

# Witness The ARCTIC

Chronicles of the Arctic System Science Research Program

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## GISP2 Ice Core Is Long, Continuous and Detailed Record

by Mark Twickler

Prediction and modeling of climate change and its effect on the environment and humankind is one of the most challenging tasks facing science today. Knowledge of how climate has changed in the past is essential to this effort.

On 1 July 1993, the Greenland Ice Sheet Project Two (GISP2) successfully completed drilling 3,053.44 m to the base of the central Greenland Ice Sheet—at 72°35'N 38°29'W, 3,200 m above sea level—recovering the deepest ice core record that is achievable in the northern hemisphere.

This core and another from the European Greenland Ice Core Project (GRIP), 30 km east of GISP2, have yielded an unparalleled record of climatic change over the past 110,000 years.

Each core contains concurrent records of many variables at a level of detail that, in many cases, captures annual and seasonal change. The cores provide evidence of a wide variety of environments, including histories of fires, sea-ice extent, volcanic activity and storminess. The cores also record the frequency and magnitude of extreme events, and elusive cyclical components of the region's environment.

Similarity of the GISP2 and GRIP records is compelling evidence that the stratigraphy of the ice at the Greenland Summit location is unaffected by extensive deformation from the surface to 2,790 m (110,000 years ago) and that even minor features of the records (*e.g.*, 1-2 year onset and termination of climate-



The GISP2 drill dome at Summit Camp on the Greenland Ice Sheet (photo by Debra Meese).

change events) are reliable. It is clear from the two parallel records that:

- both agrarian and industrial societies developed during a period which has exhibited by far the most stable climate of the past 110,000 years,
- major changes in climate have occurred during the period of human occupation in the Arctic,
- climate change has been amplified in the Arctic relative to lower latitudes.

The following highlights some of the environmental record thus far deduced.

### The Anthropogenic Era

Relatively recent increases in sulfate ( $\text{SO}_4$ ) and nitrate ( $\text{NO}_3$ ) previously

observed in ice cores from south Greenland have been identified and contrasted to earlier atmospheric conditions recorded in the GISP2 core. An observed increase in chloride at GISP2, as of the 1940s, is believed to be a by-product of nitrate and sulfate generated by human activities; the latter are believed to aid in volatilization of hydrochloric acid from sea-salt aerosol.

### Little Ice Age and Medieval Warm Period

The Little Ice Age (LIA) and Medieval Warm Period (MWP) are the most recent examples of conditions cooler and warmer, respectively, than the present century. The records of carbon dioxide ( $\text{CO}_2$ ), stable isotopes, major ions, accumulation

*continued on next page*

rate and particles in the GISP2 core support the following observations:

- The LIA appears to span the period from AD 1400±50 years (depending upon measurement type) to AD 1900.
- The sensitive oxygen isotope record from GISP2 indicates that there was a relatively subdued temperature effect at this site during the LIA.
- Accumulation rate, a function of transport distance from the ocean plus temperature *en route*, is generally lower during the LIA than the MWP.
- Levels of dust from continental sources and marine sea salts increased during the LIA.
- The LIA is characterized by the most rapid onset of all the Holocene cold periods recorded here and correlated with other paleoclimate records.
- Measurements of CO<sub>2</sub> in air bubbles indicate that, between AD 1530-1810, atmospheric CO<sub>2</sub> levels remained relatively constant. After this period, concentrations rise rather abruptly and smoothly. This agrees with atmospheric observations at Mauna Loa Volcano Observatory in Hawaii.
- Individual volcanic signatures have been studied in the GISP2 core by measuring electrical conductivity and the presence of sulfate and particles from volcanic sources. Although volcanoes cause prominent, short-lived coolings, they do not appear to be a major forcing agent on climate at a multi-decadal scale.

### The Younger Dryas and Other Rapid Climate-Change Events

Transitions into the Preboreal, Younger Dryas (YD) and Holocene each occurred over a period of a decade or less. Evidence from the GISP2 core confirms that the YD was an event of 1300±70 years duration that terminated abruptly 11,640 years before present (BP), as evidenced by a 7°C rise in temperature and a twofold increase in accumulation rate. The end of the YD was, accordingly, the most significant rapid climate-change event during the last North Atlantic deglaciation.

Isotopic temperature records show 23 interglacial events between 110,000 and 15,000 years BP. These millennial-scale reorganizations of the climate system represent quite large deviations—probably many degrees C in temperature, twofold



GISP2 investigators logging a freshly drilled 6-m ice core in the drill dome (photo by Mark Twickler).

changes in snow accumulation, order-of-magnitude changes in windblown dust and sea-salt loading, and almost a twofold increase in methane (CH<sub>4</sub>).

These events are observed in local climatic indicators (*e.g.*, snow accumulation rate, isotopic composition of snow, both linked to temperature), in regional climatic indicators (*e.g.*, windblown sea salt, continental dust), and in regional-to-global indicators (*e.g.*, atmospheric concentrations of CH<sub>4</sub>, CO<sub>2</sub>, nitrate, ammonium). Some events are readily identified in the ocean-sediment record in regions critical to global ocean circulation.

### Gathering More Evidence

With GISP2 drilling complete, investigators are working to develop new ice-core records for the Southern Hemisphere and to fill in regional details around the world. The recovery of ice cores from Antarctic sites with accumulation rates similar to those at GISP2 will allow comparison of both polar records.

Continued ice-coring activities across the Arctic (*e.g.*, north Greenland, the Arctic Islands of Canada and Russia) and at high-elevation sites around the world (*e.g.*, Asia, South America) are essential to understanding regional climate events and linking existing paleoclimate records.

For more information, see the GISP2 Web site (<http://www.gisp2.sr.unh.edu/gisp2>) or contact Mark Twickler (603/862-1991; fax 603/862-2124; [gisp2.smo@unh.edu](mailto:gisp2.smo@unh.edu)).

### The GISP2 Program

GISP2 is a program of the NSF Arctic System Science (ARCSS) Program. Investigators from 22 institutions administer 20 programs making 46 types of measurements on the ice core. Nine other programs provide information necessary for interpretation of the record (*e.g.*, atmospheric measurements; see page 4).

GISP2 investigators wish to acknowledge the NSF Office of Polar Programs for its support and encouragement; the Polar Ice Coring Office of the University of Nebraska (1987-1989) and University of Alaska Fairbanks (1989-1993) for drilling and logistic support; the 109th Air National Guard (Scotia, New York) for many years of close cooperation, support and enthusiasm; the U.S. National Ice Core Laboratory for curatorial and scientific assistance; and GRIP colleagues for the seasons shared as neighbors in central Greenland. The Greenlandic and Danish Governments kindly granted permission for GISP2 to work in Greenland.

The Science Management Office (SMO) also thanks colleagues (scientists, drillers, support crews) for unflinching dedication, efforts and camaraderie throughout the GISP2 field reconnaissance (1987-1988) and drilling seasons (1989-1993); without them, GISP2 would not have been a success. ■

*Mark Twickler is the Associate Director of the GISP2 SMO at the University of New Hampshire in Durham.*

## ARCSS Research Community Prepares New Science Plan

At the October 1996 meeting of the ARCSS Committee (AC), members prepared for one of their most significant responsibilities to the research community—development of a new ARCSS science plan. The existing plan, *Arctic System Science: A Plan for Integration*, was published in 1993. Since then, arctic system research has made much progress; recent findings have opened new areas of inquiry and augmented opportunities for synthesis and integration of existing data.

Representatives of each major scientific element of the ARCSS Program gathered in January 1997 in Berkeley to begin work on the new science plan. The plan integrates recommendations from the May 1996 All-Investigator Workshop and other ARCSS Program planning efforts. It incorporates ARCSS findings, outlines emerging questions and key areas for synthesis and integration, and recommends new research priorities.

The new plan, *Toward Prediction of the Arctic System—Predicting Future States of the Arctic System on Seasonal-to-Century Time Scales by Integrating Observations, Process Research, Modeling, and Assessment*, emphasizes that global changes of significance in the Arctic are not limited to climate. The ARCSS Program seeks to understand climate effects in the context of other potentially important forces for change; the plan urges additional investments in research—in partnership with arctic communities and other federal and state programs—to further address arctic system and global environmental change. The following objectives are identified:

- Develop a comprehensive understanding of past environmental variability in the Arctic.
- Scale-up modern environmental assessments from the regional to the circumarctic.
- Integrate our knowledge into predictive models of climate change in the Arctic.
- Integrate our knowledge of the arctic system into models of global change.
- Validate these models with observations of past climate changes and with studies of processes that have large effects on climate feedbacks.

*Toward Prediction of the Arctic System* will be available for community review in May 1997 and will be published by ARCUS in June.

At the October 1996 meeting, the AC reviewed the draft *People and the Arctic: A Prospectus for Research on the Human Dimensions of the Arctic System* and recommended that this new initiative be incorporated into the ARCSS Program (see page 7). The prospectus has been extensively reviewed by arctic researchers, policymakers, and arctic indigenous peoples. It will be published in May 1997.

The AC forwarded comments on the draft Land/Atmosphere/Ice Interactions (LAI) updated science plan (see page 5) to the LAII Science Steering Committee (SSC) and urged the Ocean/Atmosphere/Ice Interactions (OAI) SSC to prepare an updated plan reflecting the significant progress and emerging questions in OAI (see page 5).

ARCSS Program Director Mike Ledbetter recommended that the Paleoclimates from Arctic Lakes and Estuaries (PALE) program become part of the newly formed NSF Earth System History (ESH) initiative (see page 6). The Greenland Ice Sheet Project (GISP2) has completed its mission (see Feature, page 1); Ledbetter suggested that future paleoenvironmental studies of the arctic system, including ice coring, be planned jointly under the aegis of ESH and the ARCSS Program.

Following the meeting, the AC explored with the research community ways in which an integrated paleoenvironmental initiative could provide a model for broader temporal and spatial understanding of the arctic system, and could improve synthesis, integration and data

collection across the ARCSS Program. These initial discussions may be followed by a planning workshop in 1997.

Having completed their work, the Data Management and Modeling Working Groups will be dissolved. The AC and Ledbetter acknowledged the contributions of the working groups to the ARCSS Program. Several new members will be appointed to the AC to address integration and synthesis.

W. Berry Lyons has resigned as AC chair, pending appointment of a new chair. Recent obligations prevent him from providing the leadership that he feels the ARCSS community deserves. Jack Kruse, Director of the Institute of Social and Economic Research at the University of Alaska Anchorage, has been nominated for the position. Kruse has a broad interdisciplinary understanding of arctic system science and has demonstrated excellent ability to foster productive community interactions and research efforts.

New AC members are Lloyd Keigwin (Woods Hole Oceanographic Institute), Darrell Kaufman (Utah State University), and John Weatherly (National Corporation for Atmospheric Research) representing GISP2, PALE and OAI, respectively. The AC will meet next in early October 1997; the location is not yet determined.

For more information, contact ARCSS Program Director Mike Ledbetter (703/306-1029; fax 703/306-0648; mledbett@nsf.gov) or Douglas Siegel-Causey (703/306-1029; fax 703/306-0648; dsiegel@nsf.gov), or see the ARCSS Web site (<http://arcss.colorado.edu>). For information about the ARCSS Committee and ARCSS publications, refer to the ARCUS Web site (<http://arcus.polarnet.com>). ■

### RAISE Draft Available for Review

The second draft of the new *Program Plan for a Russian-American Initiative on Shelf-Land Environments in the Arctic* (RAISE) is now available for review and comment on the ARCUS Web site at <http://arcus.polarnet.com/RAISE>.

Submit comments by 6 June 1997 to Steve Forman, University of Illinois at Chicago (312/413-9404; fax 312/413-2279; slf@uic.edu). ■

## NSF Tests Feasibility of Winter Studies at Summit Camp

During the Winter of 1997-98, the NSF Office of Polar Programs (OPP) Arctic System Science Program will support the first overwinter field experiment at Summit Camp on the Greenland Ice Sheet. From June 1997 to April 1998, four field staff will maintain life-support systems at the site, operate instruments, conduct experiments and collect samples investigating air-snow exchange processes on behalf of institutions in the United States and Europe. The studies are designed to determine:

- the factors that control the composition of air just above the ice sheet,
- how closely the composition of snow reflects that of the air, and
- the processes responsible for air-snow exchange of water, energy and chemical compounds through the winter.

The GISP2 and GRIP deep drilling programs at Summit have recovered detailed records of the physical and chemical variations in the longest ice cores that can ever be drilled in the Northern Hemisphere (see Feature, page 1). Clearly, glaciochemical records have risen to new prominence as a result of the unprecedented resolution of sampling conducted for GISP2 and GRIP, as well as the new statistical and time-series tools developed for interpretation of the data.

