BUILDING PARTNERSHIPS

IN POLAR RESEARCH AND EDUCATION

ARCTIC RESEARCH CONSORTIUM OF THE UNITED STATES

Cover: Qaiyaan Opie, Wayne Danjin, and Jayson Vinas, students at Barrow High School in Barrow, Alaska, learning to use the core barrel and Jiffy motor before drilling into the ice behind the school to collect samples (see pages 15 and 21 for more details). Photo by Tim Buckley.

Arctic Research Consortium of the United States
600 University Avenue, Suite 1
Fairbanks, AK 99709
Phone: 907/474-1600
Fax: 907/474-1604
arcus@arcus.org
http://www.arcus.org

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REPORT FROM THE ARCTIC SCIENCE EDUCATION WORKSHOP

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FOREWORD

The polar regions offer many opportunities to link research and education. Researchers and K-12 educators have already started to build partnerships in curriculum development, field-based experiences, and laboratory activities based on discoveries in the Arctic and Antarctic. More needs to be done, however, to strengthen existing partnerships and build new ones.

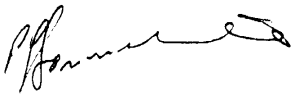
The need for research-education partnerships is particularly clear in arctic science education. On the one hand, students living in the Arctic may feel remote from modern scientific research, although they inhabit an underinvestigated region which attracts talented researchers tantalized by important questions. On the other hand, most students and members of the public outside the Arctic have a limited and often inaccurate understanding of the region and the exciting information arctic researchers and communities can provide. Both groups, however, find research in the Arctic a compelling subject to explore when given the chance. International contributions are obviously necessary for effective arctic science education, and the extensive educational opportunities developed in partnership with Antarctic research are pertinent as well. The educational potential of facilitating partnerships in polar science led the Arctic Research Consortium of the United States (ARCUS) to organize a workshop held in New Orleans in April 1997 to stimulate communication on these important issues and develop recommendations for future action.

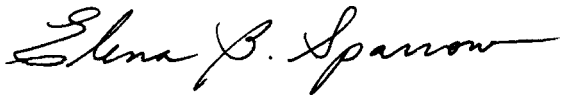
Fifty-eight scientists, educators, and other interested professionals attended the three-day workshop. The consensus reached at the workshop was the need to introduce into K-12 classrooms arctic science curricula which reflect the capabilities of emerging technologies, the contributions of local indigenous peoples to science and ways of knowing, and the collaboration of researchers with educators. The following issues were also recognized: the need for curricula to evolve with the changing face of research activities, the need for scientists and educators to address the limitations in science and education efforts placed on people with disabilities, and the benefits of the global approach to collaborative efforts particularly in polar science and education.

As co-chairs of the workshop, we would like to acknowledge the important contributions of the Office of Polar Programs (OPP) at the National Science Foundation (NSF) to polar science education. The OPP Arctic Sciences Section has provided leadership and guidance to the development of arctic science education programs, working with partners such as the OPP Antarctic Sciences Section and the NSF Education and Human Resources Directorate.

The Arctic Sciences Section provided the major funding for the workshop and this report. Readers seeking more information about arctic science education programs at NSF are encouraged to contact the identified arctic education liaison within OPP, Fae L. Korsmo (Program Manager for Arctic Social Sciences, Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; phone: 703/306-1029; fax: 703/306-0648; fkorsmo@nsf.gov).

We greatly appreciated the staff at ARCUS who were essential to the successful completion of the workshop and this report. Wendy Warnick guided both processes with great deftness; Kristjan Bregendahl, Betty Galbraith, Milo Sharp, Anne Sudkamp, Diane Wallace, and Alison York provided workshop, technical, and editorial assistance. We also appreciated the participants' abundant enthusiasm for building partnerships in polar research and education.





Peter Sommerville, Co-chair
Linking Education with Antarctic Research in New Zealand
International Centre for Antarctic Information and Research

Elena Sparrow, Co-chair
School of Agriculture and Land Resources Management
University of Alaska Fairbanks

June 1998

Executive Summary

In contrast to the ice-bound Antarctic, the Arctic has been populated by humans for more than 10,000 years. Today, the human communities of the circumpolar North range from small indigenous communities reliant on local resources to modern industrial cities. Research relevant to these diverse communities and their extraordinary environments offers exciting educational opportunities. Investigations of human migration into the New World via the Bering Land Bridge, for example, or of petroleum formation from plant and animal remains, including those of the dinosaurs which once roamed the Arctic, can foster young arctic residents' interest and involvement in scientific learning. For students living far from the Arctic, a curriculum that incorporates local knowledge from the Arctic can bring a human perspective to the science classroom. A K-12 curriculum grounded in arctic research—rich with images of fascinating plants, animals, and people thriving in a challenging environment, vast unexplored areas, and icy seas—can encourage students to pursue scientific careers, promote better understanding of publicly funded research, and improve popular awareness of the Arctic as a critical component of the global environment.

To examine the role of arctic science in U.S. primary and secondary education, 58 teachers, researchers, and curriculum specialists gathered in April 1997 in New Orleans for a workshop sponsored by the Arctic Research Consortium of the U.S. (ARCUS) and funded by ARCUS and the National Science Foundation (NSF). The workshop objectives were twofold:

- to provide a forum for the development of educational material investigating the Arctic for K-12 classrooms around the country, and
- to bring current research activities into K-12 classrooms in arctic communities.

Workshop participants shared information on a range of science education concerns. The workshop emphasized collaborations among educators, researchers, and their communities to bridge differing world views, particularly in the diverse cultures and learning styles of northern communities. Although arctic science education was the primary subject, presentations and discussions included both arctic and Antarctic perspectives, forming a broad polar theme.

Participants endorsed mechanisms to facilitate partnerships between researchers and K-12 classrooms, including ideas to reduce institutional barriers for both teachers and researchers. Because direct involvement of researchers in this process is imperative, researchers need

opportunities to learn more about the education system in order to improve the effectiveness of their work with teachers and students. Similarly, teachers need to participate actively in the research process so that they can effectively teach modern methods and convincingly share their experiences with students. School districts should be encouraged to allow release time for teachers to undertake hands-on research experiences. Most universities support researchers' work with students and teachers; some accept education- and student-oriented publications as part of their professional publication requirement. NSF can invest in these partnerships by supplementing research grants for related education activities and by encouraging researchers to publish in education- and student-oriented publications.

Presenters shared successful current educational projects and programs from both the Arctic and Antarctic as models for planning. To understand and adapt these models and advance new proposals for practical application, working groups met several times during the proceedings to advance three major objectives.

Media-based arctic science education. Workshop participants strongly recommended development of a media-oriented education program based on live video expeditions complemented by Internet and classroom activities. Such a high-profile media event could successfully focus the attention of educators and the public on research in the Arctic. Participants also recommended development of a longer term educational program that would feature curricula on the Internet, such as electronic or virtual arctic field trips, and would feature structured classroom projects with guides from the arctic community.

Curriculum development. Participants agreed on the need for a broad-based and coordinated educational effort to introduce arctic research into K-12 curricula. To address the requirements of instruction in both circumpolar and continental U.S. classrooms, the projected curriculum should be multifaceted, integrated, and universal in appeal but remain adjustable for local purposes. Ideally, to meet these complex parameters, teams including local teachers, community members, researchers, and curriculum writers will collaborate to formulate educational materials. Wherever possible, the proposed learning program will include hands-on research experience for both students and teachers. Because the Arctic is beyond the physical reach of most students and, conversely, because students in the Arctic have limited access to scientists, the use of information technology is crucial to the success of arctic science education programs. The curriculum should employ emerging technologies such as web-accessible or CD-ROM databases to stay current and give students a sense of the dynamic nature of science. Supplements to the curriculum could include interactive Internet sites, online mentoring, access to current research data in a form understandable to students, and a system for matching researchers and teachers for collaboration. Technological resources must be supported by other methods as well, because a modern communications infrastructure remains inaccessible to many remote areas of the Arctic.

Partnerships in research and education. Participants formed partnerships to develop specific interdisciplinary research-education projects. Work on the projects synthesized diverse expertise and developed connections among academic, agency, arctic community, and education participants. Several examples of successful collaborative projects evolving from the workshop are described on page 15.

Building Partnerships: Workshop Summary

Fifty-eight educators, curriculum specialists, and polar researchers gathered in New Orleans in April 1997 for a workshop on science education sponsored by the Arctic Research Consortium of the U.S. (ARCUS) and funded by the National Science Foundation (NSF). The workshop objectives were:

- to provide a forum for the development of educational material investigating the Arctic for K-12 classrooms around the country, and
- to bring current research activities into K-12 classrooms in arctic communities.

The participants articulated current strategies and goals for integrating science education into K-12 classrooms, developed educational material about the Arctic and the research taking place there, and planned methods to bring research activities into K-12 classrooms in arctic communities. Although the primary focus was on arctic science education, presentations and discussions included both arctic and Antarctic perspectives, creating a broader, polar theme.

A special session on education proposal development clarified the NSF Directorate for Education and Human Resources (EHR) granting process. Emma Walton and Wayne Sukow of EHR led the special session and reviewed types of projects funded by EHR's Division of Elementary, Secondary, and Informal Education (ESIE), evaluation criteria, and characteristics of strong project designs including:

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

Participants formed sets of *ad hoc* panels to review a previously funded ESIE proposal. A plenary session followed in which they discussed their review process and the recommendations of each panel. Carole Seyfrit, representing the NSF Office of Polar Programs (OPP), provided information about funding opportunities available through OPP.

Keynote speaker Dr. Richard Radtke demonstrates that scientists with disabilities can conduct field research in the Arctic. Above, Radtke is ice fishing for arctic char at Anders Lake, outside Tromsø, Norway, with colleague, Dr. Anders Klemetsen. They are collecting char for otolith studies to determine migration history. Radtke is a fisheries oceanographer with interests in larval fish ecology, large pelagic fish population ecology, and Antarctic fish ecology. He was the first handicapped researcher to work in Antarctica (http://www2.hawaii.edu/~radtke/Radtke.html). Photo by Judith Radtke.

The keynote address by Dr. Richard Radtke, *Arctic Science: A Challenged Look Toward Integration*, (see abstract, page 20) emphasized the opportunities and barriers to participation in research and education for people with disabilities. Radtke's descriptions of conducting field research in the Arctic and Antarctic and his discussion of the attitudes, methods, and technology that make research possible for physically disabled scientists (Dr. Radtke is quadriplegic) inspired participants. Researchers and educators emerged from this session with a new understanding of the cultural limitations placed on people with disabilities and how this problem can begin to be addressed in science education efforts.

