Witness The
ARCTIC

Chronicles of the NSF Arctic Sciences Program Autumn 2001, Volume 9 Number 1

SCICEX Sonars Chart New Topographies, New Theories

by Margo Edwards, Robert Anderson, Dale Chayes, Bernard Coakley, James Cochran, Martin Jakobsson, Gregory Kurras, Leonid Polyak, and Mark Rognstad

In the 1990s, the U.S. Navy and NSF collaborated to develop the Science Ice Exercises (SCICEX), a five-year program to investigate the Arctic Basin using Sturgeon-class nuclear-powered submarines (see *Witness* Spring 1996, Spring 1998, Spring/Autumn 1999). During the final two deployments of SCICEX in 1998 and 1999, Seafloor Characterization and Mapping Pods (SCAMP) were mounted on the hull of the USS *Hawkbill* to collect data necessary for producing the first comprehensive high-resolution maps of the surface and shallow subsurface of the arctic seafloor. The SCAMP system incorporated a 12 kHz sidescan bathymetric sonar for imaging and measuring seafloor depths over a swath of up to 10 km, and a chirp subbottom profiler for studying the subsurface.

SCAMP succeeded remarkably, acquiring more than 40 million depth soundings; the volume of textural and subbottom data collected exceeds the number of depth soundings by 2–3 orders of magnitude. In combination with the surface texture (sidescan) and subbottom data, SCAMP bathymetry data are providing a new three-dimensional perspective of the Arctic Basin seafloor that is enabling geologists to challenge widely held theories in diverse subjects. Recent letters published in *Nature* span the scientific spectrum from fire to ice, using SCAMP data to present new ideas about mid-ocean ridge volcanism and paleoclimatology.

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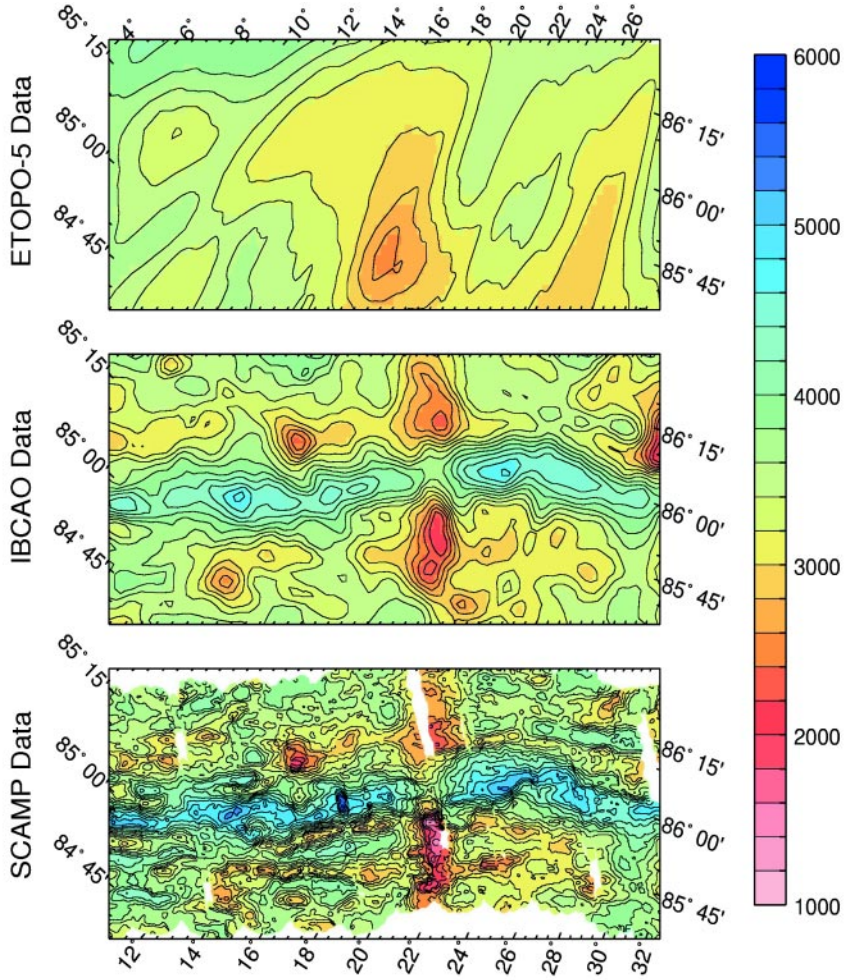

Three bathymetric representations of the same area along the western Gakkel Ridge. The uppermost chart shows the best data publicly available for the Gakkel Ridge in 1999 (ETOPO-5); the middle chart depicts data from the International Bathymetric Chart of the Arctic Ocean (IBCAO) released in 2000; the lowest chart shows data collected by the USS Hawkbill *using the Seafloor Characterization and Mapping Pods (SCAMP) in 1999.* ***Top:*** *The ETOPO-5 Earth topography dataset was created by combining the Digital Bathymetry Database-5 (DBDB5) for the oceans with several different topographic datasets for the continents (Loughridge, 1986). Grid cell size is 5 minutes x 5 minutes; data density, however, is highly variable within the bathymetric dataset (continued on next page).*

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Edwards *et al.* (2001) report the discovery of two large, relatively young volcanoes on the ultra-slow-spreading Arctic Mid-Ocean Ridge commonly referred to as the Gakkel Ridge. Prevailing models of mid-ocean ridge systems predict that as spreading rate decreases, the influence of volcanism also decreases; it has been unclear if significant volcanism occurred at all at ultra-low spreading rates (<1.5 cm/year). SCAMP data clearly demonstrate that significant volcanism does occur along the slowest spreading mid-ocean ridge on Earth. SCAMP sidescan maps for the eastern Gakkel Ridge show two volcanoes that are acoustically very reflective compared to the surrounding terrain, which SCAMP subbottom data confirm to be covered by thick sediments. The morphology of the reflective regions is consistent with that of submarine lava flows observed at other mid-ocean ridges. The location of one volcano imaged by SCAMP coincides with the average location of epicenters for more than 250 earthquakes that the global seismic network detected from January through September 1999. The USS *Hawkbill* passed directly over the volcano, at a safe altitude of approximately two miles above the seafloor, on 6 May 1999. Edwards *et al.* (2001) suggest that the submarine mapped an underwater eruption in the Arctic as, or shortly after, it occurred.

Polyak *et al.* (2001) use SCAMP sidescan and chirp data to present compelling evidence that floating ice sheets (ice shelves) as thick as one kilometer covered large parts, or perhaps all, of the Arctic Ocean at least once during the Pleistocene ice ages (from 1.6 million to 10,000 years ago). Just as glaciers alter the land beneath them, ice shelves once modified the arctic sea-floor, leaving telltale signs of how they moved across submarine ridges and plateaus. The USS *Hawkbill* and SCAMP mapped lineations and ridges that appear to have been formed at the bottom of moving glaciers and at glacier margins, respectively, in water depths ranging from 400 to nearly 1,000 m on the Chukchi Borderland, Alaska Margin, Lomonosov Ridge, and Yermak Plateau. At shallower depths, the seafloor was found to be gouged extensively by icebergs. Because stratigraphic models for Arctic Ocean sediments are controversial, assigning precise ages to the presence of the ice shelves will require further research. The deepest glacial erosion at almost 1,000 m depth on Lomonosov Ridge appears to have occurred at either 150,000 or 600,000+ years ago.

Most current paleoclimate models assume Arctic Ocean ice cover was thin during the Pleistocene ice ages, attaining just several meters at its maximum thickness. Polyak *et al.*'s (2001) report will stimulate major revisions in our understanding of the Earth's climatic history and should improve predictions of Earth's past and present climate changes. Proof that thick ice once covered the Arctic also poses an intriguing question for biologists: how did life survive under a thick ice cap in an almost isolated Arctic Ocean?

The two reports described above are the first results from the SCICEX/SCAMP database. Extended articles detailing the findings are due to be submitted before the end of this year. Additional projects using the SCICEX/SCAMP dataset focus on the Lomonosov Ridge, Alaska Margin, Northwind Ridge, and Yermak Plateau. SCAMP data are being used to support this autumn's joint U.S./European icebreaker cruise to the Gakkel Ridge (see page 17), and are included in the Ocean Drilling Project's database to support arctic drilling (see *Witness* Spring 1998).

At the present, dedicated science missions are not feasible for the Navy's nuclear submarine force; the success and broad impact of the 1998 and 1999 collaboration, however, and the fact that only a small fraction of the Arctic Basin has been mapped in this level of detail, keeps arctic scientists alert for an opportunity to collaborate again in a future submarine deployment (see page 18).

The NSF Arctic Natural Sciences Program (see pages 10–11), Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Palisades Geophysical Institution, and the governments of Canada, Norway, and Sweden funded SCAMP.

For more information about the SCICEX program and SCAMP instrumentation, see the LDEO web site (www.ldeo.columbia.edu/SCICEX/), or contact Margo Edwards in Honolulu, HI (808/956-5232; fax 808/956-6530; margo@soest.hawaii.edu). To view examples of bathymetry and sidescan charts produced from SCICEX/SCAMP, see www.soest.hawaii.edu/HMRG/. The IBCAO data are available at www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html. ■

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Polyak, L., M.H. Edwards, B.J. Coakley and M. Jakobsson. 2001. Existence of Arctic ice shelves during the Pleistocene inferred from deep-sea glaciogenic bedforms. *Nature* 410, 453–456.

M. Edwards is an Associate Researcher, R. Anderson is an Acoustician, G. Kurras is a doctoral candidate, and M. Rognstad is a Sonar Design Specialist, all at the University of Hawaii; D. Chayes is a Senior Staff Associate and J. Cochran is a Senior Research Scientist, both at Lamont-Doherty Earth Observatory, Columbia University; B. Coakley is an Assistant Professor at Tulane University; M. Jakobsson is a Research Scientist at the Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire; and L. Polyak is a Research Scientist at the Byrd Polar Research Center, The Ohio State University.

Caption (continued from page 1). ***Center:*** *The International Bathymetric Chart of the Arctic Ocean (IBCAO; see* Witness *Spring 2000) dataset was derived from approximately 1.5 million single-beam soundings and digitized bathymetric maps compiled from myriad expeditions to produce a grid with 2.5 x 2.5 km cells (Jakobsson* et al. *2000). In the central Arctic Ocean, a nearly empty database was significantly enriched by the addition of historic and modern observations collected by U.S. and British submarines, Swedish and German icebreakers, and by depths derived from a new contour map prepared by the Russian Navy. The IBCAO dataset contains single-beam profiles collected by U.S. Navy submarines from 1958 until 1988 and also during the 1995–99 SCICEX missions.* ***Bottom:*** *In the SCAMP data, it is possible to distinguish individual abyssal hills, valleys, seamounts, and ridges and thus evaluate which processes formed the topography. The SCAMP data shown were collected over approximately three days in 1999. Swath width is approximately 10 km; bathymetric data were gridded in 250 m x 250 m cells. The dataset will be made publicly available in 2002 (figure by Gregory Kurras and Margo Edwards).*

SEARCH Develops Implementation Framework

The Study of Environmental Arctic Change (SEARCH) is an interdisciplinary, multiscale program dedicated to understanding the complex of interrelated changes that have been observed in the arctic environment in the past few decades (see *Witness* Spring 2000). SEARCH is envisioned as a long-term effort of observations, modeling, process studies, and applications devoted to understanding this complex, its relation to global climate, and its impacts on ecosystems and society.

The SEARCH Science Plan, recently completed by the SEARCH Science Steering Committee (SSC) and Interagency Working Group (IWG), is available on the SEARCH web site. The SSC and IWG have been working together and separately to begin implementation of the SEARCH effort (see *Witness* Winter 2000/2001).

Interagency Planning

Because the broad SEARCH effort requires a coordinated interagency approach, the IWG is composed of key program managers from agencies that participate in the Interagency Arctic Research Policy Committee (IARPC; see box). The IWG is developing an interagency funding method for SEARCH and has completed an implementation framework for SEARCH with funding plans for 2002 and 2003. General agency priorities for 2003 are anticipated in five major thematic areas:

- human society,
- marine/terrestrial biosphere,
- atmosphere and cryosphere,
- ocean, and
- integrated projects/models/assessment.

The implementation framework has been transmitted to IARPC, the IWG's parent body; IARPC Chair and NSF Director Rita Colwell will use the implementation framework in discussions with the other agencies and the Office of Management and Budget to gain Administration approval for the program.

In August 2001, the SSC and IWG held a joint workshop to coalesce investigator and funding agency expectations of SEARCH. The group focused on identifying appropriate priorities and temporal phases for addressing SEARCH science questions. Participants also discussed possible sub-elements of SEARCH, including:

- the Arctic/Sub-Arctic Ocean Fluxes program (see *Witness* Winter 2000/2001);
- Arctic Ocean circulation and ice dynamics;
- atmospheric and cryospheric change in the Arctic; and
- the responses of ecosystems and societies to environmental change.

The latter theme was the subject of a June 2001 SEARCH Biocomplexity Incubation Activity workshop (see *Witness* Winter 2000/2001).

Future Plans

The IWG-SSC workshop participants also outlined additional planning efforts needed to guide the coordinated implementation of SEARCH. The SSC will produce a draft implementation strategy outlining possible future implementation plans, including science questions and the priority-timing phase diagram developed at the August workshop. The IWG will draft terms of reference for SEARCH operating and funding mechanisms.

The SSC and IWG will work together to develop a comprehensive SEARCH implementation plan, which will identify:

- the sub-elements necessary to address the science questions,
- a target time sequence,
- mechanisms for developing individual implementation plans for the sub-elements of SEARCH,
- opportunities for international involvement, and
- mechanisms to ensure that the SEARCH effort remains focused.

The next joint meeting of the SSC and IWG, tentatively planned for late October 2001, will review and discuss:

- the near-final implementation strategy,
- a working draft of the SEARCH implementation plan, and
- drafts of the terms of reference.

The IWG and SSC are hopeful that agency budgets for FY 2002 will be known by late October, so that agencies will be able to be more explicit about SEARCH efforts during 2002.

SEARCH will sponsor a workshop in Seattle, 27–29 November 2001, to discuss existing knowledge of large-scale atmospheric and cryospheric observing systems in the context of SEARCH. The workshop, which is advisory to the IWG and SSC, will assess how current observations can be best used and enhanced to understand and predict the ongoing changes in the Arctic. A preliminary agenda is available on the SEARCH web site, and more information is available from Jim Overland in Seattle, WA (206/526-6795; fax 206/526-6485; overland@pmel.noaa.gov).

For more information, see the SEARCH web site (http://psc.apl.washington/search), or contact SSC Chair Jamie Morison in Seattle, WA (206/543-1394; fax 206/616-3142; morison@apl.washington.edu) or IWG Chair John Calder in Silver Spring, MD (301/713-2518 ext. 288; fax 301/713-2519; john.calder@noaa.gov). ■

Agencies Contributing to SEARCH

National Science Foundation
National Aeronautics and Space Administration
Department of Commerce
National Oceanic and Atmospheric Administration
Department of Defense
Office of Naval Research
Cold Regions Research and Engineering Laboratory
Department of Energy
Atmospheric Radiation Measurement Program—North Slope of Alaska/Adjacent Arctic Ocean Site
Department of Interior
Bureau of Land Management
Fish and Wildlife Service
Geological Survey
Minerals Management Service
National Park Service
Department of Agriculture
Agricultural Research Service
Natural Resource Conservation Service
Forest Service
Environmental Protection Agency
Smithsonian Institution
Department of Transportation
U.S. Coast Guard

Auroral Studies Shed Light on the Physics of Space

Because the upper atmosphere is affected by the topography of the polar magnetic field, the solar wind, the interplanetary magnetic field, and cold mesospheric temperatures, its behavior in the arctic region is relevant to global change and space weather issues and may have implications for arctic system science. In this and following issues of Witness the Arctic*, we present overviews of current research efforts on arctic upper atmosphere topics, including studies of the aurora, occurrence and physics of noctilucent clouds, and the polar ionosphere.*

In 1859, British astronomer Richard Carrington, observing the sun as part of a long-term study of sunspot behavior, noted an enormous brightening in one sunspot group. Seventeen hours later, an intense disruption occurred in the terrestrial magnetic field, accompanied by an aurora that could be seen as far south as Cuba. In noting a possible connection between these events, Carrington marked the birth of space physics—the study of the portion of the space environment that falls within the Sun's sphere of influence and, consequently, is of direct relevance to life on Earth.

The aurora continues to be a central topic in space physics because it provides a unique window into the Earth's near-space environment. The aurora is produced mainly by electrons precipitating from space. Because the air density in the upper atmosphere is so low, auroral electrons are constrained to move in tight helical orbits along the Earth's magnetic field lines. This means that auroral arcs can be interpreted as magnetic field structures illuminated by incoming electrons in the same way that images are produced on a television screen. Similarly, auroral motions are a projection of time-dependent dynamics in the remote magnetosphere.

Early theories proposed that the aurora resulted from the direct entry of solar wind electrons into the polar atmosphere. Although still prevalent in the popular literature, this explanation was refuted by observational evidence. Auroral particles come from a population of electrons and ions which has built up over time in the stretched anti-sunward tail of Earth's magnetic cavity. The magnetic field of an approaching solar wind triggers the explosive release of the particles into the atmosphere. This triggering process—referred to as "reconnection"—is fundamental to all plasmas. Reconnection is being studied through programs funded by NSF, the National Atmospheric and Space Administration (NASA), and the Departments of Defense and Energy (DoD and DOE).

To produce the observed optical effect, auroral electrons must be accelerated to a velocity of ~50,000 km/s during their journey from the magnetosphere to the atmosphere. An outstanding issue in plasma physics, the mechanism by which this acceleration occurs is the focus of current satellite missions, such as NASA's POLAR and IMAGE spacecraft (photo courtesy of Craig Heinselman, SRI International).

Research programs supported by several agencies address the aurora's effects on space weather, global change, and the energy balance of the Earth's atmosphere. The Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR; see page 5) and Geospace Environment Modeling (GEM) programs of the NSF Division of Atmospheric Sciences examine solar influences on global change, including climate changes linked to long-term variations of the Sun. The Sun Earth Connections Program, a major NASA effort dedicated to understanding the flow of energy from the Sun to the Earth, includes the Living With a Star program, which supports research and space missions to describe the Sun's effects on space weather and global change. With contributions from NSF, NASA, DoD, DOE, and the National Oceanic and Atmospheric Administration, the interagency National Space Weather Program (NSWP) supports research leading to better predictive capabilities for space weather operational forecasting. This substantial investment in space science reflects the growing numbers of space- and ground-based technical systems that are vulnerable to adverse conditions in the space environment.

Another current research focus concerns the feedback between the arctic upper atmosphere and the distant magnetosphere. Although it is the incoming particles that produce auroral light, electrons are in fact moving into and out of the polar ionosphere in equal numbers. This coupling can influence the efficacy with which the aurora forms. For instance, the fact that the aurora is more likely to occur in nighttime than in daytime is related to the elevated electrical conductance of the sunlit ionosphere. Several new instruments designed to improve daylight observations of the aurora, under development with support from the NSF Division of Atmospheric Sciences, should contribute significantly to elucidating the mechanism by which the increased electrical conductance is communicated to the magnetosphere. In addition, the GEM program recently initiated a multimillion-dollar effort to study the coupling between the magnetosphere and ionosphere.

Permanent ground-based facilities in the Arctic provide essential observations to complement space-based investigations of the aurora. NSF supports the Søndrestrøm Facility in Greenland and the Polar Cap Observatory in Resolute Bay, Canada, and contributes to the deployment and operation of radiowave and optical instruments throughout the Arctic. While these instruments and facilities are designed to observe the aurora and other manifestations of the interaction between the atmosphere and the magnetosphere, they are also important logistics hubs for other arctic research.

For more information, see the following web sites: NSWP (www.spacescience.org/SWOP/NSWP), NSF Atmospheric Sciences (www.geo.nsf.gov/atm), and Søndrestrøm (www.isr.sri.com), or contact Jeff Thayer (650/859-3557; thayer@sri.com), John Kelly (650/859-3749; kelly@sri.com), or Joshua Semeter (joshua.semeter@sri.com) in Menlo Park, CA (fax for all: 650/322-2318). ■

CEDAR Observations Map the Arctic's Upper Atmosphere

The Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) program started in 1986 as a community initiative for instrumentation that would enable state-of-the-art investigations of the Earth's upper atmosphere. Broadened to encompass multiple diagnostic techniques, theory, modeling, and coordinated observational campaigns, CEDAR is currently the dominant national and international research program in terrestrial aeronomy.

Part of the Solar Influences Program within the NSF Division of Atmospheric Sciences, CEDAR is devoted to the characterization and understanding of the atmosphere from approximately 60 to 1,000 km above the surface of the Earth (*i.e.,* the mesosphere, exosphere, magnetosphere), with emphasis on the energetic and dynamic processes that determine the basic composition and structure of the atmosphere. Particular attention is given to how these processes are coupled both vertically and horizontally, transferring mass, energy, and momentum, and significantly affecting the global behavior of the Earth's upper atmosphere.

The science agenda of CEDAR Phase III, outlined in 1998, includes the following initiatives:

- Coupling with Lower Altitudes—the study of tidal, planetary, and gravity waves, which are forced primarily in the troposphere and stratosphere and have profound influences on the ionosphere-thermosphere-mesosphere (ITM) system;
- Solar-Terrestrial Interactions—investigations of the response of the global ITM system to solar variations and disturbances over many time scales; and
- Long-term Variations—exploring the origins of long-term atmospheric variations by building on 10 to 30-year long datasets.

Arctic Studies in CEDAR

Because limited access to polar regions has prevented a full understanding of the fundamental processes that govern the polar atmosphere, Polar Aeronomy is the fourth CEDAR Phase III initiative. Horizontal transit times are hours to days in the upper atmosphere and ionosphere, allowing rapid advection of energy and momentum between the poles and middle latitudes. The distinctive features of the arctic upper atmosphere and ionosphere can thus have major effects on the global behavior of the upper atmosphere. Research in Polar Aeronomy is directed at processes, such as the solar wind, that induce disturbances at high latitudes and in turn drive the energy and dynamics of the ITM system at lower latitudes.

Current studies of the arctic upper atmosphere through CEDAR are contributing to the development of a multi-dimensional view of the chemical, dynamic, thermodynamic, and electrodynamic coupling mechanisms throughout the atmospheric column above both poles. Major issues for future arctic upper atmospheric research in CEDAR include:

- energetics and neutral dynamics,
- plasma electrodynamics and structure,
- neutral and ion composition,
- aerosol formation and charging, and
- auroral emissions and forms.

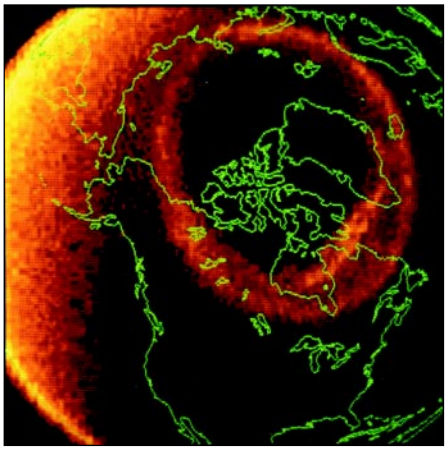
CEDAR Facilities

Beginning in 1986 with the creation of CEDAR "Class one" observatories and the NSF Upper Atmospheric Facilities program, CEDAR scientists have been provided with the best observational tools available. CEDAR observing facilities, spread across the Arctic and shared among the circumpolar nations, are located at:

- Svalbard, Norway (see *Witness* Winter 2000/2001);
- Søndrestrømfjord, Greenland;
- Poker Flat, Alaska; and
- Eureka and Resolute Bay, Canada.

