Arctic Forum

Abstracts 2006

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Cover Photos:

Top: The Brooks Range, Alaska, observed by TREC teacher Jason Petula during his trip to Umiat, Alaska, to document the Cretaceous period (65–70 million years ago) dinosaurs and their high latitude environments with researchers Paul McCarthy, Anthony Fiorillo, and Dave Norton (2006). Photo by Jason Petula.

Middle: TREC teacher Amy Clapp is assisted by children while collecting river samples to study biogeochemical fluxes in the Lena River near Zhigansk, Russia (2004). Photo courtesy of Amy Clapp.

Bottom: The arctic flower *Potentilla* sp. observed by TREC teacher Tracy Alley during field work investigating tundra ecology with researcher Michelle Mack at Toolik Lake, Alaska (2006). Photo by Tracy Alley.

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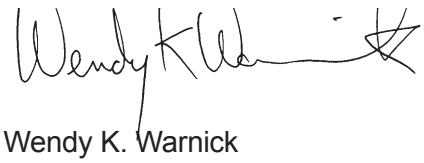
Foreword

Each year the Arctic Research Consortium of the U.S. (ARCUS) hosts the Arctic Forum in conjunction with the ARCUS annual meeting. The goal of the Arctic Forum is for arctic researchers in all disciplines to interact with colleagues and agency representatives. This collection of abstracts showcases the oral presentations and poster session at the Arctic Forum held 25–26 May 2006, in Washington, D.C.

The ARCUS annual meeting and Arctic Forum are the culmination of our efforts each year to represent the arctic research community on behalf of ARCUS' 46 voting and associated member institutions. ARCUS serves its member institutions by acting as a communication channel, providing information about current research activities and arctic science issues to the research community, and informing agencies and the public about arctic research. This work is done at many levels, including newsletters and other publications, electronic communications, K–12 education projects, workshops, and symposia like the Arctic Forum. The Arctic Forum provides access for individual researchers to information on research, education, and facilities outside of their fields, which has led to many successful collaborations. Since its inception in 1994, the Arctic Forum remains one of only a few interdisciplinary arctic science meetings. The Arctic Forum abstract series begins with *Arctic Forum 1998.*

This abstract volume illustrates the diversity and interdisciplinary nature of arctic research today. The theme for the 2006 Arctic Forum was "International Arctic Research at a Turning Point: Innovations and Collaborations for the Future." Fran Ulmer from the University of Alaska Anchorage gave the opening keynote address, and U.S. Senator Lisa Murkowski from Alaska gave the concluding keynote.

As executive director of ARCUS, I appreciate the efforts of the many researchers who shared their results with the community through the Arctic Forum. We thank Volker Rachold and Craig Tweedie for chairing the Forum and the National Science Foundation for supporting this opportunity. Sarah Behr and Birte Horn-Hanssen of ARCUS were the managing editors for this abstract volume. We invite you to join us at the Arctic Forum in 2007.



Wendy K. Warnick
Executive Director

Introduction to the Session
International Arctic Research at a Turning Point: Innovations and Collaborations for the Future

Volker Rachold, International Arctic Science Committee; and
Craig Tweedie, University of Texas at El Paso (Arctic Forum Co-Chairs)

In response to the growing realization that the Arctic is a complex integrated system of natural, physical, and social domains inextricably connected to the larger global system, there has been considerable movement toward new collaborative modes of and approaches to science. Initiatives and programs such as the International Polar Year (IPY), the Arctic Climate Impact Assessment (ACIA), and the Second International Conference on Arctic Research Planning (ICARP II) underscore the importance of these developments. Arctic science is at a turning point, the research community poised to develop unprecedented partnerships and innovations transcending disciplinary, geographical, political, and mission-related boundaries.

The ability of arctic researchers to successfully forge and maintain novel innovations and international partnerships will be critical to the success of arctic science in the near future, especially in view of likely agency budget constraints. The arctic community, however, is only beginning to understand how to successfully design research and education activities to meet these new directions. Issues such as stakeholder involvement, multi- and interdisciplinary research, training of the next generation of scientists, technological innovations, and data management are all issues in which innovation and collaboration are critical, yet still remain a challenge in most contexts.

What new methods, approaches, or innovations will prove successful and sustainable to advance our understanding of the Arctic? What are the barriers to success in formal and informal partnerships, and what is needed to overcome these barriers?

Arctic Forum 2006 addressed these questions with a 1.5-day open forum featuring a combination of invited and contributed plenary and poster presentations as well as moderated panel discussions.