A session on paradigm shifts in science education emphasized important changes occurring in the delivery of arctic science education and presented a variety of programs that:

- involve students directly in research with scientist mentors;
- create research experiences for teachers and students in the Arctic and the Antarctic;
- provide media-based educational programs featuring live electronic field trips;
- implement research-guided, long-term changes in science instruction to increase student interest and achievement;
- serve nontraditional students from rural and northern communities by emphasizing interdisciplinary studies, real-life relevance, and process-oriented learning; and/or
- promote inquiry-based learning and comparative studies of the polar regions to develop scientist-educator partnerships and to attract a larger public audience.

A session on integrating data into curricula and classroom projects included demonstrations of a variety of computer and CD-ROM materials and applications.

Participants formed working groups that met several times during the proceedings to work on three major tasks:

- planning for media-based arctic science education,
- developing curriculum resources, and
- creating specific partnership projects in research and education.

The first working group focused on planning media-based educational programs, including an electronic field trip to the Arctic. The other two working groups discussed collaborations needed to accomplish their goals, identified promising projects for further planning and development, and discussed strategies for implementing ideas. Participants initiated development on several collaborative projects during the working group sessions; work on them has been ongoing (see Initial Accomplishments, page 15).

The other major workshop theme—science education efforts within Alaska—explored the idea of an education system that respects and uses the philosophical and pedagogical bases of diverse cultural traditions. Keynote speaker Dr. Oscar Kawagley, of the University of Alaska Fairbanks School of Education, spoke about teaching and learning through the local culture as a cornerstone for all education (see abstract, page 24). Kawagley described his experiences as a Yup'ik and a professional educator and researcher, including the ways in which these equally valid world views complement and oppose each other. His address introduced a variety of presentations offering diverse perspectives on:

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

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

WORKING GROUP RECOMMENDATIONS

Media-based arctic science education

The first working group focused on planning for a media-based educational program based on live video expeditions complemented by Internet and classroom activities, as well as a longer term media-based program featuring an electronic field trip to the Arctic.

Live video expeditions. The concept of a live video arctic educational program generated considerable interest. Passport to Knowledge producer Geoff Haines-Stiles spoke about how *Live from Antarctica* functioned as a 100% video, 100% Internet, and 100% curriculum effort, emphasizing that the use of *real scientist*, *real location*, and *real time* were key to its success. He suggested the group plan to identify opportunities, difficulties, and solutions should it recommend undertaking such an educational venture.

The U.S. Arctic Research Commission and the Alaska Native Science Commission should be briefed early in any effort and invited to advise on appropriate content. The production of a real time arctic educational program would stimulate collaborations among the many federal agencies and indigenous peoples' organizations which would be involved, benefitting the video production and the organizations themselves.

A live video expedition to the Arctic would be a high-profile opportunity through which federal agencies, indigenous arctic peoples, researchers, and educators could reach a wide international audience with positive and realistic information about the Arctic.

A multi-year electronic educational program. Interest in developing a multi-year educational effort linking students from around the United States and the world with arctic science researchers, educators, and arctic science problems intensified during the workshop. The potential value of such a program mandated the highest priority for its development. ARCUS was encouraged to facilitate a follow-on workshop to move this initiative forward.

The logistically challenging expeditions characteristic of polar research can spark students' interest in science, while new information technologies allow researchers to communicate with students from remote regions. Above, second mate Tom Baker takes students from Prebbleton School in Lyttleton, New Zealand, on a tour of the research icebreaker Nathaniel B. Palmer *before she puts to sea to investigate the Antarctic for eight weeks in 1998. Students at the school and from all over the world are following the voyage of the* Palmer *on a web site (http://learnz.icair.iac.org.nz/98/index.htm) as part of the LEARNZ program. See pages 17 and 23 for more details. Photo by Peter Sommerville.*

The program would include multi-month blocks of educational curricula offered on the WWW as electronic or virtual arctic field trips. The blocks would initially focus on topics relating to existing programs such as the Rural Systemic Initiative (RSI) or Global Learning and Observations to Benefit the Environment (GLOBE). Concurrent with these blocks would be curricula developed around topical, seasonal, or otherwise noteworthy arctic science.

A relatively inexpensive and attractive educational model exists in the Linking Education with Antarctic Research in New Zealand (LEARNZ) program. LEARNZ is a real time, interactive, multimedia resource for schools that uses a range of educational resources, including live audio-conferencing from remote locations in Antarctica, to promote understanding in science and technology. An arctic program would add to this model a networking feature with students from the Arctic mentoring or guiding students from outside the Arctic in their electronic quests. An international partnership with LEARNZ could develop a program featuring the polar regions, allowing students in New Zealand and the United States to develop a more comprehensive understanding of arctic and Antarctic research and international research and logistics collaborations.

Other recommendations. ARCUS was encouraged by participants to take a significant coordinating and developmental role in arctic science education.

Participants applauded the efforts of the NSF-OPP to integrate science education with polar research and suggested several measures to strengthen these endeavors.

- The Office of Polar Programs Arctic Section was encouraged to establish partnerships to increase support throughout the Foundation for the development of education programs which complement arctic research efforts; and
- The Office of Polar Programs was urged to provide supplemental funding to existing arctic research grants for project-based educational efforts.

Curriculum development

The second working group assessed the linkages among researchers, educators, and communities with an emphasis on building better communication among these groups. A set of common themes for researchers, teachers, and community members was a key objective. The development of a universal curriculum that could be tailored for local views was

encouraged. For example, lessons could focus on global change in relation to the polar regions and include information relevant to specific locales.

Improving communication. Jargon in science and education is an obstacle to building better communication. This working group stressed the importance of using ordinary words, where possible, and recommended that ARCUS develop a glossary of technical terms with plain language interpretations to promote understanding among disciplines and between educators and researchers.

Cross-cultural communications in research and education need improvement. Participants recommended using *Communicating Across Cultures*, the four-part video series featuring Russian Orthodox priest Father Michael Oleksa, to help researchers better understand how to communicate with Native peoples. In this series produced by Juneau, Alaska, television station KTOO, Father Oleksa describes the differing world views of the world's dominant and traditional cultures and offers guidelines for communication among them.

Encouraging classroom collaborations. Collaborations among teachers, researchers, and curriculum writers are essential for developing curricula that bring research into the classroom. Researchers' participation in classrooms is also important; researchers will both disseminate information and gain greater understanding of the challenges and opportunities teachers face. Remaining in the classroom for an extended period of time (a few days or a week) will help researchers understand the ways in which different grade levels can comprehend and use scientific data.

Researchers and educators must be conversant with the National Science Education Standards[1] to play a significant role in developing curricula. These standards were defined most recently in 1996 by the National Research Council (http://www.nap.edu/online/nses/html/overview.html) and include standards for science teaching, professional development for teachers of science, assessment in science education, science content, science education programs, and science education systems. The State of Alaska is reviewing a set of cultural standards for adoption as well (http://www.ankn.uaf.edu/standards.html). The development of a condensed, abridged edition of the national standards—highly recommended by participants—would enhance the ability of scientists and researchers to use them.

Participants at the 1998 Old Minto Cultural Camp build a basket for a new fishwheel. Most of the camp participants are teachers in rural Alaska schools who are enrolled in the University of Alaska's Cross-Cultural Orientation Program. Benjamin Howard (left), a teacher at the Shishmaref School, and Byron Rice (right), a teacher in Glennallen, learn directly from Minto Elders like Lige Charlie (center) by sharing the many chores of an Athabascan fishcamp. In summer, Native people in many areas of the North move to fishcamps to harvest salmon and other resources for subsistence. The Athabascan fishwheel rotates in the river's current to catch fish efficiently. For more information on the camp see page 13. Photo by Jennifer McCarty.

1. National Research Council. 1996. *National Science Education Standards.* National Academy Press: Washington, DC. 262 pp.

ARCUS' directory of arctic researchers and projects should be widely advertised to help educators improve access to current research. The directory and other information about arctic research can be found on the ARCUS web site (http://www.arcus.org). Arctic data are archived and available to the public through the National Snow and Ice Data Center (http://www-nsidc.colorado.edu/NSIDC/CATALOG/catalog_index.html). Researchers and research projects should also be encouraged and funded to create web sites about their work. This information will keep teachers and other researchers informed about new research and research groups appropriate for collaborative projects.

Several steps taken at the agency level would encourage greater interaction among researchers and educators in a variety of ways. NSF and other funding agencies should consider in the proposal review process whether researchers plan to share their findings with the communities where they work, as well as the general public, and whether any grant funds will be used for disseminating results or for specific educational activities. The review process should also assess whether partners essential for implementation of educational activities are included in the project plan. Researchers should be encouraged to publish research results in educational journals; it is important that the science community and funding agencies give credit for these types of publications.

The group identified the following specific means to help bring arctic science into the classroom:

- identify and translate useful data into age- and grade-appropriate formats;
- make research data accessible by putting it on the Internet, on CD-ROM, in print or video media; by developing meta-data and Directory Interchange Formats (DIFs) and relating them to the National Science Standards;
- develop a catalog for teachers of classroom activities that involve students in research stories; and
- use National Science Teachers Association (NSTA) connections to advertise arctic research activities.

Internet resources can facilitate collaboration; technology must be supported by other methods, however, because a modern communications infrastructure remains inaccessible to many remote areas of the Arctic. A web site to promote partnerships could include:

- a database of research data and teachers and researchers who are interested in collaboration;
- images of agency-sponsored research to make research more accessible and visual;
- sign-up lists for potential researcher-educator partnerships;
- interactive Internet sites where researchers and teachers could communicate; and
- a research report clearinghouse where educators could access data and information to incorporate into classrooms.

Additional steps to encourage collaborations between researchers and educators were recommended:

- encourage publication opportunities for both researchers and teachers;
- inform science and education agencies of ongoing research activities appropriate for educational involvement;
- support curriculum production from teachers' research experiences; and
- identify potential financial and logistics contributors to research-education collaborative projects. Sponsoring these partnerships would benefit a variety of agencies and organizations, including school districts, foundations, and corporations. Agencies not generally considered as possible partners, such as the Air National Guard and Coast Guard, should also be tapped. Inform potential sponsors of opportunities and facilitate favorable press coverage of contributions.