The new Polar Cap Observatory at Resolute Bay is slated for further development to house the new Relocatable Atmospheric Observatory in a few years.

CEDAR observational programs normally couple radio, optical, and geomagnetic techniques through the co-location of instruments at strategic sites, as well as the use of arrays of automated stations and remote sensing from satellites. Where possible, the sites have an Incoherent Scatter Radar (ISR), which can determine atmospheric and ionospheric properties to heights exceeding 1,000 km. Many sites have Light Detection and Ranging (LIDAR) instruments that probe up to approximately 100 km altitude, obtaining density, temperature, and in some cases, wind measurements as a function of altitude. All-sky imagers, photometers, interferometers, imaging spectrographs, ionosondes, and ionospheric absorption mappers complement these measurements. Arrays of magnetometers and SuperDARN coherent radars (see *Witness* Spring/Autumn 1999) provide information about ionospheric currents and drift motions.



The close coalignment of the axis of the Earth's geomagnetic field and the axis of the Earth's rotation facilitates the entry of energy and momentum from the solar wind and interplanetary space into polar regions. The aurora, shown here from space, is the most commonly known example of this phenomenon (image from NASA's Dynamics Explorer satellite, courtesy of Louis Frank, University of Iowa).

Science Management

A science steering committee (SSC) appointed by the directors of the NSF Aeronomy and Upper Atmospheric Facilities program provides guidance to the CEDAR program. CEDAR has attracted many graduate students and international collaborators through its open workshop structure and its cooperative approach, which focuses a wide range of techniques and expertise into comprehensive studies.

For more information, see the NSF Solar Influences web site (www.nsf.gov/egch/gc_solar.html#cedar), or contact Roger Smith, chair of the CEDAR SSC, in Fairbanks, AK (907/474-7416; fax 907/474-5882; roger.smith@gi.alaska.edu). ■

ARCSS Plans All-Hands Workshop for February 2002

The second Arctic System Science (ARCSS) Program All-Hands Workshop will take place 20–23 February 2002 at the Bell Harbor International Conference Center in Seattle, Washington. The first ARCSS All-Hands Workshop was held in 1996 at Snowbird, Utah.

The 2002 workshop will provide information and recommendations to guide the ARCSS Program through a major transition from the current disciplinary components organized geographically (terrestrial vs. marine) and temporally (current vs. past) to a broader approach of interdisciplinary issues, questions, and themes.

To assist in this transition, the ARCSS Committee (AC) will organize the 2002 All-Hands meeting around the five thematic priorities that formed the basis of the second ARCSS Science Plan, *Toward Prediction of the Arctic System* (ARCUS 1998). These thematic questions are:

- How will the climate of the Arctic change over the next 10 to 100 years?
- How will future climate change interact with human activities to affect the sustainability of natural ecosystems and human societies?
- How will changes in arctic biogeochemical cycles and feedbacks affect arctic and global systems?
- How will changes in arctic hydrological cycles and feedbacks affect arctic and global systems?
- Are the predicted changes in the arctic system detectable?

The major objective of the meeting is a comprehensive assessment of the ARCSS Program in terms of:

- progress to date in addressing these priorities,
- identifying gaps in research needed to pursue important questions,
- developing opportunities to integrate results and questions across ARCSS research components, and
- articulating novel questions arising from this analysis.

The AC is working with the ARCSS science steering committees to gather information to begin this assessment, including:

- the principal research questions guiding each of the current ARCSS components,
- a database of ARCSS-funded projects, and
- an outline of results to date.

This information will contribute to a broad understanding of the accomplishments of and appropriate future directions for the ARCSS Program.

More information and preregistration for the 2002 All-Hands meeting is available on the ARCUS web site (www.arcus.org/ARCSS/allhands2002/).

For more information about the ARCSS Program, see the ARCSS web site (www.nsf.gov/od/opp/arctic/system.htm), or contact Program Director Mike Ledbetter in Arlington, VA (703/292-8030; fax 703/292-9082; mledbett@nsf.gov) or AC Chair Jack Kruse in Leverett, MA (413/367-2240; fax 413/367-0092; jkruse@geo.umass.edu). ■

ARCSS Components to Meet November 2001

In an important contributing step toward the February 2002 ARCSS All-Hands meeting (see article this page), two of the major components of the NSF Arctic System Science (ARCSS) Program will hold their annual all-investigator meetings in mid-November 2001 in Salt Lake City, Utah. Ocean-Atmosphere-Ice Interactions (OAII) and Land-Atmosphere-Ice Interactions (LAII) investigators will take advantage of this proximity to meet with representatives from other ARCSS components.

OAII All-Hands Meeting

The OAII All-Hands Meeting will convene 14–16 November 2001. In addition to poster sessions on general arctic science activities and OAII research and outreach, researchers will present proposals for initiatives dealing with atmospheric and nearshore processes (see page 9). For more information, registration, and the agenda, see the OAII web site (http://arcss-oaii.hpl.umces.edu/AllHands/Mtg2001.html), or contact Jane Hawkey in Cambridge, MD (410/221-8416; fax 410/221-8490; hawkey@hpl.umces.edu).

LAII All-Hands Meeting

The LAII All-Hands Meeting will convene 14–17 November 2001. Investigators in the International Tundra Experiment (ITEX), Arctic Transitions in the Land-Atmosphere System (ATLAS), and Russian-American Initiative on Shelf-Land Environments in the Arctic (RAISE) projects will meet separately for part of the meeting to supplement the plenary and poster sessions (see page 7). For more information and the agenda, see the LAII web site (www.laii.uaf.edu/mtg.htm), or contact Patricia A. Anderson in Fairbanks, AK (907/474-5415; fax 907/474-6722; patricia@iarc.uaf.edu).

Joint Meetings for OAII or LAII Registrants

A morning plenary session on 15 November 2001, open to registrants from either meeting, will bring together OAII, LAII, RAISE, and PARCS (see page 8) investigators to

- update one another on the various components' activities and initiatives,
- foster interdisciplinary discussions, and
- identify the contributions needed to facilitate an effective ARCSS All-Hands Meeting in February 2002.

The OAII, LAII, and RAISE Science Steering Committees will meet jointly on the afternoon of 16 November 2001 to follow up on the plenary discussions.

In addition, the Barrow Arctic Science Consortium (BASC) Science Advisory Group will convene an open meeting on the evening of 15 November 2001, followed by an informational session. For more information, see the BASC web site (www.sfos.uaf.edu/basc), or contact Glenn Sheehan in Barrow, AK (907/852-4881; fax 907/852-4882; basc@nuvuk.net). ■

LAII Prepares for All-Hands Meeting, Upgrades Web Site

The next Land-Atmosphere-Ice Interactions (LAII) All-Hands Meeting will convene 14–17 November 2001 in Salt Lake City, Utah (see box page 6).

The goals of the meeting are to:

- develop explicit plans for synthesis of the past decade of research on land-atmosphere-ice interactions;
- meet jointly with the other major ARCSS programs to discuss ways in which LAII research might be better integrated in the future; and
- finalize a new science plan that outlines the priorities for arctic terrestrial-atmospheric research for the next decade. The draft science plan will be posted on the LAII web site for community review in September 2001.

Participants will focus on:

- planning and implementation of LAII research synthesis for International Tundra Experiment (ITEX), Arctic Transitions in the Land-Atmosphere System (ATLAS), and Russian-American Initiative on Shelf-Land Environments in the Arctic (RAISE) projects;
- opportunities for integration across LAII, OAII (see page 9), RAISE (see below), and PARCS (see page 8) in both synthesis and future research; and
- a discussion of the new LAII science plan as the land-atmosphere contribution to future ARCSS research.

More information on meeting arrangements and registration can be found on the LAII web site (www.laii.uaf.edu/).

Improvements to the LAII Web Site

The LAII Program Science Management Office (SMO) at the University of Alaska Fairbanks has renovated the LAII web site. The site now includes:

- current field reports,
- direct links to archived LAII data,
- links to individual projects' dedicated web sites, and
- online viewing of SMO publications.

Site enhancements will ultimately provide users with complete access to all LAII-related information and locations of archived data. Plans for additional improvements include:

- a community outreach section,
- a speakers' bureau,
- a media guide, and
- employment and research/funding opportunities.

Comments from site visitors and LAII researchers will guide further site improvements.

For more information about the LAII web site (www.laii.uaf.edu/), or contact Christopher Shock in Fairbanks, AK (907/474-1534; fax 907/474-6251; fncds1@uaf.edu). For more information about the LAII program, contact Patricia A. Anderson at the LAII SMO in Fairbanks, AK (907/474-5415; fax 907/474-6722; patricia@iarc.uaf.edu;).

RAISE Plan Focuses on Ship-Based Research in Russia

The Russian-American Initiative on Shelf-Land Environments in the Arctic (RAISE) has been developing a new science plan with the goal of facilitating ship-based research in the Russian Arctic.

Although land-based joint research projects under the RAISE umbrella have moved forward over the past few years, including studies of:

- organic material and nutrient fluxes from Russian rivers,
- seasonal flooding dynamics along rivers, and
- reconstruction of late-Pleistocene glacial and sea-level history on Wrangel Island,

research topics in the nearshore waters of the Russian continental shelf have not been adequately addressed. These scientific issues range from:

- the biogeochemical fate of organic materials contributed to the Arctic Ocean by shoreline erosion and river runoff, to
- the social and biological impacts of changes in sea-ice distributions.

Science planning for ship-based research in Russia must address both:

- the logistical and political challenge of providing costly ship support in remote areas for groups of researchers, and
- government authorities' concerns about scientific access within the Russian Exclusive Economic Zone (see page 16).

It is hoped that the RAISE effort will lead to a joint announcement of opportunity by both NSF and the Russian Foundation for Basic Research, promoting joint ship-based research on a variety of topics by Russian and U.S. investigators.

Current and past research programs such as the successful Russian-German cooperation of the 1990s, as well as the joint U.S.-Russian Bering and Chukchi Seas Expeditions (BERPAC) program that led to several joint research cruises in the 1970s, '80s, and '90s, are being used as successful models of bilateral research.

Members of the international research community wishing to contribute to the development of the new science plan are invited to contact Science Steering Committee (SSC) Chair Lee Cooper.

Transfer and development of an improved RAISE web site (www.raise.uaf.edu) has been completed, including:

- links to current research summaries by RAISE investigators,
- links to other arctic research sites,
- contact information for Russian and U.S. members of the International Science Steering Committee (ISSC), and
- information on past and planned meetings of the ISSC.

A Russian language version of the web page is planned.

The next meeting of RAISE investigators and the ISSC will be in Salt Lake City, Utah, on 14–17 November 2001 (see box page 6).

For more information, contact Lee Cooper in Knoxville, TN (865/974-2990; fax 865/974-7896); lcooper1@utk.edu) or RAISE Project Office Director Vladimir Romanovsky in Fairbanks, AK (907/474-7459; fax 907/474-7290; ffver@uaf.edu).

PARCS Develops Two Updated Research Goals

The Paleoenvironmental Arctic Sciences (PARCS) community held its principal investigator meeting in March 2001 at the University of Massachusetts, in conjunction with the annual Arctic Workshop. Two major issues affecting arctic paleo research dominated the agenda:

- a recent shift in NSF funding administration, and
- a need to revise and renew the PARCS science goals (see *Witness* Spring 2000) with respect to the ARCSS Program.

An important change in the proposal-application and funding system for arctic paleosciences at NSF will take place in FY 2002. The Earth System History (ESH) program will no longer administer proposals funded by Arctic Natural Sciences (ANS; see page 10) or ARCSS; instead, these programs will deal directly with their respective proposals.

Current Status of PARCS

Arctic paleo research is currently carried out in many forms that are important in the general context of arctic science. This broad mission is clearly set out in the 1999 PARCS science and implementation plan, *The Arctic Paleosciences in the Context of Global Change Research* (see *Witness* Spring/Autumn 1999); the PARCS Science Steering Committee (SSC) intends that PARCS will continue to work toward these goals, both in the U.S. research community and through international organizations and collaborations. Updates on PARCS activities and future directions will be available soon in an edition of the PARCS newsletter *PaleoTimes*.

PARCS Research Goals for ARCSS

PARCS also remains an essential ARCSS component. Much of the 2001 PARCS meeting was devoted to developing a focused set of research goals for the next three to five years, consistent both with new directions in the research community and, specifically, with anticipated progress in the ARCSS Program over the next five to ten years. As the ARCSS Program becomes more integrative in its science and structure, paleo research activities will be important to the development of a coherent perspective. With this in mind, meeting participants defined two major research goals.

A key area of concern is how much do recent observations of climate change in the Arctic reflect natural climate cycles? The first PARCS goal is, therefore, to describe the spatial and temporal context of 20th-century warming and current observations of climatic change with reference to high-resolution records of the past 2,000 years and the Holocene (the past 10,000 years). Major topics include:

- the medieval warm period (approximately AD 1000–1400) and Little Ice Age (approximately AD 1400–1850),
- high-amplitude Holocene climate cycles, and
- the possible connection of the onset of the neoglacial (a mid-Holocene cooling particularly evident at high northern latitudes) with shifts in the frequency and amplitude of such climate cycles.

More and more evidence suggests that the Arctic is shifting to conditions that are warmer than any within living memory. The second PARCS goal is to describe the consequences of very warm arctic climates for marine and terrestrial systems. Very warm past arctic scenarios that can serve as analogues for future warming include:

- the early Holocene, when the Arctic experienced high summer insolation anomalies; and
- the last interglacial (marine isotope stage 5), which appears as a very strong warming in the paleo record approximately 125,000 years ago.

Key topics to investigate in relation to these periods are:

- feedbacks and nonlinear changes (surprises) as consequences of strong warming—particularly the role of sea ice, ice sheets, and land-surface cover;
- the implications of strong warming for arctic and global carbon budgets.

These two goals will contribute to discussions at the February 2002 ARCSS All-Hands meeting (see page 6) and, possibly in modified form, will be the key foci for ARCSS-related paleo research.

At the end of 2001, Darrell Kaufman (Northern Arizona University) and Feng-Sheng Hu (University of Illinois) will replace Bruce Finney and Julie Brigham-Grette on the PARCS SSC.

For more information, see the PARCS web site (www.ngdc.noaa.gov/paleo/parcs), or contact PARCS Co-chairs Glen MacDonald in Los Angeles, CA (310/825-2568; fax 310/206-5976; macdonal@geog.ucla.edu) and Mary Edwards in Trondheim, Norway (+47/7359-1915; fax +47/7359-1878; mary.edwards@sv.ntnu.no); or Mike Retelle in Lewiston, ME (207/786-6155; fax 207/786-8334; mretelle@bates.edu). ■

HARC Explores Ways to Stimulate Discussion

Because human activities in the Arctic depend closely upon the environment, natural or human-caused changes are likely to have far-reaching social, cultural, and economic effects. To address these issues, NSF/ARCSS launched the Human Dimensions of the Arctic System (HARC) initiative in 1997 (see *Witness* Spring 1997, Autumn 1998). In light of the specific disciplinary and cultural challenges that researchers face in assembling research teams and developing appropriately integrated approaches, the recently funded HARC Science Management Office (SMO) is exploring new ways of engaging the scientific community and others in creative discussions.

Beginning in fall 2001, a series of Internet-based open workshops will provide opportunities for communication across disciplinary, cultural, and national boundaries, bringing expertise from many perspectives to bear on the critical research questions that HARC was developed to address. Workshop announcements will be disseminated through ArcticInfo (see www.arcus.org) and the HARC web site.

For more information, see the HARC web site (www.arcus.org/harc), or contact SMO Director Henry Huntington in Eagle River, AK (907/696-3564; fax 907/696-3565; hph@alaska.net). ■

SHEBA Data Helping to Evaluate Performance of Models

For one year beginning in October 1997, SHEBA conducted field work from a ship frozen into the arctic ice pack (see *Witness* Autumn 1998). SHEBA is now in its third and final phase, with 17 projects focused on using the 1997–98 dataset to study processes and mechanisms that affect climate feedback in the arctic system. The goals of SHEBA are:

- to improve simulations of the Arctic in global climate models, and
- to improve our capability to monitor arctic climate using satellites and autonomous remote platforms.

SHEBA's Phase III principal investigators (PIs) met in Boulder, Colorado, in July 2001 for updates on the Phase III objectives of modeling and in-depth analysis of processes and feedback mechanisms.

SHEBA data have been used to evaluate the performance of the global, coupled Community Climate System Model (CCSM), which proved to be simulating more winter cloud cover and incident surface long-wave irradiance than are actually observed. Ongoing SHEBA research is addressing the cloud and radiation problems but has not yet resulted in implemented improvements in the CCSM. The polar physics of the most up-to-date version of the CCSM includes a multicategory ice-thickness-distribution model with a surface albedo parameterization, which tracks the SHEBA observations fairly well. This new model is to be released in approximately January 2002.

SHEBA data are also being used to simulate and diagnose the energy and mass budget of the ocean-atmosphere-ice column at the SHEBA experimental site. The initial arctic single-column model (SCM) provides a credible starting point for model improvement, capturing much of the variability in surface temperature, heat budget components, ice thickness, and upper ocean temperature on time scales ranging from a few days to a season. The most notable weakness is that, like the global CCSM, the SCM oversimulates cloud cover during winter and early spring.

The Arctic Regional Climate Model Intercomparison Project (ARCMIP; see *Witness* Winter 2000/2001) is concentrating its initial efforts on simulating SHEBA. ARCMIP results will be applied, in turn, to the SHEBA SCM.

The Joint Office for Science Support (JOSS; see page 15) at the University Corporation for Atmospheric Research provides data management support to SHEBA. During the final two years of Phase III, JOSS expects to process an estimated 50–100 new, extended, or revised SHEBA datasets, totaling approximately 100 Gbytes. Highest-priority integrated data sets are gridded fields (*e.g.*, surface temperature), a SHEBA column dataset for the entire SHEBA year, and datasets for specific case study periods (see next column). Results of the 2001 SHEBA data questionnaire conducted by JOSS are available at www.joss.ucar.edu/sheba/phase3/webresponse/.

The ARCSS Data Coordination Center (see *Witness* Winter 2000/2001) has posted satellite reconnaissance imagery of the SHEBA experimental region (5 km^2 and 20 megabytes each) on the web at http://arcss.colorado.edu/Projects/ShebaRecon/metadata1.html.

Breakout groups at the workshop discussed single-column modeling, ice-albedo feedback and solar energy, atmosphere and ocean boundary-layer modeling, global and regional models, radiative transfer modeling, and model evaluation and feedback analysis. These discussions generated:

- a more detailed definition of the SHEBA-column integrated dataset, and identification of the individuals who will oversee completion of the elements within each of 12 categories—top-of-the-atmosphere radiation, atmospheric structure, atmospheric boundary layer, surface flux forcing, atmospheric advection, cloud properties, surface optical properties, state of the sea-ice and snow cover, ice deformation, ocean structure, ocean turbulence and boundary layer, and miscellaneous; and
- updated and more detailed definition of SHEBA's six case study periods in 1998 (14–20 January; 25–29 April; 20–24 May; 20–24 July; 10–20 June; and 28 July–2 August) as well as associated datasets, model experiments, and case study leaders. These periods are to be analyzed in detail by all Phase III PIs.

The Phase III PIs aim to complete the extended, updated, integrated column data set in approximately six months and to meet again within a year to develop first drafts of collaborative, project-wide papers.

Renovations of the SHEBA web site include a restructuring into two sections—one for the general public and one for SHEBA Phase III scientists.

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

OAII Considers New Initiatives

The Ocean-Atmosphere-Ice Interactions (OAII) component of the ARCSS Program has made progress on several fronts in the first half of 2001, including publishing a new science plan, preparing for the OAII All-Hands Meeting in November 2001 (see box on page 6), considering new research initiatives dealing with nearshore and atmospheric processes that will be discussed at the OAII All-Hands meeting, and adding an outreach page to the OAII web site. Phase III of the Surface Heat Budget of the Arctic (SHEBA) program continues to use data from the 1997–98 field work to study climate feedbacks and processes (see article this page), while Shelf-Basin Interactions (SBI) researchers have submitted proposals for Phase II field work (see page 10).

For more information, see the OAII web site (http://arcss-oaii.hpl.umces.edu), or contact Lou Codispoti or Jane Hawkey at the University of Maryland Center for Environmental Science's Horn Point Laboratory in Cambridge, MD (410/221-8479; fax 410/221-8490; codispot@hpl.umces.edu, hawkey@hpl.umces.edu). ■

ARCSS Program

Shelf-Basin Interactions (SBI) Prepares for Field Work

The Western Arctic Shelf-Basin Interactions (SBI) project, sponsored by the ARCSS Program and the U.S. Office of Naval Research, is investigating the arctic marine ecosystem to improve our capacity to predict environmental change (see *Witness* Winter 2000/2001). Since 1999, SBI Phase I principal investigators have conducted retrospective research and analyses, opportunistic sampling studies, and modeling to prepare for Phase II field work in the Chukchi and Beaufort seas.

The *SBI Phase II Field Implementation Plan* outlines a five-year (2002–06) sampling program combining moorings, seasonal survey and process studies, and modeling efforts. This phase focuses on three research topics in the core study area:

- northward fluxes of water and bioactive elements through the Bering Strait input region;
- seasonal and spatial variability in the production and recycling of biogenic matter on the shelf-slope area; and
- temporal and spatial variability of exchanges across the shelf-slope region into the Canada Basin.

Phase II funding decisions are expected by October 2001.

Following an SBI presentation at the 2001 Arctic Science Summit Week (see page 22), discussions at the Arctic Ocean Science Board meeting generated support for an International SBI working group to foster pan-arctic scientific collaboration on studies of shelf-basin interactions. Formation of an International SBI group was one recommendation of the November 2000 SBI pan-arctic meeting (see *Witness* Winter 2000/2001). Jackie Grebmeier, director of the U.S. SBI Project Office, will initially chair this group.

For more information, see the SBI web site (http://utk-biogw.bio.utk.edu/SBI.nsf), or contact Jackie Grebmeier in Knoxville, TN (865/974-2592; fax 865/974-7896; jgrebmei@utk.edu). ■

Arctic Natural Sciences Program

Arctic Natural Sciences Supports Fundamental Research

The Arctic Natural Sciences Program (ANS) is a multidisciplinary program within the NSF Office of Polar Programs, supporting research primarily in the atmospheric, biological, and earth sciences, including glaciology and oceanography. This program provides core support for disciplinary research in the Arctic.

Two ANS program directors share the program's diverse portfolio. For the most part, Jane Dionne, a geologist with specialty in sedimentary geology, handles proposals in glaciology, geology, and geophysics. Neil Swanberg, a zoologist and oceanographer who has also worked with the international global change science community, manages proposals in atmospheric sciences and space physics, biology, oceanography, and contaminants.