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Presentation Abstracts

Polar Politics: The Marriage of Scientists, Stakeholders, and Policy Makers

Fran Ulmer, University of Alaska Anchorage

In the Arctic, the rate of change is accelerating in the physical environment, ecosystems, and societies. This makes it much more difficult for decision makers to absorb and process information that might improve their understanding of conditions and their decisions. In both the public and private sectors, the combination of this accelerating rate of change and the complexity of problems we face has increased the need for relevant scientific research and analysis. However, cultural differences between scientists and policy makers often get in the way. Many scientists feel uncomfortable working with policy makers and prefer "pure" to "applied" research. Moreover, research results are not communicated in ways that non-scientists can understand easily or utilize. How can scientists become better communicators about their research so stakeholders and policy makers understand it? How can we make it easier (and more desirable) for policy makers and stakeholders to use that research to improve decisions? How can we make science that is relevant to policy makers and stakeholders more interesting to the scientific establishment? Fran Ulmer discussed why it is important for us to explore these questions now more than ever for the future of the Arctic and the planet.

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New Approaches to Understanding a Changing Arctic

Peter Schlosser, Lamont-Doherty Earth Observatory, Columbia University

Recent observations have revealed rapid system-scale changes in the physical, chemical, biological, and human domains of the Arctic. Placing these changes into the context of past changes and natural variability of the arctic environment, as well as into the global context of a warming world with possible non-linear, abrupt transitions, pose major challenges to our scientific understanding. To address these challenges, new observational approaches including system-scale, integrated, long-term observing systems and development of new observing methods are required. The data streams of the observing platforms have to be captured and readily made available to the research community. Synthesis activities and model studies have to be synchronized with observing efforts and linked to the development of Earth system models capable of projecting the future evolution of the planet and its subsystems including the Arctic. This presentation outlines the nature of these new challenges, possible ways to address them, programs that have been formulated to meet them, and the progress in the implementation of these programs on the national and international level.

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Panel Discussion: Challenges and Needs of System-Scale Science

John E. Walsh, University of Alaska Fairbanks; Tore Furevik; Julienne Stroeve; Jörn Thiede; and Cynthia Tynan

John Walsh of the International Arctic Research Center moderated a panel discussion entitled "Challenges and Needs of System-Scale Science." The panel responded to the following questions:

- What are the key gaps in our understanding of the Arctic?
- As arctic research increasingly moves towards an integrated perspective, what are the scientific, disciplinary, and/or institutional barriers to implementing pan-arctic or system-scale science? What is needed to overcome these barriers?
- What short-term and long-term approaches should be taken to gain a predictive understanding of the arctic system that is useful for decision makers?

The panelists identified key gaps in our understanding of the Arctic, including paleo records of the Arctic Ocean, the effect of climate change on the structure and function of the arctic marine ecosystem, lack of satellite data, lack of an ecological integrated time-series and long term records of the Arctic, and understanding and model formulations of feedback processes. The panel also generally emphasized that there is a lack of knowledge in key variables measuring the arctic environment, as mentioned in the recent Arctic Observing Network report detailing geographical gaps, temporal gaps, thematic gaps, human dimensions gaps, and gaps in data management and access.

The panelists identified several scientific, disciplinary, and institutional barriers to implementing pan-arctic or system-scale science, including the lack of new funding sources, the inability to make year-round measurements, the discontinuity in satellite monitoring, old data sets, the incomplete coverage of a topic, and a lack of technology.

The panelists and Arctic Forum participants discussed possible solutions to these gaps and barriers, emphasizing the importance of pan-arctic collaboration and international coordina-

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tion in order to gain a predictive and useful understanding of the Arctic for decision makers. Fundamental issues for consideration include: ensuring political stability through international collaboration to guarantee access to all arctic regions for all scientific partners, setting common standards and reference frames, providing useful tools for data access and delivery, funding large scale-studies of key processes and long-term monitoring, investing in better equipment such as new research vessels, and including the human dimension in system-scale science models.

Panel Discussion: Challenges and Needs of Stakeholder and Community Partnerships

John Crump, United Nations Environment Programme/GRID-Arendal; Hadi Dowlatabadi; Kristina Lasko; Honorable Paul Okalik; and Frances Raskin

John Crump of the United Nations Environment Programme moderated a panel discussion on "Challenges and Needs of Stakeholder and Community Partnerships." The panelists, with backgrounds in various areas within arctic research and policy-making, including territorial government, conservation, law, and education, responded to the following questions:

- What are science or research priorities for arctic stakeholders and communities? How do they vary among stakeholder groups and how do they vary across the Arctic?
- What is the role of stakeholders and communities in guiding and participating in arctic research activities?
- What defines a successful science-stakeholder partnership? What are the barriers to successful partnerships and what is needed to overcome these barriers?
- How do we identify and choose stakeholders for collaboration?
- Given that most communities are interested in the policy applications of research, how do we integrate science and policy goals?
- How do we establish a relationship of equals between researchers and stakeholders?