Dan Stein of the Alaska Boreal Forest Council shows first and sixth grade students at Pearl Creek Elementary School in Fairbanks, Alaska, how to tap birch trees to collect sap. The Council collaborated with Pearl Creek science teacher, Deb Wilkinson, also shown here, and with a local syrup-processing business to develop a pilot educational program, Tapping into Spring, in which students measured ecological variables of 90 individual trees and correlated them with the amount of sap collected from each. The students will help design the program's expansion to other schools next year. Photo © Douglas Yates 1998.

The group recommended that NSF and other funding agencies support opportunities to provide:

- teachers with hands-on experience with actual research projects;
- classroom participation for researchers, so they can share their work directly with students; and
- opportunities for students to participate in research processes.

Participants encouraged NSF and other agencies to support development of secondary and undergraduate educational programs that make use of existing research sites and platforms with a strong scientific infrastructure and logistics base.

Partnerships in research and education

The third working group suggested numerous science education partnership projects during the first work session. Members integrated their ideas into four projects that they developed more thoroughly in the following work session.

Possible projects:

Pack ice research. High school students work with scientists to learn more about the relationship of algae production and ice thickness.

Cultural map. Students work with elders and researchers to study traditional land-use patterns to post on a web site.

Stories of principal investigators. Life stories of principal investigators provide role models of scientific professionals and make the process of research more accessible to students.

Arctic ring of life. Science community and Alaska Natives work together to observe, measure, map, and publish information on the dynamic ice edge across the entire Arctic.

Field botany course. Elders, Western scientists, students, and teachers survey flora across the Arctic. Scientists and elders share and compare to explore diverse ways of knowing. The course could be expanded to other topics like fauna, geology, etc.

Fellowship grants for Native graduate students. Fund partnership research between Native graduate students and scientists.

Chart the change of the Beaufort Sea. Use old data from the Naval Arctic Research Laboratory (NARL) in Barrow, Alaska, current observations, and knowledge of elders for research to chart changes in the Beaufort Sea. Partner teachers, scientists, and students and integrate social and natural sciences.

Many effective science education activities are sponsored by state and federal agencies. Above, sixth grade students from Kalifornsky Beach School measure pH of Slikok Creek in Soldotna, Alaska, as part of the long-term Adopt-a-Stream program started in 1992 by the Kenai Fisheries Resource Office of the U.S. Fish and Wildlife Service. With the assistance of Jeff Booth (shown here) and other USFWS employees, students monitored physical, chemical, and biological features of streams once a month through the school year. Photo courtesy of U.S. Fish and Wildlife Service.

National Petroleum Reserve-Alaska (NPR-A) project. Build a partnership between industry and researchers to foster communication and deal with environmental and cultural concerns.

Integrating data at Gambell School. Return previously gathered data about Native lifestyles in early Gambell, on Alaska's St. Lawrence Island, to Gambell School. Teachers and students develop student-generated texts.

Harvest practices. Involve students, teachers, and researchers in documenting the traditional processes of decision making around hunting and harvesting.

Global change. Partner scientists, teachers, and students to monitor signs of global change across the Arctic.

Oral histories of Alaska's North Slope. Work with researchers, students, teachers, and

Native elders to document land use, sea-ice movement, etc., over time through oral histories. Some documents exist now, but many have been translated inaccurately.

Connecting urban Alaska to the Arctic. Link Native students in urban Alaska, who may have become somewhat disconnected from their cultural roots and traditional environment, to researchers engaged in science in the Arctic.

Projects that were developed in further detail:

Global change and sea ice. This multifaceted project envisions students collecting data on current sea-ice conditions and comparing this to available information on past conditions to characterize global change in the Arctic, including the effects of changes in sea ice on whale populations. Portions of this project have been implemented at Barrow High School in Barrow, Alaska. Participation in a 1996 research cruise through the NSF-funded Teachers Experiencing the Arctic Program provided critical motivation and research experience for the teacher directing the project (see page 15 for more details).

Researchers will train teachers in modern environmental monitoring techniques. For example, investigators at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) have instructed teachers how to estimate primary productivity within sea ice by measuring nutrients and chlorophyll-a. Additional measurements include radionuclides, organics, and major ions which provide information on ice formation conditions and transport mechanisms. This was done in preparation for a lesson on how ice conditions affect algae (which feed zooplankton, which feed whales). Dr. Elena Sparrow, a national GLOBE trainer, has offered to provide training for the Global Learning and Observations to Benefit the Environment

Both teachers and researchers are busy with normal responsibilities; organizing science education partnership programs often requires the assistance of a dedicated organization. The CRREL Arctic Education Office, for example, facilitates partnerships between scientists and local schools. Above, Deb Meese shows "arctic" sea ice grown in a cold room tank to fifth grade students from the Bernice Ray School in Hanover, NH. In this program, four classes came to CRREL daily for a week to learn about the differences between sea and glacial ice, develop hypotheses about ice, and test their ideas using CRREL facilities. A time-series study of sea ice, for example, included daily measures of the salinity of the developing ice, salinity and temperature at the top and bottom of the tank, and observations of thin sections of the ice. Several classes communicated regularly via email with students working on sea ice in Barrow, Alaska. Below, Don Perovich and Jackie Richter-Menge make periodic presentations at the school to update students on the Surface Heat Budget of the Arctic Ocean (SHEBA) project. Several classrooms have monitored the SHEBA experiment through its web site (http://sheba.apl.washington.edu/), comparing weather information such as snow depth at the SHEBA site and at the school. Photos courtesy of CRREL and the Bernice Ray School.

(GLOBE) protocol. The training includes content material, kits, and supporting classroom hands-on activities to collect data on temperature, precipitation, cloud cover, hydrology, and land-cover. The global change and sea-ice project would enter data into the GLOBE Network so that participating students could use their own data and data gathered by students around the globe to make inferences and predictions.

Potential sources of relevant data on past conditions which need compiling and translation include transcripts of youth and elder conferences, old and endangered tapes in Inupiaq, the NARL collection, National Oceanic and Atmospheric Administration (NOAA) data, early acoustical data from several sources, and accounts in New England museums from early whaling voyages. Students from Alaska's North Slope high schools and Ilisagvik College in Barrow, Alaska, could add to this information by interviewing contemporary whaling captains and subsistence hunters. The students could monitor signs of global change by comparing their observations of current local conditions and condition changes over time related to wind speed and direction, temperature, ice structure, and dates each year for sea and lake freeze-up and break-up. The final component of the project would be a multimedia presentation of the findings. This multifaceted project has several valuable aspects. It would:

- collect and consolidate data that are in danger of being lost;
- develop new data—on whale behaviors and on indicators of global change;
- deliver relevant and up-to-date science content to teachers for use in classroom instruction;
- provide opportunities for elders and researchers to learn from each other; and
- further the use of Native ways of knowing and scientific methods together.

Traditionally, after a successful year of hunting, an Inupiaq village sent a messenger to invite neighboring villages to join in a great feast and celebration of gift giving, known as Kivgiq, the Messenger Feast. This ceremony disappeared in the early part of this century but was revived in a modern form in Alaska in 1986. In a recent celebration of Kivgiq, a Wainwright hunter named Alak gave this polar bear skin to the people of Anaktuvuk Pass. Because Anaktuvuk Pass is located inland, residents cannot hunt polar bear themselves, and skins are highly prized. Learning about traditional hunting practices and community values advances understanding of indigenous ways of knowing. Photo © Bill Hess, Running Dog Publications.

Arctic science—an interactive CD. This proposal to develop an interactive CD-ROM program for secondary schools would have two goals: to educate students throughout the U.S. on arctic science topics and to nurture an interest in science among Native students in Alaska. The planned program, developed collaboratively by educators, researchers, and arctic students, would allow students to work at their own pace and explore aspects of arctic science that interest them. The program demonstrates the relevance of research to real-life problems in arctic communities and maintains a holistic approach, stressing the connections between physical and biological systems. Program content focuses on the arctic system: the physical

environment, the biological realm, and human interactions with arctic landscapes. A series of brief, online classroom lessons is followed by an interactive action adventure on the same theme. The user helps characters in the story reach their goals by answering questions posed during the story. For example, by answering a question on sea-ice thickness, the user helps the children in the sea-ice story get back to land. By selecting a character to tell his or her version of the story, users experience the action from a variety of perspectives—young Caucasian, young Inuit, adult Caucasian, or adult Inuit. The topics are supplemented by access to an electronic "library".

Harvesting practices. This project was envisioned as a three-year study promoting cross-cultural, intergenerational, and multidimensional understanding of village-based harvest practices, with particular attention to community rationales for harvesting decisions. The Alaska Department of Fish and Game and other state or federal management agencies might be potential collaborators on such a project. The Alaska Rural Systemic Initiative would be an important contributor as well.

The research would be based on a hunter survey performed in local communities, supplemented by student monitoring and management agency data. The survey on harvest practices could include detailed questions on such topics as:

- preparations required for the hunt, including selection of people and equipment;
- effects of weather conditions on preparations and the actual hunt;
- roles of traditional morals, values, myths, and celebrations, including respect for nature, life, and traditional ways of knowing; and
- reasons for decisions about distribution of the catch.

For five days each summer, Athabascan Elders share their cultural heritage at the Old Minto Cultural Camp on the Tanana River in Interior Alaska. The camp, on the site of the old village of Minto, has been offered since 1988 as a cooperative program among UAF Summer Sessions, the Cultural Heritage and Education Institute of the village of Minto, and the Alaska Rural Systemic Initiative. Above, at the 1996 Camp Janine Dorsey, a graduate student in Northern Studies at the University of Alaska, pours muddy water from the river into an Athabascan water filtration system. The water poured through the barrel, which is filled with clean sand and gravel, comes out free of sediment. Learning how Native people use universal scientific principles to solve the problems of everyday life adds relevance to arctic science education. Photo by Michael Dorsey.

Linking urban Alaska to the Arctic. This project would link Native students in urban Alaska to researchers engaged in arctic science—perhaps through links to their traditional communities or regions. Some urban Native students may be more removed from their cultural heritage and physical environment than are students who live in villages. Research on indigenous cultures, arctic natural history, global change, and fish and wildlife management, for example, provide opportunities to integrate Western and indigenous ways of knowing while reconnecting students to their history and acquainting them with modern science.