These drilling programs supported extensive investigation of atmospheric transport and air-snow exchange processes of gases and particles reaching the atmosphere directly above Summit. Until now, however, investigations of air-snow relationships have been limited to the summer season (late-April through early-September). Understanding the meteorological, physical and chemical processes that interact to determine the composition of snow and firn at Summit during winter will foster quantitative reconstruction of the chemical composition of the atmosphere over Greenland in the past at the same temporal resolution now provided by the Summit ice cores.

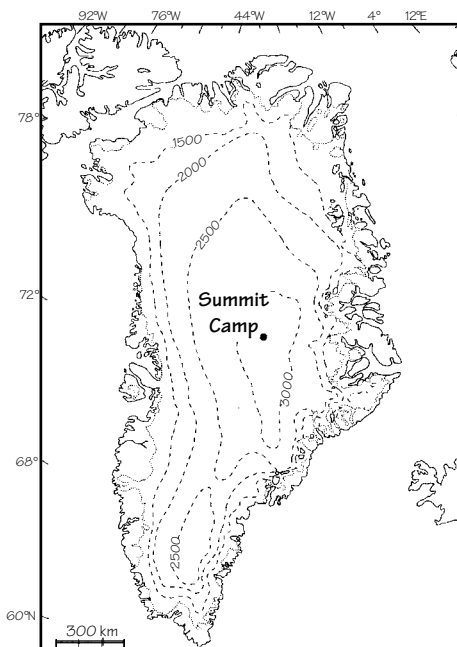
Samples and data collected during the overwinter experiment will be analyzed at the University of New Hampshire, Cold Regions Research and Engineering Laboratory (see Member Insert, this issue),

University of Arizona, University of California at Irvine, Carnegie Mellon University, University of Wisconsin at Milwaukee, University of Colorado, the Finnish Meteorological Institute, Laboratoire de Glaciologie et Geophysique de l'Environment, and University

Heidelberg. Two additional projects from the Danish Meteorological Institute and National Environmental Research Institute will also have instrumentation at the site.

The Polar Ice Coring Office (PICO) at the University of Nebraska-Lincoln and cooperating authorities in Greenland and Denmark will provide logistic support. Successful completion of this experimental season will provide unique year-round data on chemistry and exchange processes, and is expected to pave the way for a manned presence year-round at Summit for several years into the future. International interest in such a station has already been expressed, leading OPP and the Danish Polar Center to schedule a workshop in May 1997 to explore the range of scientific projects that could make use of a year-round Summit station (see box).

Contact Jack Dibb at the University of New Hampshire in Durham (603/862-3063; fax 603/862-2124; jack.dibb@unh.edu) regarding the 1997-98 overwinter experiments; Marijane England at PICO in Lincoln, NE (402/472-9833; fax 402/472-9832; mengland@unl.edu) regarding operations, or ARCSS Program Director Mike Ledbetter (703/306-1029; fax 703/306-0648; mledbett@nsf.gov) regarding long-term plans for Summit. ■



The Greenland Summit Camp is located at 3,207 m above sea level at 72°35'N, 38°29'W longitude (figure courtesy of GISP2 Science Management Office).

### Greenland Overwinter Studies Meeting

In anticipation of a successful Winter 1997-98 pilot project (see article this page), the NSF Office of Polar Programs and the Danish Polar Center are jointly supporting a small workshop 21-22 May 1997 at the Kangerlussuaq International Science Center in Greenland to explore joint interest in science programs that could utilize a new overwinter capability at the Summit Camp at 10,000' on the Greenland Ice Sheet.

In a letter distributed to the research community in February 1997, NSF invited researchers in all disciplines to submit brief descriptions of research projects that could benefit from this capability—research projects that could be enhanced, for example, by measurements for a full annual cycle at this altitude or by the dark skies and clear, still conditions experienced at Summit in winter.

For more information, contact ARCSS Program Director Mike Ledbetter (703/306-1029; fax 703/306-0648; mledbett@nsf.gov) or Arctic Natural Sciences Program Director Odile de La Beaujardiere (703/306-1029; fax 703/306-0648; odelabe@nsf.gov). ■

## First OAI Investigator Workshop Is Open to All

Major near-term activities of the Ocean/Atmosphere/Ice Interaction (OAI) research program include initiating the main Surface Heat Budget of the Arctic Ocean (SHEBA) field experiment, updating the *OAI Science Plan*, publishing the *Shelf Basin Interactions Research Plan*, and holding the first OAI All-Hands Meeting and Planning Workshop.

SHEBA management has selected a Canadian icebreaker as the research platform that will be frozen for one year in pack ice in the southeast portion of the Canada Basin. Observations will be taken during all seasons. Plans are being made to accommodate non-SHEBA experiments on a space-available basis.

In cooperation with SCICEX '97, SHEBA observations will include data collected from a Sturgeon-class nuclear submarine provided by the U.S. Navy. Scientific programs supported by the submarine receive funding from the Office of Naval Research and NSF.

The OAI Science Steering Committee (SSC) is updating the *OAI Initial Science Plan*, first published in August 1992. The basis of the updated plan will be that:

- the general priorities outlined in the *Science Plan* are still valid,
- atmospheric sciences warrant more attention,
- significant results have emerged from OAI research, and
- these results will have a major influence on development of new hypotheses.

For example, data collected by SCICEX cruises (see *Witness*, Spring 1996) and the Arctic Ocean Section expedition (see *Witness*, Autumn 1995), have stimulated discussion about whether or not expansion of warm Atlantic waters into the Canada Basin represents a cyclical change. There is increasing recognition that circulation in the Canada Basin may flip-flop between two distinct modes.

Participants at the September 1996 Shelf-Basin Interaction (SBI) workshop

are completing the *SBI Research Plan*, which will be published in April 1997. SBI is a developing OAI program that will investigate the effects of global change on physical forcing, biogeochemical transformations, biotic structure and human interactions within the arctic ecosystem (see *Witness*, Autumn 1996).

The OAI All-Hands Meeting and Planning Workshop will be held 8-10 May 1997 in Virginia Beach, Virginia to review scientific progress and to discuss future priorities. All interested parties are encouraged to attend.

For more information, refer to the OAI Web site (<http://www.ccpo.odu.edu>) or contact Louis Codispoti at the OAI Science Management Office (757/683-5770; fax 757/683-5550; [lou@ccpo.odu.edu](mailto:lou@ccpo.odu.edu)) or OAI SSC Chair Jackie Grebmeier (423/974-2592; fax 423/974-3067; [jgreb@utkux.utk.edu](mailto:jgreb@utkux.utk.edu)). ■

## LAI Moves Into Synthesis of Current Phase

The Land/Atmosphere/Ice Interactions (LAI) March 1997 All-Investigator meeting in Seattle, Washington initiated the synthesis process and planning for the next phase, which begins with release of an Announcement of Opportunity by NSF in June 1997. The LAI synthesis will include papers on several major topics:

- **Trace-gas fluxes:** Sources and sinks of trace gases (carbon dioxide and methane); interannual and seasonal variability, and spatial distribution of trace-gas fluxes. Lead authors: Walt Oechel and Bill Reeburgh.
- **Landscape evolution:** Tundra late-succession avoidance hypothesis; effects of landscape evolution on key ecosystem processes, animals and people. Lead author: Skip Walker.
- **Detection of change:** Evidence of changes in temperature, permafrost, glaciers, CO<sub>2</sub> flux, arctic circulation, species, sea level, storm surges, etc.; sensitivity and time lag of these parameters to change. Lead author: Mark Serreze.

- **Snow and the winter regime:** Snow-cover properties and their importance for vegetation, permafrost, energy balance, trace-gas fluxes, humans and other animals. Lead author: Matthew Sturm.
- **Feedback processes:** Albedo and trace-gas feedbacks of arctic ecosystems to the regional and global climate, including vegetation controls on surface fluxes, and the effects of surface fluxes on arctic regional climate. Lead author: Amanda Lynch.
- **Hydrologic cycle:** Hydrologic connections between the land and ocean, primarily the export of water and dissolved and particulate matter from the land to the ocean. Lead author: Jim McNamara.
- **Scaling:** Spatial variability, sampling and scaling in relation to regional assessments of trace-gas fluxes, based on sampling techniques and case studies from the LAI program. Lead author: Fritz Nelson.

- **Carbon storage and sensitivity** Carbon storage and sensitivity to change—past, present and future—in different arctic ecosystems. Lead authors: Chien-Lu Ping (past) and David McGuire (future). Other topics cut across the major synthesis themes:

- new techniques and tools used in LAI,
- the system perspective developed for LAI, and
- overall assessment of the achievements and limitations of the LAI program.

A synthesis meeting, open to invited participants, will take place on Orcas Island, Washington on 22-29 June 1997. At that meeting, draft papers on the topics outlined above will be presented and discussed to further resolve linkages, in preparation for publication.

For more information, contact Patricia A. Anderson (907/474-5698; fax: 907/474-6722; [patricia@gi.alaska.edu](mailto:patricia@gi.alaska.edu)) or Gunter Weller (907/474-7371; fax 907/474-7290; [gunter@gi.alaska.edu](mailto:gunter@gi.alaska.edu)). ■

## PALE Merges with NSF Earth Systems History Initiative

At the October 1996 meeting of the ARCSS Committee (AC), NSF ARCSS Program Director Mike Ledbetter announced his recommendations that PALE become part of the Office of Polar Programs (OPP) contribution to the newly formed NSF Earth System History (ESH) initiative.

ESH is the U.S. contribution to Past Global Changes (PAGES), a core project of the International Geosphere-Biosphere Programme (IGBP). PALE is an important element of the PAGES focus on Paleoclimate and Environmental Variability in Polar Regions; incorporating this program into ESH would clarify lines of administration. Other advantages include:

- increased funding for projects,
- clearly articulated PALE science objectives as priorities for ESH proposals,
- higher visibility for PALE, and
- strengthened connections with scientists working in other geographic areas.

At this and several subsequent meetings, the AC, the PALE Science Steering Committee (SSC), and PALE investigators:

- asserted that ARCSS should retain a strong paleoenvironmental component, and
- advocated strongly that ideas for multidisciplinary arctic research and intellectual contacts initiated at the May 1996 ARCSS All-Investigator Workshop (see *Witness*, Fall 1996) continue to be integrated with PALE.

Herman Zimmerman, Program Director for the NSF Atmospheric Sciences Paleoclimate Program (which administers ESH), assured the SSC that PALE would remain an ARCSS program and that there would be no additional administrative expectations under ESH. Monies currently allotted to PALE would be transferred to the general ESH fund; PALE would retain its identity as an area of special interest within ESH. The scientific focus and research questions of PALE remain the same, as do interactions with the ARCSS Program and the CircumArctic PaleoEnvironments (CAPE) program, an international umbrella organization instigated by PALE researchers within IGBP/PAGES.

This plan was presented to the ESH Steering Committee in December 1996. Accordingly, PALE will be listed in the ESH announcement as an area of emphasis in 1997 and will be included in all ARCSS literature as well.

The proposal deadline will change from 1 October to 15 January. Principal investigators seeking renewal awards for field projects beginning in early 1998 may contact Zimmerman (hzimmerm@nsf.gov) regarding flexibility on the deadline.

For more information about ESH-PALE, please contact PALE SSC Co-chairs (contact information below).

### PALE Leadership in CAPE

PALE principal investigators met in Lammi, Finland in April 1997 at the first working meeting of the CAPE program (see *Witness*, Autumn 1996). This meeting focused on 1000-year time-slice reconstructions for the Arctic, based on pre-meeting syntheses by regional working groups. The goals of the meeting were to:

- synthesize regional reconstructions, and
- compare the observational database to climate model simulations.

The PALE Data Coordination group compiled CAPE metadata (*e.g.*, latitude, longitude, elevation) for nearly 700 terrestrial and marine sites around the Arctic.

The PALE Data Coordination Group and Paul Morin (University of Minnesota) continue to archive CAPE data and pursue visual representation of syntheses. The resulting products will be available on the PALE Web site (see below).

### More Data-Coordination Achievements

As a result of collaboration with the National Oceanic and Atmospheric Administration (NOAA) Paleoclimatology Program, the PALE database is now available on the PALE Web site. Data include:

- pollen and other records from Beringia,
- Lake Basin data for the PALE Modern Calibration Network on Baffin Island, and
- pollen and other records from the NW Atlantic region.

Through the Web site, PALE researchers can alert the PALE Data Coordination Group to new sites for inclusion.

The goal is to eventually include all sites where PALE research is being or has been conducted.

### Paleoenvironmental Atlas of Beringia

The preliminary version of the *Paleoenvironmental Atlas of Beringia* is available for review and use at <<http://www.ngdc.noaa.gov/paleo/pale/atlas.html>>.

The *Atlas* is an Internet document designed to provide access to diverse paleoenvironmental data and syntheses from the arctic region as they become available (see *Witness*, Autumn 1996).