The panelists outlined various ways that researchers can improve their collaboration with local stakeholders, including: working to better recognize local community needs and interests; being respectful of traditional knowledge; listening and learning from the elders in the community; and reaching out to younger generations to encourage community participation in research. The panel discussion stressed that researchers need to be respectful of culture and realize that culture is not static—it is the day-to-day lives of local inhabitants. It was also emphasized that researchers need to pursue activities that benefit both the research community and stakeholders and move beyond pure science into research that has practical applications for local communities.

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International Policy Cooperation in the Arctic

Scott Barrett, Johns Hopkins University

Beginning in the 1950s, the arctic states faced the environmental challenge of protecting polar bears from possible extinction. At first they responded unilaterally. These efforts failed, however, because the bears crossed national borders. A country that restricted hunting at home risked losing its bears to its neighbors. So an international agreement was negotiated - the Polar Bear Treaty. It entered into force in 1974 and has been fairly successful.

Today, of course, the bears are threatened once again, but not by hunting. Their new threat, like for all of the Arctic, is global climate change. To address this problem, a global agreement is required, and this will prove a much harder challenge.

Two agreements already address the problem: the Framework Convention on Climate Change and the Kyoto Protocol. Unfortunately, neither is very helpful. The Framework Convention emphasizes the need to avoid "dangerous interference" with the climate, but no one knows exactly what level of atmospheric concentrations is dangerous. The Kyoto Protocol by design limits the emissions of just a small number of countries by a little bit for a short period of time. Even if it worked as intended, it would have almost no effect. However, as I shall explain, the agreement will not work as intended. A different approach needs to be tried.

That approach must do more than just seek to limit emissions. It must also undertake research and development to develop and diffuse new technologies. It must address the challenge of adaptation, since climate change is sure to occur—indeed, it seems already to be occurring in the Arctic—no matter how successful mitigation proves to be. Finally, because of the threat of "abrupt" climate change, consideration needs to be given to a very different kind of response: geoengineering, or deliberate climate modification.

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Overview of Arctic Organizations—Who is Who?

Volker Rachold, International Arctic Science Committee; and
Craig Tweedie, University of Texas at El Paso (Arctic Forum Co-Chairs)

Volker Rachold presented an overview of some of the many organizations that focus on the Arctic. The organizations are listed here as they were categorized in the presentation. Please note that this is not a comprehensive list but examples of organizations involved in arctic issues.

Rachold listed organizations that focus on international circumarctic coordination and not research projects.

International Organizations

a) Governmental

- Arctic Council (www.arctic-council.org): Working Groups include:
  - The Sustainable Development Working Group (SDWG)
  - The Arctic Monitoring and Assessment Programme (AMAP)
  - Protection of the Arctic Marine Environment (PAME)
  - Conservation of Arctic Flora and Fauna (CAFF)
  - Emergency, Prevention, Preparedness, and Response (EPPR)

Permanent Participants include:

  - Aleut International Association (AIA)
  - Arctic Athabaskan Council (AAC)
  - Gwich'in Council International (GCI)
  - Inuit Circumpolar Conference (ICC)
  - Saami Council
  - Russian Association of Indigenous Peoples of the North (RAIPON)
  - Indigenous Peoples Secretariat (IPS)
- Conference of the Parliamentarians of the Arctic Region (www.arcticparl.org)
- Nordic Council and Nordic Council of Ministers (www.norden.org)
- Northern Forum (NF; www.northernforum.org)

b) Non-Governmental

- International Arctic Science Committee (IASC; www.iasc.se):
  - Pacific Arctic Group (PAG; www.arctic.noaa.gov/aro/pag)
  - International Science Initiative in the Russian Arctic (ISIRA; www.iasc.se/isira)
- Arctic Ocean Sciences Board (AOSB; www.aosb.org)
- European Polar Board (EPB; www.esf.org/epb)
- International Arctic Social Sciences Association (IASSA; www.iassa.gl)
- Climate and Cryosphere (CliC; www.clic.npolar.no)
- International Permafrost Association (IPA; www.geo.uio.no/ipa)

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c) In Between

- Forum of Arctic Research Operators (FARO; www.faro-arctic.org)
- IASC Regional Board (IASC RB; www.iasc.se)
- Northern Research Forum (NRF; www.nrf.is)

Global Organzations with Arctic Components

- International Council for Science (ICSU; www.icsu.org)
- World Meteorological Organization (WMO; www.wmo.ch)
- UN Educational, Scientific, and Cultural Organization (UNESCO; www.unesco.org)
- UN Environment Programme (UNEP; www.unep.org)
- World Wildlife Fund (WWF; www.wwf.org)

