat in Iceland (+354/463-0582; fax +354/463-0589; jhi@svs.is or tolli@unak.is; http://www.urova.fi/home/uarctic/activities/nrf.html).

December 5-8 Land-Ocean Interactions in the Russian Arctic—New Approaches and Methods. Moscow, Russia. Contact Vyacheslav Gordeev (+7-095/124-5983; fax +7-095/124-5968; gordeev@geo.sio.rssi.ru).

December 15-19 American Geophysical Union Fall Meeting. San Francisco, CA. Contact the American Geophysical Union (AGU) in Washington, DC (202/462-6900; 800/966-2481; service@agu.org; http://www.agu.org).

Check the ARCUS web site Calendar (http://www.arcus.org/misc/fr_calendar.html) for more...

Publications

Arctic System Science Program: Understanding Global Change in the Arctic. 2000. ARCUS, Fairbanks, AK. 8 pages. Available in hard copy from ARCUS or at http://www.arcus.org/ARCSS/brochure/index.html.

Climate Change Impacts for the United States: The Potential Consequences of Climate Variability and Change. Draft. U.S. Global Change Research Program, Washington, DC. Available only online at http://www.gcrio.org/NationalAssessment.

A Note From the Executive Director

Like many groups engaged in the scientific enterprise, we at ARCUS depend heavily on electronic communication technologies. Email and the Internet bring together the international, geographically dispersed community of arctic researchers in ways otherwise impossible. This morning, for example, I "conversed" with researchers in Magadan, Russia and Thule, Greenland, and with colleagues in New Zealand and India. I also looked at an arctic research site in "real-time" via the Internet—all before breakfast.

The nearly instantaneous communications now possible allow unprecedented exchanges of information and foster new levels of collaboration and cooperation. But electronic communications, even with 24-hour video cams, cannot replace the benefits of person-to-person interactions and the understanding that develops best from sharing a common experience, breathing the same air—communication that includes the crinkle of an eye, the wrinkle of a forehead in response to a question, the long pause while thoughts are gathered.

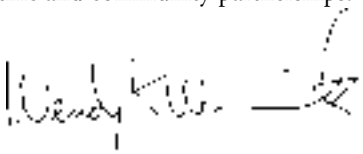
As part of its continuing commitment to foster scientific research in the Arctic, and to create opportunities for establishing common ground, ARCUS launched the Arctic Visiting Speakers Series in April 2000. The goals of the Series are to:

- increase communication and collaboration within the dispersed arctic research community;
- nurture better understanding and communication among arctic researchers and arctic community residents; and
- improve the general public's understanding of arctic research.

ARCUS will accept applications from academic institutions and community organizations that wish to host a speaker who can share knowledge about some aspect of the Arctic. We are also developing a "Speaker's Bureau" of researchers, residents, and others with arctic experience who are interested in engaging in discussions, giving lectures, and conducting seminars in communities that have requested such contributions.

The Speakers Series supports visits to host organizations for one or two days, allowing time for a formal presentation or seminar, and extensive informal interaction with faculty, students, local media, and community members. The Series is supported by the NSF Office of Polar Programs through a cooperative agreement with ARCUS. For more information on the Arctic Visiting Speakers Series, see the ARCUS web site (http://www.arcus.org/arctic_speaker/index.html).

Communication that is based on a foundation of relationship and shared information is a powerful tool for enhancing knowledge and increasing understanding. We hope that you will participate, as a speaker, a host, or both, in this new program to promote scholarship and build scientific and community partnerships.



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In Memoriam: Malcolm Alexander Ramsay

Malcolm Ramsay, a professor of biology at the University of Saskatchewan and the world's leading expert on polar bears, was killed in a helicopter accident on 21 May 2000. Malcolm and Stuart Innes, of the Canadian Department of Fisheries and Oceans Canada, were returning from tagging polar bears on Lowther Island, approximately 100 km southwest of Resolute, Nunavut, when their Bell 206L helicopter crashed. Innes was also killed. The pilot survived the crash and is expected to recover. The cause of the crash is under investigation.

From 1997–99, Malcolm made important contributions to the OAII Science Steering Committee. His death is a great loss to many who had the pleasure of working with him, and to the arctic scientific community as a whole.

Malcolm received his B.Sc. in 1977 and M.Sc. in 1980, both from Simon Fraser University. In 1986 he earned a Ph.D. from the University of Alberta and won a Postdoctoral Visiting Fellowship in the Department of Fisheries and Oceans in Winnipeg. His research interests were in vertebrate physiological and behavioral ecology, primarily in the Arctic. Although he was best known for his research on nutrition and reproduction in polar bears, his interests were broad. He published papers on diverse topics, including aspects of pharmacology and toxicology, the material properties of narwhal tusk, and the evolution of viviparity in amniotes. He had recently begun to investigate the biology of two large cold water fish—Greenland sharks and Bluntnose sixgill sharks. Malcolm was increasingly concerned about the effects of environmental change on organisms, particularly in the North, and the reductions in support for ecological research in Canada. He was an eloquent spokesman for these issues, and his research received wide coverage in the popular press.

Contributions in memory of Malcolm can be sent to the Malcolm Ramsay Memorial Fund, Department of Biology, 112 Science Place, University of Saskatchewan, Saskatoon, SK S7N 5E2 Canada.

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