Data managers are currently incorporating sites and presenting pollen percentages at 0, 6,000, 11,000 and 21,000 years before present. All Beringian researchers are encouraged to review the *Atlas*, offer suggestions at this early stage of development, and submit records for inclusion. To do so, contact Matt Cross at the ARCSS Data Coordination Center in Boulder, CO (303/492-5532; fax 303/492-2468; [cross@kryos.colorado.edu](mailto:cross@kryos.colorado.edu)).

The *Atlas* is being constructed in collaboration with the NOAA Paleoclimatology group. PALE researchers Pat Anderson, Pat Bartlein and Mary Edwards form an *ad hoc* Atlas Committee.

### Other Workshops

In addition to helping sponsor the CAPE Meeting, PALE supported a Fall 1996 workshop on annually laminated lake sediments and a March 1997 workshop on Arctic Paleohydrology, at the University of California Los Angeles. In Fall 1997, PALE and NSF-OPP will convene a Beringia workshop.

For more information, refer to the PALE Web site (<http://www.ngdc.noaa.gov/paleo/index.html>), or contact Jay Moore at the PALE Science Management Office in Boulder, CO (303/492-0246; fax 303/492-6388; [moorej@spot.colorado.edu](mailto:moorej@spot.colorado.edu)) or PALE SSC Co-chairs Patricia M. Anderson (206/543-0569; fax 206/543-3836; [pata@u.washington.edu](mailto:pata@u.washington.edu)) and Gifford Miller (303/492-6962; fax 303/492-6388; [gmiller@spot.colorado.edu](mailto:gmiller@spot.colorado.edu)). ■

## New Initiative Seeks Regional and Integrative Syntheses

**P***eople and the Arctic—A Prospectus for Research on the Human Dimensions of the Arctic System* presents a strategy to incorporate research on human interactions with arctic environmental change into existing arctic system science research. This research initiative is a response to the 1993 recommendation in *Arctic System Science: A Plan for Integration* that human/environmental interactions be incorporated into ARCSS research. That recommendation was based upon observations that:

- humans are a catalyst of change on global, regional and local scales;
- changes in the Arctic are tied historically to both local and global processes;
- some physical changes that originate in the Arctic propagate to lower latitudes, changing air and sea temperatures, and affecting economies;
- the Arctic is expected to experience amplified climate change effects and is, therefore, seen as an early warning system for global changes that will ultimately affect other areas as well;
- the experience of arctic peoples, whose survival has depended upon adaptability, is instructive for humans elsewhere in the world who are striving to accommodate exacerbated fluctuations and accelerating rates of change in their natural and social environments.

The Human Dimensions of the Arctic System (HARC) initiative is, thus, designed to broaden understanding of the arctic system, to assist arctic peoples to respond to the effects of large-scale changes, and to elucidate the effects of change in the arctic system on people who live outside the Arctic. The initiative provides a significant opportunity to integrate ecosystem and climate studies with a broad range of the social sciences.

The human-dimensions questions are organized within five research themes:

- What are the impacts of human activity on arctic and global systems?
- What are the types and sources of global change in the Arctic?
- What are the effects of global changes on human societies in the Arctic?
- What are alternative approaches to current practices?



*Ella Tulik taking down dried herring at Umkumiut fish camp in Alaska. Many villagers in western Alaska depend on herring for a large part of their annual food supply (© James H. Barker).*

- What are the effects of changes in the arctic system on people living outside the Arctic?

Each of these research themes is elaborated upon by a discussion of possible research questions, the relevance of each, and the maturity and tractability of each in the context of existing research.

The focus of the HARC initiative on comparative and place-based study of the Arctic is an important contribution toward the regional and integrative syntheses that are universally sought but not yet widely achieved. Introduction of human dimensions to arctic system models entails a substantial increase in complexity. The challenges include:

- combining the interactions between different subsystems (*e.g.*, terrestrial hydrology, fisheries ecology, human economics, human population);
- modeling changes over a period of decades; and
- modeling these changes at a regional scale in a way that effectively addresses larger-scale problems relevant to global change scenarios.

Researchers have emphasized the importance of adapting the methodologies of the diverse science disciplines that will contribute to HARC, so that the methods and the data they generate can be linked with other social and biophysical science findings to address arctic system concerns. These include methodologies used in the social sciences such as surveys, oral histories, census data, health records, ships logs and artifacts, as well as those more commonly used in the natural sciences such as modeling and Geographic Information Systems (GIS).

The prospectus recommends strongly that HARC researchers—indeed all arctic researchers—follow the *Principles for the Conduct of Research in the Arctic*, promulgated by the Interagency Arctic Research Policy Committee, as well as guidelines established for each respective social science discipline and by the relevant governments.

The HARC Prospectus recommends strong educational components that link scientists and research with arctic residents. This educational goal is to be reflected in proposal designs, grant awards, and implementation and dissemination of results. Where research is related to the lives of people in northern communities, those communities should have a primary role in its development. This cooperation will contribute to a better understanding of arctic systems and to the active development of northern sciences through traditional knowledge and experience.

Initial recommendations for the HARC prospectus were developed at a community workshop in October 1995 and have subsequently undergone considerable review and discussion by arctic researchers, policymakers and arctic indigenous peoples. The Prospectus will be available from ARCUS in May 1997.

For more information, see the ARCUS Web site (<http://arcus.polarnet.com>), or contact ARCSS Associate Program Director Douglas Siegel-Causey (703/306-1029; fax 703/306-0648; [dsiegel@nsf.gov](mailto:dsiegel@nsf.gov)). ■

# Northern Sea Route Draws International Involvement

by Lawson Brigham

The coastal seas and rivers of the Russian Arctic constitute a vast arctic marine transportation system. The USSR devoted a huge capital investment to the Northern Sea Route (NSR) and developed a large polar fleet including nuclear-powered icebreakers. Since the late 1970s, year-round navigation across the Barents and Kara seas to the Yenisey River has supported the industrial complex at Noril'sk.

Recent years have witnessed a decrease in marine traffic along the NSR. Today, Russia is challenged to fully open the route and all arctic ports, and to develop the NSR as an economically viable international waterway. International interest in gaining access to the Russian Arctic *via* the NSR appears to be strong.

## International Northern Sea Route Programme

The International Northern Sea Route Programme (INSROP) is a major arctic initiative designed to build a knowledge base about the NSR. Conceived in the late 1980s in response to Mikhail Gorbachev's October 1987 Murmansk speech on international and arctic affairs, this multidisciplinary research aims to foster informed decisions regarding use of the NSR. Public and private sponsors in Japan, Norway and Russia are represented by a research committee composed of the Ship and Ocean Foundation (Tokyo, Japan), the Fridtjof Nansen Institute (Lysaker, Norway) and the Central Marine Research and Design Institute (St. Petersburg, Russia).

Since 1993, INSROP-sponsored research has produced more than 110 technical reports within four subprograms:

- Natural Conditions and Ice Navigation;
  - Environmental Factors;
  - Trade and Commercial Shipping; and
  - Political, Legal and Strategic Factors.
- Within this framework, research has been conducted on such diverse and significant topics as:
- an NSR environmental atlas;
  - international legal issues related to the Russian Arctic straits;
  - economic development throughout the entire Russian North;
  - marine insurance and liability issues for ships plying the NSR;
  - the NSR and regional arctic economies;
  - environmental response;
  - arctic port development;
  - icebreaking cargo ship design; and
  - impacts on indigenous peoples along the NSR.

An International Evaluation Committee that reviewed INSROP during January-May 1996 recommended that the project move to a two-year Phase II to integrate and synthesize data gathered in the four subprograms. It is hoped that INSROP workshops will address several complex, multidisciplinary issues facing NSR shipping.

## Harmonization of Polar Shipping Rules

An international project related to the NSR and all arctic shipping is an ongoing

effort, led by Canada, to harmonize the various rules and standards for ships navigating in polar waters. The objective is to provide the International Maritime Organization (IMO) at the end of the century with a draft set of international rules or codes (technical rules for shipbuilding as well as navigational standards for operations) for use by all non-naval ships operating in Arctic and Antarctic waters. Since 1993, meetings have included government officials and representatives of the ship-classification societies from Australia, Canada, Denmark, Finland, France, Germany, Iceland, Japan, Norway, Russia, Sweden, the United Kingdom and the United States. Russia has been represented by the Head of the NSR Administration within the Ministry of Transport; several Russian technical institutes have also been involved. Key goals of the harmonization process are to:

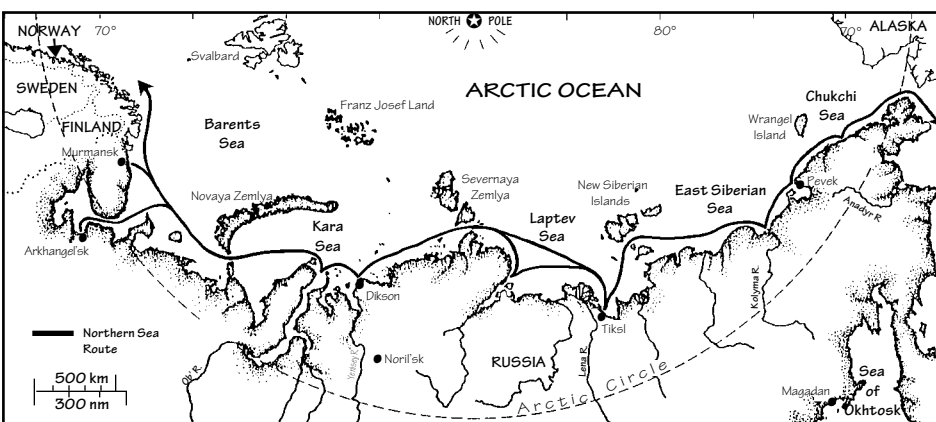
- improve marine safety, and
- enhance environmental protection in all regions of polar shipping.

## Future Issues

Several complex and interesting issues arise when considering the future of the NSR:

- How will trade between Europe and western Siberia develop *via* the NSR?
- What will be the European Union's role and interests in the NSR's development?
- How might the significant sustainable development and environmental security issues that relate to the NSR be addressed by the Arctic Environmental Protection Strategy and Arctic Council (see page 9)?
- How might global environmental change (especially any decrease in extent of seasonal sea ice) impact the future of the NSR as an international waterway?
- What are the interests and roles (if any) of the United States in development of the NSR and Russia's maritime Arctic? ■

*During 1996-97, Lawson Brigham holds the Office of Naval Research Arctic Chair at the Naval Postgraduate School. As a U.S. Coast Guard captain, he commanded the icebreaker Polar Sea 1993-95 and crossed the Arctic Ocean during the 1994 Arctic Ocean Section expedition. He recently chaired the International Evaluation Committee for INSROP.*



The Russian maritime Arctic: strictly defined by Russian authorities, the Northern Sea Route stretches from the southern tip of Novaya Zemlya to Bering Strait (illustration by Lawson Brigham, adapted by Marty Peale).



## AEPS, Indigenous Delegates Prepare for Arctic Council

In September 1998, the Arctic Council is scheduled to begin functioning as a circumpolar policy forum for the eight Arctic nations and three groups representing indigenous communities in those countries (see *Witness*, Autumn 1996). The Arctic Council will, in essence, take over the work conducted by the Arctic Environmental Protection Strategy (AEPS) since 1991 (see *Witness*, Summer 1993).

Senior Arctic Affairs Officials (SAAOs) from the eight arctic nations conduct the work of the AEPS under the direction of AEPS Ministers. The SAAOs and representatives of the three indigenous groups that will participate in the Arctic Council met in Kautoksino, Norway in March 1997 to continue preparations for the transition from AEPS to the Council. Discussions focused on:

- preparation for the final AEPS Ministerial Meeting to be held in Alta, Norway on 12-13 June 1997;
- development of "Rules of Procedure" for the Arctic Council; and
- development of "Terms of Reference for Sustainable Development" for the Arctic Council.

The following discussion outlines highlights of the meeting.

### The Work of AEPS

Three AEPS working groups—Conservation of Arctic Flora and Fauna (CAFF); Protection of the Arctic Marine Environment (PAME); and Emergency Prevention, Preparedness, and Response (EPPR)—submitted progress reports to the SAAOs. The fourth working group, the Arctic Monitoring and Assessment Program (AMAP), distributed a revised draft of the *State of the Arctic Environment Report*, which is due to be released at the AMAP and AEPS meetings in June 1997 (see Calendar, page 15). The report will be available in the United States by July 1997.

The AMAP report's detailed scientific discussions address the following topics:

- Polar Ecology, Contaminant Pathways, Persistent Organic Pollutants, Heavy Metals, Radioactivity, Hydrocarbons, Acidification and Arctic Haze;
- Climate Change, Ozone Depletion and Ultraviolet Radiation; and

- Human Health Impacts.

Publication of the report brings to a close Phase 1 of AMAP's work. Proposals for Phase 2 will be addressed at an April 1997 AMAP meeting in Stockholm, Sweden. This is likely to include:

- filling of data gaps revealed in the compilation of the AMAP report, and
- continued monitoring and clean-up of contaminants in areas of significant concern identified in *Arctic Pollution Issues*.