National and Bilateral Arctic Organizations with International Focus

- Arctic Research Consortium of the U.S. (ARCUS; www.arcus.org)
- International Arctic Research Center (IARC - USA/Japan; www.iarc.uaf.edu)
- Otto Schmidt Laboratory (OSL – Russia/Germany; www.otto.nw.ru)
- Fram Climate Research Laboratory (FAL – Russia/Norway; www.fram.nw.ru)
- Arctic Institute of North America (AINA – Canada/USA; www.arctic.ucalgary.ca)
- Arctic Centre – Finland (www.arcticcentre.org)

International Programs and Initiatives

- International Polar Year (IPY; www.ipy.org)
- 2nd International Conference on Arctic Research Planning (ICARP II; www.icarp.dk)
- Arctic Climate Impact Assessment (ACIA; www.amap.no/acia)
- Arctic Human Development Report (AHDR; www.svs.is/ahdr)
- Arctic Science Summit Week (ASSW; www.assw2006.de)
- International Study of Arctic Change (ISAC/Study of Environmental Arctic Change SEARCH; www.arcus.org/search)
- University of the Arctic (UArctic; www.uarctic.org)

Beyond 2009: Broadening the Legacy of the International Polar Year

Karen Kraft Sloan, Foreign Affairs Canada

The first International Polar Year (IPY) in 1881 was built on the rationale that research of certain global phenomena must not only be polar based but must also be achieved through international cooperation. That spirit, which served the first IPY so well, continues to inform polar research.

IPY 2007 will build on the legacies of its three predecessors. It will also illustrate the enormous energy and resources required to scale up for such international efforts and thereby challenge us to sustain the momentum and enhance the benefits that it will create.

IPY 2007 can serve to focus attention on the value of international arctic science cooperation, inspiring a discussion of practical measures to formalize and institutionalize that collaboration.

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Case Study 1: The Need for Technological and Scientific Collaboration: Arctic Upper Atmospheric Research

John D. Kelly, SRI International

The upper atmosphere in polar regions has direct electrical coupling with the solar wind, giving rise to energy input via electrical currents and particle precipitation often manifested by visual aurora. Instruments that are needed to study these phenomena are complex, expensive, and, as a result, few in number. In order to develop the next generation instrumentation, we need to share innovative ideas and resources. SRI International, in partnership with universities and industry and with funding from the National Science Foundation, is developing a new instrument called Advanced Modular Incoherent Scatter Radar (AMISR). Beyond this level of cooperation, we recognize the necessity and benefits of more formal collaboration with our peers and the need to leverage the resources of the relatively sparse set of remote sensing instruments. Of course some collaboration exists now; there are, however, obstacles preventing extended collaboration, which we need to address and eventually overcome. What can we learn from other arctic researchers who recognized the advantage of adopting the holistic approach and formed collaborations with an overarching theme?

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Case Study 2: Science-Industry Partnerships: Planning and Management Using Information Technology

Mark Sorensen, Geographic Planning Collaborative, Inc.

Geographic Information System (GIS) is not just about technology anymore. In the past, GIS has been commonly described as a "computerized system for the compilation, access, retrieval, analysis and display of geographic and geographic-related data." Modern GIS is much more than computerized mapping—it now provides the basis for a societal information infrastructure for bringing what we know about the planet together geographically to support integrated and multi-sector decision-making, exploration, and research at many levels. GIS has grown from a relatively obscure and esoteric field just two decades ago to a globally recognized and fundamental part of our modern world. The Internet and advances in computing, data gathering instrumentation, knowledge management, data mining and modeling, and spatial analysis techniques and tools are opening new horizons for scientists, resource managers, and policy makers.

As people and organizations became aware of the significant benefits from GIS analysis, they also began to realize that data within their organizations were generally scattered around in many locations and that the way information was being developed, stored, and managed made it difficult to share and optimize an organization's investment in various spatial information. It was clear that larger structures would be needed to take full advantage of what technology had to offer.

This realization within the spatial data community was paralleled by rapid expansion in information gathering of many types all over the world. There has been a massive growth in the development of new sensing technologies, monitoring, data gathering, and other technologies that have created a collective data stream that is unparalleled in human history. There is more information available in the world today, and increased access to this information could benefit many organizations and society in general.

Scientists, managers, and technologists have indicated that there are special needs of the scientific community that have not been entirely filled by existing technologies. Software tools need to be extended to fit research needs. How we think about environmental factors and how we translate these issues to abstract, computerized form needs to be rethought in the context of scientific research needs. It is also clear that dynamic modeling and environmental simulation tools need to be developed in a way that can be integrated and optimized within the GIS environment.