Summary of Workshop Recommendations

Participants repeatedly voiced the need for coordination to integrate research and education and to plan broad education initiatives. They recommended that ARCUS—as an organization representing a broad community—continue efforts to coordinate project planning and development and to facilitate partnerships and collaborations in arctic science education.

Media-based arctic science education. Pursue development of media-based science education programs focusing broadly on the Arctic:

- a high-profile, real-time electronic field trip to the Arctic, and
- a multi-year electronic educational program in arctic science, perhaps patterned on the LEARNZ model.

Curriculum development. Produce flexible science curricula based in polar research. Collaborations among teachers, researchers, and curriculum writers are essential for bringing research effectively into the classroom. Encourage and simplify mechanisms for communication among educators, researchers, and communities, including:

- assisting researchers in developing effective educational programs, and
- improving availability of plain language information on both research and education.
- developing Internet resources to expand collaborations;
- providing teachers with hands-on experience with actual research projects;
- facilitating classroom participation for researchers, so they can share their work directly with students; and
- increasing students' participation in research processes.

Partnerships in research and education. Use specific interdisciplinary research-education projects as nuclei for synthesizing diverse expertise and building connections among academic, agency, arctic community, and education participants. Sponsor a follow-on workshop to further develop and build on collaborative partnerships. Support development of secondary and undergraduate educational programs that make use of existing research sites and platforms with a strong scientific infrastructure and logistics base.

Examples of successful collaborative projects evolving from this workshop are described beginning on page 15.

Initial Accomplishments

In the interim between the workshop and the publication of this report, several science education projects initiated or advanced at the workshop have produced positive results. A few examples are described here.

Teachers Experiencing Antarctica and the Arctic. Teachers Experiencing Antarctica and the Arctic (TEA) is jointly funded by NSF's Office of Polar Programs and the Division of Elementary, Secondary, and Informal Education in the Education and Human Resources Directorate. TEA has been placing science teachers with research teams in Antarctica since 1992 and in the Arctic since 1996. Workshop discussions encouraged full implementation of TEA in the Arctic based on the 1996 pilot project. Three teachers worked on arctic research projects in 1997; five went to Antarctica in 1997. Twelve teachers will participate in the 1998-99 field season, four in the Arctic and eight in the Antarctic. Teachers are regular members of the research team while in the field. During their research participation, teachers post daily journals and answer questions on a web site; after the field season, they share their experience with other teachers, students, and the community. In particular, they develop related classroom materials and mentor two teachers for 100 hours each over a three-year period. TEA teachers may also continue to collaborate with the research team. Participating researchers gain valuable insights by working with a teacher who will translate the polar research experience into the science classroom in innovative ways.

NSF and the research community have identified several important differences between implementation of TEA in the Arctic *vs.* the ongoing Antarctic TEA. There is no overarching logistic infrastructure in the Arctic, and logistical support varies considerably depending upon the location and type of research. Because people live in the Arctic, the range of research experiences available to TEArctic participants is broader. One 1998 TEArctic teacher, for example, will assist with an archaeological dig in Northwest Alaska. Research in the Arctic can include exposure to unique cultures and requires sensitivity to cultural interactions, which can be a meaningful aspect of arctic science education. Teachers, students, and communities from the Arctic offer a valuable perspective to the program and benefit from the connection to the larger scientific community. TEArctic has also involved one or two high school students with each teacher in their arctic research experiences, offering exciting mentoring and learning opportunities, particularly for students from remote arctic communities; NSF is phasing out the inclusion of students in TEAntarctic. Workshop

Jeremy Harris, a high school senior from Abingdon, Virginia, and Anna Klene, a graduate student at the State University of New York at Albany, measure the depth of the active layer by pushing steel probes into the soil along Cake Eater Road in Barrow, Alaska. The active layer is the layer of seasonally thawed and frozen ground between the atmosphere and the permafrost in cold regions. This project is part of the NSF-funded Arctic System Science (ARCSS) Program Land-Atmosphere-Ice Interactions Flux Study, a multi-year project examining the flux of greenhouse gases from the tundra to the atmosphere and hydrosphere in northern Alaska. The research project shown here, headed by Dr. Frederick Nelson, has mapped the active layer across the Kuparuk River basin in the summers 1995 to 1997 to aid predictions of carbon flux in response to climate change. Jeremy joined the project in the summer of 1997 as a student participant in Teachers Experiencing the Arctic. *Data that Jeremy helped collect and analyze showed that the active layer was thinner in 1997 than previous years, primarily because of cooler climatic conditions near the coast. For more information see http://www.glacier.rice.edu/chapters/tea/tea_nevinfrontpage.html. Photo by John Nevins.*

participants recommended strongly that students, from the Arctic and elsewhere, continue to be involved in TEArctic.

The potential ongoing benefits of TEA in the Arctic are exemplified by the partnership of a teacher and principal investigator, Tim Buckley and Dr. Debra Meese, who participated in the Arctic TEA pilot project. Buckley collected and analyzed ice and water samples on a 1996 research cruise in the Arctic Ocean. Since his TEA experience, Buckley and his students at Barrow High School in Barrow, Alaska (cover photo), have been working with Meese, a principal investigator (PI) at CRREL, by drilling cores from the lagoon ice in the winter to supplement samples from Arctic Ocean research cruises in the summer. The cores then are observed by the students and at CRREL for structural features and melted samples analyzed for pH, conductivity, major ions and nutrients, and chlorophyll-a. Through another workshop-catalyzed partnership with the Department of Energy's Atmospheric Radiation Measurement (ARM) Science Education and Training (ASET) program, a Teacher Small Contract awarded to Buckley funded the arctic suits and boots the students need to do winter sampling. ASET is the ARM Program's North Slope community-based educational outreach program; DOE has implemented educational programs at each of its cloud and radiation testbed sites (http://www.arm.gov/docs/sites/nsa/educate.html).

Students with disabilities. Participants at the workshop identified a need for encouragement of students with disabilities in rural, geographically, and seasonally isolated areas, especially Alaska, toward science careers (see pages 4 and 20). In such remote areas, students with disabilities have inadequate access to empowering activities and/or role models to advance their participation in science. In response to this problem, several participants followed up workshop discussions by developing *Shaping Vocational Frontiers: Science, Engineering, and Mathematics for Persons with Disabilities in Rural and Remote Areas*, a partnership project between the University of Hawaii and Access Alaska (an advocacy program for persons with disabilities). The Division of Human Resources in NSF's Education and Human Resources Directorate has funded the planning phase of the project. Scientific organizations, educational, nonprofit, and state of Alaska agencies will come together to develop pedagogical, guidance, and system practices to support and encourage the participation of students with disabilities in science, math, engineering, and technology. Organization, cooperation, and networking among scientists,

school systems, and communities will encourage students with disabilities to pursue careers in science. Initial networking and planning activities are underway.

Indigenous Curriculum Specialist. Participants at the workshop confirmed the need for indigenous curriculum development to facilitate integration of Native and Western approaches to science. Workshop discussions identified some of the important curriculum information that could be gathered from dispersed sources and made widely available through a resource clearinghouse. ARCUS and the Alaska Federation of Natives (AFN) have entered into a Memorandum of Agreement to employ an indigenous curriculum specialist to compile and disseminate relevant information and ensure strong connections to arctic research activities. The resources are entered into a curriculum resource database maintained through the Alaska Native Knowledge Network. The listing of resources is available at http://www.uaf.alaska.edu/ankn. This database is an essential component of the Alaska Rural Systemic Initiative (RSI), implemented by AFN in cooperation with the University of Alaska and funded by NSF and the Annenberg Rural Challenge. The RSI systematically documents indigenous knowledge systems of Alaska Native people and develops educational policies and practices that effectively integrate indigenous and Western knowledge through a renewed educational system. The program emphasizes renewing Native pathways to education, so that traditional knowledge systems, ways of knowing, and world views can be a more effective foundation for learning all subject matter. The indigenous curriculum resource database will be an important contribution to the wider arctic science curriculum development recommended by workshop participants.

As part of the Yup'ik studies program in the Kasigluk, Alaska, school, elders take an important role in education. Ella Nichols shows students at Akula Elitnaurvik about traditional fish preparation. Her information was integrated into a larger unit about animal biology and native knowledge. Photo from Nutemllaput-Our Very Own, *a video produced by KYUK-TV, Bethel.*

LEARNZ: Sea Ice Voyage 98. The International Centre for Antarctic Information and Research (ICAIR) has been funded by NSF, the International Antarctic Centre, and the New Zealand Ministry of Education to place a teacher on board the research icebreaker *Nathaniel B. Palmer* (see photo, page 6), from which he is leading a virtual field trip called Sea Ice Voyage 98. In this pilot LEARNZ program, which germinated from discussions at the workshop, Dr. Andy Dennis is documenting an eight-week voyage to observe ice sheets around the Antarctic with digital photographs and articles about the crew, scientists, environment, and shipboard life which are posted on a web site (http://learnz.icair.iac.org.nz/98/index.htm). Students from all over the world have read his ongoing diary and emailed to ask questions. Using information technology to allow students to participate in ongoing research was repeatedly discussed at the workshop and has obvious applications to both arctic science education and polar collaborations.

GLOBE Program. NSF's GLOBE Program is funding a partnership project at the University of Alaska Fairbanks called "Seasons: The Global Plant Waves" which grew out of connections made at the workshop. When conditions stimulate new plant growth in spring, satellite data show the wave of greenup moving across the Earth. In other areas of the globe, a simultaneous wave of senescence occurs as plant growth decreases. With global climate change, the growing season (the period between greenup and senescence) may change. Some researchers estimate that the growing season has increased in northern latitudes by eight days since the early 1980s. Students at four schools in Alaska started providing ground observations and verification to the remotely sensed data in a pilot protocol in 1998. At the end of the four-year project, organizers anticipate contributions from students all over the world. A related project still in the proposal stage will connect "Seasons" with Alaska Native ways of knowing. The GLOBE Program also provides training for teachers and students involved in environmental research (see pages 11 and 19).

Live from the Poles. As part of NSF's Science and Technology Week, whose 1998 theme is Polar Connections: Exploring the World's Natural Laboratories, Passport to Knowledge (PTK; see page 21) developed *Live from the Poles*, which was supported by NSF, NASA, and public television and broadcast on 28 April 1998. In this live video program, viewers, including visitors to the Imaginarium in Anchorage, Alaska, interacted with researchers in Antarctica and a panel of arctic experts from the Office of Polar Programs and the Smithsonian's Arctic Studies Center in Washington, DC. The two poles were compared using Smithsonian documentary footage of the Arctic and sequences from the two previous *Live from Antarctica* programs produced by PTK. Students sent in 45 questions to the scientists by email during the broadcast; the near real-time answers are available on the PTK web site (http://passport.ivv.nasa.gov/ptk_poles.html). This program advanced public understanding of research projects in the polar regions; a more comprehensive real-time, real-location exploration featuring investigators on-site in the Arctic remains to be done.