After the June 1997 AEPS meeting, David Stone of Canada will relinquish the Chairmanship of AMAP to Lars-Eric Lijelund of Sweden. Filip Facius of Denmark will become the AMAP Vice-Chair.

### Accreditation of Observers

Enabling language for the Arctic Council provides for accredited observers to contribute to the work of the Council. Iceland continued to object to the World Wildlife Fund's (WWF) application for observer status at the June 1997 Ministerial Meeting; WWF is attempting to resolve the issue. Norway and Canada rejected the International Fund for Animal Welfare's (IFAW) application for observer status. Applications by other groups for accreditation are being considered according to current AEPS procedures.

### June 1997 Declaration on the AEPS and Senior Officials Report to Ministers

SAAOs rejected drafts of the AEPS Declaration prepared by Norway for the June 1997 Ministerial Meeting. Instead, the officials adopted a more concise approach highlighting national and common priorities for action, and cooperative activities to address these priorities, based on the achievements of the AEPS working groups and other concerns. SAAOs will assign specific tasks to the four working groups at a later date. The AEPS Declaration is expected to address the following topics:

- Arctic Council process and programs (U.S. lead);
- Finances (Norway);
- Guidelines for the Conduct of Research in the Arctic (U.S.);
- Barents Council/Arctic Council Cooperation (Iceland);

- Environmental Impact Assessment Guidelines (Finland); and
- Waste Management Project (Denmark/Greenland).

### Arctic Council Rules of Procedure

SAAOs rejected the proposed draft of Arctic Council "Rules of Procedure" as too restrictive. Representatives of the indigenous groups and Denmark drafted a new version that was accepted as a basis for further work. SAAOs aim to complete the "Rules of Procedure" at the September 1997 meeting in Kuujjauq, Canada.

### Arctic Council Terms of Reference for Sustainable Development

SAAOs agreed that language describing broad program areas that may be the focus of specific cooperative activities of the Arctic Council will:

- adhere to terms used in Arctic Council declaration, including references to sustainable development ("economic and social development, improved health conditions and cultural well-being") and environmental protection ("health of arctic ecosystems, maintenance of biodiversity in the arctic region, and conservation and sustainable use of natural resources");
- incorporate U.S. text from October 1996; and
- affirm the need to examine environmental effects (Norway).

The AEPS Secretariat will prepare and circulate a new draft before the September 1997 SAAO meeting.

SAAOs will meet again in January and April 1998 before the first official Arctic Council Ministerial Meeting in September 1998.

For more information, contact Polar Affairs Chief Robert Senseney at the U.S. State Department in Washington, DC (202/647-4972; fax 202/647-1106). ■

## USARC Pursues Collaboration in Russia and Canada

The U.S. Arctic Research Commission (USARC) met in December 1996 to initiate George Newton as the new USARC Chair, to review the Greenpeace report on radionuclide contamination on Amchitka Island in Alaska (see Publications, page 19), and to hear a review of NASA's arctic programs by Robert Thomas.

Sarah Horigan of the U.S. Office of Management and Budget discussed the Government Performance and Result Act that standardizes the process by which federal agencies develop strategic plans for setting goals and measuring achievements. The revised USARC planning effort will build upon the existing biennial report on *Goals and Opportunities in Arctic Research*. Seventeen USARC Advisors met in late March 1997 to help draft the current version of this report. The Commission will submit its strategic plan in September

1997; the annual assessment will be part of the USARC annual report.

In December 1996, USARC Chair George Newton and Executive Director Garry Brass met with the Canadian House of Commons Committee on Foreign Affairs and International Trade in Ottawa to discuss USARC activities and the relationship to Canadian arctic research programs. As a result of that meeting, Brass and Newton met in early 1997 with Bonnie Hrycyk, Head of the Canadian Polar Continental Shelf Program, to further explore the possibilities for a coordinated arctic logistics program.

An abbreviated USARC meeting in late March 1997 included a briefing on the SCICEX '96 arctic cruise. The Commission also was briefed on the Polar Icecap Space and Weather Observatory soon to be constructed by the United

States at Resolute Bay, on Cornwallis Island in the Canadian Arctic.

In October 1996, Lyle Perrigo, Director of the USARC Alaska Office, joined a delegation to Bilibino, Russia to review operations of the four nuclear reactors there. Brass traveled to the Arctic and Antarctic Research Institute in St. Petersburg, Russia for discussions on the operations phase of the international Nansen Arctic Drilling (NAD) Program (see page 18). A revised proposal is being prepared; members will be submitting proposals to their respective governments to fund drilling. (In the United States, a university will submit to NSF). Brass is the U.S. member of the NAD Executive Committee.

For more information, contact Garry Brass (800/287-6722 or 703/525-0111; fax 703/525-0114; g.brass@arctic.gov). ■

## Polar Research Board

### PRB Addresses Fisheries, Spill Response, Contaminants

In October 1996, the Polar Research Board (PRB) met to address the status of the Arctic Monitoring and Assessment Program (AMAP) and formation of the Arctic Council (see page 9). The PRB also reviewed research activities at various federal agencies, considered the status of the U.S. Arctic Research Plan, talked at length about the International Arctic Science Committee (IASC) and its evolving role as a planning and coordination organization for research in the Arctic, and looked in depth at activities of the international Scientific Committee on Antarctic Research (SCAR).

In an effort to increase its contacts with researchers in Alaska, the Board held its April 1997 meeting in Anchorage. It heard presentations including:

- an overview of environmental studies being conducted by the Minerals Management Service,
- lessons learned from research on the effects of the *Exxon Valdez* oil spill, and

- an update on the status of the International Arctic Research Center to be built in Fairbanks, Alaska.

The PRB:

- drafted terms of appointment for U.S. representatives to SCAR and IASC, and formed a task group to review U.S. participation in IASC now that the organization has existed for five years;
- discussed at length a report soon to be released to NSF on how to rebuild the deteriorating research facilities at the South Pole, and formed a task group to draft a PRB response;
- continued to design and seek support for a PRB study on arctic contaminants;
- decided to pursue a possible study to synthesize lessons learned from oil-spill response efforts in Alaska; and
- made final changes to its report, *Research Frontiers in Polar Science*.

The PRB will play a supporting role in a new project by another National Research Council (NRC) unit, the Ocean

Studies Board, that will evaluate different methods for assigning rights for fish harvesting—"rights-based allocations" and "community-development quotas." The study committee is to be appointed soon; field meetings are expected this summer.

The PRB, a unit of the NRC/National Academy of Sciences/National Academy of Engineering complex, was established in 1958 to promote polar science and enhance understanding of the Arctic and Antarctic. The Board:

- serves as the U.S. National Committee to SCAR and IASC,
- facilitates communication among policymakers and the polar community, and
- conducts focused studies in areas of polar science, technology, and resource management.

For more information, refer to the PRB Web site (<http://www2.nas.edu/prb/>) or contact PRB Director Chris Elfring (202/334-3479; fax 202/334-1477; celfring@nas.edu). ■

## Traditional Knowledge Systems in the Arctic

In March 1997, the Alaska Native Science Commission (ANSC) hosted *Traditional Knowledge Systems in the Arctic*, a planning workshop held in Anchorage, Alaska to identify critical issues related to the conduct of scientific research in the Arctic, and to the needs and concerns of arctic residents.

The many ways to acquire knowledge are referred to as “knowledge-acquisition systems.” The experimental, scientific method is the system familiar to most westerners. Other systems include different ways to conduct science—and some that do not use scientific methods at all. Traditional Wisdom and Knowledge (TWK) encompasses the processes by which local people gather information and evaluate it in the context of existing knowledge, as well as the ways in which knowledge is disseminated, utilized and incorporated into daily survival.

The environmental aspect of TWK (also commonly referred to as Traditional Ecological Knowledge [TEK], Indigenous Knowledge and Wisdom [IKW], and several other terms) is receiving increasing attention. However called, TWK is based on thousands of years of observation of the arctic environment by residents whose survival depended upon the environment and their awareness of it. Researchers, developers and managers are rapidly recognizing the value of this body of information and the ways in which it is maintained.

The purpose of the March 1997 workshop was to:

- assign priorities to various aspects of Arctic TWK using criteria that address key concerns of arctic residents and the data needs of scientific researchers, and
- devise a format for a future conference on Arctic TWK, designed to be open to diverse participation.

Participants in this initial planning workshop included Arctic Native elders, researchers, policymakers, managers from federal agencies, and educators and representatives from Native American groups in Canada and the Lower 48 states. Together, they recommended that a conference be held in Alaska in Fall 1997

or Spring 1998 that would bring together researchers and local people to discuss scientific and societal issues regarding:

- how TWK is gathered and assessed,
- how it ought to be utilized in scientific research, and
- how local people and their wisdom can be incorporated into decisions that have local, regional and global impacts.

The workshop was supported by a grant from the NSF Arctic Sciences section.

Additional information about the workshop and ongoing planning will be available soon on the ARCUS Web site.

For more information, contact the organizers, Patricia Cochran at ANSC (907/786-7704; fax 907/786-7739); [anpac1@uaa.alaska.edu](mailto:anpac1@uaa.alaska.edu) and Oscar Kawagley at the University of Alaska Fairbanks (907/474-5403; fax 907/474-5451; [rfok@aurora.alaska.edu](mailto:rfok@aurora.alaska.edu)), or see the ARCUS Web site. ■



Elders from Koyuk, Elim and Shaktoolik, Alaska participate in documenting traditional ecological knowledge about beluga whales in the Koyuk Community Hall in April 1995. High-school students seated in the background are observing the process and recording the discussions on videotape as part of a leadership-training program (photograph by Ricky Nassuk, Sr.).

### Arctic Information and Data Guide On-line

The on-line version of the second edition of *Arctic Information and Data: A Guide to Selected Resources* is now available at <http://arcus.polarnet.com>.

This guide is intended for teachers, undergraduate and graduate students, librarians and other information specialists, and the lay public with a general interest in the Arctic. Researchers will also find it useful for locating information peripheral to their own specialties.

The guide leads to the information resources of U.S. federal and state agencies; universities and research institutes; nongovernmental and private organizations; and electronically and traditionally published databases, journals and monographs. While the document encompasses data and information for both arctic and non-arctic regions, it concentrates on information published or generated within the United States.

The guide was compiled and edited by Martha Andrews and members of the U.S. Polar Information Working Group. Publication of the guide was supported by NSF Office of Polar Programs and ARCUS. Copies of the 56-page printed version of the *Guide* are available from ARCUS. ■

## CIFAR Receives Funding To Administer Bering Sea Study

In fiscal year 1997, Congress allocated \$1 million to the National Oceanic and Atmospheric Administration (NOAA) for an Arctic Research Initiative. This broad initiative focuses on the health of the Western Arctic/Bering Sea Ecosystem. It is being managed for NOAA by the Cooperative Institute for Arctic Research (CIFAR) at the University of Alaska Fairbanks. The initiative has two major areas of scientific study:

- natural variability of the ecosystem, and
  - anthropogenic influences on it.
- Research subtopics include:
- processes and ecosystem production of the Bering Sea green belt,
  - atmosphere-ice processes that influence ecosystem variability, and
  - arctic atmospheric, cloud and boundary-

layer processes that affect the system. Studies of anthropogenic influences on the Western Arctic/Bering Sea ecosystem address arctic haze; ozone and UV flux; and the sources, fate and effects of contaminants in the ecosystem. Fifteen projects are presently funded under the initiative.

The Western Arctic/Bering Sea region hosts one of the largest remaining international fisheries in the world, marine mammals, nonrenewable resources and coastal communities. To better understand the ecologically and culturally diverse region, NOAA formed a partnership with the University of Alaska establishing CIFAR and providing initial funding in May 1994 (see *Witness*, Autumn 1995).

This partnership offers the advantage of NOAA's long history of leadership in

atmospheric and oceanic studies and the University's expertise and close contacts with the academic research community in the Arctic.

CIFAR addresses six research areas:

- Fisheries Oceanography and Bering Sea Ecosystem Studies
- Hydrographic Studies and Sea-Ice Dynamics
- Atmospheric Research
- Climate Dynamics and Variability
- Tsunami Research and Prediction
- Environmental Assessment, Monitoring and Numerical Modeling

For more information, contact CIFAR Director Gunter Weller in Fairbanks, AK (907/474-7371; fax 907/474-7290; [gunter@gi.alaska.edu](mailto:gunter@gi.alaska.edu)). ■

## New Digital Library Features a Lifetime of Colville Data

When a lifetime of arctic research yields thousands of photographs, slides and maps, and scores of publications, the historical and scientific records are markedly enriched. Louisiana State University (LSU) is currently working with geomorphologist H. Jesse Walker to

make his 40-year collection of research on the Colville River Delta widely available *via* the Internet.