ANS research in arctic atmospheric sciences focuses on stratospheric and tropospheric processes as well as arctic climate and meteorology. ANS has supported work on past climates and atmospheric gases as preserved in arctic snow and ice cores, as well as atmosphere-sea and atmosphere-snow/ice interactions.

In upper atmospheric and space physics, research interests include auroral studies, magnetosphere-ionosphere coupling, and atmospheric dynamics and chemistry (see pages 4 and 5). Conjugate studies are considered jointly with the Antarctic Aeronomy and Astrophysics Program.

In the biological sciences, OPP supports research in freshwater, marine, and terrestrial biology; organismal adaptation to the arctic environment; ecology; ecosystem structure and processes; and biological consequences of ultraviolet radiation.

In the earth sciences, ANS supports all sub-disciplines of terrestrial and marine geology and geophysics. Special emphasis is placed on understanding geological processes important to the arctic regions and geologic history dominated by those processes.

Glaciological research in ANS is concerned with the study of the history and dynamics of all naturally occurring forms of snow and ice, including seasonal snow, glaciers, and the Greenland ice sheet. Program emphases include ice dynamics, numerical modeling, glacial geology, and remote sensing of ice sheets.

Oceanographic research funded by ANS is improving knowledge of the structure of the Arctic Ocean and adjacent seas, their physical and biological interactions with the global hydrosphere, and formation and maintenance of the arctic sea-ice cover. Areas of interest are the distribution of life in high-latitude oceans; low-temperature life processes; formation, movement, and mixing of arctic water masses; growth and decay of sea ice; exchange of salt and heat with the Atlantic Ocean and the Bering Sea; magnetic anomalies, heat flow, and gravity variations; sedimentary history; and the role of the Arctic Ocean and adjacent seas in global climate.

ANS supports research on contaminants in the Arctic, including their physical, chemical, and biological behavior and human impacts. Such research may focus on one component or address complex interdependencies. Priority is placed on fundamental questions, including those that will contribute to the development of increasingly comprehensive models of large-scale arctic physical phenomena.

For more information, see the ANS web site (www.nsf.gov/od/opp/arctic/natural.htm), or contact Jane Dionne or Neil Swanberg in Arlington, VA (703/292-8030; fax 703/292-9082; jdionne@nsf.gov; nswanber@nsf.gov). ■

Fossils may Harbor Pathogens that Caused Extinctions

Under a grant from the Arctic Natural Sciences Program, scientists from the American Museum of Natural History in New York City are collecting remains of extinct late-Quaternary mammals from the Taimyr Peninsula and elsewhere in the Arctic to determine if they contain evidence of ancient infectious diseases. The investigation will test a new hypothesis about the cause of certain ice-age mammal extinctions—that they may not have been due to climate change or overhunting by humans, but instead to superplagues of great virulence and lethality.

Late-Quaternary extinctions were extensive. In northern Asia and the continental parts of the New World, at least 130–140 species of mammals went extinct over a period of probably much less than 1000 years. These extinctions, mostly among species of large or "megafaunal" body size (*e.g.*, woolly mammoth), occurred immediately after the first appearance of humans in the respective areas. Many researchers believe that the extinctions could only have been caused by direct impacts related to migrating humans, such as overhunting. Very few kill sites of relevant age have been discovered in the Americas or northern Asia, however, and how small bands of hunters with unsophisticated tool kits could have wrought so much destruction in so short a period remains unclear.

Proponents of the disease hypothesis suggest that this "dreadful syncopation"—the humans come, the animals go—was connected with human presence, but indirectly. Humans, or more likely their commensals or synanthropics, might have acted as carriers for infectious diseases to which they themselves were well adapted. The immunologically-naive species that humans encountered in the course of their migrations to the northern parts of the world were unprepared for this microbial onslaught.

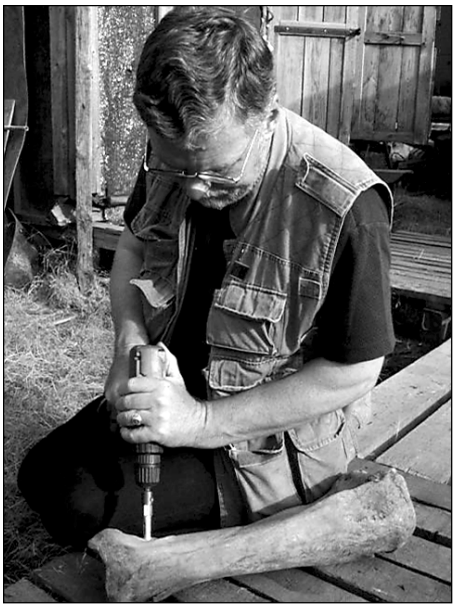
Emerging infectious diseases can follow many different courses, but the classic host reaction to completely novel infections (as in the case of Ebola disease in humans) is poor or inappropriate immune response followed by massive symptomology, systemic collapse, and often death in a matter of days. If the agent is easily transmitted from host to host, epidemics (epizootics) of exceptional mortality can be ignited. Worse, if epizootics started simultaneously in several different species, the infectious agent could have continued to spread rather than simply "burn out"—the usual fate of highly lethal pathogens that quickly run out of new individuals to infect. In any species, serious infectious diseases commonly hit the two ends of the age distribution particularly hard—the old and the very young. This pattern is especially devastating for species that reproduce slowly, such as large mammals.

Other factors, including climate change and human hunting, may have contributed to population declines, but the researchers are trying to determine whether emerging diseases were the prime cause of the Pleistocene extinctions. Evidence to test the disease hypothesis will probably come in several forms, including:

- small pieces of genetic material from pathogen genomes, and
- fragments of the proteinaceous coats that enclose some kinds of viruses.

To recover and identify these microbial fossils, Alex Greenwood, Ross MacPhee, and their associates are using an array of techniques drawn from modern molecular biology and immunology. Recovering the remains of ancient pathogens depends largely on the quality of preservation under natural conditions. Because cold conditions can slow the rate of degradation of DNA, the researchers are concentrating on the analysis of relatively young fossils (10–20,000 years old) from areas like Taimyr that have experienced persistently cold conditions since the last glaciation.

The investigators have been able to recover well-preserved mitochondrial DNA—and, for the first time, nuclear DNA—from mammoths and muskox from Taimyr. The team has also demonstrated the presence of endogenous retrovirus-like sequences in mammoth specimens from Alaska and Siberia (Greenwood *et al.* 2001). Although these particular entities are not infectious, the same techniques can be used to recover information on exogenous (foreign) microbes. The researchers must identify and isolate candidate pathogens and then collect enough samples to determine if any were prevalent enough to be regarded as the agents of superplagues.



Ross MacPhee (American Museum of Natural History) uses a specially adapted drill bit to access the marrow cavity of a woolly mammoth tibia found on the Taimyr Peninsula. Because the marrow cavity is connected to the vascular system in a living animal, pathogens that were travelling through the circulatory system near time of death may be preserved in marrow tissue. Bone plugs are used for host DNA studies and ^{14}C dating. MacPhee and colleagues are working in Taimyr because the youngest radiocarbon dates yet found for mainland mammoths (ca. 9,600 years BP) come from the area and because relatively cold conditions have prevailed there, increasing prospects of recovering DNA samples that have been well preserved (photo by Clare Flemming).

This project has benefited greatly from the active participation of European colleagues in various investigations and strong in-country support by the secretariat of the International Mammoth Committee in St. Petersburg.

For more information, contact Ross MacPhee in New York, NY (212/769-5480; fax 212/769-5239; macphee@amnh.org).

References

Greenwood, A.D., F. Lee, C. Capelli, R. DeSalle, P.A. Marx, and R.D.E. MacPhee. 2001. Evolution of endogenous retroviral-like elements of the woolly mammoth (*Mammuthus primigenius*) and its relatives. *Mol. Biol. Evol.* 18: 840–847.

Inuit Perceptions of Aging Withstand the Test of Time

The following two articles profile research made possible by dissertation-improvement awards through the Arctic Social Sciences Program (see box). Opportunities for graduate student support through NSF include:
- *standard research grants,*
- *Graduate Fellowships,*
- *dissertation-improvement awards, and*
- *grants for Graduate Fellows in K–12 Education (see page 26).*

Simon leaned forward and stirred some sugar into his tea before answering the question. "How come my body's no more good? I eat well, alright, but all Inuit is not the same, you know. Some of them, they can still go a long ways even though they're *inutquaq* (old men). But I get old quick because I work too hard. I remember when I was younger, I used to travel from here to Fish Lake, I'd get there before anybody was up and having breakfast. I worked too hard, so my body wore out quick. Not like white people, these Eskimos."

As part of his dissertation project funded by the Arctic Social Sciences Program, Peter Collings (University of Nebraska – Lincoln) interviewed Simon and 37 other Inuit to investigate Inuit conceptions of aging and elderhood in Holman, Northwest Territories, Canada. Because much of the current literature on Inuit has focused on the sweeping social, economic, and political changes occurring in the Canadian Arctic, the research focused on the following issues:
- the ways in which Inuit of different generations define the life course and expect their lives will unfold;
- how changes to Inuit society—particularly settlement in the permanent community, schooling, and modernization—have altered relationships between elders and juniors in Holman; and
- how Inuit definitions of individual health and an individual's ability to manage senescence correlate with successful aging.

Lengthy, open-ended interviews with Inuit ranging from 20–85 years old revealed that, contrary to Collings' original expectations, there remains a great deal of cultural continuity within the community. The narratives of young Inuit males, for example, suggest that, although they are not fluent in *Inuinaqtun*, and few can hope to become full-time hunters and trappers, they continue to value their relationships with their older relatives. Indeed, these young men, and all other Inuit interviewed, seem to define their lives and their passage through their life course in nearly identical fashion. The narratives reveal that Inuit are using the concept of *ihuma* (often translated as "knowledge" or "wisdom") as an organizing principle of personal development and as a marker of an individual's age.

To date, much of the literature that focuses on contemporary Inuit society has assumed that Inuit culture is changing, or "acculturating" toward southern Canadian values, and that Inuit culture is slowly but surely fading away as Inuit youth are exposed to southern Canadian culture. Collings' field work in Holman, however, suggests that much of what is distinctly Inuit remains in Holman, and that, at least in the domain of aging and life course, Inuit culture remains not only intact but vibrant.

For more information, contact Peter Collings in Lincoln, NE (402/472-9422; fax 402/472-9642; pcollings@unl.edu). ■

Arctic Social Sciences Program Grows

The Arctic Social Sciences Program (ASSP) received a 25% funding increase in FY 2001, bringing the total budget—including research support and logistics—to $2.3 million. The ASSP is currently funding projects in political science, sociology, linguistics, traditional knowledge, anthropology, archaeology, and interdisciplinary research. This diverse portfolio is deepening understanding of past and present northern societies.

The ASSP sponsored a January 2001 workshop to enhance the continued development of social science research in the Arctic and sub-arctic (see www.arcus.org/ASSP_ workshop). Over 70 participants, including academic arctic researchers, social scientists based in other regions, federal and state agency scientists, and policy and decision makers working on related issues, explored:
- interdisciplinary linkages among the social sciences,
- opportunities for international collaboration, and
- the interrelationships between social and physical and biological sciences.

The workshop identified additional opportunities for ASSP, including support of data sharing and management, networking, and increased facilitation of bottom-up, community-based research. The Polar Research Board (see page 19) organized an innovative round-table discussion on the perspectives of federal and state agencies on arctic social science research. To follow up on the workshop, the ASSP is beginning planning for a large social sciences conference in fall 2002.

In August, Program Manager Fae Korsmo announced that she will begin serving as a program director in the office of the NSF Experimental Program to Stimulate Competitive Research (EPSCoR) in September; she will continue to manage the Arctic Social Sciences Program until a replacement can be recruited.

The ASSP welcomes proposals in August and February of each year. For more information, see the ASSP web site (www.nsf.gov/od/opp/arctic/social.htm), or contact Program Manager Fae Korsmo in Arlington, VA (703/292-8030; fax 703/292-9082; fkorsmo@nsf.gov). ■

Ph.D. Study Documents Athabascan Language Structure

Many of the indigenous languages spoken in the interior region of northwestern North America belong to the Athabascan family, a large group of closely related languages including, for instance, Navajo and Apache.

Evidence from the study of linguistic diversity clearly indicates a northern homeland for the Athabascan languages; more than half of the Athabascan languages are spoken in Alaska and the neighboring Yukon Territory, Canada. Furthermore, the closest relatives to the Athabascan family—Eyak and Tlingit—are also spoken in this region. Many of these northern languages, however, remain only cursorily documented, with few published materials and no comprehensive dictionaries or grammatical description.

Among these is Tanacross, a language now spoken by fewer than 50 people in eastern interior Alaska. As with most other Alaska Native languages, Tanacross is no longer learned as a first language by children or used as the language of daily communication. Tanacross remains the first language of the Elders, however, and reflects and shapes the Tanacross culture. As the Elders pass on, knowledge of the language and its attendant culture pass with them, creating an urgent need to record that linguistic knowledge.

With support from an Arctic Social Sciences dissertation research grant, Gary Holton, then a graduate student at the University of California, Santa Barbara (UCSB), spent 16 months in 1999–2000 working with Tanacross speakers to document the language. Most of the work was conducted in interview format with bilingual speakers. Several Native speakers also worked as consultants for the project, interviewing Elders and transcribing and translating recordings. With support from Tanacross Village Corporation and the University of Alaska Tok Center, two multi-day community language workshops provided the opportunity for Tanacross speakers and nonspeakers to learn about the modern orthographic system, fostering further interest in language documentation within the community itself.

The interdependence of language and culture is revealed most often, and most subtly, in Tanacross discourse patterns, but it is also readily apparent in the structure of the words themselves. For example, Tanacross pays particular attention to the way an object is handled; this is reflected

Language consultant Laura Sanford identifies Native plant names near Tanacross, Alaska. This willow (Salix discolor) *is* dahłigaay *(photo by Gary Holton).*

in the use of different verb stems to refer to the handling of different types of objects. Thus, the word meaning "give me that object" varies depending on the way that object is handled:

- *shtl'á'inkaayh* is used for an object in an open container (*e.g.*, a cup of water),
- *shtl'á'inkɬiyh* is used for an elongated object (*e.g.*, a gun), and
- *shtl'á'inchuuth* is used for a flat, flexible object (*e.g.*, a blanket).

Taken as a whole, such words form an elaborate system of indigenous classification, reflecting and embodying Tanacross world views.

The phonology, or sound system, of Tanacross contrasts at least four different types of tone—high, low, rising, and falling. As with other tone languages, knowledge of the tone associated with a Tanacross word is necessary in order to pronounce the word correctly. The Tanacross word *t'ah* (pocket), for instance, is pronounced with a low tone, while the word *t'áath* (cottonwood tree) is pronounced with a high tone, indicated in the orthography by an acute accent. Because the realization of tone on a particular word is dependent on where that word occurs in a phrase, careful work is required to document the underlying lexical (defining) tone correctly.

Another area of investigation is morphology, or word structure. Like other Athabascan languages, Tanacross words are composed of many meaningful parts (morphemes) combined in fixed orders. For example, the Tanacross word that means "we are eating something" is *yi-ts'e-'áał*, composed of the morphemes:

- *yi* (something),
- *ts'e* (we), and
- *áał* (to be eating).

In the neighboring Ahtna language, the word is *sc'eyaan*, composed of:

- *s* (we),
- *c'e* (something), and
- *yaan* (to be eating).

While each individual morpheme is cognate (related) across the two languages, the ordering of the morphemes differs. This is just one example of the variability between the Athabascan languages—while they are related in much the same way that French, Italian, and Spanish are related, they are distinct enough to require independent linguistic documentation.

The new data from Tanacross:

- add to our understanding of cross-linguistic variation within the Athabascan family,
- provide the basis for further documentation in neighboring Han and Upper Tanana languages, and
- have been incorporated into teaching materials for language instruction.

In addition to providing a foundation for further research in both theoretical and applied linguistics, the results of Holton's research formed the basis for his 2000 Ph.D. dissertation supervised by Marianne Mithun, a specialist at UCSB in the typology and morphology of the languages of Native North America.

For more information, contact Gary Holton in Fairbanks, AK (907/474-6585; fax 907/474-6586; gary.holton@uaf.edu). ■

The North Alaskan Eskimo Revisited after 40 Years

In 1959, Robert Spencer, an anthropologist at the University of Minnesota, published *The North Alaskan Eskimo. A Study in Ecology and Society*, on the basis of interviews he and his wife Marietta conducted with Elders in Barrow and Anaktuvuk Pass during the summers of 1952 and 1953. Spencer's monograph was intended, and has been widely regarded, as a comprehensive summary of 19th century Iñupiaq Eskimo culture on Alaska's Arctic Slope.

The publication has served as the major source on the structure of moderately complex hunter-gatherer societies, and as the basic reference on the 19th century social organization and ecology of the Iñupiaq Eskimos of arctic Alaska. Spencer's book, which has been reprinted twice, made two enduring contributions to Alaskan ethnography. The first was to give inland Eskimos equal billing with their coastal counterparts. The second was to describe in some detail the dominant role family relationships played in the operation of Eskimo societies.

Anthropologists have used Spencer's reconstruction to model early contact Iñupiaq social organization, to make inferences about how the bearers of the prehistoric Thule Culture might have lived in the same part of the world at an earlier time, and to elucidate a pre-contact hunter-gatherer type of social system. Spencer apparently was comfortable with these uses of his work, since he believed his study depicted a situation that existed throughout the 19th century. Anthropologists working in northern Alaska in recent years, however, have come to suspect that, while Spencer's account is accurate regarding the situation existing near the end of the 19th century, it may not apply as well to earlier portions of the post-contact era.

In 1999, the Arctic Social Sciences Program recognized the continuing significance of Spencer's book by funding a reexamination of the document on the 40th anniversary of its publication. For this purpose, E.S. Burch, Jr. of the Arctic Studies Center at the Smithsonian Institution is using several sources of information, including:

- 19th century journals and commentaries that have been discovered since 1959,
- a few 19th century publications that Spencer overlooked,
- Spencer's own field notes (thanks to the generosity of Marietta Spencer),
- Point Hope field notes compiled by Froelich Rainey in 1940,
- Point Hope field notes compiled by Don Foote in the early 1960s, and
- data Burch has obtained from Elders in the region.

Burch is conducting the study without drawing on Spencer's analysis; he will then compare Spencer's results to those derived from the independently acquired material.

Burch has found evidence, both in Spencer's book and in his field notes, that Spencer assumed that no significant social change occurred in arctic Alaska during the 19th century. He did not seek evidence of change in his conversations with Elders, therefore, and he ignored most that crossed his path. This was unfortunate, because evidence now available shows that famine and epidemic disease reduced the Iñupiaq population over the course of the 19th century to such an extent that the early contact societal structure had largely collapsed by 1900.

Accordingly, Burch is concentrating on social and demographic change, with special attention to three periods for which information is particularly abundant: 1826–39, 1849–54, and 1880–90. Burch's study should provide a more rigorous understanding of both early contact Iñupiaq societies and the changes they experienced over the 19th century.

For more information, contact Ernest Burch in Camp Hill, PA (717/975-3590; fax 717/975-3592; esburchjr@aol.com).

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Beechey, F.W. 1831. *Narrative of a Voyage to the Pacific and Beering's Straits in the Years 1825, '26, '27, '28.* London, Colburn and Bentley (2 vols.).

Spencer, R.F. 1959. *The North Alaskan Eskimo. A Study in Ecology and Society.* Washington: Smithsonian Institution. Bureau of American Ethnology, Bulletin 171.

The Iñupiaq village of Nuwuk, at Pt. Barrow, Alaska, as first seen by Europeans in 1826. The people with upraised arms are signalling a desire to trade (from Beechey 1831).

Science Use Expands at Toolik Field Station

Toolik Field Station (TFS; see *Witness* Spring 2000), on the north slope of Alaska, supported 4,811 science days in 2000, up 30% from 3,715 days in 1999. Projections for 2001 exceed 5,200 days. Twelve temporary tent platforms and Weatherports, provided by VECO Polar Resources (VPR; see page 16), provided housing during periods of peak demand.

The increased use of TFS coincides with a new funding framework. Since June 2000, the NSF Arctic Research Support and Logistics Program has covered base operations costs at TFS through a cooperative agreement with the Institute of Arctic Biology (IAB) at the University of Alaska Fairbanks (UAF). Users now pay only the incremental costs of their station use. The cooperative agreement allows IAB to operate and develop TFS in a stable funding and planning environment.

Funded by NSF, a major communications upgrade for the station was completed in July 2001. VPR, VECO Alaska, SRI International, UAF Facility Services, UAF Telephone Services, and IAB collaborated on this project, which included:

- connecting a buried fiber-optic cable from the TFS to the fiber-optic cable that parallels the Trans-Alaska Pipeline; this new fiber link supplements existing radiotelephones and allows Internet access via the UAF computer network;
- installing a wireless building-to-building Local Area Network (LAN); and
- installing a telephone network based on internet protocol, for in-camp and external communications.

During the past two seasons, additional upgrades have included:

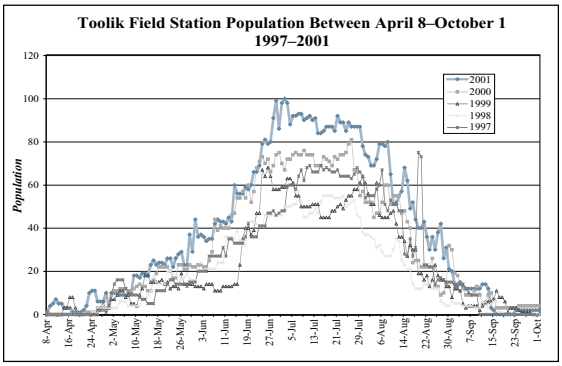
- new snow machines, boats and outboard motors, four-wheeler and trailer, laboratory furniture, and beds; and
- installation of a temporary dining tent, an electric panel, and modules for a generator and temporary shower and washroom.

Designs have been completed and site preparation has begun for:

- new residences,
- a washhouse, and
- a year-round science support building,

all to be completed in coming years.

For more information, see the TFS web site (www.uaf.edu/toolik), or contact Mike Abels in Fairbanks, AK (907/474-5063; fax 907/474-5513; fnmaa@uaf.edu).



User days at Toolik Field Station have increased in both the peak and shoulder seasons since June 2000, when NSF began covering base operations costs (figure prepared by Mike Abels).

JOSS Helps Arctic Researchers Manage Datasets

For nearly 20 years, the Joint Office for Science Support (JOSS) at the University Corporation for Atmospheric Research (UCAR) has provided scientific, technical, and administrative support for field research anywhere in the world. JOSS participates, for instance, in data-management coordination for the international Arctic Climate System Study/Climate and Cryosphere (ACSYS/CliC) projects of the World Climate Research Programme.

In 1996, NSF enlisted JOSS (see *Witness* Winter 2000/2001) to help archive the volumes of data that are being generated, often simultaneously across many disciplines, by the ARCSS Program's largest field projects:

- the Surface Heat Budget of the Arctic Ocean (see page 9),
- Arctic Transitions in the Land-Atmosphere System (see *Witness* Autumn 1998),
- the International Tundra Experiment (see *Witness* Winter 2000/2001), and
- the Shelf-Basin Interactions project (see page 10).