Various discussions and forums have developed and are working on raising and answering questions and challenges related to globally available data in the technical, institutional, and societal frameworks that are necessary to absorb and optimize the use of this information for application at all levels of society.

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Case Study 3: International Education Collaboration: Research Experiences for Undergraduates

Julie Brigham-Grette, University of Massachusetts Amherst; Ross D. Powell; Al Werner; Steve Roof; and Mike Retelle

The Svalbard Research Experience for Undergraduates (REU) program, initiated in 2003, provides a research opportunity for undergraduate students in arctic Quaternary geology and climate change. The Svalbard archipelago, between 74° and 81° N latitude, lies at the northern end of the warm Gulf Stream and North Atlantic currents and, therefore, is sensitive to subtle climate and oceanic changes. Svalbard has warmed considerably during the past 90 years and climate proxies indicate even greater Holocene climate variability. Despite this, little is known of sub-century-scale climate change and virtually nothing is known of decadal scale variability in this region. In this program, undergraduate students are conducting glacilacustrine research at Lake Linne, west of Longyearbyen, and pilot studies of glacimarine systems in Kongsfjorden, near Ny Ålesund, in order to establish linkages between climate, glacier mass balance, sediment transport, and lake and fjord sedimentation.

Our program provides genuine research experiences in arctic quaternary science. Students receive a total immersion experience and are surrounded by scientists and students from different nations and disciplines who are associated with the University Centre in Svalbard (UNIS) and the large international research center of Ny Ålesund. They interact with these scientists and among themselves to develop their own research plans, making decisions and modifying sampling schemes throughout the field season. Following summer fieldwork, we require that a strong home academic advisor guide the student through completion of the project during each student's senior academic year. Many students have continued on in graduate studies and consider their REU exposure to have been invaluable.

The key to the success of our field program is tight logistics and the integration of research objectives from UNIS. In the future, we plan to work closer with a growing number of UNIS faculty developing stronger linkages for curriculum planning and summer fieldwork.

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Case Study 4: Planning and Cooperation of Multinational Field Projects

Heidemarie Kassen, The Leibniz Institute of Marine Sciences

To secure funding for future research endeavors, one has to look for new forms of international cooperation and partnerships. In order to successfully convince funding agencies of the importance of a research project, the impacts (local, global, social, economic) and uniqueness of the research must be explained; communication channels, both official and personal, need to be established and nurtured as early in the process as possible. This talk will discuss several successful Russian-German collaborations in the Siberian Arctic as indicators of how international collaboration can be applied to arctic research.

My first example is the Laptev-Sea System project, which focused on process studies of permafrost dynamics in the Siberian Arctic. The Laptev-Sea System project has used different research platforms involving both Russian research vessels and German-built research equipment. This project has had 30 successful research expeditions since 1992 with funding from both Russian and German research partners.

Various educational institutions and initiatives have been established as joint Russian-German partnerships to support international research cooperation. One example is the Otto-Schmidt-Laboratory for Polar and Marine Research in Saint Petersburg (www.otto.nw.ru), which supports highly qualified young Russian scientists and increased collaboration among international researchers. A second example is the Masters Program for Applied Polar and Marine Sciences (www.pomor.de) at the Saint Petersburg State University that is associated with six universities, the Alfred Wegener Institute for Polar and Marine Research, and the IFM-GEOMAR in Germany.

Examples of future international cooperative endeavors include the major international scientific-coordination meeting for polynya research, IMPETUS, which will be held in the summer of 2006 in Saint Petersburg, and two large multinational field projects in the circumarctic polynya system that are planned for the summer, spring, and fall of 2007 and 2008. To better support all science activities in the Russian Arctic, the International Polar Year Eurasian Arctic Sub-Office at the Institute for Arctic and Antarctic Research in Saint Petersburg (www.ipyeaso.aari.nw.ru), in cooperation with the Otto Schmidt Laboratory and the Fram Arctic Laboratory (www.fram.nw.ru), will open in Saint Petersburg in 2006.

International collaboration and cooperation is becoming more and more vital to arctic research and we all have to start thinking and planning field projects as partnerships to best understand the changing Arctic.

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Establishing Successful Community-Research Partnerships

Craig Fleener, Council of Athabascan Tribal Governments

The Council of Athabascan Tribal Governments has been working to create successful research partnerships with universities, state and federal agencies, non-governmental organizations, and foundations since its inception in 1985. Our goal has been to improve the lives of members of the ten tribes that we serve. We have focused on education, natural resource management, and health.