The Colville River drains approximately 29% of the North Slope of Alaska, entering the Arctic Ocean between Barrow and Kaktovik. Its 600-km<sup>2</sup> delta includes

distributaries, lakes, dunes, sandbars and mudflats. Unlike most deltas in the world, it also exhibits such arctic features as permafrost and ice-wedge polygons and is subject to long periods of snow and ice cover.

Walker's collection of 15,000 slides, 10,000 photographs, 5,000 aerial photos; 75 publications, theses and dissertations; many notebooks of field data; echo-sounding traces; laboratory analyses; and 16 mm motion picture film dates back to the late 1950s.

As of April 1997, approximately 350 maps, slides, aerial photos, charts and diagrams have been digitized; 94 are available on the Internet at LSU's Digital Library (<http://appl003.lsu.edu/lsudigit.nsf>).

The digital library is considered to be a pilot study, demonstrating the potential of the Internet to provide access to valuable historical data with clear attribution to the original investigator.

For more information, contact Lynn Hadden at the LSU Office of Computing Services in Baton Rouge (504/388-3725; fax 504/388-3709; [lynnh@lsu.edu](mailto:lynnh@lsu.edu)) or H. Jesse Walker (504/388-6130; fax 504/388-4420; [hwalker@lsu.edu](mailto:hwalker@lsu.edu)). ■



H. Jesse Walker conducted research on Alaska's Colville River Delta for more than 30 years. Portions of his extensive collection are now available on-line from Louisiana State University Digital Library (photo provided by Jesse Walker).

## Arctic Icebreaker Coordinating Committee Forms

In September 1996, the U.S. Coast Guard, NSF and University-National Oceanographic Laboratory System (UNOLS) established a UNOLS Arctic Icebreaker Coordinating Committee (AICC) to address support for U.S. academic investigators carrying out arctic science research aboard U.S. Coast Guard icebreakers. The immediate concerns of this committee are the *Polar Sea*, *Polar Star* and *Healy*.

The Coast Guard, NSF, UNOLS and the AICC are promoting the best utilization of high-latitude facilities on a global scale. Past methods of planning discouraged expeditions to remote areas by failing to provide sufficient lead time for planning, and failing to provide incentives for the scientific community to organize the critical mass of research projects necessary to justify voyages.

The AICC will:

- provide oversight and advice to the Coast Guard, NSF and UNOLS to enhance and facilitate science aboard U.S. icebreakers and other vessels carrying out arctic research;
- provide planning and scheduling assistance for arctic science projects;
- fulfill an ombudsman role for the high-latitude science community, ensuring efficient and effective utilization of U.S. icebreakers and championing the utilization of high-latitude assets;
- encourage the advancement of cooperative international programs for multidisciplinary polar science;
- promote new technology for high-latitude assets; and
- maintain cutting edge capability for these facilities.

AICC membership includes:

Lisa Clough (East Carolina University), Joe Coburn (Woods Hole Oceanographic Institute), Glenn Cota (Old Dominion University), Kelly Falkner (Oregon State University), Lawrence Lawver (University of Texas-Austin), Dan Lubin (University of California San Diego (UCSD)/California Space Institute), James Swift (UCSD/Scripps Institution of Oceanography), and Tom Weingartner (University of Alaska Fairbanks). The UNOLS Chair Ken Johnson, Executive Secretary Jack Bash, and the UNOLS Office provide support.

The constituency of the AICC is the scientific community that wishes to use U.S. icebreakers to support arctic research.

For more information, contact AICC Chair, Jim Swift (619/534-3387; fax 619/534-7383; jswift@ucsd.edu) or the ARCUS Web site (<http://arcus.polarnet.com>). ■

## Researchers Circulate Letter on 'Study of Arctic Change'

As of early April 1997, 42 researchers in seven countries (Canada, China, Germany, Japan, Norway, the United Kingdom and the United States) have supported development of a program to track and understand major changes presently underway in the arctic environment.

Signers of an open letter to the community recommending a "Study of Arctic Change" have summarized evidence from many sources that strongly suggests:

- the Arctic Ocean is currently undergoing a significant shift in temperature and circulation pattern, and
- atmospheric pressure is implicated in these changes.

This documentation substantiates the researchers' call for a program of data collection using existing or planned scientific efforts and logistical support. They cite mounting evidence that warm Atlantic Water has been penetrating more deeply into the Arctic Ocean during the 1990s than was noted in previous decades (e.g., data from the 1991 cruise of the *Oden*, 1993 cruises of the *USS Pargo* and *Henry Larsen*, 1994 Arctic Ocean Section

of the *Polar Sea* and *Louis S. St. Laurent*, 1994 Transarctic Acoustic Propagation experiment, Russian hydrographic data [1950-89] published in January 1997).

This shift in oceanic conditions may be associated with a decadal trend in the atmospheric pressure pattern:

- In 1993, whole patterns of pressure-field and ice-drift data shifted counterclockwise 40-60° from the 1979-92 pattern.
  - Yearly average pressure maps from the International Arctic Buoy Program (IABP) show the shift in atmospheric pressure pattern beginning in 1988-89.
  - Annual mean atmospheric pressure has been below the 1970-95 mean in every year since 1988 (Walsh *et al.* 1996).
- Therefore, the temporal shift in the atmosphere roughly corresponds to the estimate of when ocean changes began.

These changes may represent a decadal-scale change—as predicted by simulations of wind-forced and thermohaline-forced regimes—or the start of a longer-term shift. Examining the further evolution of conditions in the Arctic Ocean, as well as retrospective studies, will likely tell a good

deal about the interplay of the Arctic with the rest of the globe.

The researchers cite an urgent need for hydrographic measurements to monitor ongoing changes. They propose repeated large-scale hydrographic surveys along with buoy, mooring and remote sensing observations.

Analysis of existing data and modeling are also highlighted. These data can be compared to decadal and longer-term changes at lower latitudes.

Signatories to the letter propose:

- a pilot survey in Spring 1998 (to NSF),
- collection of hydrographic data from future SCICEX cruises (to ONR/NSF),
- an open international meeting on the arctic change as a springboard to further work on this urgent issue (to NSF).

For more information, contact Jamie Morison at the Polar Research Center in Seattle (206/543-1394; fax 206/543-3521; morison@apl.washington.edu). ■

### References

Walsh, J.E., W.L. Chapman and T.L. Shy. 1996. Recent decrease of sea level pressure in the central Arctic. *Journal of Climate* 9, 480-486.

## Workshop Expands Integration of Education, Research

Approximately 60 arctic researchers, educators, curriculum specialists and others gathered in New Orleans in April 1997 for a workshop on science education. The workshop articulated current strategies and goals for integrating science education and research, and initiated the development of collaborative projects. Workshop objectives were to:

- provide a forum for the development of educational material about the Arctic and the research taking place within it for K-12 classrooms nationwide, and
- bring those research activities into K-12 classrooms in arctic communities.

Presentations and discussions included Arctic and Antarctic perspectives, creating a broad polar focus.

A special session on education proposals clarified the NSF Education and Human Resources (EHR) grantmaking process. Emma Walton and Wayne Sukow of EHR reviewed types of projects funded by EHR, evaluation criteria and characteristics of strong project designs including:

- collaborations among science educators, assessment specialists, curriculum specialists and researchers; and
- large-scale, far-reaching objectives.

Participants formed sets of *ad hoc* panels to review a previously funded EHR proposal; a plenary discussion of their respective review processes and recommendations followed.

Carole Seyfrit, representing the NSF Office of Polar Programs (OPP), provided information about OPP education funds.

A keynote address by Richard Radtke emphasized opportunities and barriers for people with disabilities. Radtke described his Arctic, Antarctic, and tropical fieldwork in fisheries; he discussed the attitudes, methods and technologies that make possible an active research and education career, even with disabilities (Radtke is quadraplegic).

A session on paradigm shifts in science education presented programs that:

- involve students and teachers directly in research,
- implement long-term changes in science instruction, and
- serve non-traditional students from rural and northern communities

through interdisciplinary studies, life relevance and process-oriented learning.

A session on integration of polar scientific data into curricula included demonstrations of a variety of computer and CD-ROM materials and applications.

The other major workshop theme—science education efforts within Alaska—explored the development of education that respects the philosophical and pedagogical foundations provided by both indigenous and western cultural traditions. Keynote speaker Oscar Kawagley spoke about engaging Native peoples in education. Kawagley described his experiences as a Native Yup'ik and professional educator and researcher and the ways in which these worldviews complement and oppose each other. His keynote introduced presentations offering diverse perspectives on:

- improving educational methods in arctic schools,
- bridging differing worldviews, and
- incorporating traditional knowledge into science curricula.

The context of discussions ranged from the socialization of young children, the K-12 educational process, undergraduate and graduate education, scientific research activities, the importance of community, and the role of elders in education.

Working groups met throughout to address several major tasks; they identified specific projects for further development in their respective areas and discussed strategies for implementing these ideas. Work on several collaborative proposals begun in these sessions has been ongoing.

The Science Education Workshop was funded by NSF Office of Polar Programs and coordinated by ARCUS.

For more information see the ARCUS Web site (<http://arcus.polarnet.com>); or contact workshop Co-chairs Elena Sparrow in Fairbanks, AK (907/474-7699; fax 907/474-6184; [ffebs@aurora.alaska.edu](mailto:ffebs@aurora.alaska.edu)) or Pete Sommerville in Christchurch, New Zealand, (+64-3-358-4450; fax +64-3-358-4480; [psommerv@icair.iac.org.nz](mailto:psommerv@icair.iac.org.nz)). ■

### Students Receive 1st Annual ARCUS Award

In March 1997, ARCUS announced the winners of the First Annual ARCUS Award for Arctic Research Excellence. The award is designed to encourage undergraduate and graduate students to pursue their interests in arctic sciences. Awards were made to four students who were major contributors to the research and primary authors of the papers they submitted:

- **J. A. "Tony" Beesley** *Toward an Explanation of the Annual Cycle of Low-Cloud Amount Over the Arctic Ocean* (Department of Atmospheric Sciences/University of Washington)
- **Julia Boike** *Thermal and Hydrological Dynamics of the Active Layer at a Continuous Permafrost Site (Taymyr Peninsula, Siberia)* (Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany)
- **Scott Forrest** *Territoriality and State-Sami Relations* (University of Northern British Columbia)
- **Chris K. Guay** *Barium as a Tracer of Arctic Halocline and River Waters* (College of Oceanic and Atmospheric Sciences, Oregon State University)

These students will receive a \$500 award and have been invited to present their papers at the May 1997 *Arctic Forum* in Washington, DC.

The deadline for submission of papers for the 1998 award is December 1997. Students from any institution may apply. For more information, see the ARCUS Web site (<http://arcus.polarnet.com>), or contact any ARCUS Member Institution Representative (see Insert) or ARCUS. ■

## Science Education and Training Program Opens Doors

The close of the school year in Barrow, Alaska finds high-school students observing the butchering of a bowhead whale taken by local hunters. Sixth-grade and high-school science students in Point Hope have been identifying arctic plants; they have collected herbarium specimens, recorded habitat data, and interviewed village elders regarding the uses of plants for food, medicine and meat preservation. They will now compile an on-line guide for the Internet.

Middle-school students in Barrow and Wainwright have been studying weather monitoring and data collection. They have

also learned first-hand about the setbacks scientists experience in the arctic environment when they must use instruments designed and built in southern California.

These hands-on experiences incorporating climate research and local knowledge are part of new curricula developed by North Slope teachers with funding from the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program (see *Witness*, Autumn 1994). The ARM Science Education and Training project (ASET) was implemented in 1995 by ARCUS to build a mutually supportive relationship between North Slope

communities and the ARM program (see *Witness*, Spring 1996).

ARCUS and North Slope-based Ilisagvik College will work together to implement the next phase of ASET. Projects planned for 1997/98 will focus on community participation, in preparation for development of an overall North Slope science-education outreach plan.

For more information, contact Edna MacLean, President, Ilisagvik College (907/852-9101; fax 907/852-9102; emaclean@co.north-slope.ak.us); Frank Willingham (907/852-9141; fax 907/852-2729; wa4buf@barrow.com), or ARCUS. ■

## International News

### NABO Planning Advances Data Integration

The North Atlantic Biocultural Organization (NABO) is a regional research cooperative that has coordinated international, interdisciplinary research in the North Atlantic since 1992 (see *Witness*, Autumn 1996). NABO operates a network of interdisciplinary working groups that are developing specific data products pertaining to major problems (e.g., northern agricultural impacts, the present fisheries crisis) and improving communication among specialists.

The NABO Zooarchaeology Working Group met in January 1997 in New York to address issues shared by researchers working with both Norse and Native American collections of animal bones.

Vertebrate and invertebrate animal remains from circumarctic archaeological sites have made important contributions to ARCSS Program climate research, other paleoenvironmental investigations, and human/resource/landscape issues of immediate interest to modern managers and northern residents.