JOSS supports data-sharing mechanisms, including web-based tools and workshops, for ARCSS scientists engaged in these research programs.

The JOSS support is determined by close coordination with project scientists and science management offices—the common thread is to help the researchers archive and share data while fostering access to datasets by the rest of the arctic science community. Specific JOSS data management capabilities include:

- an on-line interactive data catalog archival and distribution system (CODIAC), which offers scientists a means to archive data while allowing others to identify datasets, view selected data and meta-data, and obtain data via the Internet or other media; and
- the JOSS on-line field catalog, which provides participants the ability to submit—in near real-time—field reports, equipment status summaries, and data products that are valuable for in-field analysis. These logs can become the permanent record of field activities.

In addition, JOSS can work with the investigators to build composite datasets, form new datasets, or provide quality-control processing for selected types of data.

The large ARCSS datsets that are benefitting from JOSS support as field data are generated will be transferred, ultimately, to the ARCSS Data Coordination Center at the Snow and Ice Data Center in Boulder, Colorado, (see *Witness* Winter 2000/2001), for long-term management.

The National Oceanic and Atmospheric Administration (NOAA) and NSF are principal sponsors of JOSS.

For more information, see the JOSS web site (www.joss.ucar.edu/), or contact Jim Moore in Boulder, CO (303/497-8635; fax 303/497-8158; jmoore@ucar.edu).

Russian Logistics are Challenging, Not Insurmountable

The Russian Arctic remains a logistical challenge for American investigators. Although access to colleagues, facilities, and information is now less hampered by security concerns than before, economic and political difficulties can make logistics, permitting, and transportation in the vast Russian Arctic problematic.

Advice from Researchers

Western investigators who have worked recently in the Russian Arctic offer the following general advice.

Collaborating with Russian investigators, rather than institutions, is the most direct way to access appropriate logistic systems, sampling platforms, and field stations. It is vital to begin planning with Russian colleagues at least a year in advance for remote field work. Although foreigners may now establish bank accounts in Russia and transfer funds to remote areas, it remains difficult to arrange permits and transportation and to negotiate customs both entering and leaving the country for personnel, scientific equipment, and chemicals. Arrangements for communications equipment and GPS units are best handled entirely by Russian collaborators.

Many scientific field stations have closed, and those that remain are not well supported. The biological field stations associated with nature reserves *(zapovedniki)*, although fairly common, are not much more than shelters.

Transportation beyond major cities is a challenge. Many high-arctic towns with rail and air service during the Soviet period are now closed or nearly so. Use of small fixed-wing aircraft is inadvisable because runways are not maintained in many areas. Helicopters, the remaining option for areas not accessible by boat, are expensive and increasingly unreliable. Ship-based investigators face additional barriers to accessing research sites (see page 7).

Less rigorous safety standards for everything from sidewalks to availability of life jackets increase the likelihood of accidents. Medical Advisory Systems, Inc. (MAS) and a few other organizations can provide medical advice and evacuations if needed.

Office of Polar Programs Efforts

The Arctic Section of the NSF Office of Polar Programs (OPP) has taken several steps to aid U.S. investigators working in the Russian Arctic. OPP has tasked VECO Polar Resources (VPR; see box) to provide support to specific projects in Russia.

The Barrow Arctic Science Consortium (BASC), through its cooperative agreement with OPP, has developed the Chukotka Science Support Group (CSSG) to provide permitting, customs, and logistical support in Chukotka. Staffed by members of two Native groups—the Yup'ik Eskimo Society and the Naukan Production Cooperative (Chukchi)—CSSG is supporting several U.S.-funded projects in Chukotka and developing logistical infrastructure in Lavrentiya and Provideniya. At the invitation of Governor Roman Abramovich of the Chukotka Autonomous Okrug, BASC and CSSG are developing background data to help select sites for environmental observatories and may organize a U.S. Coast Guard icebreaker scientific cruise to Chukotka for 2002.

In partnership with the NSF Geosciences Directorate and International Office and the U.S. Civilian Research and Development Foundation (CRDF), OPP established a science liaison office in Moscow in 1999. The CRDF can assist researchers with financial and permitting arrangements in Russia.

Information about Russia is becoming more available on the Internet, and the OPP-supported Arctic Logistics Information and Support (ALIAS) web site will provide a portal to the most useful sites on logistics issues in Russia.

For more information, see these web sites: VPR (www.vecopolar.com), BASC (www.arcticscience.org), CRDF (www.crdf.org), ALIAS (www.arcus.org/alias), MAS (www.mas1.com), or contact Arctic Research Support and Logistics Program Manager Simon Stephenson in Arlington, VA (703/292-7435; fax 703/292-9082; sstephen@nsf.gov). ■

VECO Completes Second Arctic Field Season

The NSF Arctic Research Logistics Support Services (ARLSS) contractor, VECO Polar Resources (VPR; see *Witness* Winter 2000/2001) has completed its second arctic field season, collaborating with researchers, other logistics providers, and local organizations to provide high-quality logistics support to NSF investigators.

In its second year, VPR has supported more than 70 research projects in Greenland, Alaska, Canada, Russia, near the North Pole, and several vessel-based research cruises. Accomplishments in 2001 include:

- doubling the ARLSS satellite telephone inventory and upgrading to newer, more robust models of INMARSAT mini-M and Iridium;
- organizing wilderness first aid and safety training for 25 arctic researchers;
- providing specifically tailored first aid kits and a remote medical care service (Medical Advisory Systems; see article this page) to 10 field projects;
- completing the 2000–01 Summit, Greenland, winter campaign and planning for 2001–02;
- installing a new generator system and additional sleeping quarters at Summit Camp;
- coordinating more than 600 hours of aircraft support for researchers working in remote locations of Alaska;
- supporting a 12-person research team at Cherskii in Siberia (see article this page); and
- providing logistics costs estimates for almost a dozen research proposals.

Plans for 2002 include further enhancements to field communications capabilities, additional Russia-based projects, offering field training courses at several U.S. universities during the off-season, and continued enhancements to VPR's web site.

For more information, see the VPR web site (www.vecopolar.com), or contact Project Manager Jill Ferris in Englewood, CO (720/344-5619; fax 720/344-6514; jill.ferris@veco.com). ■

With *Healy* Underway, AICC Turns to Science Facilitation

With the U.S. Coast Guard Cutter *Healy* safely through science trials and working in the eastern Arctic on her first funded science cruises, the Arctic Icebreaker Coordinating Committee (AICC) is now turning its full attention to science facilitation for the three U.S. Coast Guard icebreakers (*Healy, Polar Sea,* and *Polar Star*). On behalf of the University-National Oceanographic Laboratory System (UNOLS), the AICC is developing a post-cruise assessment procedure for all funded cruises and continues to work with the Coast Guard and NSF on:

- long-range planning,
- establishing procedures for ongoing data collection, and
- prioritizing science equipment needs for the icebreakers.

The Coast Guard is working to standardize equipment (*e.g.,* salinometers, debubblers, CTDs) across all three vessels.

The *Healy*'s maiden science mission is a joint voyage with the German research vessel, *Polarstern*, to the Gakkel Ridge. From July to October 2001, investigators from five nations are following up on the new evidence, obtained by the 1999 SCICEX cruise, of volcanism at the ultra-slow spreading ridge (see page 1). The mission includes petrological, geophysical, hydrothermal, and biological studies of the ridge system. Sponsored by the NSF Teachers Experiencing Antarctica and the Arctic Program (see *Witness* Winter 2000/2001), a seventh-grade science teacher is also participating in the cruise (see http://tea.rice.edu/tea_adamsfrontpage.html). For more information on the *Healy*'s cruise to the Gakkel Ridge, see www.earthscape.org/rr1/hea01/hea01.html.

Other arctic science missions for 2001 have included:

- a *Polar Star* cruise to the St. Lawrence Island polynya in March,
- a second *Healy* cruise in the eastern Arctic Ocean, and
- both funded and opportunistic science to the Bering and Chukchi seas on board the *Polar Sea* in July and August.

Final details are being worked out for a busy year in 2002 as well. NSF proposals to use any of the icebreakers in 2003 are due by 15 February 2002. Critical information for icebreaker cruise planning in general and the *Healy* in particular can be found on the Coast Guard web site (www.uscg.mil/pacarea/iceops/cpmanual/cpmanual.htm).

The AICC acknowledges the contributions of the members who are cycling off the committee—Joe Coburn (Woods Hole Oceanographic Institution), Glenn Cota (Old Dominion University), and Dan Lubin (Scripps University). The three new members—Bob Bourke (Naval Postgraduate School), Margo Edwards (University of Hawaii), and Peter Minnett (Rosenstiel School of Marine and Atmospheric Science, University of Miami)—came on board in September 2001 for the AICC meeting in Washington, DC.

For more information on the AICC, see the UNOLS web site (www.unols.org), or contact AICC Chair Lisa Clough in Greenville, NC (252/328-1834; fax 252/328-4178; cloughl@mail.ecu.edu) or the UNOLS office (office@unols.org). ■

UNOLS Develops Design for an Arctic Mid-Sized Vessel

In September 2000, the Ship Acquisition and Upgrade Program of the NSF Division of Ocean Sciences provided funding to the University of Alaska Fairbanks (UAF) for a concept design study for an Alaskan Region Research Vessel (ARRV). The vessel will replace the 35-year-old RV *Alpha Helix* for year-round research in the North Pacific Ocean and sub-arctic waters, as well as serving seasonally in the Arctic (see *Witness* Spring 2000).

The just-completed concept design will have applications to both the ARRV and to the development of future intermediate vessels in the University-National Oceanographic Laboratory System (UNOLS) fleet. The UNOLS Fleet Improvement Committee developed the science mission requirements and is overseeing development of the ARRV; a joint committee of investigators from UAF and the Woods Hole Oceanographic Institution collaborated on the design study, which includes:

- a technical description of the ship (*e.g.*, expected speed, power, stability, seakeeping, range, endurance), and
- a description of the general arrangements, (*e.g.*, inboard and outboard profiles, machinery and science arrangements).

The ARRV is expected to be used for a variety of science missions, with an emphasis on general oceanographic and fisheries investigations in high-latitude open seas, nearshore regions, and seasonal sea ice. As part of its strengthening for use in seasonal sea ice, the vessel will have:

- a two-foot reamer on each side of the hull to reduce hull pressure and allow efficient turning in ice, and
- an ice wedge beneath the keel to push ice sheets aside.

Other specifications include:

- length of 226 ft. (69 m),
- endurance of 45 days,
- science berths for 24,
- a 1,024 sq. ft. main lab,
- a 500 sq. ft. wet lab,
- a 220 sq. ft. analytical lab,
- a 240 sq. ft. electronics shop, and
- a 309 sq. ft. electronics/computer lab.

All the labs will be on the main deck. Adaptable laboratory and deck space will accommodate diverse capabilities such as over-the-side fisheries sampling and acoustic procedures.

Glosten Associates of Seattle developed the completed concept design, and Arno Keinonen of AKAC, Inc., consulted on the hull features related to sea ice. The design committee, chaired by Vera Alexander (UAF), is seeking additional funding from NSF to develop a more detailed preliminary design for the ARRV.

For more information, contact Vera Alexander, Robert Elsner, or Terry Whitledge in Fairbanks (907/474-6824; fax 907/474-7386; vera@sfos.uaf.edu; ffre@uaf.edu; whitledge@ims.uaf.edu). ■

Working Group Outlines New Edition of Logistics Report

The Arctic Research Support and Logistics Working Group (RSLWG) is supported by NSF to represent the research community in providing long-term expertise and advice on arctic logistics and science support issues (see *Witness* Winter 2000/2001).

The Working Group organized a session on Arctic Research Support and Logistics (RSL) during the ARCUS 13th annual meeting in May 2001. Presentations included:

- an update from NSF Arctic Research Support and Logistics Program Manager Simon Stephenson;
- discussion of RSLWG activities and community perspectives on arctic logistics;
- a report on 2000 and 2001 field support activities by Jill Ferris, VECO Polar Resources project manager (see page 16); and
- an update on the results of the April 2001 workshop on infrastructure support for arctic science in the Barrow region.

Members of the RSLWG are drafting an update of *Logistics Recommendations for an Improved U.S. Arctic Research Capability* (ARCUS 1997), using community input gathered at the May 2001 session and from previous community surveys and town meetings. The update will:

- develop recommendations for future arctic logistics investments, in light of emerging science priorities, and
- identify new science opportunities made possible by improved research support and logistics capabilities.

The report, while not intended to be a comprehensive review of arctic research issues, will outline the scientific priorities driving the updated assessment. This assessment will include discussion and recommendations for specific research-support investments needed for investigations of:

- variability in the physical environment,
- biogeochemical cycling and contaminants,
- effects of change on biological resources,
- dynamics of human systems,
- upper atmosphere and space weather studies,
- solid earth issues, and
- life in extreme environments.

The report also will discuss needed improvements in several general research-support areas identified by the science community, including:

- field safety,
- long-term observing systems,
- access to modeling capacity and results to develop a predictive capability,
- technology investments,
- synthesizing local and research-based knowledge,
- interagency cooperation, and
- international collaboration and access to key locations.

The first draft of the next edition of *Logistics Recommendations for an Improved U.S. Arctic Research Capability* will be available for community review in spring 2002.

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

The Future of SCICEX

The USS *Hawkbill*, the last Sturgeon-class nuclear submarine operated by the U.S. Navy, was inactivated at Pearl Harbor in 1999, ending the first phase of the Science Ice Exercises (SCICEX) program. Five vessels from this class supported SCICEX cruises from 1995 to 1999 (see page 1). The scientific community remains hopeful that opportunities will emerge for future submarine-based research in the Arctic. The U.S. Arctic Research Commission (USARC; see facing page), which fostered the development of the SCICEX program, is tracking six possibilities, most on a relatively distant time scale.

The USARC, NSF, the Office of Naval Research, and the operational Navy have concluded a Memorandum of Understanding to continue SCICEX operations on a "Cruises of Opportunity" basis. This will allow short data-collection opportunities but without science riders or special instrument installation. In summer 2001, both the USS *Scranton* (Los Angeles class) and USS *Connecticut* (Seawolf class) were deployed to the Arctic, proving the capability of these submarine classes. The *Scranton* surfaced at the North Pole in June 2001 and obtained temperature and salinity data.

New, high-endurance, survey autonomous underwater vehicles (AUVs), under development at the Monterey Bay Aquarium Research Institute and the Navy's Underwater Warfare Center, appear promising for use in the Arctic. With significant development efforts, these AUVs may be capable of continuing the regional mapping of ice, water, and bottom properties begun with the SCICEX cruises.

The USARC is continuing discussions with other navies with nuclear submarines, including:

- the Royal Navy, about the possibility of mounting Seafloor Characterization and Mapping Pods (SCAMP; see page 1) on a Royal Navy submarine, and
- the Russian government, about the use of a Victor-class submarine for arctic research.

At least two nations—Sweden and Germany—are manufacturing conventional submarines with air-independent power systems, which may be capable of extended under-ice operations.

The Japanese Nuclear Power Institute has produced a concept paper for a small nuclear submarine with full science capabilities, dedicated to research.

The U.S. Navy is considering the construction of a new nuclear research submarine, a successor to the small *NR-1*, which would have arctic capability.

For more information, contact USARC Director Garry Brass (see facing page). ■

USARC Represents Research from Alaska to Svalbard

Throughout the spring and summer of 2001, the U.S. Arctic Research Commission (USARC) has advocated in the U.S. Arctic, in Washington, DC, and abroad for arctic research activities.

USARC Chairman George Newton and Executive Director Garry Brass attended the ARCUS Annual Meeting in May 2001, where Brass participated in a panel on arctic research advocacy on Capitol Hill (see page 28). Newton and Brass also discussed several topics with personnel in the Office of Naval Reactors, including the possibility of a new nuclear research submarine with arctic capabilities to replace *NR1*, a small Navy nuclear submarine currently in service (see facing page).

Newton and Brass also testified at a Senate Appropriations Committee hearing in Fairbanks, Alaska, on climate change in the Arctic in May (see page 21).

The Commission convened at the Arctic National Wildlife Refuge in early June. In Arctic Village and Nuiqsut, Commissioners met with residents who voiced concerns about energy resources, water and waste water, distance education, telemedicine, and housing.

The Commission met in mid-June at U.S. Fish and Wildlife Service headquarters in Arlington, Virginia, for briefings on NOAA, NSF, and FWS agency activities. Commissioners honored David Garman for his support of the arctic research community while on Senator Frank Murkowski's (R-AK) staff; Garman is now the Assistant Secretary of Energy for Energy Efficiency and Renewable Energy.

The USARC traveled to Svalbard, Norway, in late June for a two-day meeting which included a visit to Ny-Ålesund—the research center on Svalbard (see *Witness* Winter 2000/2001)—and the British and German research stations. Having observed Norwegian conduct of arctic research support, the Commission will recommend to NSF that the United States establish a station there.

Also in June, Brass represented the USARC at the inaugural meeting of the North Pacific Research Board (NPRB), created to oversee the distribution of $10 million per year in federal funds for fisheries and ecosystem research in the North Pacific, Bering Sea, and Arctic Ocean. For more information about the NPRB, see www.sfos.uaf.edu/npmr/dsands.html.

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

Committee to Assess Oil and Gas Impacts in Alaska

Congress asked the National Academy of Sciences (NAS) to contribute to its debate about oil development on Alaska's North Slope. In response, the Polar Research Board (PRB) and the Board on Environmental Studies and Toxicology have appointed a study committee to "review information about oil and gas activities (including exploration, development, and production) on Alaska's North Slope." The committee has been asked to assess the known and probable cumulative impacts on the physical, biological, and human environments of Alaska's North Slope (including the adjacent marine environment) of oil and gas activities there from the early 1900s to the present. It will also look at potential future cumulative effects and different scenarios of oil development in combination with other human activities such as tourism, fishing, and mining.

The 18-member committee has gathered information in Anchorage, Arctic Village (including an overflight of the Arctic National Wildlife Refuge), Barrow, Deadhorse and surrounding oil facilities, Fairbanks, Nuiqsut, and Kaktovik. The committee has held public sessions in each community to gain insights into impacts, as well as briefings from academic and oil industry scientists, engineers, and citizens. The committee is chaired by NAS member Gordon Orians (University of Washington); its final report is expected in July 2002. For more information, see "Current Projects" at http://national-academies.org.

The PRB's Committee on Abrupt Climate Change has completed a draft report and submitted it for outside review. The final report is expected in fall 2001. The Committee on the Gulf of Alaska Ecosystem Monitoring Program continues to assist the *Exxon Valdez* Oil Spill Trustee Council as it develops a long-term plan for research and monitoring in the Prince William Sound area. Finally, a new committee to assist the Oil Spill Recovery Institute by reviewing its research program is expected to get underway in fall 2001.

For more information, contact PRB Director Chris Elfring in Washington, DC (202/334-3479; fax 202/334-1477; celfring@nas.edu).

PRB Members

Spring 2001

Donal Manahan, *Chair*, University of Southern California, Los Angeles • Richard Alley, Pennsylvania State University, University Park • Robin Bell, Lamont-Doherty Earth Observatory, Palisades, NY • Akhil Datta-Gupta, Texas A&M University, College Station • Henry Huntington, Eagle River, AK • Amanda Lynch, University of Colorado, Boulder • Robie Macdonald, Fisheries and Oceans Canada, British Columbia • Miles McPhee, Naches, WA • P. Buford Price, Jr., University of California, Berkeley • Carole Seyfrit, Old Dominion University, Norfolk, VA • Marilyn Walker, University of Alaska, Fairbanks

Senate Proposes 5.6% Increase in NSF Budget

Before the month-long August 2001 recess, both the U.S. House and Senate appropriations committees passed their respective versions of the VA-HUD bill, which funds independent federal agencies, including NSF.

The two versions of the bill have a wide disparity in their overall funding levels that will have to be settled. The Senate version of the VA-HUD bill provides significantly less money for NSF in FY 2002 than does the House bill (Senate: $4.67 billion, up 5.6% from FY 2001; House: $4.84 billion, up 9.4%). President Bush's FY 2002 budget request for NSF proposed an increase of 1.3% (see *Witness* Winter 2000/2001). For more information about either bill, see House Report 107-159 and Senate Report 107-43.

Although Senators Kit Bond (R–MO) and Barbara Mikulski (D–MD), co-chairs of the VA-HUD subcommittee, advocate a doubling of the NSF budget over five years, the proposed funding would provide approximately one third of the amount required to move forward with this strategy. Bond and Mikulski cited the allocation from the Senate budget committee as the reason for their smaller-than-expected offering for NSF.

Following the 11 September attacks, the White House and members of Congress agreed to new funding levels to accelerate completion of the FY 2002 appropriations bills. President Bush has acknowledged to Congress the need for $25 billion more in discretionary spending than the levels in the FY 2002 budget resolution.

At press time, appropriations staff are resolving differences in the House and Senate versions of already passed bills, and both the House and Senate have named members to the VA-HUD conference committee.

Specific Funding Areas

For Research and Related Activities (RRA), the Senate bill provides an increase of 4.9% from FY 2001, to $3.515 billion. The House bill provides an 8.7% increase to $3.642 billion. Within RRA, House appropriations committee report language specifies funding for the Office of Polar Programs (OPP) of $299 million, 9.4% over the amount in the president's budget. The Senate bill traditionally does not stipulate an amount for OPP or any other directorate. The Senate Report does, however, specifically designate two items to be administered by OPP:

- continued funding of the International Arctic Research Center (IARC; see page 24), under a recent three-year $15 million cooperative agreement with NSF, citing the importance of climate change research (see facing page); and
- consultation with NOAA to determine the feasibility of establishing an Arctic Research Center in Barrow, Alaska.

Within Education and Human Resources, the Senate bill increases the Experimental Program to Stimulate Competitive Research (EPSCoR) budget by $10 million to $85 million; an additional $25 million in co-funding through the RRA account brings the total EPSCoR budget to $110 million. The House bill proposes a level EPSCoR budget.

For more information, see the following web sites: the Library of Congress (http://thomas.loc.gov), American Institute of Physics (www.aip.org), U.S. Senate (www.senate.gov), U.S. House of Representatives (www.house.gov).

NSF will Survey Grant Recipients on Funding Needs

In response to a request by the president's Office of Management and Budget (OMB), NSF has begun a major survey of principal investigator and institutional views on grant size and duration. The surveys, the first of their kind for the agency, are being conducted in the fall of 2001. According to Thomas Cooley, NSF Chief Financial Officer and Director of the Office of Budget, Finance, and Award Management, the survey was prompted by word from OMB that budget increases for NSF would follow only demonstrated need, and that OMB was looking closely at grant size and duration as avenues for possible increases.

NSF Director Rita Colwell pointed out in her annual Community Budget Briefing in April 2001 that the average annual size of an NSF grant is approximately $100,000, and average duration is less than three years. "This puts our investigators at a disadvantage," she said. "It forces them to immediately begin applying for a new grant as soon as they've gotten the first one—time they could be spending doing their research."

At the ARCUS 13th annual meeting in May 2001, Cooley outlined the plan for the agency-wide survey effort:

- all researchers who received NSF grants in 2000 will be sent a survey; and
- all institutions with researchers on active grants will be sent an institution survey.