ARCSS Program. NSF's ARCSS Program has funded the National Snow and Ice Data Center at the University of Colorado to produce an educational CD-ROM based on the longest climate record available, the Greenland ice coring projects. Data from the American Greenland Ice Sheet Project 2 (GISP2) and European Greenland Ice Core Project (GRIP) contributed to the development of a curriculum resource for lower high school students to investigate aspects of climate change and climatic variability. The CD-ROM is expected to be available in the summer of 1998.

Toolik Field Station. The multi-institutional Toolik Field Station (TFS) Steering Committee asked ARCUS to survey the arctic research community to assess support for educational opportunities using TFS facilities (http://www.uafbio.alaska.edu/toolik/toolik.html). ARCUS distributed the survey in March 1998; respondents expressed strong interest and encouraged development of educational programming. Operated by the Institute of Arctic Biology of the University of Alaska Fairbanks, TFS, located off the Dalton Highway about 400 miles north of Fairbanks and 150 miles south of Prudhoe Bay, has served as a base for field research in northern Alaska since 1975. TFS offers access to an arctic environmental transect along the highway corridor from the peaks of the Brooks Range to the coastal plain.

Appendix: Presentation Abstracts

Sunday, April 6, 1997

Hands-on Work Session: Development and Preparation of Science Education Grant Proposals

Emma Walton, NSF Presidential Awards for Excellence in Science and Mathematics Teaching; and Wayne Sukow, NSF Teacher Enhancement

This session will provide information on planning science education programs. As part of the agenda, there will be a hands-on workshop on the development and preparation of grant proposals. The target audience will be scientists, science educators, and community members. The objective of this session is to promote working partnerships between scientists, teachers, and the community, with the end result of well-developed proposals for science education projects based on current arctic research.

Monday, April 7, 1997

Introductory Remarks: What is So Special about the Arctic and How Can We Share This With Students in the Classroom?

Elena Sparrow, School of Agriculture and Land Resources, University of Alaska Fairbanks

Prominent features of the Arctic besides its magnificent landscapes are its extreme environment, large areas of undisturbed ecosystems, richness in natural resources, vulnerability to pollution, its people, and key role in many global processes. It is a sensitive indicator of global change through its permafrost, sea and lake ice, glaciers, snow features, boreal forests, tundra, and biota. I am working on two projects in which one goal is to bring arctic research into the classroom. One is through an Environmental Protection Agency-funded course on Earth Systems/Global Environmental Changes delivered to K-12 teachers in three sites by two-way video technology. The course consists of a content portion (research results presented by scientists) and an implementation portion (classroom activities presented by master teachers). The other project will involve Alaska teachers and their students in a research project using the GLOBE (Global Learning and Observations to Benefit the Environment) program.

Arctic Science: A Challenged Look Towards Integration

Richard L. Radtke, School of Ocean and Earth Science and Technology, University of Hawaii

Science has been pertinent to addressing world problems, and even more so in recent times. Nevertheless, science has become less understood by those other than scientists. Actual examples are provided of research led by a disabled scientist to demonstrate the practicality of inclusion of challenged individuals. Overall it is suggested to assist students (particularly students with severe disabilities) to become aware of what arctic science, science education, physical access, and inclusion can mean for them, including career and vocational possibilities and resources. We need to plan activities where students and the community can learn: (1) that they can actively contribute to ongoing scientific research; (2) that careers in science are possible and that post-secondary education at a university is a viable option; (3) that persons with severe disabilities can be "cutting edge" scientists; (4) that all of us, regardless of abilities and disabilities, are more alike than different; (5) that interesting projects can be aired and shared on public television so that the broader community can learn about what's new in science, science education, and social integration. Such ideals are imaginable if we:

- involve students and parents in "real" science (research in progress) with actual scientists;
- provide students with the role models of scientists;
- create heterogeneous cooperative groups of students with and without disabilities in order to change students' self-perceptions and their perceptions and attitudes toward one another;
- empower students with severe disabilities to see themselves as future scientists;
- demonstrate that students with severe disabilities can actively participate in experiential, field-based science;
- involve students in video and computer activities to evaluate, document, and disseminate project activities; and
- share project outcomes with the larger community via a creative use of public television and electronic media (Internet). It is hoped that investigations will identify deficiencies in our current approaches to "inclusion" in science education. Interdisciplinary policy recommendations may well stem from such projects.

Alaska Science for Kids and Other Successful Hands-On Approaches to Arctic Science Education

Neal Brown, Geophysical Institute, University of Alaska Fairbanks

"The intellect by which the pupil can learn from his teacher is the very same intellect by which he can learn by himself. For indeed he has no other one. This is the true reason why the ultimate end of our pedagogy should be to teach children to learn by themselves, because, in fact there is nothing else we can teach." Etienne Gilson

We live in a society that every day uses and discovers new astounding advances that have been made through the use of science and math. Yet, we are failing to motivate the typical student beyond the sixth grade to the idea that these subjects are relevant in their lives. Using activities and themes tied to arctic science and related topics of exploration, I have developed activities that lead students, teachers, and parents to get excited about math and science and want to know more. The mechanics are exceedingly important. We find ways to hook or grab interest, set up cooperative work groups or teams that both cooperate and compete, and, perhaps most important, set up age-appropriate mentoring at several levels. The program involves college students mentoring high-school students who in turn mentor middle-school students.

- I will discuss Alaska Space Ventures, an innovative summer science camp.
- I will show and discuss a brief and catchy video about fifth-grade students tracking migrating geese with "radio feathers." This video was telecast throughout Alaska last December as a two-minute Alaska Science for Kids public-service clip. We are proposing other projects of this type.
- I will discuss how I am currently using the launch of rockets to study the aurora from Poker Flat Research Range and radio studies of the ionosphere by High Frequency Active Aurora Research Program (HAARP) project as examples of the opportunities to use existing science operations to teach, reach, and motivate students to understand math and science.

The Arctic West Section Cruise: Research Experiences for High School Teachers and Students Pilot Project

Deb Meese, CRREL; and Tim Buckley, Barrow High School

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) engaged a high school biology teacher (Tim Buckley) from Barrow, Alaska, in research on the Arctic West Section 1996 (AWS-96). AWS-96 consisted of a cruise aboard the U.S. Coast Guard Cutter *Polar Sea* in the Chukchi and Beaufort seas to determine the prevalence of radionuclides in the sea ice in this region of the Arctic. Additional studies of biological populations of varying scales within the ice, water, and bottom sediment were also completed. Tim Buckley's participation in the cruise was funded through CRREL by the National Science Foundation's Arctic System Science (ARCSS) Program within the Office of Polar Programs and the Division of Elementary, Secondary, and Informal Education in the Education and Human Resources Directorate. This program served as a pilot study for the full program, Research Experiences for High School Teachers and Students, which will begin this year.

Antarctica through a Teacher's Eyes: Can This be Applied to Arctic Education?

Peter M. Amati, Jr., Holliston High School

I will discuss the concept of Teachers Experiencing Antarctica (TEA), its creation, its goals, and its activities. I will share with the group my experiences as a TEA by way of a slide presentation of my fieldwork as a researcher (along with one of my students) in the Weddell Sea. I will share with the group an ongoing research project that my students are doing as a direct result of my trip to "The Ice" (we are studying road salt migration). I will share with the group my experiences of sharing with the public, both schools and civic groups, the word about Antarctica and how the same could be done for the Arctic.

Live from Antarctica: A Model for Electronic Field Trips to the Arctic

Geoff Haines-Stiles, Passport to Knowledge

In the past three years, Passport to Knowledge (funded in part by NASA, NSF, and public television) has created two electronic field trips to Antarctica. The live videos have connected students across America direct to the South Pole, McMurdo Station, the Dry Valleys, and to Palmer Station on the Antarctic Peninsula. The videos are complemented by Internet resources and hands-on science activities (in the form of an online and printed teacher's guide.) We will present the results, in terms of distribution, and educational outcomes, as documented in an ongoing evaluation by the Center for Children and Technology of the Education Development Center of Boston and New York, and suggest ways in which *Live From the Arctic* might be developed in association with arctic researchers, associates, and educators.

A New Paradigm for Undergraduate Studies and its Relevance to Secondary Education

Karim-Aly Kassam, Arctic Institute of North America; and David Norton, North Slope Higher Education Center

Our collective experiences have generated a coherent new paradigm for student-centered learning. This approach, called a "Theme School", has relevance to both undergraduate and secondary education. The fundamental area of focus of the Theme School is service to nontraditional students from rural and/or northern communities. The essence of the Theme School includes interdisciplinary learning and application, emphasis on relevant use of ideas geared to the needs of communities, textbook avoidance in favor of examining the historical and thematic development of ideas, process-oriented learning directed to insightful research output by students, an internship program with a view to employment opportunities for students, and sensitivity to student needs and cultural diversity which may extend to financial support.

POLARIS (Project on Leading Alaska Restructuring in Science)

Bob Nanney, Anchorage School District

The Project On Leading Alaska Restructuring In Science (POLARIS) is a four-year secondary (7-12) science teacher enhancement project funded by NSF and reinforced by support from Anchorage, Fairbanks, Kenai, and Matanuska-Susitna School Districts, public agencies, universities, and industries. The mission of POLARIS is to implement research-guided, long-term changes in science instruction for the purpose of increasing student interest and achievement. The mission is being accomplished through implementation of goals related to content, classroom practices, networking, and leadership.

Integrating Curricula and Climate Data: the GISP2 Ice Core Project

Dave McGinnis, National Snow and Ice Data Center/Cooperative Institute for Research in Environmental Sciences (NSIDC/CIRES); and Brenton Burnett, Eaglecrest High School

Climate variability and potential anthropogenic climate change are constant "hot topics" regarding the global environment today. The Greenland ice coring projects, Greenland Ice Sheet Project 2 (GISP2) and European Greenland Ice Core Project (GRIP), provide the longest climate record available to date. Our project involves using these data to develop curricula appropriate for lower high school students to investigate various aspects of climate change and climate variability. The curricula will be available on CD-ROM in the near future.