We have partnered with:

- University of Alaska on food security issues, vocational training, on assessing climate change impacts forests and ecosystems, and our ability to adapt;
- U.S. Department of the Interior on refuge management functions and fisheries and fire management;
- World Conservation Union on restoring threatened species;
- Alaska Department of Fish and Game on cooperative moose, wolf, and bear management; and
- Environmental Protection Agency on measuring air and water quality, PCB cleanup and environmental restoration, and Yukon River water temperature assessment.

Our plans include creating partnerships to improve high school education, developing a broader approach to ecosystem restoration and management, and creating long-term employment opportunities within our communities by developing locally sustainable and culturally relevant industry. We have been successful at forging partnerships because we ask questions and look for answers to the questions that are most important to us from an indigenous perspective. We seek partnerships in order to resolve common problems. We have a proficient and specialized staff with an increasing track record of professionalism and dependability.

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Arctic Rush Film Presentation

Andrew C. Revkin, The New York Times*; and Craig Duff*

This film by the Discovery Times Channel/CBC takes a look at scientific efforts to research the arctic ice cap, including sea ice studies and drilling for ocean-bed cores. The film portrays a sense of environmental, economic, and political urgency as the ice cap rapidly diminishes and alters global climate and commerce and the energy industries further encroach upon the unstable ecosystem.

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Panel Discussion: Managing Challenges Facing the Arctic Research Community

Andrew C. Revkin, The New York Times*; John Crump; Paul Egerton; Shari Gearheard; Andy Mahoney; Susanne Moser; and Simon Stephenson*

Andrew Revkin of *The New York Times* moderated a panel discussion on "Managing Challenges Facing the Arctic Research Community." The panelists' backgrounds encompassed various disciplines, including international policy, science support and management, and physical and social science. The panelists responded to the following questions:

- What are the approaches and solutions—scientific, logistical, institutional, or societal—that can be enacted to advance our understanding of the Arctic and provide relevant information for decision makers?
- How can the arctic community enhance coordination between the different levels and types of stakeholders (students, educators, investigators, agency staff, countries, etc.) to work toward (1) a better understanding of system-scale science, and (2) partnerships with stakeholders and communities and with other nations?
- In what ways can the science education and research community better equip scientists with the skills needed to succeed in inter- and multi-disciplinary science, and to better communicate with decision makers, the public, and the media?

Panelists discussed their thoughts on how scientists, policy makers, and stakeholders can better collaborate to meet the challenges facing the Arctic. They stressed the need for links between those who report the facts, those who make decisions based on those facts, and those who must live with those decisions. These linkages between scientists, policy makers, and stakeholders must be facilitated through an equal relationship among all involved. Panelists also discussed the importance of educating those living outside the Arctic on arctic climate change issues, which affect not only northern inhabitants but also people worldwide.

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Advancing Arctic Research Through Policy and Science Advocacy (Speaking Notes)

Lisa Murkowski, U.S. Senator, Alaska

Thank you for inviting me to be with you today. It is a pleasure to join ARCUS members for the 2006 Arctic Forum. I appreciate that you are still here late on a Friday afternoon after two days of speeches and workshops.

I would like to start by saying how much we in Congress appreciate and count on the work you are doing when it comes to arctic research. The Arctic is still a new frontier for many in Congress. From climate change and development of our natural resources to international treaties and maritime rights, more knowledge about each of these issues is needed to help us formulate and shape the policies that will impact the Arctic for future generations.

While differences of opinion on the aforementioned issues remain, one area that I believe we cannot lose focus on is the human dimension. Our policies of today, and our policies of tomorrow, have a direct impact on those who live in the arctic region.

The fast approaching International Polar Year offers a tremendous opportunity to move the United States forward with its arctic policies. It has been nearly 50 years since the last International Polar Year—14 years since the U.S. last developed an arctic policy.

The world was a different place 14 years ago. The Cold War had just ended; climate change was barely being considered as an issue; an accessible, navigable Arctic Ocean was nowhere near as real a prospect as it is today; the Arctic Council was just getting started; and we had nowhere near the sensitivity to the changes life is bringing to indigenous residents.

When I visit Native villages in northern Alaska, I ask the village elders what climate change means to them. They don't speak about the Pacific Decadal Oscillation or attempt to debunk the now infamous hockey stick theory. They tell me what they have personally observed over the years. Native whaling captains tell me that the ice pack is less stable and that there is more open water requiring them to travel greater distances to hunt. The snow pack is coming later and melting earlier than in years past. Salmon are showing up in subsistence nets in greater numbers across the Arctic. Different types of vegetation now grow where they never grew before. The migratory patterns of animals have changed. Warmer, drier air has allowed the voracious spruce bark beetle to migrate north, moving through forests in the south-central part of Alaska. At last count, over three million acres of forest land has been devastated by the beetle, providing dry fuel for outbreaks of enormous wild fires. To give you some perspective, that is almost the size of Connecticut.