The survey will ask investigators a range of questions, including:

- the history of their grants,
- time taken to apply and administer the grants, and
- what needs they have for their research.

Answers to these questions, along with information gathered from institutions, will be used by NSF administrators to help develop their FY 2003 budget, which will be delivered to OMB sometime in the fall of 2001. Survey results will be available to the public in early 2002.

Karl Erb, director of the NSF Office of Polar Programs, reiterated the importance of this survey at the 2001 ARCUS annual meeting. "I encourage all who receive the survey to complete it," he said. "The results of this survey will help us understand how and whether larger, longer grants would benefit our grantees, including those who conduct remote field research in the Arctic. If the results favor increases in grant size or duration, they will help us make the cases for increased funding in our budget requests."

For more information, contact Thomas Cooley in Arlington, VA (703/292-8200; fax 703/292-9007; cooley@nsf.gov).

Climate Change in the Arctic and the 107th Congress

by Senator Ted Stevens

This past May I chaired the Senate Appropriations Committee's field hearing on global climate change at the University of Alaska Fairbanks. Representatives from NSF, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the U.S. Geological Survey, and professors from the nation's top research institutions attended the hearing. This was a valuable discussion on the status of scientific research on climate change, particularly in the arctic region, and how climate change is impacting our area.

Testimony from researchers at this hearing underscored an important message—the Arctic has been affected by climate change more than any other area on planet Earth. Understanding what has taken place here may be key to unlocking the uncertainties of global climate change. Many witnesses at the hearing noted that recent climate change activity likely stems from a number of factors, including natural variances and human activity.

Regardless of cause, many changes predicted worldwide appear to be happening first and with greater severity in arctic regions, including Alaska. For instance, the pack ice that protects our state's coastal villages formed later in the year and was much softer, allowing storms to batter and erode the coastline. Forests have gradually moved farther north and west in Alaska as permafrost has receded. The Northwest Passage has been seasonally ice free for the past three years, generating increased interest from commercial shippers to use this route. In addition, recent studies show the world has increased in temperature by one degree, but the arctic temperature has increased by seven degrees.

We are not sure whether the changes taking place in the Arctic are part of a natural climatic cycle in our region or the beginning of a long-term, possibly irreversible, trend. Ironically, the Arctic is among the least studied regions in the world, yet it is experiencing the greatest immediate impacts of a noticeable warming climate change. The changes to the arctic region are not just theoretical prognostications of what future climate change may bring to our planet; the effects of change are real and occurring now.

Undoubtedly, the hearing in Fairbanks accentuated the need to better understand climate change; it also revealed the shortcomings of our nation's current efforts to address this issue. Although several different federal agencies have programs related to climate change, federal funding for relevant research and development has steadily declined over the past 10 years. The resources for coordination and over-arching organization among the different agencies have been inadequate, resulting in unnecessary duplication of effort and the ultimate failure to address the singular issue of climate change. Consequently, areas like the arctic region have gone without adequate climate change observation and data compilation.

On 29 May 2001, Senator Ted Stevens convened a field hearing of the Senate Appropriations Committee in Fairbanks, AK, to discuss global climate change. A member of the U.S. Senate since 1968, Stevens chaired the Appropriations Committee from 1997 to 2001; he currently serves as the Committee's ranking member (photo by Eric Engman).

I have co-sponsored, with Senator Byrd of West Virginia, legislation to create a process for the United States to seriously address climate change. Our bill, titled "The Climate Change Strategy and Technology Innovation Act of 2001," would not interfere with or replace existing efforts of federal agencies related to climate change. Rather it would complement current agency programs by coordinating our nation's approach to global climate change. This would be accomplished through the implementation of a national strategy based on emission mitigation measures, investments in energy-efficient technologies, expanded research into climate adaptation, and resolving remaining scientific and economic uncertainties regarding climate change.

Paramount to this effort, the bill authorizes new funding for research and development to create the next generation of innovative energy technologies, with the goal of greatly reducing emissions from the use of fossil fuels. The eventual result will be to achieve the goal of lowering or leveling off of concentrations of CO_2 in the atmosphere.

On 18 July the Senate Governmental Affairs Committee held a hearing on the Climate Change Strategy and Technology Innovation Act of 2001 (SB 1008). I invited the members of the committee to visit Alaska and witness first-hand the effects that climate change has had on the arctic environment. The bill received thoughtful discussion, and, shortly thereafter, the committee approved it by unanimous consent. Presently, the bill is on the Senate calendar and awaits further debate before its ultimate disposition.

There is an immediate need to stimulate our nation's research and development in innovative energy technologies. Through this regimen our country can develop the necessary tools for the entire world to employ in decreasing the base of pollution we collectively generate and put into the atmosphere. The ongoing climate change taking place in the Arctic has put the world on notice of what global warming may look like. It is our job to take heed and make responsible decisions now.

For more information, see the Senator's web site (http://stevens.senate.gov/), or contact him in Washington, DC (202/224-3004; fax 202/224-2354; senator.stevens@stevens.senate.gov). ■

Arctic Council Marks Culmination of its First Ten Years

Delegates to the 10th anniversary celebration of the Arctic Environmental Protection Strategy (AEPS) met in June 2001 in Rovaniemi, Finland. The AEPS, first proposed by Finland, evolved into the Arctic Council in 1996. Finnish Environment Minister Satu Hassi and Prime Minister Paavo Lipponen both spoke at the commemoration. U.S. State Department Assistant Secretary for Oceans and Fisheries Mary Beth West described the Council as a model for regional cooperation on environmental and sustainable development issues. Iceland announced officially that it is willing to take over the chair of the Council from Finland in 2002.

The AEPS commemoration was followed by the semiannual meeting of the Senior Arctic Officials (SAOs). The meeting included status reports from Arctic Council working group chairs and presentations on the Arctic Climate Impact Assessment (see *Witness* Winter 2000/2001), arctic transportation, and the World Summit on Sustainable Development. Five of the six indigenous groups attended, as well as many observer nations and nongovernmental organizations. The European Commission attended as invited guest of the Finnish chair.

Working Group Activities

Arctic Monitoring and Assessment Program (AMAP): Fact sheets on radioactivity and heavy metals in the Arctic were released in Rovaniemi. Updates of the pollution studies published in 1997 are expected to be completed by the next Ministerial meeting in September 2002.

Conservation of Arctic Flora and Fauna (CAFF): *Arctic Flora and Fauna: Status and Conservation,* the first truly circumpolar overview of arctic biodiversity and related conservation issues (see Publications, page 27), was released in Rovaniemi. The study concludes that species are showing the effects of overexploitation, habitat loss, and pollution, and that distance has not made the Arctic immune to global environmental issues. CAFF will develop policy recommendations for governments based on these findings.

Emergency Prevention, Preparedness, and Response (EPPR): The release of the *Circumpolar Map of Resources at Risk from Oil Spills in the Arctic* is expected in time for the November 2001 SAO meeting. Finland is coordinating a new project—a survey on major accidents and natural disasters in the Arctic over the past decade.

Protection of the Arctic Marine Environment (PAME): The Russian National Plan of Action for the Protection of the Arctic Marine Environment from Anthropogenic Pollution has been approved by the Russian Duma. The U.S. chair of PAME is organizing a meeting in Washington, DC, in 2001 to encourage governmental, private sector, and international financing for the program. The next PAME meeting, scheduled for 9–11 October 2001 in Moscow, will include a half-day seminar on offshore oil and gas issues.

Sustainable Development Working Group: The children and youth project is collecting data on maternal and infant health, suicide prevention, and infectious diseases. The United States and Finland have presented proposals for a circumpolar transportation and infrastructure project. Joint workshops are scheduled for September 2001.

Arctic Council Action Plan to Eliminate Pollution of the Arctic: The SAOs approved three project proposals for further development:

- Reduction of Atmospheric Mercury Releases from Arctic States,
- Environmentally Sound Management of Stocks of Obsolete Pesticides in Russia,
- Outspread and Implementation of Cleaner Production Methodology in the Russian Arctic.

Arctic Climate Impact Assessment (ACIA): Scientists from all eight arctic nations and Europe have begun drafting the scientific impact assessment chapters (see *Witness* Winter 2000/2001). The ACIA steering group and lead authors have agreed on the baseline climate change scenario to be used—SRES B-2.

Meetings on the Arctic Horizon

The next SAO meeting will take place in Espoo, Finland, 6–7 November 2001. The next Ministerial-level meeting of the Arctic Council will be held in September 2002 in Inari (Saariselka), Finland.

For more information, see the Arctic Council web site (http://arctic-council.org), or contact Hale VanKoughnett at the Department of State in Washington, DC (202/647-4972; fax 202/647-4353; vankoughnetthc@state.gov).

Arctic Science Summit Week 2001 Draws Researchers to Iqaluit

Approximately 300 people participated in the third Arctic Science Summit Week (ASSW) in April 2001 in Iqaluit, Nunavut. Several international and regional arctic science organizations also convened meetings in Iqaluit, offering participants opportunities for both formal and informal interactions during the week.

Leading arctic scientists contributed to a Science Day on "Science and Technology for Sustainable Communities" and enjoyed the demonstration of a novel way to share the findings of scientists with northern residents. Anders Karlqvist, Director-General of the Swedish Polar Research Secretariat, conceived and wrote an arctic theatre play as a forum for reporting about current research findings. The play, which revolves around both the historic Franklin Expedition and a contemporary Swedish tundra expedition, was originally performed by professional artists at a major theater in Stockholm. The Iqaluit mini-version was performed by two professional actors, a jazz musician, a Native drummer from Iqaluit, and five scientists.

The ASSW is convened annually by the International Arctic Science Committee (IASC). ASSW 2002 will be held 21–26 April 2002 in Groningen, The Netherlands.

For more information about IASC and ASSW, see the IASC web site (www.iasc.no), or contact Odd Rogne in Oslo, Norway (+47/2295-9900; fax +47/2295-9901; iasc@iasc.no).

Cold Water Flux from Nordic Seas has Decreased

The main source for the deep water of the North Atlantic is the overflow of cold, dense water from the Nordic seas across the Greenland-Scotland Ridge and into the Atlantic Ocean; this overflow helps drive the inflow of warm, salty surface water into the Nordic seas. The Faroe Bank Channel (FBC; see figure) is the deepest passage (approximately 840 m deep) across the ridge, and the deep flow through the FBC has been estimated to carry approximately 33% of the total overflow of cold water from the Nordic seas into the Atlantic. A report in the 21 June 2001 *Nature* presents evidence that the overflow of cold water through the FBC has weakened since 1950. The investigation was funded by the Nordic Environmental Research Programme and the VEINS project of the European Community.

Bogi Hansen, an oceanographer at the Faroese Fisheries Laboratory, describes the flow of cold water over the FBC as a submarine river 15 kilometers wide and 200 meters deep, carrying twice as much water as all the world's freshwater rivers combined. Since November 1995, Hansen and colleagues Bill Turrell (Scotland) and Svein Østerhus (Norway) have been able to collect nearly continuous measurements of velocity from an upward-looking Doppler current profiler moored at the sill of the channel.

Previous work had documented that the water flowing over the FBC had become warmer and less saline over time (Turrell *et al.* 1999, Hansen *et al.* 1999). The new instrumentation showed that, in addition, the flow of water colder than 0.3°C through the FBC decreased 2–4% per year in 1995–2000. The authors argue that the decrease probably also includes warmer components of the overflow.

This data, considered in combination with hydrographic observations collected from a weather ship (OWS-M on figure) since 1948, suggests that the flux of cold water (≤0.3°C) flowing over the FBC decreased by at least 20% in the period 1950–2000. Most of the decrease took place after 1970 and apparently accelerated considerably during the last decade of the 20th century.

The Greenland-Scotland Ridge stretches approximately 1700 kilometers from Greenland in the west to the Shetland Islands, just north of Scotland. Areas shallower than 700 meters are shown as light blue. The four low channels where cold Nordic water flows across the ridge to the Atlantic are indicated by arrows. Approximately 50% of the overflow passes through the Denmark Strait (DS) between Greenland and Iceland. Approximately 33% flows through the Faroe Bank Channel (FBC). The remainder flows across the Iceland-Faroe Ridge (IFR) and the Wyville Thomson Ridge (WTR) (figure prepared by Bogi Hansen).

There are no measurements to confirm whether the flow of cold water elsewhere over the Greenland-Scotland Ridge has increased to compensate for the FBC decrease, or has also decreased. If the total overflow from the Nordic seas has decreased over the latter half of the 20th century, then the global thermohaline circulation may also have been affected.

The cold overflow from the Nordic seas requires a compensating inflow of (warmer) water from the Atlantic to the Nordic seas. Reduced cold-water overflow can be expected to lead to reduced Atlantic inflow. Such a reduction could explain why some of the areas most affected by the Atlantic inflow (*e.g.*, the Faroe Islands) have not experienced global warming.

The heat and salt transported by the Atlantic inflow is vitally important in maintaining conditions in the Nordic seas and the Arctic Ocean, and far-reaching consequences can be expected if the FBC flux continues to decrease.

While the observed decrease in cold water flow from the Arctic to the Atlantic over the FBC may be part of naturally occurring variations, the observations are consistent with predicted consequences of anthropogenic climate change. Increased melting of sea-ice and increased freshwater supply due to global warming would tend to lower the density of surface waters in affected areas, reducing the efficiency of convection and other processes that form and drive the cold arctic water overflow. Thus, the decreased FBC flux may indicate that global warming has affected the global thermohaline circulation and oceanic heat transport toward the Arctic.

For more information, contact Bogi Hansen in Tórshavn, Faroe Islands (+298/315-092; fax +298/318-264; bogihan@frs.fo). ■

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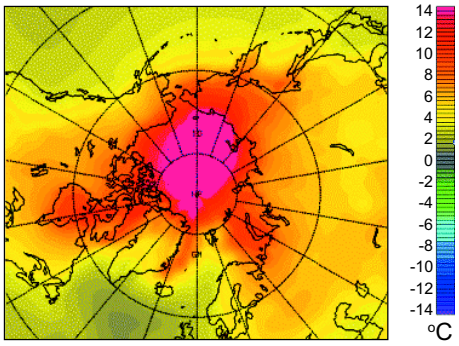
IARC Outlines Research Contributing to Global Models

The International Arctic Research Center (IARC) was established on the campus of the University of Alaska Fairbanks (UAF) in August 1999 for the purpose of integrating and synthesizing global climate change research conducted by arctic scientists from around the world (see *Witness* Autumn 1997). The National Science Board authorized NSF to negotiate a cooperative agreement with UAF, effective May 2000, funding IARC operations and four major projects:

- the Community Arctic Modeling Project (CAMP),
- the Nansen and Amundsen Basins Observational System (NABOS),
- the establishment of methane and permafrost database centers, and
- the Arctic Climate Impact Assessment project (ACIA; see *Witness* Winter 2000/2001).

CAMP will develop 21st century scenarios of arctic climate change, using model intercomparisons and experiments designed to identify and improve parameterizations critical to long-term arctic climate simulations (see figure). This work will contribute to the Atmospheric Model Intercomparison Project and the Coupled Model Intercomparison Project, both coordinated by Lawrence Livermore Lab, the Arctic Ocean Model Intercomparison Project, and the Arctic Regional Climate Model Intercomparison Project (see *Witness* Winter 2000/2001).



Variability among eight global climate models' projections of arctic warming by the late 21st century (figure from J. Walsh and W. Chapman).

The NABOS project will measure circulation, water-mass transformation, and transformation mechanisms in the Eurasian Basin of the Arctic Ocean. NABOS will deploy 12 moorings in four transects of the continental slope of the Nansen and Amundsen Basins. Data from these moorings will complement data from a set of moorings across Fram Strait operated by European Union programs.

The database center for methane research will be coordinated with the International Arctic Science Committee's Feedbacks and Arctic Terrestrial Ecosystems project (FATE; see *Witness* Spring 2000) and the International Tundra Experiment (ITEX; see *Witness* Winter 2000/2001). The permafrost research center will be coordinated with the International Permafrost Association, the National Snow and Ice Data Center in Boulder, Colorado (see page 6), and the Ecosystem Database Center at the National Institute of Agro-Environmental Science in Japan.

The Frontier Research System for Global Change, established in 1997 by the Japan Marine Science and Technology Center and the National Space Development Agency of Japan, also supports research at IARC. Frontier investigators are organized into:

- a physics group focused on atmosphere/ocean/ice interactions, and
- a multidisciplinary group emphasizing biogeochemistry.

The cooperative agreement that funded IARC also created an Oversight Council to advise both NSF and UAF on IARC. A Science Advisory Board advises the director and staff on the institution's general research priorities, and national and international collaboration.

For more information, see the IARC web site (www.iarc.uaf.edu), or contact IARC Director Syun Akasofu in Fairbanks, AK (907/474-6012; fax 907/474-5662; sakasofu@iarc.uaf.edu). ■

Global Change Conference Organizers Call for an Ethical Social Response

In July 2001, more than 1,600 people from 100 countries gathered in Amsterdam, The Netherlands, for an open science conference on "Challenges of a Changing Earth." The conference was sponsored by four international global change programs, in part to call attention to the contributions of the first full decade of global change research.

The sponsoring organizations—the International Geosphere-Biosphere Programme, the International Human Dimensions Programme on Global Environmental Change, the World Climate Research Programme, and the international biodiversity program DIVERSITAS—drafted "The Amsterdam Declaration on Global Change," affirming that:

- the Earth System is a single, self-regulating system;
- in the "Anthropoecene Era," human-driven changes are now comparable to great forces of nature;
- global changes are difficult to predict;
- Earth System dynamics are characterized by critical thresholds and abrupt changes; and
- there are no precedents for the magnitudes and rates of some of the changes observed today.

In light of these observations, the authors urge the people of the world—and their governments and NGOs, scientists and policy makers—to reach across customary boundaries to create an ethical framework and deliberate strategies for sustaining the Earth system while meeting social and economic objectives.

Three days of presentations and plenary sessions focused on topics such as:

- fisheries and food production,
- the proliferation of large dams (5,000 in 1950; 45,000 in 2001) and their impacts,
- links between biogeochemical cycles,
- environmental changes driven by social change in Southeast Asia, and
- changes in biodiversity and fire regimes.

For more information, see www.sciconf.igbp.kva.se, or contact Will Steffen in Stockholm, Sweden (+46/816-6448; fax +46/816-6405; will@igbp.kva.se). ■

Students Examine Industry in Northwest Russia

During the past few decades, mineral and energy industries have expanded in arctic regions. This development has coincided with increasing local empowerment among arctic indigenous people. As home rule areas seek local economic development, the region's enormous reserves of minerals, oil, and gas are obvious sources of income. In many areas of the Arctic, conflicts over resource exploitation have pitted indigenous populations against newcomers. Conflicts revolve around issues such as:

- self government *vs.* domination by the southern majority,
- traditional *vs.* modern lifestyles,
- renewable *vs.* nonrenewable resources, and
- the consequences of transboundary contamination.

The sixth annual summer course in the Circumpolar Arctic Social Science (CASS; see *Witness* Spring 2000) network examined these conflicts regarding industrialization in northwest Russia in September 2001. The course, *Industrial Development in the Arctic,* places special emphasis on the social, economic, and cultural consequences of the development process.

Portions of the course take place in collaboration with the Circumpolar Arctic Environmental Studies (CAES) network's 2001 course, *Industrial Impacts on Natural and Social Environments,* enabling students to explore cross-disciplinary approaches to the study of environmental consequences of industrialization. The CAES network, established in 1998, is based on the same principles as CASS and held its first course in 2000.

About 40 students and 19 faculty members visited the Kola Peninsula to view first-hand the huge mining sites and mineral processing plants in Nikel, Monchegorsk, and Apatity, as well as the small Sami minority's cultural and economic center in Lozovero. The group also visited Murmansk and Archangelsk—two major infrastructural and military centers in the Russian Arctic. In addition to the contributions of the faculty and students, local authorities and governmental representatives involved in the development process participated in the course.

This apatite mine in Kirovsk is the world's largest source of apatite ore, which is crushed and exported to the south as a phosphorus source for fertilizers. The copious dust produced in the mining and crushing processes is a serious health hazard for the 115,000 people living in Kirovsk and Apatity (photo by Rasmus Ole Rasmussen).

The 2001 CASS/CAES course focuses on:

- social science topics,
- environmental science topics, and
- an interdisciplinary approach to the interrelations between the social and the environmental consequences of industrialization in the Russian Arctic.

As part of the course, small groups of students pursue interdisciplinary research projects on the interrelationships among industry, environment, and society in northwest Russia.

More than 60 doctoral students from all arctic nations have participated in the CASS courses since 1996, creating an international interdisciplinary network of arctic social science students and faculty members (see *Witness* Spring 2000).

For more information, see the CASS course web page (www.geo.ruc.dk/nors/phd_net/nwruss.htm), the CAES network web site (www.caesnetwork.cjb.net), or contact Rasmus Ole Rasmussen in Roskilde, Denmark (+45/467-42137; fax +45/467-43031; rasmus@ruc.dk) or Katja Ruth in Luleå, Sweden(+46/9207-2800; fax +46/9209-1697; ekru@sb.luth.se).

University of the Arctic Launched

In June 2001, after four years of planning by northern institutions in all eight arctic nations, more than 200 northern educators and politicians gathered at the University of Lapland, Finland, to formally launch the University of the Arctic (UArctic).

In fall 2001, UArctic offers its first undergraduate course, "The Circumpolar World," focusing specifically on northern topics and northern needs. The course will be available in traditional classrooms at participating institutions in Russia, Europe, and North America, and also on the Internet. The use of the Internet to facilitate learning, particularly for students in remote areas, is central to the UArctic concept.

For more information, see the UArctic web site (www.uarctic.org), or contact Asgeir Brekke in Tromsø, Norway (+47/7764-5151; fax +47/7764-5580; asgeir@phys.uit.no).

SDSU Graduate Students Open Doors in Arctic Classrooms

In October 1999, NSF launched an initiative to support graduate students and advanced undergraduates in the sciences, mathematics, engineering, and technology to serve directly as resources in K–12 schools. Partnering of science undergraduates and graduates with elementary teachers is facilitated by yearly stipends and tuition. The program for Graduate Teaching Fellows in K–12 Education (GK–12) is designed to:

- improve the Fellows' communication and teaching skills,
- enrich learning for K–12 students,
- provide professional development opportunities for K–12 teachers, and
- strengthen partnerships between institutions of higher education and local school districts.

The San Diego State University (SDSU) Global Change Research Group, one of 31 institutions to receive GK–12 funding in 1999, has been investigating plant and ecosystem responses to elevated CO_2 as well as CO_2 fluxes in the natural ecosystems on the North Slope of Alaska since 1981. The group, led by Walt Oechel, proposed to collaborate with teachers in Barrow and Atqasuk to explore ways to use hands-on laboratory materials as part of their K–6 curricula. Their GK–12 program is Partnerships Involving the Scientific Community in Elementary Schools (PISCES).

While many arctic researchers have been able to spend a day or several hours of their own time with elementary students, the GK–12 funding has allowed the PISCES fellows and teachers to have more consistent contact over longer periods of time—and this has made a difference. Glenn Sheehan of the Barrow Arctic Science Consortium (BASC) has assisted with the PISCES program and writes, "the SDSU researchers have 'proven' themselves both as good communicators of science and as good collaborators with the teachers and administrators who must plan far in advance to have effective additions or changes to what would otherwise be a routine school year or class."