Accessing Arctic Information through a Digital Library

Jesse Walker, Department of Geography and Anthropology; and Lynn Hadden, Office of Computing Services, Louisiana State University

Actively engaging students in primary research is the most effective way of having them learn scientific information. As access to arctic areas is beyond the reach of most students, a digital library can fill the void by providing the results of primary arctic research including field notes, photographs, journal articles, and even video over the Internet. Louisiana State University (LSU) has developed a prototype for the delivery of such information. In this presentation, we will discuss the issues involved in and our experiences with developing a digital library collection of Jesse Walker's research on the Colville River Delta, Alaska. We will also discuss emerging standards in digital libraries and the benefits of this type of delivery mechanism over more traditional methods and/or proprietary database systems. If facilities allow, we will demonstrate the LSU digital library collection.

Sea Ice in Polar Regions and the Arctic Observatory CD-ROM

Farzad Mahootian, Ambient Systems Inc., Gonzaga College High School

"Sea Ice in the Polar Regions and the Arctic Observatory" is a multimedia application on CD-ROM designed to enable students (grades 9-16) to understand and investigate polar processes. The CD is organized into two modules. "Sea Ice in the Polar Regions" is a multimedia introduction to the role of sea ice in the Earth's climate system by NASA scientist Claire Parkinson. This module is a presentation on arctic and Antarctic sea ice, illustrating a variety of sea-ice types, the relevance of sea ice to the climate system, and the value of satellite observations for monitoring the ice cover and determining its seasonal cycle and interannual variations. "The Arctic Observatory" contains a database of images derived from remote sensing and model data. Using the Arctic Observatory's dual-screen interface, students can compare various parameters over a period of seven years or observe animated time series. Though the number of data parameters is limited to five, students can investigate climatic phenomena associated with global change in order to understand environmental characteristics and changes in the arctic system. The Arctic Observatory also contains a teacher's guide, which includes instructions, information, resources, and lesson guides, as well as a series of short articles about the arctic system, written by University of Alaska faculty and scientists. The speaker will demonstrate the instructional design, interface design, and functionality of this educational application and discuss the science,

education, and technology challenges involved in developing such products for non-scientific communities. The speaker will discuss the use of this CD-ROM in the high school classroom. Through the efforts of the University of Alaska Fairbanks, every school in Alaska received a copy of the CD-ROM in the winter of 1996. Recently, the CD-ROM was distributed by Scholastic Publishers as an enclosure in their Teacher's Edition of *Science World* magazine November 1996 issue (Vol. 53, No. 6). It will also be packaged with a forthcoming issue of the *Marine Pollution Journal*. To date, a total of 40,000 CD-ROMs have been circulated by the Consortium for International Earth Science Information Network (CIESIN), the Global Change Research Information Office and NASA's Goddard Space Flight Center Distributed Active Archive Center, and through the NASA Mission to Planet Earth booth at National Science Teacher Association conferences. The CD-ROM is available free of charge to educational and nonprofit organizations. It was produced through the cooperation of the Consortium for International Earth Science Information Network, the Office of Naval Research, and the National Aeronautics and Space Administration.

Interactive Arctic Science CD-ROM

Scott Elias, Institute of Arctic and Alpine Research, University of Colorado

The presenter is working on the development of an interactive CD-ROM program for arctic community schools (grades 7-12) that deals with arctic science topics, such as arctic geology, biology, paleontology, and archaeology. The program will feature information gathered by the Institute of Arctic and Alpine Research and other arctic researchers.

GLACIER/TEA Project: A Model for Science Education

Stephanie Shipp, Department of Geology and Geophysics, Rice University

Presentation of the GLACIER/Teachers Experiencing Antarctica (TEA) program. The GLACIER/TEA WWW site will be available, along with videos, slides, operational materials, glacier materials, TEA materials, and even information on Antarctic clothing.

Alaska Native Marine Science Undergraduate Student Intern Program

John Kelley, Institute of Marine Science, University of Alaska Fairbanks

The Institute of Marine Science in the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks has conducted an internship program for the past decade with the primary goal of significantly increasing the numbers of Native (Alaska Indian and Eskimo) undergraduate students graduating with degrees in science, engineering, and mathematics. The program consists of the following strategies: work study (nurturing through mentors); seminars (application of college skills); field experience (learning by doing); establish strong support group (American Indian Science and Engineering Society [AISES] participation); and partnership (developing cooperative projects with village corporations and federal and state agencies).

Science Education: Lessons from the Other End of the World

Peter Sommerville, International Centre for Antarctic Information and Research

The International Antarctic Centre (IAC) has developed methods and tools to promote student understandings in science using contemporary Antarctic research. IAC has also initiated scientist-educator partnerships that have led to inquiry-based learning in classrooms. IAC is very concerned with adding value to education programs to reach larger audiences. Our experiences in the Antarctic, building on an understanding of the first *Live from Antarctica* program, provide a unique perspective. Value can also be derived from comparing the polar regions and their respective science research programs in classrooms around the world. Research into global change in the polar regions is as relevant to indigenous peoples in the Arctic as it is to indigenous peoples in New Zealand. Clearly arctic science education needs to develop, amongst its own populations and local schools, an appreciation and understanding of the arctic environment. In addition, both the Arctic and Antarctic are faced with issues affecting the world's indigenous people, and appreciating their cultural views of science and education.

Always Getting Ready—*Upterrlainarluta*—Yup'ik Eskimo Subsistence in Southwest Alaska

James Barker and Robin Barker

A slide presentation and discussion about orienting Yup'ik Eskimo children to the cycles of subsistence in Southwest Alaska.

TUESDAY, APRIL 8, 1997

Introductory Remarks: World Views and Other Ways of Knowing

Elena Sparrow

World views and other ways of knowing are also known as traditional wisdom and knowledge, local knowledge, indigenous knowledge or Native ways of knowing. It is an innate part of a culture's lifeways that embraces the experience, customs, religion, community laws and the attitudes of a society concerning their lives and those of other living beings. It is handed down across generations by oral tradition and represents successful ways in which people have dealt with their environments. It is the basis for resources management, forestry, agriculture, environmental conservation, education, anthropology, arts, and economics. In environmental impact assessments, traditional ecological knowledge is vital because it provides a holistic view that does not disjoin the biophysical components from each other nor from the human aspect of the environment. I believe that traditional knowledge of local and indigenous people needs to be integrated with Western ways of knowing in sustainable resource management, the development of the arctic region, environmental impact assessments, arctic research, and arctic science education. We have submitted to NSF a preliminary proposal to use indigenous and Western science in providing global change education to rural Alaska.

Terms of Engaging Native People into Education

Oscar Kawagley, School of Education, University of Alaska Fairbanks

The world view and life experiences of a Yup'ik and of a professional educator and researcher both complement and oppose each other. By understanding both the Native and Western world views, we will be better able to bridge the cultures, combine traditional knowledge and Western science into meaningful science curricula, and improve educational methods in arctic schools.

Education Indigenous to Place

Ray Barnhardt, Center for Cross-Cultural Studies, University of Alaska Fairbanks

The paper explores the relationship between Native ways of knowing and those associated with Western science and formal education. The aim is to outline some of the issues involved in devising a system of education for all people that respects the philosophical and pedagogical foundations provided by both indigenous and Western cultural traditions. While the examples used are drawn from the Alaska Native context, they are illustrative of the issues that emerge across the Arctic wherever efforts are underway to reconnect education to a sense of place.

The Education Program of the Institute of Archaeology, Iceland

Orri Vesteinsson, Institute of Archaeology, Iceland

The Institute of Archaeology in Iceland is involved in raising public awareness about the value of archaeological sites as an integral part of its project "The registration of archaeological sites in Iceland." Another aim of this project is to find better ways to make information on archaeological sites available to administrators, scholars, and the public. In 1997 the Institute is starting a summer course on Icelandic archaeology based on its excavation at Hofstair (a North Atlantic Biocultural Organization [NABO] project) aimed at students and scholars with a research interest in Icelandic archaeology.

Transforming Stories: Creating Meaningful Materials from Life History Texts in Arctic High School Classrooms

Carol Zane Jolles, Indiana University-Purdue University at Indianapolis

Stories told by Yup'ik elders have been the major resources used to create bilingual social science texts for students on St. Lawrence Island and elsewhere in rural Alaska. In Gambell, for example, teachers in Yup'ik culture classes depend on these texts, but lament that Yup'ik students are not always inspired by them. In this paper, I consider the relevance of locally collected texts and their possible uses. My starting point is a group of recently collected life histories recorded by Yup'ik women elders, whose stories cross the boundaries of history, religion, science, and economy.

Incorporating Inupiat Knowledge into College Science Courses: The Bowhead Whale—A Case Study

Frank Willingham, Ilisagvik College

Faculty at Ilisagvik College, the primary institution of higher learning on the North Slope of Alaska, have been challenged to incorporate indigenous Inupiat knowledge into their courses. The Bowhead Whale, *Balaena mysticus*, was chosen as a model for achieving this in the natural sciences. The course that was constructed around this animal is summarized, and the connections between Western science and traditional environmental knowledge are pointed out. Also discussed are the difficulties encountered in delivering the course and thoughts for improving it in the future. Suggestions are made for other possible course topics.

Two Inupiat Students' Views of Western Education

Todd Sformo, Ilisagvik College

It is possible for instructors to develop successful strategies for uniting indigenous knowledge with Western, standardized skills. This paper concentrates on two teaching experiences, which lead to greater understanding of how Inupiat students view Western education. This understanding is crucial for all educators, not merely scientists, because it reveals deeply rooted experiences that Western-style education has upon the North Slope student body.

The Human Dimensions of the Arctic System Prospectus: A Link to the Next Millennium in Arctic Science Education

Carl Hild, Rural Alaska Community Action Program and Chairperson of the Science Steering Committee of the Human Dimensions of the Arctic (HARC) Initiative

The Human Dimensions of the Arctic (HARC) research initiative will consider how humans interact with physical and biological environmental change in the Arctic. The major thrusts of the HARC initiative are to broaden our understanding of the arctic system and to assist arctic peoples to understand and respond to the effects of large-scale changes. HARC is also concerned with the effects of change in the arctic system on people who live outside the Arctic. HARC is designed to facilitate discourse between researchers, educators, and arctic communities to enhance their ability to understand research findings, encourage collaborative partnerships, and develop new approaches to gain and use information. A strong educational component will help to make HARC research explicit and understandable to the general public and arctic peoples. The HARC prospectus describes a program designed to support the development of innovative research that:

- cuts across traditional social, biological, and physical science disciplines;
- employs varied scientific methodologies;
- collects data at different levels of analysis or across a broad range of time and spatial scales;
- involves local people and communities in research design and implementation; and
- incorporates a strong educational component in all research projects.