Times have changed and we need a new arctic policy. But how do we craft it?

I believe the upcoming International Polar Year can play a large role in focusing our na-

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tion, and for that matter the world, on the work that is being done and needs to be done in the Arctic. It can play a large role in crafting a new arctic policy.

But what those of us who care the most about the Arctic must do—and I put this forward as a challenge to you—is find a way to generate the public's interest in this area. What is the theme of IPY? What is the catch phrase used to describe it? After all, ask anyone on the street what the International Polar Year is and you get a blank look in return.

According to the National Academy of Sciences, the purpose of the International Polar Year is to "further our understanding of physical and social processes in the polar regions, examine their globally connected role in the climate system, establish research infrastructure for the future, and serve as a mechanism to attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues."

For me, as a member of Congress, it is important that I can easily explain to my colleagues what IPY is without going into a deep explanation about what an Arctic Observing Network is or what lives in the cold and dark—two of the currently proposed themes set for IPY.

The theme should spark an interest in those whose expertise may not be in the polar regions. Most importantly, the theme should be international. The polar regions bring every country together, whether in the area of climate change or in the issue of commerce, especially if shipping routes in the Arctic are opened.

The worst case scenario for IPY is for great scientific achievements to happen over the next two years and nobody knows about it. Showcasing IPY is essential.

So what made the International Geophysical Year in 1957–1958 successful? The focus at that time was simple—provide a burst of coordinated international research that leads to significant discoveries about our planet and leaves a long-term legacy for future generations. During the last IPY, we made advances in weather prediction and how to measure ice sheets in the polar regions.

It is important that we not lose focus of why we are having IPY— to make a contribution that will not only serve as a benchmark in understanding the polar regions but also help leave a legacy for future scientists and researchers.

I plan to use the occasion of the International Polar Year to bring more of my colleagues to the North. It is always rewarding when a member of Congress actually travels to the Arctic and sees for him or herself what the Arctic is really like. Last summer, I helped host Senators McCain, Clinton, Collins, and Graham during their brief time in Alaska, and Senator Stevens hosted many more.

On the Administration side, earlier this year I pressed Secretary of State Condoleezza Rice for the State Department's support during the International Polar Year. Alaska and the United States have the opportunity to shine during IPY and bring the Arctic to the forefront.

If you combine the budgets of every agency involved in the Arctic, roughly $300 million to $400 million is allocated to arctic research. The

National Science Foundation deserves praise for taking on the bulk of the work on the Arctic.

On both international and national levels, we are increasing our collaboration with local communities and indigenous people as partners in research—from designing the projects and collecting and interpreting the data to disseminating the results.

There are already projects trying to achieve a greater partnership. For example, the Student Partners Project, headed by the Woods Hole Research Center, unites students, teachers, and scientists to study the role of rivers in the arctic system and create an innovative and effective education and outreach program. By partnering with K–12 students and teachers living beside the largest arctic rivers in Russia, Canada, and Alaska, the high frequency river water samples that are needed to understand hydrologic and biogeochemical fluxes in the river systems will be obtained. In the process, the capability we seek in a multinational arctic river observing network will be developed.

As another example, in the Bering Strait School District in Alaska, teachers are trained to educate students in grades K–12 about climate change data collection and scientific study. The project blends modern science with Native tradition, language, and subsistence needs. Full community involvement has been achieved in 13 of the 15 villages in the school district.

Scientists from the Geophysical Institute work with teachers and students to collect and use data on weather, erosion, sea ice movement, and wave and wind action. Native elders are involved in teaching the students using the Native language, culture, and historical observations. The elders use the data to assist them in predicting dangerous weather and sea conditions as they plan for subsistence activities.

What they are doing not only benefits the community and sustains Native traditions, it also generates a new generation of individuals interested in arctic science.

IPY can and will be one of the most important periods of scientific discovery in the history of the Arctic. It can be used as a vantage point to update and revise U.S. policies toward the Arctic. It is an opportunity to craft greater coordination and cooperation among arctic nations. It is a chance to ensure that those who live in the Arctic benefit from the attention to the Arctic.

And perhaps most importantly of all, it is an opportunity to develop the next generation of arctic researchers to carry on your important work.

Thank you again for the opportunity to be with you today.