In the first year of funding, PISCES fellow Alejandra Rios helped with science activities during the 2000 summer school and created educational exhibits for the Iñupiat Heritage Center (IHC). In January 2001, Rios and Maggie Reinbold spent two weeks with Barrow students preparing them for a Global Change Institute, sponsored by PISCES and the IHC, in collaboration with BASC. Students were able to discuss:

- historical accounts of change in weather and climate with Elders,
- scientific perspectives with both local researchers (Richard Glenn, Dan Endres, and Kenneth Toovak) and SDSU researchers (Walter Oechel and Glen Kinoshita), and
- the weather and biology of the local area with elementary students in San Diego.

Responding to the SDSU researchers' enthusiasm and ability to communicate science to students, the North Slope Borough School District organized the entire 2001 summer school program—including math, language arts, and science (the latter taught by Rios and Reinbold)—around an ecosystem theme: rain forests. As students compared the familiar arctic environment with the tropical rain forest, they began to understand that they are local experts about their own environment.

In September 2001, Rios and Nancy Taylor, PISCES co-PI and science coordinator for the San Diego County Office of Education, will give workshops for teachers in Barrow and two other North Slope villages on the kit-based science lessons used in the Barrow PISCES program.

NSF's GK-12 Program is managed by the Directorate for Education and Human Resources (EHR). Required letters of intent for 2002 GK-12 proposals were due in August 2001. NSF expects $10 million to be available.

For more information on PISCES, see the PISCES web site (www.sdsa.org/pisces), or contact Nancy Taylor in San Diego, CA (858/292-3854; fax 858/292-9827; ntaylor@sdcoe.k12.ca.us).

For more information on GK-12, see the EHR web site (www.ehr.nsf.gov/dge/programs/gk12/), or contact GK-12 Program Director Terry Woodin in Arlington, VA (703/292-8697; fax 703-292-9048; nsfgk12@nsf.gov). ■

NSF Supports Interdisciplinary Ph.D. Training

In August 2000, NSF awarded $49 million to 19 innovative graduate programs. The Integrative Graduate Education and Research Traineeship (IGERT) awards support graduate training for scientists and engineers to pursue multidisciplinary approaches to challenging contemporary questions. All NSF directorates and the Office of Polar Programs participate in the IGERT program, which has made 57 awards since its inception in 1998.

The University of Alaska (UA) received one of the FY 2001 IGERT awards for a program in Regional Resilience and Adaptation (RR&A). In fall 2001, RR&A will begin training scholars, policy makers, and managers to address the challenge of sustaining the desirable features of Earth's ecosystems and society at a time when all of the major forces that shape the structure and functioning of ecosystems and society are undergoing major changes (see page 22). RR&A will apply ecology, economics, anthropology, climate dynamics, and philosophy in a systems framework to understand the functioning of regional systems, with an emphasis on high-latitude ecosystems. It will also emphasize cross-cultural communication through intensive involvement with the Alaska Native community, managers, businesses, and conservation groups. Up to 10 fellowships will be awarded to Ph.D. students each year; M.S. and M.A. students are also encouraged to participate.

For more information about RR&A, contact Terry Chapin in Fairbanks, AK (907/474-9722; fax 907/474-6967; terry.chapin@uaf.edu).

For more information about IGERT, see www.nsf.gov/igert, or contact Lawrence Goldberg in Arlington, VA (703/292-8339; fax 703/292-9147; lgoldber@nsf.gov). ■

ARCUS
3535 College Road, Suite 101
Fairbanks, Alaska 99709 USA
Phone: 907/474-1600
Fax: 907/474-1604
arcus@arcus.org
www.arcus.org

Executive Director: Wendy K. Warnick

ARCUS is a nonprofit organization consisting of institutions organized and operated for educational, professional, or scientific purposes. ARCUS was established by its member institutions in 1988 with the primary mission of strengthening arctic research to meet national needs. ARCUS activities are funded through a cooperative agreement and grants from NSF, by the Alaska Federation of Natives, and by membership dues.

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Managing Editor: Alison York
Editor/Designer: Marty Peale
Copy Editors: Sue Mitchell, Diane Wallace

Contributors: M. Abels, S. Akasofu, P.A. Anderson, R. Anderson, B. Barnes, R. Behnke, S. Bishop, G. Brass, A. Brekke, E. Burch, J. Calder, V. Carney, F.S. Chapin III, M. Chapin, W. Chapman, D. Chayes, L. Clough, B. Coakley, J. Cochran, L. Codispoti, P. Collings, T. Cooley, L. Cooper, R. Crain, J. Dionne, M. Duvall, M.E. Edwards, M.H. Edwards, C. Elfring, R. Elsner, E. Engman, K. Erb, J. Ferris, C. Flemming, L. Frank, J. Grebmeier, B. Hansen, S. Hastings, J. Hawkey, C. Heinselman, G. Holton, H. Huntington, M. Jakobsson, J. Kelly, F. Korsmo, J. Kruse, G. Kurras, M. Ledbetter, G. MacDonald, R. MacPhee, M. McClaren, J. Moore, J. Morison, R. Moritz, S. Ortega, J. Overland, M. Paxton, L. Polyak, T. Pyle, R.O. Rasmussen, A. Rios, B. Robinson, O. Rogne, M. Rognstad, V. Romanovsky, K. Ruth, P. Schlosser, J. Semeter, G. Sheehan, C. Shock, R. Smith, W. Steffen, T. Stevens, N. Swanberg, N. Taylor, H. VanKoughnett, J. Walsh.

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

October 1–5 Bering Sea Summit 2001. **Postponed to April 22–26, 2002.** Anchorage, AK. Contact Suzanne Marcy at the Environmental Protection Agency in Anchorage (907/271-2895; fax 907/271-3424; marcy.suzanne@epa.gov).

October 18–19 Beringia Days 2001. Anchorage, AK. Sponsored by the National Park Service and the Anchorage Museum of History and Art. See www.nps.gov/akso/beringia/.

October 25–27 Arctic Feedbacks to Global Change. Rovaniemi, Finland. Sponsored by the Nordic Arctic Research Programme and the Academy of Finland. Contact Peter Kuhry at the Arctic Centre in Rovaniemi, Finland (+358/16341-2755; fax +358/16341-2777; peter.kuhry@urova.fi), or see www.urova.fi/home/arktinen/feedback.htm.

October 31–November 2 Changes in Climate & Environment at High Latitude. Tromsø, Norway. Arranged by the Norwegian Polar Institute and the University of Tromsø. Contact Conference Secretary Kai-Rune Mortensen (+47/7764-4428; fax +47/7764-5600; kairm@ibg.uit.no), or see www.ibg.uit.no/geologi/konferanser/clienvir/.

November 5–7 The Arctic Ocean—Progress in Arctic Ocean Research of the Past Decades. The Royal Swedish Academy of Sciences, Stockholm, Sweden. Contact Leif G. Anderson at Göteborg University in Sweden (+46/31772-2774; fax +46/31772-2785; leif@amc.chalmers.se), or see www.polar.kva.se/aktuellt/the_arctic_ocean2001.html.

November 14–16 Ocean-Atmosphere-Ice Interactions (OAII) All-Hands Meeting. Salt Lake City, UT. Contact Jane Hawkey in Cambridge, MD (410/221-8416; fax 410/221-8490; hawkey@hpl.umces.edu), or see the OAII web site (http://arcss-oaii.hpl.umces.edu/AllHands/Mtg2001.html).

November 14–17 Land-Atmosphere-Ice Interactions (LAII) All-Hands Meeting. Salt Lake City, UT. Contact Patricia A. Anderson in Fairbanks, AK (907/474-5415; fax 907/474-6722; patricia@iarc.uaf.edu), or see the LAII web site (www.laii.uaf.edu/mtg.htm).

November 26–30 Arctic Coastal Dynamics Workshop. Potsdam, Germany. Contact Volker Rachold in Potsdam (+49/471-4831-1202; fax +49/471-4831-1149; vrachold@awi-potsdam.de), or see www.awi-potsdam.de/www-pot/geo/acd.html.

February 20–23, 2002 Arctic System Science (ARCSS) Program All-Hands Workshop. Seattle, WA. Contact Alison York at ARCUS in Fairbanks, AK (907/474-1600; fax 907/474-1604; york@arcus.org), or see the ARCUS web site (www.arcus.org/ARCSS/allhands2002/).

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

Publications

Conservation of Arctic Flora and Fauna (CAFF). 2001. *Arctic Flora and Fauna: Status and Conservation*. Edita, Helsinki. 272 pp. Contact Jukka Helisjoki in Helsinki, Finland (+358/20-4502248; fax +358/20-4502380; jukka.helisjoki@edita.fi). 375 Fmk, including shipping and handling (approximately $58 U.S.). Edita accepts Visa, MC, Euro, and Amex cards.

United Nations Environment Programme (UNEP). 2001. *GLOBIO. Global methodology for mapping human impacts on the biosphere. The Arctic 2050 scenario and global application.* UNEP/DEWA/TR.01-3. Available as a PDF file at www.grida.no/prog/polar/globio.

Vörösmarty, C.J., L.D. Hinzman, B.J. Peterson, D.H. Bromwich, L.C. Hamilton, J. Morison, V.E. Romanovsky, M. Sturm, and R.S. Webb. 2001. *The Hydrologic Cycle and its Role in Arctic and Global Environmental Change: A Rationale and Strategy for Synthesis Study.* Arctic Research Consortium of the U.S., Fairbanks, AK. 84 pp. Contact ARCUS.

A Note from the President

The ARCUS Washington, DC, office opened in September 2000 to provide science policy information to ARCUS members, and to act as a liaison between ARCUS members and key federal and congressional staff. ARCUS members have long urged the organization to develop a presence in our nation's capital.

ARCUS Federal Liaison Suzanne Bishop has begun working on issues and activities that will provide useful information to our members, including:

- tracking and advocating for the FY 2002 and 2003 budgets of the many federal agencies that fund or influence arctic research, including NSF, the departments of Commerce, Agriculture, Defense, Interior, NASA, and the Smithsonian Institution;
- working and sharing information with agency staff on a variety of issues, including briefings on ARCUS capabilities, member concerns, and other pertinent information;
- providing assistance to member representatives visiting the DC area, including help finding agency staff, directions to agency buildings, etc.;
- publication and advocacy support of SEARCH, a project of the Interagency Working Group of IARPC (see page 3);
- providing briefing papers on relevant topics, requests for member action, and other materials to the ARCUS Board of Directors and membership; and
- participating in a June 2001 exhibition on Capitol Hill for congressional members and staff, sponsored by the Coalition for National Science Funding, of which ARCUS is now a member.

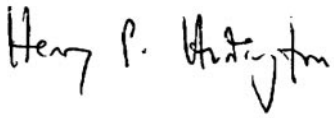
At the 2001 ARCUS annual meeting, Bishop organized and moderated a panel presentation entitled "Arctic Science Takes the Hill." Panelists were:

- Allen Cutler, then-majority staff member for the Senate Budget Committee;
- George Leventhal, senior federal relations officer for the Association of American Universities;
- David Verardo, director of Paleoclimate Programs at NSF; and
- Garry Brass, executive director of the U.S. Arctic Research Commission (see page 19).

This distinguished panel discussed a wide range of issues, including information about contacting one's congressional delegation, protocol for requesting help on a particular issue, and issues important to the arctic research community on the Hill.

More information about the panel, issues and policies, Capitol Hill, and other topics can be found on the new ARCUS Washington, DC, web pages (www.arcus.org/washington).

We encourage all of our members to use the DC office as a resource whenever they need science policy information. The knowledge we gain from having "eyes and ears in DC" will help our members be more effective and active advocates for arctic research.



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ARCUS

Arctic Research Consortium of the United States

3535 College Road
Suite 101
Fairbanks, AK
99709
USA

Non-Profit Org.
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Anchorage, AK

The Conceptual Challenges of Climate Change Education

by Milton McClaren

This article has been abstracted from "The Conceptual Challenges of Education About Climate Change," published in Clearing *109, Spring 2001, by Creative Educational Networks Environmental Education Project.* *Milton McClaren is an emeritus professor of education at Simon Fraser University in Burnaby, British Columbia. His email address is mcclaren@sfu.ca.*

The release of the most recent report of the Intergovernmental Panel on Climate Change has renewed discussions of environmental education responses to this global issue. Environmental education and information programs directed at both students and the general public are often elements of policy proposals to address these potential changes. Environmental educators and curriculum developers are challenged to develop materials and instructional approaches to help the public understand climate change and think critically about various options and proposals to address its consequences and reduce human influences on climate.

The challenges of education about climate change confront environmental educators with important questions about the differences among education, information, and indoctrination and require educators to blend the best of current knowledge about learning with the best of current earth science.

Modern learning theory is grounded on three fundamental propositions:

- new learning is influenced by prior knowledge and experiences. Learners do not come to learning situations as blank slates ready to be impressed with the right stuff. Their prior knowledge and experiences exert an active influence on new learning.
- learning for deep understanding requires both a body of content and a set of organizing concepts through which the content becomes meaningful and transferrable to other situations.
- learners can be taught things about their own learning that will help them monitor their own progress, make appropriate adjustments to their approaches, and become effective self-regulators of their learning processes.

These three ideas present learners as active participants in their education. I will focus this paper largely on the first concept, and to a lesser extent on the second, and try to show how these ideas apply to education about climate change.

Prior Knowledge and Misconceptions

When learners begin to develop their understanding of climate change or other global changes, their existing ideas, knowledge, and personal experiences affect what they will learn and how they will learn it. New learning may require learners to modify existing ideas and assumptions, or it may challenge preconceptions and create dissonance or disbelief. In both situations, the learner plays an active role, and teachers and curriculum developers assist by creating and selecting experiences, resources, and activities that engage the learner with new ideas and information in ways that provoke thinking.

The challenges of education about climate change confront environmental educators with important questions about the differences among education, information, and indoctrination and require educators to blend the best of current knowledge about learning with the best of current earth science.

If students view the Earth as a relatively static, unchanging planet or as one in which major changes ended with the appearance of humans, this will influence how they think about and learn new ideas and information about global climate change. If students have misconceptions about processes such as the water cycle, photosynthesis, or the role of solar energy in the climate, it will be difficult for them to learn and apply new ideas. Misconceptions often don't simply "go away" when learners are presented with correct concepts and accurate information; they remain active and can shape future reasoning in surprisingly durable ways.

Learning for deep understanding means that learners change their minds and literally see the world through different conceptual lenses. To accomplish this, teachers and program developers must allow learners to consider their ideas in light of new experiences and information and to question, challenge, explore, investigate, puzzle, tinker, and ultimately construct new knowledge structures. As educators (or parents and mentors), we can model learning and thinking through our own behaviors, nurture critical thinking and questioning, and provide learners with resources to support inquiry.

None of this is radically new in educational thought, but it should be clearly affirmed as we consider education about climate change. Let me turn now to the consideration of specific conceptual areas in which climate change presents particular educational challenges and opportunities.

Climate and Weather

People think about climate through the weather they actually experience. Students confronted with a record cold winter or severe ice storm may find the idea of global warming confusing. It is important to help students distinguish between climate and weather and to understand that increases in Earth's average temperature could change climate patterns in ways that result in colder, more snowy conditions in some areas; this is not proof that global warming predictions are in error.

Changes on Top of Changes

The idea that the Earth is a dynamic, changing system is a critical concept in environmental education. It is essential that students appreciate that the Earth's climate has changed significantly in the

continued on next page

past and will be different in the future. If students think of the Earth in the past as largely being the same as at present, they need opportunities to explore the non-human forces that have changed the Earth in the past before they can begin to develop an understanding of how humans may now be affecting the climate and of the possible consequences of climate change.

Greenhouse Effect

Because people know that the greenhouse effect is caused by carbon dioxide, they think that CO_2 must be abundant in the atmosphere. One way to test students' prior knowledge of this topic is to ask them to make pie charts in which the size of each pie sector corresponds to the percentage of each gas in the atmosphere. Students need to appreciate that gases like CO_2 and ozone comprise very small fractions of the total gas volume of the atmosphere. When greenhouse gases are termed "pollutants," students tend to think of solving the global warming problem by somehow taking CO_2 out of the air or by stopping its production, as the problem of ozone depletion was "solved" by taking CFCs out of aerosol cans and coolants.

Teachers should ask students to discuss the meaning of terms like greenhouse effect, greenhouse gas, and global warming; teachers also need to know what students already understand about the Sun's energy and its actions on the Earth, including:

- How much of incoming solar energy is reflected by clouds, ice, water, or snow, absorbed by land and seas, or used by plants in photosynthesis?
- When solar energy causes heating, what does the heat energy do?
- Do students understand that energy is not created or destroyed in normal physical/chemical reactions when it comes to how solar energy drives planetary processes such as the water cycle?

If students have major misconceptions in these areas it will be difficult for them to develop a solid understanding of the way greenhouse gases work in the atmosphere. Students need ample time to make their own charts and diagrams, ask questions, try out ideas and propositions, make models, do basic research, and go to source materials to sort out and reconstruct their existing ideas and build new ones based on accurate concepts.

Technology as Solution and Problem

Some claim that in the time it will take for global climate change to become a serious problem, engineers and scientists will figure out technical solutions to address it. The educational challenge is to have students consider the costs and benefits of various approaches to addressing human impacts on climate, including the option of continuing on the current course of increasing use of fossil fuels. In this case, students should appreciate that doing nothing is in fact an action and has consequences as well. Students need to be able to use their critical thinking skills to consider the consequences of various technological options, in both the short and longer term.

Our task as educators is not to advocate particular policies or solutions but to invite students to consider the best available scientific evidence and to review the options proposed by politicians, lobbyists, and advocacy groups with a clear understanding of that evidence and of the procedures that scientists use to gather data, test hypotheses, and weigh claims. Because climate change is a topic about which people disagree and have many different perspectives, it is a rich field for the integration of science with other forms of knowledge.

Positive Feedbacks

The release of methane from thawing permafrost is an example of a positive feedback in which warming results in processes that result in even further warming in an upward spiral of accelerating climate changes. The concepts of positive *vs.* negative feedbacks are critical for students to grasp as they develop their understanding of the mechanisms that cause climate change. An understanding of positive feedbacks will help students realize the difficulties inherent in predicting future changes and that it is unwise to assume that even current rates of fairly rapid climate change will continue. Possible "surprises" need to be considered as students weigh arguments about costs and benefits or risk.

Life on the Earth versus Life of the Earth

Many people seem to view the biogeosphere as a passive environment in which humans live relatively separate from the rest of the natural system. In contrast, students need to understand that every atom and molecule in our bodies derives from the planet and has been cycled through the natural system, as well as how life has shaped the planet. The best example of this is the present oxygen-rich atmosphere. When students consider whether or not living things, like humans, can affect the destiny of an entire planet, they should remember the oxygen they breathe as an immediate example of the world-shaping capacities of life.

Educational Challenges and Opportunities

Climate change is an example of an area where normal global geobiospheric processes can be influenced by human activities, even though humans aren't in control. The challenge for environmental educators is to develop programs that provide opportunities for students to develop a better and more durable understanding of these fundamental processes and invite them to think critically about the human dimensions of global changes in personal, individual terms.

Our task as educators is not to advocate particular policies or solutions but to invite students to consider the best available scientific evidence and to review the options proposed by politicians, lobbyists, and advocacy groups with a clear understanding of that evidence and of the procedures that scientists use to gather data, test hypotheses, and weigh claims. Because climate change is a topic about which people disagree and have many different perspectives, it is a rich field for the integration of science with other forms of knowledge, including economics, politics, ethics, history, and anthropology. The study of global climate change is a wonderful opportunity to engage students in thinking critically about important topics that are likely to affect the quality of their lives and those of the species with which we share the Earth. ■

Aspects of Traditional Iñupiat Education

by Paul Ongtooguk

This article has been abstracted from "Aspects of Traditional Iñupiat Education," published in Sharing Our Pathways *Volume 5, Issue 4, Sept/Oct 2000, by the Alaska Rural Systemic Initiative. Paul Ongtooguk is a senior research associate at the Institute of Social and Economic Research, University of Alaska, Anchorage, and member of the project team for Alaska Native Studies Curriculum and Teacher Development Project (www.alaskool.org). His email address is afpo@uaa.alaska.edu.*

Traditional Iñupiat society was, and is, about knowing the right time to be in the right place, with the right tools, to take advantage of a temporary abundance of resources. Such a cycle of life was, and is, based on a foundation of knowledge about and insight into the natural world. Such a cycle of life was, and is, dependent upon a people's careful observations of the environment and their dynamic response to changes and circumstances. Developing this cycle of life was critical to the continuance of traditional Iñupiat society. Also critical was a system to share this knowledge and insight with the next generation.

While some elements of traditional ways of learning have survived decades of societal change, they tend to be fragmented and difficult to recognize as portions of an entire way of learning. One of the most credible sources is the personal story. The examples that follow are personal and illustrate how the role of the male hunter was learned by boys in a contemporary Iñupiat community.

Observation and Apprenticeship

Observation, beginning at a very early age and continuing for years, is a critical element of the traditional educational system. The first knowledge about hunting comes as boys watch how hunters prepare their equipment, their clothing, and themselves. At first the boy observes how relatively easy it seems to load a boat, for example. Later, he notices the balance of the load, what will be readily needed, what must not be allowed to sit under the load, what knots should be used to properly tie things down in the various parts. What had appeared simple at the first observation gradually becomes extremely complicated as the issues are understood. The sophisticated observer finally extracts the principles that become the threads by which what has been "seen and done" is understood.

Often a young hunter is guided by an uncle in another aspect of traditional education, an apprenticeship. When apprentice hunters begin going to a hunting camp they might spend most of their time on chores like hauling water and collecting firewood. While out at camp, the young boy learns about:

- good locations for certain animals, fish, or materials during certain seasons;
- locating the hunting camp;
- what equipment to bring for certain areas and for different kinds of hunting, fishing, or trapping;
- terrain, travel routes, and hazards;
- local weather and basic weather prediction; and
- maintaining hunting equipment.

A boy would also begin to observe the techniques and skills used by hunters in locating and stalking an animal. The apprentice hears the male hunters discuss the nature of the hunt and anything learned, anything unusual or notable. Often the discussion revolves around how and why things turned out the way they did. The apprentice is taught to think about what he is going to do and to ask himself: What can go wrong? What are the dangers? He learns not to take unnecessary risks, because the necessary ones are dangerous enough.

Stories and Customs

Before his first hunt, the child has listened to hunting stories for years, learning about the traditions, values, and beliefs associated with hunting in an Iñupiat community. As a result of the entertaining and informative stories told by Elders and veteran hunters, the young child constructs a mental image of all that is required and some sense of the important aspects of preparing and engaging in the hunt. The stories often stress how clever, thoughtful, and ingenious a person has been in becoming successful as a hunter and a provider to the community. Many of the stories emphasize the attitude of the hunter, condemning bragging and pride in personal accomplishment while encouraging respect for the hunted animal. Pride and arrogance can be fatal in the Arctic where the best lesson to keep in mind is how little we actually know and how easily we can be swept from the world.