A short summary of the development of HARC under the Arctic System Science (ARCSS) Program funded by NSF along with discussions to date will be given. A review of the HARC prospectus will be offered.

Education Programming in the Museum and Public Sector: Current Efforts and Future Requirements

William Fitzhugh, Department of Anthropology, Smithsonian Institution

This presentation will review previous efforts in cultural education in public and museum areas, building on experiences of the Arctic Studies Center's exhibitions and public programs; will outline what seems to have worked and why; and what seems to be needed to broaden and expand the cultural education effort. Needs for biological and natural science programming will be discussed as well.

Turning Research into Communication

Ted Timreck, Spofford Films Inc.

This presentation will focus on the Arctic Studies Center's approach to "Turning Northern Research into Communication" and the expansion of the educational audience. This will cover a number of processes that the ASC is going through including an introduction to our World Wide Web effort.

Use of Internet Museum Resources for Arctic Education

Kathy and John Prusinski, CyberGrafix

This presentation will look at how the Arctic Studies Center World Wide Web site may be used in the K-12 classroom today and how the site may be expanded to include more educational components in the future. We may also touch on other online and video/print educational projects we have been involved in and how the methods that made them successful could be adapted to future arctic projects.

Plenary discussion/talking circle

Attendees discussed the workshop and the issues it raised.

Appendix: Workshop Agenda

Sunday afternoon, 6 April 1997

Plenary

12:45 p.m. Welcome and Comments
Workshop Co-chairs, Peter Sommerville and Elena Sparrow
ARCUS Executive Director, Wendy Warnick

1:00 p.m. Panel Discussion: Challenges and Opportunities for Educator, Researcher, and Community Collaborations
Moderator, Bill Fitzhugh

Panel Participants: Peter Amati, Tim Buckley, Scott Elias, Leslie Gordon, Carole Seyfrit, Wayne Sukow

2:00 p.m. Hands-on Work Session: Development and Preparation of Science Education Grant Proposals
Wayne Sukow, Emma Walton
NSF-Education and Human Resources Directorate

3:30 p.m. Break

3:45 p.m. Development and Preparation of Science Education Grant Proposals (continued)

5:30 p.m. Panel Commentary: How has this session changed my perspective and ideas about what makes a successful arctic science education project?

Panel Participants: Peter Amati, Tim Buckley, Scott Elias, Leslie Gordon, Carole Seyfrit, Wayne Sukow

7:00 p.m. Special Working Group Session: 1. Planning for a "Live From the Arctic" Production
Chair, Neal Brown

Monday, 7 April 1997

Plenary

8:00 a.m. What is So Special about the Arctic?
Workshop Co-chair, Elena Sparrow

8:20 a.m. Keynote Address: Arctic Science: a challenged look towards integration
Richard Radtke

9:00 a.m. Session One: Paradigm Shifts in Science Education
Session chair, Ray Barnhardt

Alaska Science for Kids and Other Successful Hands-on Approaches to Arctic Science Education
Neal Brown

The Arctic West Section Cruise: Research Experiences for High School Teachers and Students pilot project
Debra Meese and Tim Buckley

Antarctica through a Teacher's Eyes: can this be applied to arctic education?
Peter Amati

10:45 a.m. Break

11:00 a.m. Paradigm Shifts in Science Education (continued)
Live from Antarctica: A model for electronic field trips to the Arctic
Geoff Haines-Stiles
A New Paradigm for Undergraduate Studies and its Relevance to Secondary Education
Karim-Aly Kassam and David Norton
POLARIS (Project on Leading Alaska Restructuring in Science)
Robert Nanney

12:30 p.m. Lunch

1:30 p.m. Session Two: Off the Ice and Into the Classroom: using data to develop curriculum resources
Session chair, Dave McGinnis
Integrating Curriculum and Climate Data: The GISP2 Ice Core Project
Dave McGinnis and Brenton Burnett
Accessing Arctic Information through a Digital Library
Jesse Walker and Lynn Hadden

2:30 p.m. Off the Ice and into the Classroom (continued)
Concurrent interactive poster presentations
Sustainability of Arctic Communities
Jack Kruse
Sea Ice in Polar Regions and the Arctic Observatory CD-ROM
Farzad Mahootian
Interactive Arctic Science CD-ROM
Scott Elias
GLACIER Project : A model for science education
Stephanie Shipp
Non-interactive posters
Alaska Native Marine Science Undergraduate Student Intern Program
John Kelley

3:30 p.m. Session Three: Concurrent working group sessions
Workshop Co-chair, Peter Sommerville
1. Planning for "Live From the Arctic"
Neal Brown
2. Working with Researchers to Develop Curriculum Resources
Dave McGinnis
3. Creating Better Partnerships in Research and Education among Educators, Researchers, Students, and Communities
Leslie Gordon

Plenary

5:00 p.m. Working Group Recommendations
1. Planning for "Live From the Arctic"
2. Working with Researchers to Develop Curriculum Resources
3. Creating Better Partnerships in Research and Education Among Educators, Researchers, Students, and Communities

5:45 p.m. Science Education: Lessons from the other end of the world
Workshop Co-chair, Peter Sommerville

6:45 p.m. Banquet
Special Presentation: Always Getting Ready -*Upterrlainarluta*-
Yup'ik Eskimo Subsistence in Southwest Alaska
James Barker and Robin Barker

TUESDAY, 8 APRIL 1997

Plenary

8:00 a.m. World Views and Ways of Knowing
Workshop Co-chair, Elena Sparrow

8:10 a.m. Keynote Address: Terms of Engaging Native People into Education
Oscar Kawagley

9:00 a.m. Session Four: Bridges between Differing World Views
Session chair, Nick Flanders

Education Indigenous to Place
Ray Barnhardt

The Education Program of the Institute of Archaeology, Iceland
Orri Vesteinsson

Transforming Stories: creating meaningful materials from life history texts in Arctic high school classrooms
Carol Zane Jolles

10:45 a.m. Break

11:00 a.m. Bridges between Differing World Views (continued)

Incorporating Inupiat Knowledge into College Science Courses: The bowhead whale — a case study
Frank Willingham

Two Inupiat Students' Views of Western Education
Todd Sformo

The Human Dimensions of the Arctic System Prospectus: A link to the next millennium in arctic science education
Carl Hild

12:30 p.m. Lunch

1:30 p.m. Bridges between Differing World Views (continued)

Education Programming in the Museum and Public Sector: current efforts and future requirements
William Fitzhugh

Turning Research into Communication
Ted Timreck

Use of Internet Museum Resources for Arctic Education
Kathy and John Prusinski

2:30 p.m. Session Five: Concurrent working group sessions
Workshop Co-chair, Peter Sommerville

1. Planning for "Live From the Arctic"
Neal Brown
2. Working with Researchers to Develop Curriculum Resources
Dave McGinnis
3. Creating Better Partnerships in Research and Education Among Educators, Researchers, Students, and Communities
Leslie Gordon

Plenary

3:30 p.m. Panel Discussion: Good Ideas: how do we get from vision to action?
Moderator, Carl Hild

Panel: Oscar Kawagley, Deb Meese, Mike Davis, Carole Seyfrit, plus a reporter from each working group

4:30 p.m. Where Do We Go From Here?
Nick Flanders, Wendy Warnick

4:45 p.m. Adjourn

Appendix: Workshop Participants

Peter Sommerville, *Co-chair*
Linking Education with Antarctic Research in New Zealand (LEARNZ)
International Centre for Antarctic Information and Research (ICAIR)
Orchard Road
PO Box 14-199
Christchurch, New Zealand
Phone: +64/3-358-4450
Fax: +64/3-358-4480
psommerv@icair.iac.org.nz

Elena B. Sparrow, *Co-chair*
School of Agriculture and Land Resources Management
University of Alaska Fairbanks
PO Box 757200
Fairbanks, AK 99775-7200
Phone: 907/474-7699
Fax: 907/474-6184
ffebs@aurora.alaska.edu

Katherine Ahgeak
Ilisagvik College
PO Box 749
Barrow, AK 99723
Phone: 907/852-9177
Fax: 907/852-1752
kahgeak@co.north-slope.ak.us

Peter M. Amati
Holliston High School
4 Amherst Drive
Milford, MA 01757-1812
Phone: 508/473-1249
Fax: 508/429-0677
amatip@holliston.mec.edu

James H. Barker
4700 Drake Street
Fairbanks, AK 99709
Phone: 907/479-2107
Fax: 907/479-2107
jbarker@polarnet.com

Robin Barker
Head Start—Tanana Chiefs Conference
122 First Avenue, Suite 600
Fairbanks, AK 99701
Phone: 907/452-8251
Fax: 907/459-3851
rbarker@polarnet.com

Raymond J. Barnhardt
Center for Cross-Cultural Studies
University of Alaska Fairbanks
PO Box 756480
Fairbanks, AK 99775-6480
Phone: 907/474-6431
Fax: 907/474-5451
ffrjb@aurora.alaska.edu

Melinda Berg
Hopson Middle School
North Slope Borough School District
PO Box 509
Barrow, AK 99723
Phone: 907/852-3880
Fax: 907/852-7794
mberg@arctic.nsbsd.k12.ak.us

Kristjan Bregendahl
Department of Animal Science
Iowa State University
337 Kildee Hall
Ames, IA 50011-3150
Phone: 515/294-2724
Fax: 515/294-1399
kristjan@iastate.edu

Neal B. Brown
Alaska Science Explained
1569 La Rue
Fairbanks, AK 99709-6631
Phone: 907/479-2773
nbrown@polarnet.com

Tim Buckley
Barrow High School
PO Box 960
Barrow, AK 99723
Phone: 907/852-8590/9754
Fax: 907/852-8969
tbuckley@arctic.nsbsd.k12.ak.us

Brenton Burnett
Science Department
Eaglecrest High School
5100 South Picadilly Street
Aurora, CO 80015
Phone: 303/699-0408 x7305
Fax: 303/766-8976
bburnett@ccsd.k12.co.us