Several fundamental problems constrain many regional syntheses in northern zooarchaeology. These include:

- problems of comparability in site-specific recovery and taphonomy,

- variation in osteological identification methods, and
- lack of common formats for data presentation and curation.

Other scientific communities face similar data-collection and reporting problems. The North American Quaternary paleontological community addressed many of these issues during its FAUNMAP project. Human osteologists have created an impressive set of standards for data collection from human skeletal remains. PALE Protocols (Anderson, Andrews, Bradley *et al.* 1993) are cited throughout the circumarctic paleoenvironmental community.

Workshop participants identified areas of general agreement and created a timetable for specific data products. Products currently under development include:

- **Northern Environmental Sampling Manual**—This guide for collecting bioarchaeological samples in northern field conditions identifies priority data needs and effective ways of coordinating field and lab work. Editors: James Rackham and Morten Meldgaard; draft circulating in Spring 1997.
- **North Atlantic Osteological Keys**—A series of keys for North Atlantic species of sea mammals, birds and fish

incorporates the expertise of zoological museum staff and field workers, and identification traditions from both sides of the Atlantic. Editors: Tom Amorosi, Gitte Gotfredsen, Sophia Perdikaris; drafts available in Fall 1997.

- **NABONE**—A multi-user, relational database capable of handling multiple recording methods, and producing standardized and custom reports and graphics. Development team: Richard Robinson (programmer), Tom McGovern, James Rackham; beta version available for review in Spring 1998. The working group is soliciting comments and participation from scholars generating and using northern zooarchaeological data.

For more information on the Zooarchaeology Working Group and copies of the draft products, contact Tom Amorosi in New York, NY (212/772-5410; fax 212/772-5423; nabo@voicenet.com). For more information on other NABO initiatives, contact Sophia Perdikaris (212/772-5655; fax 212/772-5423; nabo@voicenet.com). ■

#### References

- Anderson, P.M., J. Andrews, R. Bradley *et al.* (eds.). 1993. Research Protocols for PALE, PAGES, IGBP. Report Series 94-1.

## ITEX Investigators Meet To Cooperatively Analyze Data

Predicting the response of arctic vegetation to summer warming requires a combination of modeling, monitoring and experimentation. The International Tundra Experiment (ITEX) is a coordinated, circumpolar-alpine experiment on the responses of selected species to a 2-5°C summer warming (see *Witness*, Autumn 1996). In order to standardize results, ITEX researchers follow a formal, published set of protocols for experimental design and measurements of plant growth, reproduction and phenology. Approximately 26 ITEX installations have been in place throughout the Arctic and temperate alpine for a period of one to four years.

A major challenge for ITEX investigators has been to conduct meaningful synthetic analysis on combined data sets. The NSF-funded National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California Santa Barbara

funded preparation, participation and follow-up for a December 1996 meeting for this purpose. NCEAS is dedicated to supporting ecological synthesis that may be difficult to accomplish through traditional means.

The meeting brought together 30 ITEX investigators and experts on spatial and meta-analysis. The goals were to determine whether there was a response of ITEX species to the experimental warming, and how the response or lack thereof varied within and among species, growth forms and climate.

Initial results reveal patterns that may significantly alter existing understanding of plant responses to warming:

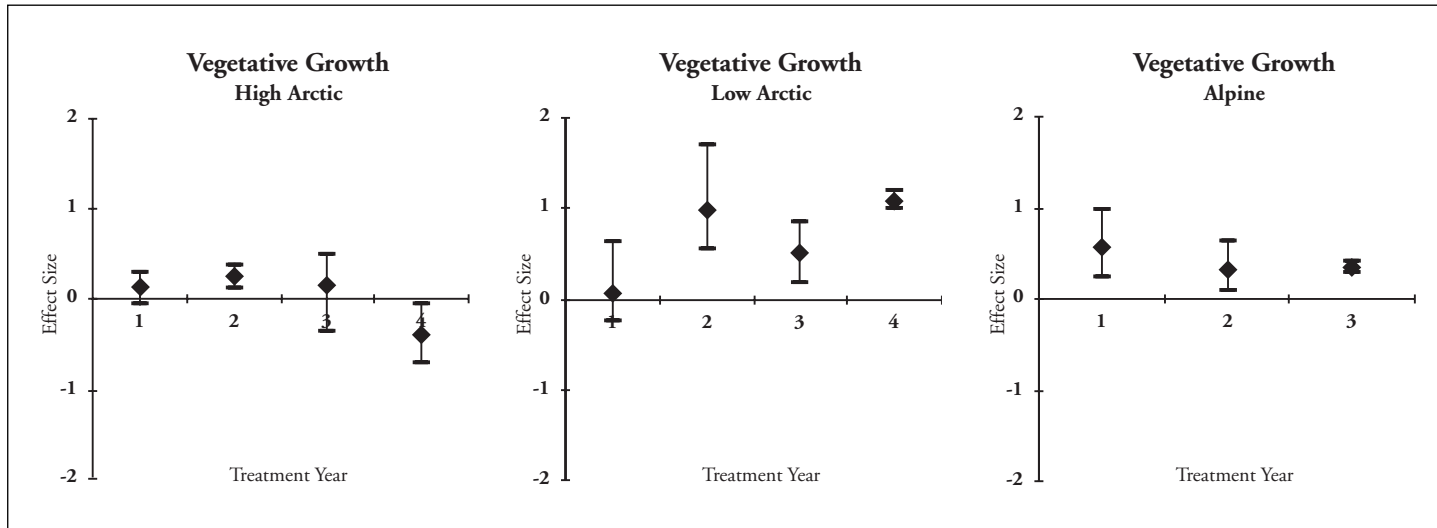
- High-arctic sites, for which the experiment represents the greatest proportional increase in temperature, showed little or no response to warming, whereas low-arctic and alpine

sites showed a significant response beyond the first year (see figure). The lack of response in high-arctic sites may be due to a lack of available nutrients.

- Reproductive effort and success showed little or no response to warming. While phenology shifted to earlier leaf and flower bud burst in all systems, end-of-season phenology remained unchanged.

While these results must be considered as preliminary—they are unpublished and analysis is ongoing—they demonstrate the type of result that will be available. The group is continuing analysis of the meeting data and is using results to make recommendations about future needs and directions for the ITEX network.

For more information, contact Marilyn Walker in Boulder, CO (303/492-5276; fax 303/492-6388; mwalker@taimyr.colorado.edu). ■



Effect of experimental warming on vegetative growth in high-arctic, low-arctic and alpine sites. Effect size is measured by "Hedges D", a quantification of the difference between experimental and control means. Confidence intervals that overlap the 0 line indicate a non-significant effect. A rule of thumb for interpreting the metric is that a D of 0.2 is a small effect, 0.5 is a moderate effect, and 0.8 is a large effect (figure by Marilyn Walker).

### IASC Funding Report Available

In 1995, the International Arctic Science Committee (IASC) appointed an international group of funding specialists to survey international funding opportunities and sources available to arctic scientists. The group was chaired by Patrick Webber (Michigan State University). The report is intended for scientists involved in IASC projects; it can also be used as a preliminary guide for other scientists or groups seeking international funding. The report is available free of charge from the IASC Secretariat in Oslo, Norway (+47-2295 9600 or 9602; fax +47-2295 9601; <http://www.npolar.no/iasc>). ■



## New Ecological Research Station Increases Arctic Access

Greenland's Ice Sheet is the largest in the Northern Hemisphere and second in the world only to that of Antarctica. For this and related reasons, arctic and subarctic Greenland are exceptional regions for scientific research.

On 15 August 1997, the Danish Polar Center (DPC) will officially open the Zackenberg Arctic Field Station on the coast of northeast Greenland (74°28'N 20°33'W).

Operation of the station takes place within the framework of Zackenberg Ecological Research Operations (ZERO), encompassing issues dealing with ecosystem science, monitoring and logistics in high-arctic Greenland. Zackenberg offers:

- the highest flora, fauna and landscape diversity in the European High Arctic;
- entire high-arctic drainage monitoring;
- fully integrated, long-term biotic and abiotic ecosystem monitoring including 50-year records;
- proximity to the Greenland Sea, a density-driven water pump, crucial to global heat flux;
- a shallow estuary of regional importance to shorebirds;
- comprehensive ecosystem database;
- thematic, digital 3D terrain model of the study area;
- easy access to paleoenvironmental archives; and
- logistics management.

Meltwater plains, braided streams (sandurs) and terminal moraine systems dominate the study area. Adjacent fjords are ice-covered October-July. The current margin of the Greenland Ice Cap is situated 60 km west; only a few small, local glaciers exist within the study area. Permafrost is continuous. The youngest (lowest) portions of the landscape were deglaciated 10,000 years ago. Adjacent mountains were weathered as etchplains in a tropical climate.

Zackenberg is owned and operated by the Danish Polar Center, an institution under the Danish Ministry for Research and Information Technology. The Danish Commission for Scientific Research in Greenland considers applications for U.S. research projects annually. The new facility



*A researcher secures a top-down view of the Zackenberg valley, the core study area of ZERO. The station and the runways are visible just above the rock crevasse (photo courtesy of DPC, Henning Thing).*

complements three other major research stations—Kangerlussuaq International Science Support (KISS) facility, Arctic Station and Sermilik Station.

KISS is a year-round facility located just north of the Arctic Circle on Greenland's southwest coast. The site has a long history as an important base for geophysical and glaciological research, but only limited life-sciences research thus far.

Other terrestrial arctic research facilities available to U.S. and international scientists include Toolik Field Station at Toolik Lake in Alaska, 150 km north of the Arctic Circle (68°38'N, 149°38'W). This location affords access to three major physiographic provinces including the Brooks Range, Arctic Foothills and Arctic Coastal Plain (see <http://zorba.uafadm.alaska.edu/iab/toolik.html>).

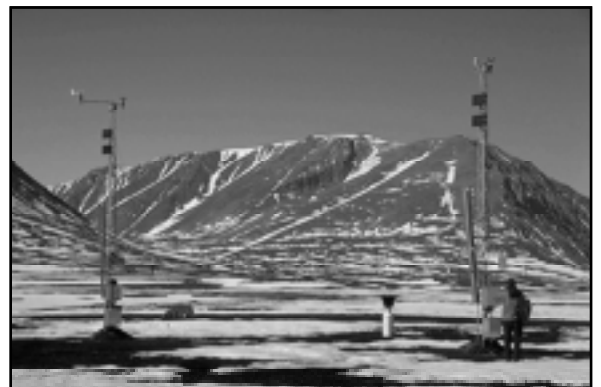
Abisko Scientific Research Station in Sweden lies 200 km north of the Arctic Circle (68°21'N, 18°49'E), on the south of Lake Torneträsk. Here, 60% of the 3,300-km<sup>2</sup> catchment area is below treeline (see <http://www.kiruna.se/-martint/>).

For more information on research stations in Greenland, see the DPC Web site (<http://www.dpc.dk/Sites/>).

For information on logistics, contact Henrik Lassen at the DPC in Copenhagen, Denmark (+45-3288 0133; fax +45-3288 0101; [hl@dpc.dk](mailto:hl@dpc.dk)). For information regarding scientific issues, contact Henning Thing (+45-3288 0120; fax +45-3288 0101; [hth@dpc.dk](mailto:hth@dpc.dk)). ■



*The Muskox is the largest land mammal species in the High Arctic and is indigenous to the Zackenberg region and the rest of Northeast Greenland. The Zackenberg study area holds abundant numbers of this interesting herbivore (photo by Henning Thing).*



*The automated climate station in mid-June in Zackenberg core study area. This station measures a total of 13 climate parameters at different levels (i.e., from 1.55 m below surface to 7 m above) (photo by Ole Humlum).*

## Nansen Drilling Implementation Plan Being Developed

Obtaining long cores from the Arctic Ocean requires scientific teamwork as well as multinational funding and support. The international Ocean Drilling Program (ODP) currently samples all the world's oceans except the Arctic. The ODP has drilled as far north as 80°N in Fram Strait; the Arctic Ocean proper remains to be explored.

Significant scientific opportunities in the Arctic Ocean led to the formation of the Nansen Arctic Drilling Program (NAD) in 1989 and preparation of a *NAD Science Plan* in 1992 (see *Witness*, Spring 1995). To achieve NAD's scientific goals and to develop a stepwise plan for scientific drilling in the Arctic Ocean, a workshop was held in St. Petersburg, Russia in October 1996. The workshop was hosted by Russia's Arctic and Antarctic Research Institute, and partially supported by NSF. A *NAD Implementation Plan* is now being developed, on the basis of workshop discussions among the 68 participants from Canada, Finland, Germany, Great Britain, Norway, Sweden, Russia and the United States.