The Community as a School

In traditional Iñupiat society, the community is a school. Older men tell stories about everything, and the stories are the lessons. When, where, and what lessons occur are dependent upon the time, the place, and the season. The lessons are tied to the traditional cycle of life.

Preservation of the communities and societies depends on the cooperation of its members, and the apprenticeship is best understood in traditional Iñupiat education as occurring within the context of a community of hunters. While the apprentice might focus on a particular task, the task is a part of the larger context—the realities of the hunting community.

An educational goal of traditional Iñupiat society is a careful preparation of the young for the roles of adults. The values of traditional Iñupiat education include cooperation and intense effort. These values are rewarded in many ways, including the satisfaction that the hunter feels when people are fed and he knows that he has contributed to the effort that has provided some of the food.

This description is only a fraction of the traditional educational system. Knowledge about the traditional educational system of Alaska Natives might, even today, result in schools that are more completely integrated into our communities.

This essay is an attempt to break some of the stereotypes about the Iñupiat that persist in American society and by doing so to promote better opportunities for Native students.

The Scientist's Guide to Making Classroom Visits

The following are some suggestions on how to make the transition from your research site to the classroom, adapted from The Scientist's Guide to Making Classroom Visits, *with permission from the Alaska Mineral and Energy Resource Education Fund. For a copy of the complete booklet, contact them at 907/276-0700.*

One of the best tools any classroom teacher can have is a person who knows and understands science. Scientists in the classroom can help students:

- understand how science is used in the real world,
- see scientists as real people and role models,
- develop a sense of how science and other subjects work together, and
- understand the role of science in day-to-day living.

Before Your Visit

Discuss with the teacher:

- how your topics can fit in with what the class is currently learning,
- how it will be covered both before and after your visit,
- background information already covered, and
- exactly what you will present to the class.

You may want to suggest resources, provide the teacher with background material to introduce before your visit, or develop a worksheet or an activity to follow up on your presentation. Have the teacher get the students to develop two or three questions each about your topic to stimulate discussion.

Tailor the length and style of your presentation to the age group of the class:

- Kindergarten students: up to 20 minutes. This group especially likes hands-on items and activities and will ask lots of questions.
- Grades 1–3: 20 to 30 minutes. Visuals and hands-on objects or activities always engage students. Expect questions and stories.
- Grades 4–6: 45 to 60 minutes. Visuals and activities are more effective for the longer presentation. Consider including a short assignment (worksheet) or question/answer session. If possible, incorporate technology into your presentation.
- Grades 7–12: Presentations 50 minutes or longer. The length usually depends on class schedules. As with younger students, the more engaging your activities and items, the more interactive the students will be.

"Wiggles" by any grade level indicate a need for a change in pace or activity. Bring along cool gadgets, items that you work with, and pictures. Pictures should be large enough to be seen, and objects for handling by students should be safe.

During Your Presentation

Introduce yourself. Tell the class why you are visiting. Ask questions to determine what they already know about the topic. Tie your topic into what they have been studying. Tell them what to expect out of your visit.

Have the students answer some basic questions before beginning. Examples: "What are the three basic types of rocks?" "What do you think geologists do?"

Be sure to discuss why you became a scientist. What makes you excited about the work you do? How does your work affect their lives? Give an example if you can and have them come up with some. Discuss how technology is a part of your work.

Review as you go. Make connections about what you said and did by asking questions. Have them make connections.

Provide a way for the student to use the information you have presented them. Have them do an experiment, play a game, or do a worksheet that you and/or the teacher developed for that purpose. Actually work directly with the students if they are engaged in an activity.

At the end of the presentation, ask the students three or four review questions and have them tie in personal experiences or share stories. Remember to leave contact information so they can send you their worksheets, or contact you for more information.

Most of all—remember the enthusiasm and curiosity that drove you to become the scientist you are today. Remember to have fun! ■

ARCUS
3535 College Road, Suite 101
Fairbanks, Alaska 99709 USA
Phone: 907/474-1600
Fax: 907/474-1604
arcus@arcus.org
www.arcus.org

Executive Director: Wendy K. Warnick

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Managing Editor: Alison York
Education Editor: Janet Warburton
Editor/Designer: Marty Peale
Copy Editors: Diane Wallace, Sue Mitchell
Contributors: J. Brune, M. McClaren, P. Ongtooguk.

Selected Science Education Web Sites

www.ankn.uaf.edu
The Alaska Native Knowledge Network (ANKN) compiles and exchanges information related to Alaska Native knowledge systems and ways of knowing. The site includes a searchable database of culturally based curriculum resources.

www.enc.org
The Eisenhower National Clearinghouse for Mathematics and Science Education (ENC) was collects all types of teaching materials for K–12 math and science educators and disseminates information about federally funded programs.

www.globe.gov
Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide, hands-on, primary and secondary school-based science and education program. Their web site offers on-line student activities and resources for both scientists and educators.

www.ericse.org
The Educational Resources Information Center, sponsored by the U.S. Department of Education, provides access to the best information available for teaching and learning about science, mathematics, and the environment.

www.epa.gov/enviro/html/em
The EnviroMapper application provides users with interactive Geographic Information System (GIS) functionality using Environmental Protection Agency (EPA) spatial data, including air releases, drinking water, hazardous wastes, water discharge permits, and Superfund sites.

www.epa.gov/globalwarming/visitorcenter/educators
The Educators' section of this EPA site offers materials on climate change science, potential impacts, and mitigation options. Tools include a Greenhouse Gas Calculator, a Global Warming Wheel Card, case studies, and interactive software to measure energy consumption, impact, and reduction opportunities.

NSF Office of Polar Programs Arctic Section Addresses — Autumn 2001

Arctic Sciences Section • www.nsf.gov/od/opp/arctic/start.htm

Office of Polar Programs (OPP)
National Science Foundation (NSF)
4201 Wilson Boulevard, Suite 755 S
Arlington, VA 22230
Phone: 703/292-8029 • Fax: 703/292-9082

Thomas E. Pyle, *Section Head*
tpyle@nsf.gov

Charles E. Myers, *Head of Interagency Arctic Staff*
cmyers@nsf.gov

Robin Muench, *Program Officer*
rmuench@nsf.gov

Arctic System Science Program (ARCSS)
www.nsf.gov/od/opp/arctic/system.htm

Michael T. Ledbetter, *Program Manager*
mledbett@nsf.gov

Arctic Social Sciences Program
www.nsf.gov/od/opp/arctic/social.htm

Fae L. Korsmo, *Program Manager*
fkorsmo@nsf.gov

Arctic Natural Sciences Program
www.nsf.gov/od/opp/arctic/natural.htm

Jane V. Dionne, *Program Manager*
jdionne@nsf.gov

Neil Swanberg, *Program Manager*
nswanber@nsf.gov

Research Support & Logistics
www.nsf.gov/od/opp/arctic/suplog.htm

Simon N. Stephenson, *Program Manager*
sstephen@nsf.gov

Arctic System Science Program (ARCSS) Program Addresses

ARCSS Program Coordination

ARCSS Committee (AC)
www.arcus.org/ARCSS/ARCSS.html

Jack Kruse, *Chair*
Department of Geosciences
University of Massachusetts
117 N. Leverett Road
Leverett, MA 01054
Phone: 413/367-2240 • Fax: 413/367-0092
jkruse@geo.umass.edu

F. Stuart (Terry) Chapin, III
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757000
Fairbanks, AK 99775-7000
Phone: 907/474-7922 • Fax: 907/474-6967
terry.chapin@uaf.edu

Rudy J. Dichtl
CIRES/National Snow & Ice Data Center
University of Colorado
Campus Box 449
Boulder, CO 80309-0449
Phone: 303/492-5532 • Fax: 303/492-2468
dichtl@kryos.colorado.edu

Lawrence C. Hamilton
Department of Sociology HSSC
University of New Hampshire
20 College Road
Durham, NH 03824-3509
Phone: 603/862-1859 • Fax: 603/862-3558
lawrence.hamilton@unh.edu

O. W. (Bill) Heal
The Granary - Allerwash - Newbrough - Hexham
NE47 5AB Northumberland, UK
Phone/Fax: +44/1434-674-715
b.heal@ed.sac.ac.uk

Lloyd D. Keigwin
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: 508/289-2784 • Fax: 508/457-2183
lkeigwin@whoi.edu

Amanda Lynch
CIRES/Program in Atmospheric & Oceanic Sciences
University of Colorado
Campus Box 216
Boulder, CO 80309-0216
Phone: 303/492-5847 • Fax: 303/492-1149
manda@tok.colorado.edu

Jonathan T. Overpeck
Institute for the Study of Planet Earth
University of Arizona
715 North Park Avenue, 2nd Floor
Tucson, AZ 85721
Phone: 520/622-9065 • Fax: 520/792-8795
jto@u.arizona.edu

Bruce J. Peterson
The Ecosystems Center
Marine Biological Laboratory
Woods Hole, MA 02543
Phone: 508/289-7484 • Fax: 508/457-1548
peterson@mbl.edu

Michael J. Retelle
Department of Geology
Bates College
44 Campus Avenue
Lewiston, ME 04240
Phone: 207/786-6155 • Fax: 207/786-8334
mretelle@bates.edu

John Weatherly
Cold Regions Research & Engineering Laboratory
72 Lyme Road
Hanover, NH 03755
Phone: 603/646-4741 • Fax: 603/646-4644
weather@crrel.usace.army.mil

ARCSS Committee Coordination
www.arcus.org

Wendy K. Warnick, *Executive Director*
Arctic Research Consortium of the United States (ARCUS)
3535 College Road, Suite 101
Fairbanks, AK 99709-3710
Phone: 907/474-1600 • Fax: 907/474-1604
warnick@arcus.org • arcus@arcus.org

ARCSS Data Coordination Center
http://arcss.colorado.edu

Rudy J. Dichtl, *Data Manager*
Cooperative Institute for Research in Environmental Sciences (CIRES)
National Snow & Ice Data Center
University of Colorado
Campus Box 449
Boulder, CO 80309-0449
Phone: 303/492-5532 • Fax: 303/492-2468
dichtl@kryos.colorado.edu

Chris McNeave, *Data Coordinator*
address and fax same as Rudy J. Dichtl
Phone: 303/492-1390
mcneave@kryos.colorado.edu

Published by the Arctic Research Consortium of the United States • 3535 College Road • Suite 101 • Fairbanks, AK 99709

Land-Atmosphere-Ice Interactions (LAII) • www.laii.uaf.edu

LAII Science Steering Committee

F. Stuart (Terry) Chapin, III, *Chair*
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757000
Fairbanks, AK 99775-7000
Phone: 907/474-7922 • Fax: 907/474-6967
terry.chapin@uaf.edu

Jonathan Foley
Center for Climatic Research
University of Wisconsin - Madison
1225 West Dayton Street
Madison, WI 53706-1695
Phone: 608/265-5144 • Fax: 608/262-5964
jfoley@facstaff.wisc.edu

Gail A. Fondahl
NRES/Geography
University of Northern British Columbia
3333 University Avenue
Prince George, BC V2N 4Z9 Canada
Phone: 250/960-5856 • Fax: 250/960-5539
fondahlg@unbc.ca

Bernard Hallet
Quaternary Research Center
University of Washington
P.O. Box 351360
Seattle, WA 98195-1360
Phone: 206/685-2409 • Fax: 206/543-3836
hallet@u.washington.edu

Henry P. Huntington
Huntington Consulting
23834 The Clearing Drive
Eagle River, AK 99577
Phone: 907/696-3564 • Fax: 907/696-3565
hph@alaska.net

Amanda Lynch
CIRES/Program in Atmospheric & Oceanic Sciences
University of Colorado
Campus Box 216
Boulder, CO 80309-0216
Phone: 303/492-5847 • Fax: 303/492-1149
manda@tok.colorado.edu

Roger A. Pielke, Sr.
Department of Atmospheric Science
Colorado State University
Fort Collins, CO 80523
Phone: 970/491-8293 • Fax: 970/491-8449
dallas@cobra.atmos.colostate.edu

Joshua Schimel
Dept. of Ecology, Evolution, & Marine Biology
University of California Santa Barbara
507 Mesa Road
Santa Barbara, CA 93106
Phone: 805/893-7688 • Fax: 805/893-4724
schimel@lifesci.lscf.ucsb.edu

Matthew Sturm
Cold Regions Research & Engineering Laboratory
PO Box 35170
Ft. Wainwright, AK 99703-0170
Phone: 907/353-5183 • Fax: 907/353-5142
msturm@crrel.usace.army.mil

Marilyn Walker
School of Agriculture & Land Resources Management
University of Alaska Fairbanks
PO Box 756780
Fairbanks, AK 99775-6780
Phone: 907/474-2424 • Fax: 907/474-6251
mwalker@lter.uaf.edu

Robert G. White
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757000
Fairbanks, AK 99775-7000
Phone: 907/474-7028 • Fax: 907/474-6967
ffrgw@uaf.edu

LAII Science Management Office

F. Stuart (Terry) Chapin, III, *Director*
address, phone & fax same as above
terry.chapin@uaf.edu

Patricia A. Anderson, *Deputy Director*
Center for Global Change & Arctic System Research
University of Alaska Fairbanks
PO Box 757740
Fairbanks, AK 99775-7740
Phone: 907/474-5698 • Fax: 907/474-6722
patricia@iarc.uaf.edu

LAII and OAII to Meet November 2001

Ocean-Atmosphere-Ice Interactions (OAII) and Land-Atmosphere-Ice Interactions (LAII) investigators will hold their annual all-investigator meetings in mid-November 2001 in Salt Lake City, Utah.

OAII All-Hands Meeting

The OAII All-Hands Meeting will convene 14–16 November 2001. In addition to poster sessions on general arctic science activities and OAII research and outreach, researchers will present proposals for initiatives dealing with atmospheric and near-shore processes. For more information, registration, and the agenda, see the OAII web site (http://arcss-oaii.hpl.umces.edu/AllHands/Mtg2001.html), or contact Jane Hawkey in Cambridge, MD (410/221-8416; fax 410/221-8490; hawkey@hpl.umces.edu).

LAII All-Hands Meeting

The LAII All-Hands Meeting will convene 14–17 November 2001. Investigators in the International Tundra Experiment (ITEX), Arctic Transitions in the Land-Atmosphere System (ATLAS), and Russian-American Initiative on Shelf-Land Environments in the Arctic (RAISE) projects will meet separately for part of the meeting to supplement the plenary and poster sessions. For more information and the agenda, see the LAII web site (www.laii.uaf.edu/mtg.htm), or contact Patricia A. Anderson in Fairbanks, AK (907/474-5415; fax 907/474-6722; patricia@iarc.uaf.edu).

Joint Meetings for OAII or LAII Registrants

A morning plenary session on 15 November 2001, open to registrants from either meeting, will bring together OAII, LAII, RAISE, and PARCS investigators to

- update one another on the various components' activities and initiatives,
- foster interdisciplinary discussions, and
- identify the contributions needed to facilitate an effective ARCSS All-Hands Meeting in February 2002.

The OAII, LAII, and RAISE Science Steering Committees will meet jointly on the afternoon of 16 November 2001 to follow up on the plenary discussions.

In addition, the Barrow Arctic Science Consortium (BASC) Science Advisory Group will convene an open meeting on the evening of 15 November 2001, followed by an informational session. For more information, see the BASC web site (www.sfos.uaf.edu/basc), or contact Glenn Sheehan in Barrow, AK (907/852-4881; fax 907/852-4882; basc@nuvuk.net).

Ocean-Atmosphere-Ice Interactions (OAII) • http://arcss-oaii.hpl.umces.edu

OAII Science Steering Committee

Louis A. Codispoti, *Chair*
Center for Environmental Science
Horn Point Laboratory
University of Maryland
PO Box 775
Cambridge, MD 21613-0775
Phone: 410/221-8479 • Fax: 410/221-8490
codispot@hpl.umces.edu

Richard A. Caulfield
Dept. of Alaska Native & Rural Development
University of Alaska Fairbanks
PO Box 756500
Fairbanks, AK 99775-6500
Phone: 907/474-5573 • Fax: 907/474-6325
ffrac@uaf.edu

Dennis A. Darby
Dept. of Ocean, Earth, & Atmospheric Sciences
Old Dominion University
4600 Elkhorn Avenue
Norfolk, VA 23529-0276
Phone: 757/683-4701 • Fax: 757/683-5303
ddarby@odu.edu

Thomas L. Delworth
Geophysical Fluid Dynamics Laboratory
National Oceanic & Atmospheric Administration
PO Box 308
Princeton, NJ 08542-0308
Phone: 609/452-6565 • Fax: 609/987-5063
td@gfdl.gov

Hajo Eicken
Geophysical Institute
University of Alaska Fairbanks
PO Box 757320
Fairbanks, AK 99775-7320
Phone: 907/474-7280 • Fax: 907/474-7290
hajo.eicken@gi.alaska.edu

Kelly K. Falkner
College of Oceanic & Atmospheric Sciences
Oregon State University
104 Ocean Administration Building
Corvallis, OR 97331-5503
Phone: 541/737-3625 • Fax: 541/737-2064
kfalkner@oce.orst.edu

Jacqueline M. Grebmeier
Department of Ecology & Evolutionary Biology
University of Tennessee
10515 Research Drive, Suite 100, Building A
Knoxville, TN 37932
Phone: 865/974-2592 • Fax: 865/974-7896
jgrebmei@utk.edu

Dan Lubin
California Space Institute
University of California at San Diego
9500 Gilman Drive
La Jolla, CA 92093-0221
Phone: 858/534-6369 • Fax: 858/534-7452
dlubin@ucsd.edu

Robie W. Macdonald
Institute of Ocean Sciences
Department of Fisheries & Oceans
PO Box 6000
Sidney, BC V8L 4B2 Canada
Phone: 250/363-6409 • Fax: 250/363-6807
macdonaldrob@dfo-mpo.gc.ca

Patricia A. Matrai
Bigelow Laboratory for Ocean Sciences
180 McKown Point Road
West Boothbay Harbor, ME 04575-0475
Phone: 207/633-9614 • Fax: 207/633-9641
pmatrai@bigelow.org

Don K. Perovich
Cold Regions Research & Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290
Phone: 603/646-4255 • Fax: 603/646-4644
perovich@crrel.usace.army.mil

Albert J. Semtner
Department of Oceanography
Naval Postgraduate School
833 Dyer Road, Room 328
Monterey, CA 93943-5122
Phone: 831/656-3267 • Fax: 831/656-2712
sbert@meeker.ucar.edu

Paul B. Shepson
Departments of Chemistry, Earth & Atmospheric Sciences
Purdue University
1393 Brown Building
West Lafayette, IN 47907-1393
Phone: 765/494-7441 • Fax: 765/494-0239
pshepson@purdue.edu

John Weatherly
Cold Regions Research & Engineering Laboratory
72 Lyme Road
Hanover, NH 03755
Phone: 603/646-4741 • Fax: 603/646-4644
weather@crrel.usace.army.mil

Andrew Weaver
School of Earth & Ocean Sciences
University of Victoria
PO Box 3055
Victoria, BC V8W 3P6 Canada
Phone: 250/472-4001 • Fax: 250/472-4004
weaver@ocean.seos.uvic.ca

Thomas Weingartner
Institute of Marine Science
University of Alaska Fairbanks
PO Box 757220
Fairbanks, AK 99775-7220
Phone: 907/474-7993 • Fax: 907/474-7204
weingart@ims.uaf.edu

OAII Science Management Office

Louis A. Codispoti, *Director*
Address, phone & fax same as above
codispot@hpl.umces.edu

Jane Hawkey, *SMO Manager*
address and fax same as Louis A. Codispoti
Phone: 410/221-8416
hawkey@hpl.unces.edu

Paleoenvironmental Arctic Sciences (PARCS) • www.ngdc.noaa.gov/paleo/parcs

PARCS Steering Committee

Mary E. Edwards, *Co-Chair*
Geografisk Institutt
Norwegian University of Science & Technology
N-7034 Trondheim, Norway
Phone: +47/7359-1915 • Fax: +47/7359-1878
mary.edwards@sv.ntnu.no

Glen M. MacDonald, *Co-Chair*
Departments of Geography and Organismic Biology, Ecology, & Evolution
University of California Los Angeles
405 Hilgard Avenue
Los Angeles, CA 90095-1524
Phone: 310/825-2568 • Fax: 310/206-5976
macdonal@geog.ucla.edu

Patrick J. Bartlein
Department of Geography
University of Oregon
Eugene, OR 97403-1251
Phone: 541/346-4967 • Fax: 541/346-2067
bartlein@oregon.uoregon.edu

Julie Brigham-Grette
Department of Geosciences
University of Massachusetts
Morrill Science Center
Campus Box 35820
Amherst, MA 01003-5820
Phone: 413/545-4840 • Fax: 413/545-1200
brigham-grette@geo.umass.edu

Marianne Douglas
Department of Geology
University of Toronto
22 Russell Street
Toronto, ON M5S 3B1 Canada
Phone: 416/978-3709 • Fax: 416/978-3938
msvd@opal.geology.utoronto.ca

Mathieu Duvall
Quaternary Research Center AK-60
University of Washington
Box 351360
Seattle, WA 98195
Phone: 206/543-0569 • Fax: 206/543-3836
duvall@u.washington.edu

Bruce P. Finney
Institute of Marine Science
University of Alaska Fairbanks
PO Box 757220
Fairbanks, AK 99775-7220
Phone: 907/474-7724 • Fax: 907/474-7204
finney@ims.uaf.edu

Aslaug Geirsdottir
Department of Geosciences
University of Iceland
Jardfraedahus Haskolans
IS-101 Reykjavik, Iceland
Phone: +354/5254477 • Fax: +354/5254499
age@rhi.hi.is

Malcolm K. Hughes
Laboratory of Tree-Ring Research
University of Arizona
105 W. Stadium, Building 58
Tuscon, AZ 85721
Phone: 520/621-6470 • Fax: 520/621-8229
mhughes@ltrr.arizona.edu

Anne Jennings
Institute of Arctic & Alpine Research
University of Colorado
Campus Box 450
Boulder, CO 80309-0450
Phone: 303/492-7621 • Fax: 303/492-6388
jenninga@spot.colorado.edu

Anatoly V. Lozhkin
Northeast Interdisciplinary Scientific Research Institute—Far East Branch
Russian Academy of Sciences
16 Portovaya Street
685000 Magadan, Russia
Phone: +7/413-223-0944
Fax: +7/413-223-0051
lozhkin@neisri.magadan.su

Gifford H. Miller
Institute of Arctic & Alpine Research
University of Colorado
Campus Box 450
Boulder, CO 80309-0450
Phone: 303/492-6962 • Fax: 303/492-6388
gmiller@colorado.edu

Bette L. Otto-Bliesner
Climate Change Research
National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307
Phone: 303/497-1723 • Fax: 303/497-1348
ottobli@ncar.ucar.edu

Michael J. Retelle
Department of Geology
Bates College
44 Campus Avenue
Lewiston, ME 04240
Phone: 207/786-6155 • Fax: 207/786-8334
mretelle@bates.edu

Gregory A. Zielinski
Institute for Quaternary & Climate Studies
University of Maine
Orono, ME 04469-5790
Phone: 207/581-3441 • Fax: 207/581-1203
gzielinski@maine.edu

Human Dimensions of the Arctic System (HARC) • www.arcus.org/harc

Web-based Workshops for HARC Investigators

To facilitate interdisciplinary discussion and development of HARC research themes, the HARC Science Management Office (see page 8) is planning three web-based workshops as an innovative and convenient way for researchers from different disciplines to discuss aspects of human dimensions research. Each workshop will be active around the clock for one week and is open to anyone who wishes to participate:

- Arctic Weather: Implications of changing weather patterns in the Arctic
  5-9 November 2001 Moderators: John Walsh and Henry Huntington
- Northern Treeline: Location of the arctic treeline and its implications for humans
  26-30 November 2001 Moderators: Sakari Kankaanpaa and Frans Wielgolaski
- Sea Ice: Effects of sea ice changes on coastal communities
  3-7 December 2001 Moderators: Jim Maslanik and Igor Krupnik

Detailed announcements will be disseminated through Arctic Info (to subscribe, see www.arcus.org/arcticinfo/fr_subscription.html) and on the HARC web site (http://www.arcus.org/harc). Through these and subsequent workshops, the SMO hopes to help the research community identify important questions about human dimensions in the Arctic and build collaborative and creative approaches to answering them.