Michael Castellini
Institute of Marine Science
University of Alaska Fairbanks
PO Box 757220
Fairbanks, AK 99775-7220
Phone: 907/474-6825
Fax: 907/474-7204
mikec@ims.alaska.edu

Walkie Charles
School of Education
University of Alaska Fairbanks
PO Box 756480
Fairbanks, AK 99775-6480
Phone: 907/474-6133
Fax: 907/474-1957
ffwc@aurora.alaska.edu

Mike Davis
North Slope Borough School District
PO Box 667
Barrow, AK 99723
Phone: 907/852-9676
Fax: 907/852-3014
mdavis@arctic.nsbsd.k12.ak.us

Scott A. Elias
Institute of Arctic and Alpine Research
University of Colorado
Campus Box 450
Boulder, CO 80309-0450
Phone: 303/492-5158
Fax: 303/492-6388
saelias@culter.colorado.edu

William Fitzhugh
Department of Anthropology
Smithsonian Institution
1000 Jefferson Drive, SW, Room 307
Mail Stop 112-NHB
Washington, DC 20560
Phone: 202/357-2682
Fax: 202/357-2684
fitzhugh@nmnh.si.edu

Nicholas E. Flanders
Institute of Arctic Studies
Dartmouth College
6114 Steele Hall, Room 407B
Hanover, NH 03755-3577
Phone: 603/646-1278
Fax: 603/646-1279
nicholas.e.flanders@dartmouth.edu

Betty Galbraith
Owen Science and Engineering Library
Washington State University
1 SE Stadium Way
Pullman, WA 99614-3200
Phone: 509/335-7930
Fax: 509/335-2534
bettyg@wsu.edu

Joyce G. Gellhorn
National Center for Atmospheric Research
PO Box 3000
Boulder, CO 80307
Phone: 303/442-8123
Fax: 303/497-8610
joyce_gellhorn@qgate.ucar.edu

Leslie S. Gordon
Partners in Science - Pearl Creek School
Fairbanks North Star Borough School District
700 Auburn
Fairbanks, AK 99709
Phone: 907/479-4157
Fax: 907/479-4025
lgordon@northstar.k12.ak.us

Lynn Hadden
Office of Computing Services
Louisiana State University
Frey Computing Center
Baton Rouge, LA 70803
Phone: 504/388-3725
Fax: 504/388-3709
lynnh@lsu.edu

Geoffrey Haines-Stiles
Passport to Knowledge
41 Rowan Road
Summit, NJ 07901
Phone: 908/273-4108
Fax: 908/277-9590
ghaines@quest.arc.nasa.gov

Rachel Hauser
Cooperative Institute for Research in Environmental Sciences - National Snow and Ice Data Center
University of Colorado
Campus Box 449
Boulder, CO 80309-0449
Phone: 303/492-5873
Fax: 303/492-2468
hauser@kryos.colorado.edu

Carl M. Hild
Institute for Circumpolar Health Studies
University of Alaska Anchorage
Anchorage, AK 99508
Phone: 907/786-4022
Fax: 907/786-4019
ancmh@uaa.alaska.edu

Carol Z. Jolles
Department of Anthropology
Indiana University –
Purdue University at Indianapolis
Cavanaugh Hall
425 University Boulevard
Indianapolis, IN 46202
Phone: 765/274-8207/756-7415
Fax: 765/274-2347
cjolles@iupui.edu

Karim-Aly S. Kassam
Arctic Institute of North America
University of Calgary
2500 University Drive, NW
Calgary, AB T2N 1N4 Canada
Phone: 403/220-4053
Fax: 403/282-4609
kakassam@acs.ucalgary.ca

Oscar Kawagley
School of Education
University of Alaska Fairbanks
PO Box 756480
Fairbanks, AK 99775
Phone: 907/474-5403
Fax: 907/474-5451
rfok@aurora.alaska.edu

Gary A. Laursen
West Valley High School
3800 Geist Road
Fairbanks, AK 99707
Phone: 907/479-5567
wvhfgal@northstar.k12.ak.us

Maxim Mashkov
24-128 Sheerokay Street
Moscow, 129224
Russia
Phone: +7/095-234-5070
mashkov@portal.ru

Farzad Mahootian
Ambient Systems, Inc.
Gonzaga College High School
19 I. Street, NW
Washington, DC 20001
Phone: 202/218-4110
Fax: 202/336-7164
farzad@jacks.gsfc.nasa.gov

David L. McGinnis
Department of Geography
University of Iowa
316 Jessup Hall
Iowa City, IA 52242-1316
Phone: 319/335-2588
Fax: 319/335-2725
david-mcginnis@uiowa.edu

Debra Meese
Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, NH 03755-1290
Phone: 603/646-4594
Fax: 603/646-4644
dmeese@hanover-crrel.army.mil

Robert J. Myers
Wheeling Jesuit University
316 Washington Avenue
Wheeling, WV 26003
Phone: 304/243-2388
Fax: 304/243-2497
bmyers@cotf.edu

Robert Nanney
C&I Science
POLARIS Grant
25500 Muldoon Road
Bartlett, Room C222
Anchorage, AK 99506-1611
Phone: 907/269-8343
Fax: 907/269-8347
nanney_robert@msmail.asd.k12.ak.us

David Norton
Barrow Arctic Science Consortium
PO Box 185
Barrow, AK 99723
Phone: 907/852-9141
Fax: 907/852-0351
ffdwn@uaf.edu

Daniel P. Odess
Department of Anthropology
Brown University
Box 1921
Providence, RI 02912
Phone: 401/863-3251
Fax: 401/863-7588
daniel_odess@brown.edu

George Palo
Gig Harbor High School
5101 Rosedale Street
Gig Harbor, WA 98335
Phone: 206/851-6131
Fax: 206/851-5656
page@narrows.com

Dennis Peacock
Office of Polar Programs
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Phone: 703/306-1033
Fax: 703/306-0139
dpeacock@nsf.gov

Jim Petrash
Hanshew Middle School
Anchorage School District
10121 Lake Otis Parkway
Anchorage, AK 99507
Phone: 907/267-0246/373-5874
Fax: 907/349-2835
petrash_jim@msmail.asd.k12.ak.us

Marjorie Porter
Woodstock Academy
57 Academy Road
Woodstock, CT 06281
Phone: 860/928-6575
Fax: 860/963-7222
marjorie.a.porter@snet.net

John Prusinski
CyberGrafix
158 Route 17A
Warwick, NY 10990
Phone: 914/986-6522
Fax: 914/986-0849
kprusins@cybergrafix.com

Kathryn Prusinski
CyberGrafix
158 Route 17A
Warwick, NY 10990
Phone: 914/986-6522
Fax: 914/986-0849
kprusins@cybergrafix.com

Richard L. Radtke
Hawaii Institute of Geophysics and Planetology
School of Ocean and Earth Science and Technology
University of Hawaii
1000 Pope Road, MS B632
Honolulu, HI 96822-2336
Phone: 808/956-7498
Fax: 808/956-9516
radtke@hawaii.edu

Carole L. Seyfrit
Dean's Office
Old Dominion University
Batten Arts and Letters Building, Room 900
Hampton Boulevard
Norfolk, VA 23529-0076
Phone: 757/683-3803
Fax: 757/683-5746
cseyfrit@odu.edu

Todd Sformo
Ilisagvik College
PO Box 798
Barrow, AK 99723
Phone: 907/852-9131
Fax: 907/852-9178
tsformo@co.north-slope.ak.us

Stephanie Shipp
Department of Geology and Geophysics
Rice University
PO Box 1892
6100 South Main-MS126
Houston, TX 77005
Phone: 713/285-5168
Fax: 713/285-5214
shippst@ruf.rice.edu

Steven Stevenoski
Lincoln High School
1801 16th Street South
Wisconsin Rapids, WI 54494-5499
Phone: 715/423-1520 x5136
Fax: 715/422-6097
ssteven@wctc.net

Wayne Sukow
Teacher Enhancement Program
National Science Foundation
ESIE/Room 885
4201 Wilson Boulevard
Arlington, VA 22230
Phone: 703/306-1613 x6818
Fax: 703/306-0412
wsukow@nsf.gov

Ted W. Timreck
Spofford Films, Inc.
35 East 30th Street
New York, NY 10016
Phone: 212/685-1134
Fax: 212/685-0376
ted@spacelab.net

Anne Tweed
Eaglecrest High School
5100 South Picadilly Street
Aurora, CO 80015
Phone: 303/699-0408
Fax: 303/766-8976

Orri Vesteinsson
Institute of Archaeology, Iceland
17 Prospect Road
London England NW2 2JT UK
Phone: +44/171-794 1225
orri@dircon.co.uk

George Vourlitis
Global Change Research Group - Department of Biology
San Diego State University
5500 Campanile Drive, Room 240
San Diego, CA 92182
Phone: 619/594-2616/6613
Fax: 619/594-7831
georgev@sunstroke.sdsu.edu

H. Jesse Walker
Department of Geography and Anthropology
Louisiana State University
Baton Rouge, LA 70803-4105
Phone: 504/388-6130
Fax: 504/388-4420
hwalker@lsu.edu

Diane R. Wallace
Arctic Research Consortium of the United States
600 University Avenue, Suite 1
Fairbanks, AK 99709-3651
Phone: 907/474-1600
Fax: 907/474-1604
arcus@arcus.org

Emma Walton
403 East Fireweed Lane
Anchorage, AK 99503
Phone: 907/274-7033
Fax: 907/274-2704
elwalton@aol.com

Wendy K. Warnick
Arctic Research Consortium of the United States
600 University Avenue, Suite 1
Fairbanks, AK 99709-3651
Phone: 907/474-1600
Fax: 907/474-1604
warnick@arcus.org

Mark Wensnahan
Jet Propulsion Laboratory-California Institute of Technology
4800 Oak Grove Drive
NASA-JPL MS 300-323
Pasadena, CA 91109
Phone: 818/354-1940
Fax: 818/393-6720
markw@pacific.jpl.nasa.gov

Frank F. Willingham
Ilisagvik College
PO Box 749
Barrow, AK 99723-0749
Phone: 907/852-9176
Fax: 907/852-9146
fwillingham@co.north-slope.ak.us

Arctic Research Consortium of the United States
600 University Avenue, Suite 1
Fairbanks, AK 99709
Phone: 907/474-1600
Fax: 907/474-1604
arcus@arcus.org
http://www.arcus.org

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