The workshop updated and set new priorities for NAD goals. Scientific themes

focused on three primary questions:

- What is the role of the Arctic in global change in regard to:
  - onset and variability of perennial sea-ice cover and impact on ocean circulation?
  - interaction of land/ocean hydrologic cycles, including freshwater input to the Arctic Ocean?
  - permafrost/gas hydrate dynamics?
- What is the role of Arctic tectonic gateways in global change in regard to:
  - pre-Miocene biogeography and circulation of the Arctic Ocean, especially the role of the Pacific Gateway?
  - the impact of the opening of Fram Strait on world climate change?
  - the effect of the gateways on the evolution and migration of northern hemisphere biota?
- What are the nature and evolution of the major structural features of the Arctic Ocean basin in regard to:
  - the rifting process that created the Lomonosov Ridge?
  - a possible large igneous province of Cretaceous age, including the Alpha Ridge and Makarov Basin?

- the character of the arctic margin plateaus (Chukchi, Yermak and Morris Jesup Rise)?

In August 1996, NAD had conducted scientific drilling on Lomonosov Ridge from the Swedish icebreaker *Oden*. The effort was sponsored by the Royal Swedish Academy of Sciences.

Although three attempts to drill were eventually aborted, the third demonstrated the method's promise for future drilling. The bottom-hole assembly and riser reached the seafloor in 963 m of water, and drilling deployment began. At 250 m water depth, an obstruction in the riser blocked the drill string and ended the attempt.

With this experience in mind, participants at the October 1996 workshop discussed the technology and available commercial platforms suitable for the Arctic and adaptable to scientific drilling. Because of the challenges of drilling in the Arctic, the primary NAD drilling strategy is to focus first on topographic highs and continental shelves. Carefully selected shelf sites will permit key intervals to be targeted for high-resolution studies of recent sedimentary sequences.

To study the long-term paleoceanography of the central Arctic, a Giant Piston Core program is recommended, to be followed by a drilling program. To extend paleorecords and reach basement rocks, an offset drilling strategy would then be adopted.

The eastern Laptev Sea rift system has been proposed as the next scientific target. The most detailed seismic stratigraphic data are available, and the complete upper Pliocene and Quaternary sequence appears to be no more than several hundred meters thick. Laptev Sea drill sites will be selected in 1997; additional surveys will be conducted in 1998 to prepare the selected sites for planned drilling in 1999.

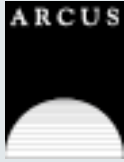
The *NAD Implementation Plan* will be available in May 1997 on the Joint Oceanographic Institutions, Inc. (JOI) Web site (<http://www.joi-odp.org>) and from the NAD Secretariat at JOI in Washington, DC (202/232-3900; fax 202/232-8203; [joi@brook.edu](mailto:joi@brook.edu)). ■

### Arctic Community Loses Ned Ostenso

Ned A. Ostenso, geophysicist and science and research administrator with the National Oceanic and Atmospheric Administration (NOAA), died of cardiac arrest on 11 April 1997 in Washington, DC at the age of 66. His death is felt as a great loss to many who had the pleasure of working with him—and to the arctic scientific community as a whole.

In 1996, Ostenso became a Fellow of the American Geophysical Union (AGU). He was simultaneously awarded AGU's Walter E. Smith medal for "extraordinary service to geophysics," in part for his significant role in the development of government science policies. Ostenso joined NOAA in 1977 and served as its chief scientist and as assistant administrator before he retired in 1996. Ostenso came to NOAA from the Office of Naval Research where he had served as deputy director and senior oceanographer. He was an assistant presidential advisor in the White House Office of Science and Technology in 1969-70. Ostenso took part in research in the Arctic, Africa, Europe and North America, and authored more than 50 technical publications. He served on the faculty of the University of Wisconsin and as a geophysicist with an International Geophysical Year expedition to Antarctica in 1957-58.

A mountain in Antarctica and a seamount in the Arctic are named in his honor. ■



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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 with NSF, by DOE, USARC, and member dues.

*Witness the Arctic* is published biannually by ARCUS. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of NSF. Submit ideas for the Autumn 1997 newsletter by 1 August 1997.

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**wit nĕss** (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

**May 1-4, 1997** Securing Northern Futures—Developing Research Partnerships. Edmonton, Alberta, Canada. Canadian Circumpolar Institute, University of Alberta. Contact the Canadian Circumpolar Institute Secretariat (403/492-4512; fax 403/492-1153; [canadian.circumpolar.institute@ualberta.ca](mailto:canadian.circumpolar.institute@ualberta.ca)).

**May 27-30, 1997** The American Geophysical Union Spring Meeting, Baltimore, Maryland. Contact AGU Meetings Department (202/462-6900 or 800/966-2481; fax 202/328-0566; [meetinginfo@kosmos.agu.org](mailto:meetinginfo@kosmos.agu.org); <http://www.agu.org>).

**May 31-June 2, 1997** ARCUS Annual Meeting and Arctic Forum. Washington, DC. Contact ARCUS.

**June 1-5, 1997** Arctic Monitoring and Assessment Programme (AMAP) International Symposium on Environmental Pollution of the Arctic and the Third International Conference on Environmental Radioactivity in the Arctic. Tromsø, Norway. Contact AMAP in Oslo, Norway (+47-2257 3400; fax +47-2267 6706; [lars-otto.reiersen@sftospost.md.dep.telmax.no](mailto:lars-otto.reiersen@sftospost.md.dep.telmax.no); <http://www.grida.no/amap>) or the Norwegian Radiation Protection Authority in Østerås, Norway (+47-6716 2564; fax +47-6714 5444).

**June 3-6, 1997** Workshop on the Impacts of Global Change in the Western Arctic/Bering Sea Region. Fairbanks, AK. Contact Gunter Weller, Center for Global Change-Arctic System Research, University of Alaska Fairbanks (907/474-7371; fax 907/474-7290; [gunter@gi.alaska.edu](mailto:gunter@gi.alaska.edu)).

**June 12-13, 1997** Arctic Environmental Protection Strategy Fourth Ministerial Meeting. Alta, Norway. Contact Gunnbjørg Nàvik at the AEPS Secretariat in Oslo, Norway (+47-2224 5974 or 5981; fax +47-2224 2755).

**June 24-28, 1997** International Conference of the Barent's Sea Region—Pomor Land in a Context of the Barents Region: Ecology, Economics, Culture. Archangel, Russia. Contact Conference Coordinator Alexandre Davydov at the Institute of Ecological Problems of the North Russian Academy of Sciences Ural Division (phone/fax +7-8182 490020; home +7-81872 433124).

**August 4-8, 1997** Science in the Community: Naval Arctic Research Laboratory's 50th Anniversary Celebration. Barrow, AK. Contact Glenn Sheehan, Executive Director of the Barrow Arctic Science Consortium (907/852-4881 or 888/627-5724; fax 907/852-8213; [basc@barrow.com](mailto:basc@barrow.com)).

**August 18-22, 1997** 11th Northern Research Basins Symposium and Workshop. Prudhoe Bay to Fairbanks, AK. Contact Douglas Kane, University of Alaska Fairbanks (907/474-7808; fax 907/474-7979; [ffdlk@aurora.alaska.edu](mailto:ffdlk@aurora.alaska.edu)).

**August 28-September 3, 1997** Fourth International Conference on Geomorphology and International Permafrost Association Executive Committee Meeting. Bologna, Italy. Contact M. Panizza at the University Degli Studi di Moden in Modena, Italy (+059-23 0394; fax +059-21 8326). ■

Check the ARCUS Web site Calendar (<http://arcus.polarnet.com>) for more...

## Publications

*The 1994 Arctic Ocean Section—The First Major Scientific Crossing of the Arctic Ocean.* 1996. Walter Tucker and David Kane (eds.). 1996. U.S. Army Cold Regions Research and Engineering Laboratory, Special Report 96-23. Hanover, NH. 116 p.

*Modeling the Arctic System: A Workshop Report on the State of Modeling in the Arctic System Science Program.* 1997. ARCUS, Fairbanks, AK. 141 p.

*Nuclear Flashback: The Return to Amchitka.* 1996. Pam Miller. Report of the Greenpeace scientific expedition to Amchitka Island, Alaska, site of the largest underground nuclear test in history. Washington, DC. 35 p. on-line only (800/326-0959; <http://www.greenpeace.org/-usa>)

*Traditional Ecological Knowledge of Beluga Whales: An Indigenous Knowledge Pilot Project in the Chukchi and Northern Bering Seas.* 1996. Henry P. Huntington and Nikolai I. Myrmin, (eds.). Inuit Circumpolar Conference, Anchorage, AK. 88 p. ■

## A Note from the President

At our recent Science Education Workshop, Oscar Kawagley told about his new laptop computer. "The thing was out of date as soon as I opened the cover." He was also talking about educating children in a world of rapidly changing science and technology.

Education is about our hopes for the future. Science education presents tremendous challenges, however. Science, by the very nature of its enterprise, constantly seeks changes in its own conceptions of the world. Science education is not just imparting a body of knowledge but also the tools to expand and question the information and the way of learning itself.

For many reasons, the U.S. arctic research community wants to become more involved in science education at all levels. While the polar regions may be perceived as remote and unrelated to the lives of most Americans, we are growing to understand their importance to the whole Earth system. We can plant the seed for this understanding in others very early in their lives.

One effective way to reach children is to reach their teachers. Peter Amati,

a teacher from Massachusetts, lobbied to accompany his student to Antarctica by pointing out to NSF that the student would return for one more year of high school, but he would teach for another 15 years. His influence would endure.

We cannot teach the body of knowledge that will be available in 20 years, but we can teach people how to question and comprehend. When teachers know how to do research, they can teach the children. Researchers, in turn, can learn much from teachers about the art of imparting knowledge.

NSF is developing a program for the Arctic that will involve teachers and students in research. Such a program will reach a few teachers, researchers, students and parents. We need other ways in which to involve teachers and students in the evolution of arctic science.

As a research community, we have another motive. We want to continue attracting the best and brightest into arctic research. The recent ARCUS Awards for Research Excellence (see page 14) are just the beginning of what we can do to recognize and encourage young researchers.

Education is an investment that can yield exceptional returns, but those returns may come 15-20 years in the future. What investment should we make now to ensure that people in 2017 can build on the research we do today? In our rapidly changing world, a generation is a relatively long time-scale. Still, such foresight is key to sustainability.

*Nicholas S. Flanders*

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# *Witness The* **ARCTIC**

Arctic Research Consortium of the United States Member Institution

Spring 1997

## **Arctic Research at the Cold Regions Research and Engineering Laboratory (CRREL)**

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), located in Hanover, New Hampshire and Fairbanks, Alaska, is an internationally renowned center for cold regions science and engineering. CRREL's single focus as a cold regions research and development (R&D) organization is to provide expertise to the Department of Defense, other federal, state and local agencies, and the private sector. This strategy results in an internationally recognized center of expertise with unique state-of-the-art facilities and a cost-effective capability. Many of the projects described below are either fully or partially funded by outside agencies. CRREL has earned an international reputation of excellence that is sustained by its exceptional technical and support staffs and by emphasis on a balance of theoretical, experimental, laboratory and field work. The hallmark of its experience and expertise is the direct interaction of its research staff with the environment in the Arctic, Antarctica, Alaska and the other northern states, northern Europe and Korea. ■

### **Ice Coring**

CRREL researchers have been involved in deep ice coring since the 1950s in Greenland. This expanded to Antarctica in 1957 and has continued most recently with the Greenland Ice Sheet Project (GISP2) core funded by NSF. In the earlier cores,



*CRREL maintains facilities in Hanover, New Hampshire (above) and Fairbanks, Alaska. Researchers conduct field work in the Arctic, Antarctica, Alaska and other northern states, northern Europe and Korea (photo courtesy of CRREL).*

CRREL was involved in drill development (electromechanical drill), logistics and science. CRREL researchers also initiated comprehensive ice-core analysis, as it is known today.

With the GISP2 core, researchers have been involved primarily with physical properties and age dating of the core. Properties studies include ice density, ultrasonic velocity, air bubbles, gas content, fabrics and ice structure/deformation. Researchers from CRREL led development

of the depth-age scale for the core. A combination of several annual parameters, including visible stratigraphy, electrical conductivity, laser light scattering of dust, oxygen isotopes and chemistry, and non-continuous parameters including volcanic signals, were used for the depth-age scale. This is the longest, most continuously dated record using so many parameters.

For more information on the GISP2 core, see the feature article in this issue of *Witness the Arctic*. ■

*(continued)*

## Sea Ice

CRREL researchers have been involved in every major arctic sea-ice initiative, from the Arctic Ice Dynamics Joint Experiment (AIDJEX) to the newly planned Surface Heat Budget of the Arctic Ocean (SHEBA) project (see *Witness*, Autumn 1996). Characterizing ice properties and processes contributes to understanding the interaction of ice with the ocean and atmosphere.

CRREL's participation in recent major programs includes the Office of Naval Research Sea Ice Mechanics Initiative (SIMI), Electromagnetic Properties of Sea Ice (EMPOSI), and the 1994 U.S./Canada Arctic Ocean Section (AOS-94) (see *Witness*, Autumn 1995).