HARC Science Management Office

Henry P. Huntington, *Director*
Huntington Consulting
23834 The Clearing Drive
Eagle River, AK 99577
Phone: 907/696-3564 • Fax: 907/696-3565
hph@alaska.net

Renée Crain, *Project Manager*
Arctic Research Consortium of the United States (ARCUS)
3535 College Road, Suite 101
Fairbanks, AK 99709-3710
Phone: 907/474-1600 • Fax: 907/474-1604
renee@arcus.org • arcus@arcus.org

ARCUS Board of Directors

Henry P. Huntington, *President*
Huntington Consulting
23834 The Clearing Drive
Eagle River, AK 99577
Phone: 907/696-3564 • Fax: 907/696-3565
hph@alaska.net

Lilian Alessa
Department of Biology
University of Alaska Anchorage
3211 Providence Drive
Anchorage, AK 99508
Phone: 907/786-1507 • Fax: 907/786-4607
lil@uaa.alaska.edu • www.uaa.alaska.edu

Raymond S. Bradley
Department of Geosciences
University of Massachusetts
Morrill Science Center
Campus Box 35820
Amherst, MA 01003-5820
Phone: 413/545-2120 • Fax: 413/545-1200
rbradley@geo.umass.edu • www.umass.edu

Harald Gaski
Faculty of Humanities–Department of Sámi
University of Tromsø
N-9037 Tromsø, Norway
Phone: +47/7764-4259 • Fax: +47/7764-4239
harald.gaski@hum.uit.no • www.uit.no

Taqulik Hepa
Department of Wildlife Management
North Slope Borough
PO Box 69
Barrow, AK 99723
Phone: 907/852-0350 • Fax: 907/852-0351
thepa@co.north-slope.ak.us

David R. Klein
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757020
Fairbanks, AK 99775-7020
Phone: 907/474-6674 • Fax: 907/474-6967
ffdrk@uaf.edu • www.uaf.edu

Daniel H. Mann, *Treasurer*
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757000
Fairbanks, AK 99775-7000
Phone: 907/474-2419 • Fax: 907/474-6967
dmann@mosquitonet.com • www.uaf.edu

Wieslaw Maslowski, *Executive Committee*
Department of Oceanography-Code OC/Ma
Naval Postgraduate School
833 Dyer Road, Room 331
Monterey, CA 93943-5122
Phone: 831/656-3162 • Fax: 831/656-2712
maslowsk@ucar.edu • www.nps.navy.mil

Michael J. Retelle, *Secretary*
Department of Geology
Bates College
44 Campus Avenue
Lewiston, ME 04240
Phone: 207/786-6155 • Fax: 207/786-8334
mretelle@bates.edu • www.bates.edu

Mark C. Serreze
CIRES/National Snow & Ice Data Center
University of Colorado Boulder
Campus Box 216
Boulder, CO 80309-0449
Phone: 303/492-2963 • Fax: 303/492-1149
serreze@coriolis.colorado.edu •
www.colorado.edu

John E. Walsh
Department of Atmospheric Sciences
University of Illinois-Urbana
105 S. Gregory Avenue
Urbana, IL 61801
Phone: 217/333-7521 • Fax: 217/244-4393
walsh@atmos.uiuc.edu • www.uiuc.edu

Patricia A. Wheeler, *Executive Committee*
College of Oceanic & Atmospheric Sciences
Oregon State University
104 Ocean Admin Building
Corvallis, OR 97331-5503
Phone: 541/737-0558 • Fax: 541/737-2064
pwheeler@oce.orst.edu • www.orst.edu

Bernard D. Zak
Environmental Characterization & Monitoring
Systems Department
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185-0755
Phone: 505/845-8631 • Fax: 505/844-0116
bdzak@sandia.gov • www.sandia.gov

ARCUS Member Institutions, Representatives, and Alternates

Alaska North Slope Borough Department of Wildlife Management

www.co.north-slope.ak.us

Thomas A. Albert
Department of Wildlife Management
North Slope Borough
PO Box 69
Barrow, AK 99723
Phone: 907/852-0350 • Fax: 907/852-0351
talbert@co.north-slope.ak.us

Arizona State University

www.asu.edu

Anthony J. Brazel
Department of Geography
Arizona State University
PO Box 870104
Tempe, AZ 85287-0104
Phone: 480/965-6436 • Fax: 480/965-8313
abrazel@asu.edu

Bates College

www.bates.edu

William G. Ambrose
Biology Department
Bates College
44 Campus Avenue
Lewiston, ME 04240
Phone: 207/786-6114 • Fax: 207/786-6123
wambrose@bates.edu

Brown University

www.brown.edu

Douglas D. Anderson
Department of Anthropology
Brown University
PO Box 1921
Providence, RI 02912
Phone: 401/863-7060 • Fax: 401/863-7588
douglas_anderson@brown.edu

The Center for Northern Studies

Steven Young
The Center for Northern Studies
479 Cross Road
Wolcott, VT 05680-4088
Phone: 802/888-4331 • Fax: 802/888-3969
cnsnorth@together.net

Steven Cox
address same as Steven Young
Phone: 802/888-4331 • Fax: 802/888-3969
cnsnorth@together.net

Cold Regions Research & Engineering Laboratory

www.crrel.usace.army.mil

Debra Meese
Snow & Ice Division
Cold Regions Research &
Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290
Phone: 603/646-4594 • Fax: 603/646-4644
dmeese@crrel.usace.army.mil

Walter (Terry) Tucker, III
address same as Debra Meese
Phone: 603/646-4268 • Fax: 603/646-4644
wtucker@crrel.usace.army.mil

Dartmouth College

www.dartmouth.edu

Oran R. Young
Institute of Arctic Studies
Dartmouth College
6214 Fairchild
Hanover, NH 03755-3517
Phone: 603/646-1278 • Fax: 603/646-1279
oran.r.young@dartmouth.edu

Ross A. Virginia
Environmental Studies Program
Dartmouth College
6182 Steele Hall
Hanover, NH 03755-3577
Phone: 603/646-1456 • Fax: 603/646-1682
ross.a.virginia@dartmouth.edu

(continued next page)

ARCUS Member Institutions, Representatives, and Alternates *(continued)*

Desert Research Institute
www.dri.edu

Randy Borys
Storm Peak Laboratory
Desert Research Institute
PO Box 770799
Steamboat Springs, CO 80477-0799
Phone: 970/879-8796 • Fax: 970/879-7819
borys@dri.edu

Joseph R. McConnell
Water Resources Division
Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512
Phone: 775/673-7348 • Fax: 775/673-7363
jmcconn@dri.edu

Embry-Riddle Aeronautical University
www.erau.edu

Gulamabas G. Sivjee
Physical Sciences Department
Embry-Riddle Aeronautical University
600 S. Clyde Morris Boulevard
Daytona Beach, FL 32114-3900
Phone: 904/226-6711 • Fax: 904/226-6713
sivjee@db.erau.edu

John J. Olivero
address same as Gulamabas G. Sivjee
Phone: 904/226-6709 • Fax: 904/226-6713
oliveroj@db.erau.edu

Iḷisaġvik College
http://ilisagvik.co.north-slope.ak.us

Frank Willingham
Iḷisaġvik College
PO Box 749
Barrow, AK 99723-0749
Phone: 907/852-1818 • Fax: 907/852-1805
fwillingham@co.north-slope.ak.us

Lamont-Doherty Earth Observatory of Columbia University
www.ldeo.columbia.edu

William M. Smethie
Lamont-Doherty Earth Observatory of Columbia University
PO Box 1000
Palisades, NY 10964-8000
Phone: 845/365-8566 • Fax: 845/365-8155
bsmeth@ldeo.columbia.edu

James R. Cochran
address same as William M. Smethie
Phone: 845/365-8396 • Fax: 845/365-8179
jrc@ldeo.columbia.edu

Louisiana State University
www.lsu.edu

H. Jesse Walker
Department of Geography & Anthropology
Louisiana State University
Baton Rouge, LA 70803-4105
Phone: 225/388-6130 • Fax: 225/388-4420
hwalker@lsu.edu

(continued next column)

George M. Strain
Research & Graduate Studies
Louisiana State University
Baton Rouge, LA 70803-4105
Phone: 225/388-5833 • Fax: 225/388-5983
strain@lsu.edu

Marine Biological Laboratory
www.mbl.edu

Bruce J. Peterson
The Ecosystems Center
Marine Biological Laboratory
Woods Hole, MA 02543
Phone: 508/289-7484 • Fax: 508/457-1548
peterson@mbl.edu

Knute Nadelhoffer
address same as Bruce J. Peterson
Phone: 508/289-7493 • Fax: 508/457-1548
knute@mbl.edu

Michigan State University
www.msu.edu

Patrick J. Webber
Department of Botany & Plant Pathology
Michigan State University
100 N. Kedzie Hall
East Lansing, MI 48824-1031
Phone: 517/355-1284 • Fax: 517/432-2150
webber@msu.edu

Robert D. Hollister
address same as Patrick J. Webber
Phone: 517/432-2399 • Fax: 517/432-2150
holliste@msu.edu

Northern Illinois University
www.niu.edu

Ross D. Powell
Department of Geology
Northern Illinois University
312 Davis Hall
DeKalb, IL 60115-2854
Phone: 815/753-7952 • Fax: 815/753-1945
ross@geol.niu.edu

The Ohio State University
www.acs.ohio-state.edu

W. Berry Lyons
Byrd Polar Research Center
The Ohio State University
1090 Carmack Road
Columbus, OH 43210-1002
Phone: 614/688-3241 • Fax: 614/292-4697
lyons.142@osu.edu

Oregon State University
www.orst.edu

Timothy Boyd
College of Oceanic & Atmospheric Sciences
Oregon State University
104 Ocean Admin Building
Corvallis, OR 97331-5503
Phone: 541/737-4035 • Fax: 541/737-2064
tboyd@oce.orst.edu

Evelyn B. Sherr
address same as Timothy Boyd
Phone: 541/737-4369 • Fax: 541/737-2064
sherrb@ucs.orst.edu

San Diego State University
www.sdsu.edu

W. Timothy Hushen
San Diego State University Foundation—Research Management
San Diego State University
5250 Campanile Drive
San Diego, CA 92182
Phone: 619/594-4102 • Fax: 619/582-9164
thushen@foundation.sdsu.edu

Douglas A. Stow
Department of Geography
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-4493
Phone: 619/594-5498 • Fax: 619/594-4938
stow@sdsu.edu

Sandia National Laboratories
www.sandia.gov

Wayne Einfeld
Environmental Characterization & Monitoring Systems Department
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185-0755
Phone: 505/845-8314 • Fax: 505/844-0116
weinfel@sandia.gov

Smithsonian Institution
www.si.edu

Aron L. Crowell
Anchorage Museum of History & Art
Smithsonian Arctic Studies Center
Smithsonian Institution
121 W. 7th Avenue
Anchorage, AK 99501
Phone: 907/343-6162 • Fax: 907/343-6130
acrowell@alaska.net

SRI International
www.sri.com

John D. Kelly
Ionospheric & Space Physics Group
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025
Phone: 650/859-3749 • Fax: 650/322-2318
kelly@sri.com

Jeff Thayer
Engineering & Systems Division
SRI International
333 Ravenswood Avenue, Mailstop G-275
Menlo Park, CA 94025
Phone: 650/859-3557 • Fax: 650/322-2318
thayer@sri.com

(continued next page)

ARCUS Member Institutions, Representatives, and Alternates *(continued)*

Texas A&M University
www.tamu.edu

David A. Brooks
College of Geosciences
Texas A&M University
3148 CAMPUS
College Station, TX 77845-3148
Phone: 979/845-3651 • Fax: 979/845-0056
dbrooks@ocean.tamu.edu

Mahlon C. Kennicutt
Geochemical & Environmental Research Group
Texas A&M University
833 Graham Road
College Station, TX 77845
Phone: 979/862-2323 • Fax: 979/862-2361
mck2@gerg.tamu.edu

University of Alaska Anchorage
www.uaa.alaska.edu

Kim M. Peterson
Department of Biological Sciences
University of Alaska Anchorage
3211 Providence Drive
Anchorage, AK 99508
Phone: 907/786-4772 • Fax: 907/786-4607
afkmp@uaa.alaska.edu

University of Alaska Fairbanks
www.uaf.edu

Roger W. Ruess
Institute of Arctic Biology
University of Alaska Fairbanks
PO Box 757000
Fairbanks, AK 99775-7000
Phone: 907/474-7153 • Fax: 907/474-6967
ffrwr@uaf.edu

Ted DeLaca
Office of Arctic Research
University of Alaska Fairbanks
PO Box 757560
Fairbanks, AK 99775-7560
Phone: 907/474-7314 • Fax: 907/474-1836
fnted@uaf.edu

University of Colorado
www.colorado.edu

Rudy J. Dichtl
CIRES/NSIDC
University of Colorado
Campus Box 449
Boulder, CO 80309-0449
Phone: 303/492-5532 • Fax: 303/492-2468
dichtl@kryos.colorado.edu

University of Massachusetts
www.umass.edu

Julie Brigham-Grette
Department of Geosciences
University of Massachusetts
Morrill Science Center
Campus Box 35820
Amherst, MA 01003-5820
Phone: 413/545-4840 • Fax: 413/545-1200
brigham-grette@geo.umass.edu

University of Miami
www.miami.edu

Peter J. Minnett
Rosenstiel School of Marine & Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149
Phone: 305/361-4104 • Fax: 305/361-4622
pminnett@rsmas.miami.edu

Zafer Top
address same as Peter J. Minnett
Phone: 305/361-4110 • Fax: 305/361-4911
ztop@rsmas.miami.edu

University of Nebraska-Lincoln
www.unl.edu

Karl C. Kuivinen
Snow & Ice Research Group
University of Nebraska-Lincoln
2255 W. Street, Suite 101
Lincoln, NE 68583-0850
Phone: 402/472-9833 • Fax: 402/472-9832
kuivinen@unl.edu

Clinton M. Rowe
Department of Geosciences
University of Nebraska-Lincoln
Bessey Hall, Room 305C
Lincoln, NE 68588-0340
Phone: 402/472-1946 • Fax: 402/472-4917
crowe1@unl.edu

University of New Hampshire
www.unh.edu

David Bartlett
Institute for the Study of Earth, Oceans, & Space
University of New Hampshire
Morse Hall
39 College Road
Durham, NH 03824-3525
Phone: 603/862-0322 • Fax: 603/862-1915
david.bartlett@unh.edu

Berrien Moore, III
address same as David Bartlett
Phone: 603/862-1766 • Fax: 603/862-0188
b.moore@unh.edu

University of Washington
www.washington.edu

Ronald S. Sletten
Quaternary Research Center
University of Washington
Box 351360
Seattle, WA 98195-1360
Phone: 206/543-0571 • Fax: 206/543-3836
sletten@u.washington.edu

Jody W. Deming
School of Oceanography
University of Washington
Box 357940
Seattle, WA 98195
Phone: 206/543-0845 • Fax: 206/543-0275
jdeming@u.washington.edu

University of Wisconsin-Madison
www.wisc.edu

James G. Bockheim
Department of Soil Science
University of Wisconsin-Madison
1525 Observatory Drive
Madison, WI 53706-1299
Phone: 608/263-5903 • Fax 608/265-2595
bockheim@facstaff.wisc.edu

Woods Hole Oceanographic Institution
www.whoi.edu

Andrey Proshutinsky
Physical Oceanography Department
Woods Hole Oceanographic Institution
Mail Stop 29
Woods Hole, MA 02543
Phone: 508/289-2796 • Fax: 508/457-2181
aproshutinsky@whoi.edu

Susumu Honjo
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: 508/540-1162 • Fax: 508/540-9439
shonjo@whoi.edu

ARCUS International Affiliates

Alfred Wegener Institute for Polar & Marine Research
www.awi-bremerhaven.de

Jörn Thiede
Alfred Wegener Institute for Polar & Marine Research
Columbusstrasse
D-27568 Bremerhaven, Germany
Phone: +49/471-4831-1100
Fax: +49/471-4831-1102
jthiede@awi-bremerhaven.de

Rainer Paulenz
address, phone & fax same as Jörn Thiede
rpaulenz@awi-bremerhaven.de

Association of Canadian Universities for Northern Studies (ACUNS)
http://aix1.uottawa.ca/associations/aucen-acuns

Peter G. Johnson
Geography Department
University of Ottawa
PO Box 450, Station A
Ottawa, ON K1N 6N5 Canada
Phone: 613/562-5800 ext. 1061
Fax: 613/562-5145
peterj@aix1.uottawa.ca • acuns@cyberus.ca

Margaret E. Johnston
School of Outdoor Recreation, Parks, & Tourism
Lakehead University
955 Oliver Road
Thunder Bay, ON P7B 5E1 Canada
Phone: 807/343-8377 • Fax: 807/346-7836
margaret.johnston@lakeheadu.ca

(continued next page)

ARCUS International Affiliates *(continued)*

GEOMAR Research Center for Marine Geosciences
www.geomar.de

Heidemarie Kassens
Department of Paleoceanography
GEOMAR Research Center for Marine Geosciences
Wischhofstrasse 1-3, Geb 4
D-24148 Kiel, Germany
Phone: +49/431-6002-850
Fax: +49/431-6002-941
hkassens@geomar.de

McGill University
www.mcgill.ca

Marianne Stenbaek
Cultural Studies Department
McGill University
853 Sherbrooke Street
Montreal, QC H3A 2T6 Canada
Phone: 514/398-6579 • Fax: 514/398-8146
mstenb@po-box.mcgill.ca

Norwegian Polar Institute
www.npolar.no

Olav Orheim
Polar Environmental Center
Norwegian Polar Institute
Polarmiljøsenteret
N-9296 Tromsø, Norway
Phone: +47/7775-0620 • Fax: +47/7775-0501
olav.orheim@npolar.no

(continued next column)

Pål Prestrud
Research Department
Norwegian Polar Institute
Polarmiljøsenteret
N-9296 Tromsø, Norway
Phone: +47/7775-0530 • Fax: +47/7775-0501
pal.prestrud@npolar.no

Scott Polar Research Institute
www.spri.cam.ac.uk

Keith S. Richards
Scott Polar Research Institute
University of Cambridge
Lensfield Road
CB2 1ER Cambridge UK
Phone: +44/1223-336-579
Fax: +44/1223-336-549
ksr10@cam.ac.uk

William J. Mills
address same as Keith S. Richards
Phone: +44/1223-336-557
Fax: +44/1223-336-549
wjm13@cam.ac.uk

The University Courses on Svalbard
www.unis.no

Lasse Lønnum
The University Courses on Svalbard
PO Box 156
N-9171 Longyearbyen, Norway
Phone: +47/7902-3305 • Fax: +47/7902-3301
lasse.lonnum@unis.no

(continued next column)

Trond Dokken
Department of Geology
address same as Lasse Lønnum
Phone: +47/7902-3331 • Fax: +47/7902-3301
trond.dokken@unis.no

University of Northern British Columbia
www.unbc.ca

Kevin Hall
Geography Program
University of Northern British Columbia
3333 University Way
Prince George, BC V2N 4Z9 Canada
Phone: 250/960-5864 • Fax: 250/960-5538
hall@unbc.ca

Katherine Parker
Forestry Program
address same as Kevin Hall
Phone: 250/960-5812 • Fax: 250/960-5539
parker@unbc.ca

University of Tromsø
www.uit.no

Ingvild Broch
Research Department
University of Tromsø
N-9037 Tromsø, Norway
Phone: +47/7764-4262 • Fax: +47/7764-4900
ingvild.broch@adm.uit.no

Frits N. Jensen
Roald Amundsen Centre for Arctic Research
address same as Ingvild Broch
Phone: +47/7764-5240 • Fax: +47/7767-6672
frits.jensen@arctic.uit.no

ARCUS Arctic Research Support and Logistics Working Group

Peter Schlosser, *Co-chair*
Lamont-Doherty Earth Observatory
Columbia University
PO Box 1000
61 Route 9 W.
Palisades, NY 10964-8000
Phone: 914/365-8707 • Fax: 914/365-8155
peters@ldeo.columbia.edu

Terry Tucker, *Co-chair*
Snow & Ice Division
Cold Regions Research & Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290
Phone: 603/646-4268 • Fax: 603/646-4644
wtucker@hanover-crrel.army.mil

Julie Brigham-Grette
Department of Geosciences
University of Massachusetts
Morrill Science Center
Campus Box 35820
Amherst, MA 01003-5820
Phone: 413/545-4840 • Fax: 413/545-1200
brigham-grette@geo.umass.edu

Jack Dibb
Glacier Research Group
University of New Hampshire
Morse Hall
39 College Road
Durham, NH 03824-3525
Phone: 603/862-3063 • Fax: 603/862-2124
jack_dibb@grg.sr.unh.edu

Jack Kruse
Department of Geosciences
University of Massachusetts
117 N. Leverett Road
Leverett, MA 01054
Phone: 413/367-2240 • Fax: 413/367-0092
jkruse@geo.umass.edu

Miles McPhee
450 Clover Springs Road
Naches, WA 98937
Phone: 509/658-2575 • Fax: 509/658-2575
miles@wolfenet.com

Craig Nicolson
Department of Natural Resources Conservation
University of Massachusetts
PO Box 34210
Amherst, MA 01003-4210
Phone: 413/545-3154 • Fax: 413/545-4358
craign@forwild.umass.edu

Roger W. Smith
Geophysical Institute
University of Alaska Fairbanks
PO Box 757320
Fairbanks, AK 99775-7320
Phone: 907/474-7416 • Fax: 907/474-5882
roger.smith@gi.alaska.edu

Matthew Sturm
Cold Regions Research & Engineering Laboratory
PO Box 35170
Ft. Wainwright, AK 99703-0170
Phone: 907/353-5183 • Fax: 907/353-5142
msturm@crrel.usace.army.mil

Taneil Uttal
Department of Radar Meteorology & Oceanography
Environmental Research Laboratory
National Oceanic & Atmospheric Administration (NOAA)—R/E/ET6
325 South Broadway
Boulder, CO 80303
Phone: 303/497-6181 • Fax: 303/497-6978
tuttal@etl.noaa.gov