During SIMI, CRREL researchers, in collaboration with the National Oceanographic and Atmospheric Administration Pacific Marine Environmental Laboratory, measured *in-situ* ice stress over a six-month period at selected edge and center sites on a multiyear floe. Concurrent measurements of stress and deformation were made to provide a direct (rather than implicit) evaluation of ice-dynamics models and to improve those models. The stress records clearly indicate that:

- ice stresses are caused by changes in air temperature as well as ice motion, and
- these components can be identified and separated.

## Areal Distribution of Snow Properties in the Arctic

The goals of this project are to:

- understand the role of snow cover in governing winter heat and mass exchange between the ground and atmosphere, and
- develop the ability to predict snow distribution from landscape features and meteorology.

Measurements of the snow cover have been made during five over-snow traverses in the Kuparuk Basin of northern Alaska. Measurements of snow depth, density and snow water equivalent have been made at over 100 stations, and a sled-mounted FM-CW radar has been used to measure an additional 250,000 snow depths.

The results are being used to develop empirical relationships describing how the snow cover is related to the regional climate, topography, landscape and vegetation. Using these relationships, preliminary end-of-winter snow-

EMPOSI was a multidisciplinary, multi-institution effort aimed at relating the electromagnetic properties of ice to its physical state and structure. CRREL's contributions included:

- hosting the laboratory portion of the effort,
- providing qualitative and quantitative characterization of physical properties of the ice,
- determining dielectric constants for the ice, and
- measuring optical properties of the ice.

An important part of the properties documentation included statistical characterization of brine and air pockets in the ice. Researchers investigated the optical properties of sea ice from the ultraviolet to the near infrared (280-1000 nm) by making spectral measurements of albedo, bi-directional reflectance, reflected light polarization and transmittance.

distribution maps for the Kuparuk Basin have been prepared.

A physically based snow-distribution model that requires precipitation and wind data has been developed in collaboration with Glen Liston of Colorado State University. The model can evolve and distribute a snow cover over the landscape, allowing for wind transport and sublimation. A relational model, developed from observed patterns of snow deposition and topographic features, has also been developed to estimate snow distribution where meteorological data are sparse.

Extensive measurements of snow thermal conductivity and snow/ground interface temperatures are being used to investigate the role of snow cover in controlling winter heat losses from the ground and snow-covered vegetation. A close positive relationship between snow



*CRREL researcher measures the albedo of the sea-ice cover off Barrow, Alaska during the Office of Naval Research Electromagnetic Properties of Sea Ice (EMPOSI) field program. The objective is to monitor spatial and temporal variability in the reflected, absorbed and transmitted light as a function of ice conditions including ice that is snow-covered, bare, sediment-laden, bio-laden, melting and/or ponded.*

On AOS-94, researchers characterized ice and snow properties across the Arctic Ocean, measured the albedo of a variety of ice surfaces, and documented melt pond and floe size distribution using precise aerial photography. Chemical properties of the ice were also characterized; measurements included major ions and nutrients. Additionally, investigations of ice-borne sediment were carried out to determine processes of incorporation, likely source areas and levels of radionuclide contamination. ■

thermal resistance and the local amount of shrubs has been observed. ■

### Scientific Disciplines

- Snow, ice and frozen ground
- Polar operations/logistics
- Non-destructive subsurface geophysical exploration
- Facility design, construction and maintenance
- Winter mobility
- Deep ice coring/climate change
- Environment quality
- Sea-ice geophysics
- River-ice management
- Low-temperature instrumentation

### Snow-Atmosphere Exchange Processes

In polar regions, gaseous chemical species found in the atmosphere become incorporated into the snow and firn; decades of snow accumulation compact the firn into glacial ice. Ice cores from polar regions provide a record of changes in concentrations of chemical species over time scales ranging from seasonal to decadal. The process of air-to-snow transfer can filter, and potentially distort, atmospheric signals before they can be preserved in the glacial record.

CRREL researchers are examining the physical processes that affect the manner in which heat, vapor and chemical species in air are incorporated into snow and polar firn. These processes control the rate at which reactive and non-reactive chemical species in the atmosphere become incorporated into the snow, firn and polar ice and, thus, affect interpretation of the polar ice-core data. The objectives of the research are to:

- define the magnitude and extent of these transfer processes, and
- develop a process-level understanding and modeling capability for the snow and firn.

Findings to date show that the firn at Summit, Greenland is very permeable and that layering is important in controlling diffusion and advection within the firn. Significant subsurface air movement in the firn is likely to occur under conditions of sustained winds, and large lateral flow can occur in buried hoar layers. ■

### Acoustic Aircraft Detection Over Polar Snow

The objectives of this research were to:

- measure acoustic aircraft signatures on the Greenland Ice Cap, and
- conduct basic acoustic measurements of parameters needed to model this environment.

Field studies during this program obtained actual signature measurements on a military aircraft as well as basic scientific information characterizing acoustic propagation, so that the effect of this environment could be assessed. The project provided information needed to assess the feasibility of acoustic detection of aircraft, cruise missiles or ground vehicles by unattended ground sensors in areas with a permanent polar snow cover.

Measurements of sound levels and spectral signatures of LC-130 Hercules fixed-wing aircraft were obtained during normal operational flybys, takeoffs and landings at Dye 2 in the center of the Greenland Ice Cap. Measurements were also made of controlled acoustic pulses propagating horizontally over the snow surface. Aircraft recordings were obtained under both calm and high-wind conditions. High winds significantly decreased the aircraft detection range, especially at low frequencies.

Controlled pulse experiments showed that surface conditions in these areas can change quite rapidly. The experiments provided information that will be used to construct an accurate propagation model. This information can be used in the design of new surveillance sensors and estimation of sensor performance in polar regions. ■

### Ground-Penetrating Radar and Northern Hydrology

Ground-penetrating radar (GPR) has been used to find useful water supplies on arctic floodplains in winter and important aquifers beneath permafrost in central Alaska year round. Most arctic river channels freeze completely by late winter. Those that don't freeze usually have ice blisters, caused by pressure from the confined water below the channel. Under all channels, thaw regimes containing water under pressure occur within the frozen alluvium.

Bottom and sub-bottom water has been profiled with high-resolution GPR operating at 500 MHz and has been verified by drilling. Excavations into the blisters have found hundreds of thousands of gallons of water. Some thaw regimes remain until mid-April and, therefore, probably never freeze completely. The regimes appear to be partially frozen but permeable, and they can produce limited flow for hours.

In central Alaska, within the broad Tanana Valley floodplain, permafrost is distributed discontinuously. At Fort Wainwright, deep aquifers, which can develop where permafrost does not extend into bedrock, transport water westward toward Fairbanks. Accidental spills and pipeline leaks can contaminate these

aquifers by passing between zones of permafrost. CRREL researchers have used GPR to map sub-permafrost groundwater and frozen bedrock and to site monitoring wells. In many cases, the groundwater appears to be eroding the permafrost.

GPR has been used to define the top of the permafrost, groundwater within perennial thaw above permafrost, and intrapermafrost zones with high percentages of ice or organics. GPR at frequencies above 100 MHz best defines the near-surface features, while GPR near 50 MHz defines the deeper features. ■

### A Winter Concreting Breakthrough

Until recently, there have been no portland cement concrete mixtures that could reliably gain strength and resist frost damage when placed in below-freezing weather. Fresh concrete had to be kept warm by covering it with insulation or enclosing it within a heated shelter. The U.S. concrete industry spends an estimated \$800 million every year to combat the cold. By adding chemicals that depress the freezing point of water and accelerate the hydration rate of cement, it is possible for concrete with an internal temperature below 0°C to gain strength at the same rate as additive-free concrete that is kept warm. The challenge was to find an effective combination of chemicals that would not harm the concrete.

Two prototype formulations were developed by W.R. Grace and Master Builders, respectively. Each prototype is capable of protecting concrete down to -5°C, while allowing the cold concrete to gain strength as if it were somewhere between 5° and 10°C. Additionally, the chemicals:

- did not corrode steel,
- did not react with siliceous aggregate,
- did not affect concrete workability, and
- did not reduce concrete durability.

Both prototype admixtures performed well in tests at the Soo Locks in northern Michigan during the winter.

Concreting with these new admixtures cost one-third less than concreting using conventional practice. ■

## Ilisagvik College

Recently, officials from CRREL traveled to Barrow, Alaska, taking the initial steps to enter into an educational partnership with Ilisagvik College (see *Witness*, Autumn 1996).

The mission of Ilisagvik College is to provide post-secondary academic, vocational and technical education to residents of the North Slope Borough, preparing them for employment and assisting them to live with dignity and economic independence while perpetuating and strengthening Inupiaq language, culture, values and traditions. (Ilisagvik translates in Inupiaq as "a place to learn.")

Ilisagvik College is located on the North Slope of Alaska. This region, including the Bering, Beaufort and Chukchi seas are among the areas in which CRREL researchers have been working for many years investigating the physical, chemical and mechanical properties of snow and sea ice.

Students will have the opportunity to work and gain academic credits by filling varied roles in real-life projects. Other benefits to the college include equipment use and the possibility for faculty and students to work on-site at the Hanover and Fairbanks facilities; the laboratory staff will be available to act as mentors as well as assist in teaching and course development. CRREL will benefit by having a work force on the North Slope. Given the present impacts of downsizing, these and other working relationships with academia are seen as valuable assets for CRREL. ■

## Partnership in Education

- Women in Science and Engineering Internships
- Disability Awareness
- High School Apprenticeship Program
- Junior Solar Sprint
- Ilisagvik College

## NUWC's Off-Site Office

In 1994, the Naval Undersea Warfare Center (NUWC) in Newport, Rhode Island and CRREL jointly established a Naval Liaison Scientist Position at CRREL. The purpose is to:

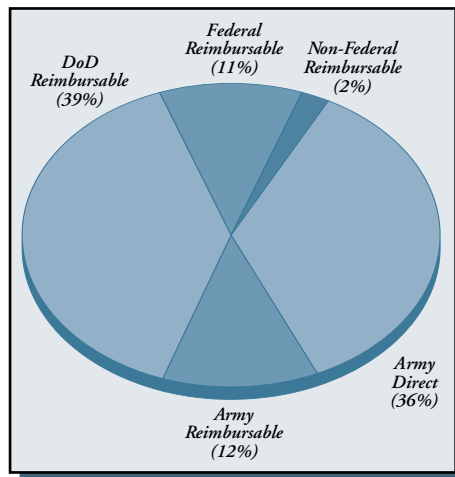
- sustain research and development capabilities associated with arctic-related issues that are of interest to both CRREL and NUWC, and
- foster technical exchange between two significant R&D organizations.

Since the establishment of this office, the two agencies have worked jointly on seven unique research efforts, including topics such as:

- a desalination process that occurs beneath the Antarctic ice shelves,
- the wetting process associated with geotextiles, and
- atmospheric icing of communications antennas.

In addition, an exchange technical lecture series enables scientists from each organization to visit and lecture at the host agency.

The intent of these combined efforts is to complement and enhance individual capabilities for current research and to attract future research projects. ■



*Sources of CRREL research dollars for FY96: CRREL receives approximately one-third of its research budget directly from the Army. The rest comes from individual reimbursable programs based on written proposals. Most of the reimbursable money comes from Department of Defense (DoD) organizations and other federal agencies (e.g., NSF, NOAA, NASA, FAA, FHA).*

## The Cold Regions Center of Expertise

The Cold Regions Center of Expertise (CRCX), an organizational element of the U.S. Army Corps of Engineers, is a joint venture between the Corps' Alaska District operations in Anchorage, Alaska and CRREL in Hanover, New Hampshire.

Established in 1996, the CRCX effectively integrates the unique R&D expertise at CRREL and the practical technical knowledge and experience of the Alaska District to accomplish applied research, engineering, construction and operations in cold regions of the world. This partnership is based on a team approach with free and open exchange of information and technology, and an emphasis on technical excellence and customer orientation.

The CRCX maintains state-of-the-art facilities and technical expertise for developing research and engineering knowledge and for managing the design and construction of projects that are affected by the special demands of the cold regions. ■

## Unique Facilities

- Ice Engineering
  - ice tank
  - flume
  - hydraulic model basin
- Frost Effects Research Facility
  - 12 test cells
  - 8 frost cycles per year
  - 24 cold laboratories (-35°F)
- Class 100 Clean Rooms
- Sleepers River Watershed
- Sea-Ice Ponds
- Remote Sensing/GIS Center
- Geophysical Research Facility
- Permafrost Research Site
- Research Permafrost Tunnel
- Cold Regions Science and Technology Information Analysis Center

For more information, visit the CRREL Home Page on the Internet at: <http://www.crrel.usace.army.mil> or contact Vicki Keating, CRREL, 72 Lyme Road, Hanover, NH 03755-1290  
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