Poster Abstracts

HOTRAX-2005: International Collaborative Research in a Trans-Arctic-Ocean Expedition

Glenn W. Berger, Desert Research Institute

The Arctic Ocean is the last great ocean to be explored with modern geophysical and geological tools, largely because of the extensive and variable ice cover. Not only is the ocean itself a "canary-in-the-mine" responder to global climate change but it may be an amplifier (via feedbacks) of the same. Furthermore, we know little of the bottom sediments (containing a "long-term" record of past climate changes) and basement rocks. Thus in 2005 the execution of only the second two-ship trans-Arctic-Ocean scientific expedition had historical importance. The two icebreakers were the USCGC *Healy* and the Swedish *Oden*. This expedition was sponsored by the U.S. National Science Foundation and the Swedish Polar Research Secretariat. On-board scientists and students were mainly from the U.S., Sweden, Canada, Norway, and Japan.

During the two-month phase of the expedition, scientists on the icebreaker *Healy* collected data on sea ice properties (thickness, albedo, etc.), recovered soft-sediment cores, conducted side-scan-sonar bottom mapping, and obtained sub-bottom sonar and seismic data. HOTRAX-05 increased the number of kilometers of seismic tracks for the Arctic Ocean by 30% (adding 2,200 km), increased the number and quality of sediment cores in the western part by perhaps 100%, and obtained 29 piston cores greater than 12 m in length across the ocean. This unique collection of cores contains valuable information on the paleoclimatic and paleo-oceanographic conditions of this ocean, as well as regional sedimentation patterns. From the on-board magnetic-susceptibility measurements on cores, we now have a new regional correlation of sediment cores. However, much work on collected ice, seismic, and core data and samples is still in progress.

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Dynamical Downscaling Over Alaska and Its Potential Applications

Uma S. Bhatt, University of Alaska Fairbanks; Jing S. Zhang; Craig S. Lingle; and Wendell Tangborn

Many applications require gridded climate data of higher resolution than is available from global climate analyses or global climate models. To provide this information, one strategy is to dynamically downscale coarse climate data to higher resolution using a regional climate model, which can resolve the complex topography over Alaska. Results will be presented from a study that uses dynamical downscaling in conjunction with a glacier mass balance model that has been employed to estimate glacier melt in Alaska. Additional uses of dynamically downscaled climate data will be explored.

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Arctic Marine Shipping Assessment of the Arctic Council: Responding to Changing Marine Access in the Arctic Ocean

Lawson W. Brigham, U.S. Arctic Research Commission; Victor Santos-Pedro; Ross McDonald; Kimmo Juurmaa; and Soffia Gudmundsdottir

The results of the Arctic Climate Impact Assessment (ACIA) provided the impetus to the Arctic Council ministers to request in November 2004 that the Protection of the Arctic Marine Environment (PAME) working group conduct a comprehensive Arctic Marine Shipping Assessment (AMSA). The lead countries for AMSA are Canada, Finland, and the United States, and the final assessment report will be presented at the 2008 Ministerial meeting in Norway. The Arctic Council acted because the arctic sea ice cover, as documented by ACIA, is undergoing an unprecedented transformation—sea ice thinning, extent reduction, and a decrease in the area of multi year ice in the central Arctic Ocean. The ACIA sea ice simulations for the 21st century indicate increasing ice-free areas and suggest plausible growth in marine access throughout the Arctic Ocean. Under PAME, the lead countries are to work closely with the Permanent Participants and all the working groups of the Arctic Council to conduct the three-year assessment. AMSA's first task has been to initiate a survey of arctic shipping or marine activity data for 2004; six arctic coastal states are responsible for providing this information. Shipping has been defined broadly to include all possible ship activities and types: tankers, container ships, bulk carriers, fishing vessels, drill ships, research ships, offshore supply/support vessels, and others. The findings of ACIA (primarily sea ice changes) will be coupled with regional economic analyses of marine shipping to develop plausible scenarios for levels of marine activity in 2020 and 2050. AMSA will assess the current (2004) and future (2020 and 2050) social, economic, and environmental impacts of these arctic marine activities on arctic communities, large marine ecosystems, and all arctic coastal states. The findings of AMSA will be passed to the arctic states, all arctic stakeholders, and the global maritime community.

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The Svalbard REU Program: A High-Latitude Undergraduate Research Experience in Glacial, Marine, and Lacustrine Processes Relevant to Arctic Climate Change

Julie Brigham-Grette, University of Massachusetts Amherst; Ross D. Powell; Al Werner; Steve Roof; and Mike Retelle

The Svalbard Research Experience for Undergraduates (REU) program, initiated in 2003, provides a research opportunity for undergraduate students in arctic Quaternary geology and climate change. The Svalbard archipelago, between 74° and 81° N latitude, lies at the northern end of the warm Gulf Stream and North Atlantic currents and, therefore, is sensitive to subtle climate and oceanic changes. Svalbard has warmed considerably during the past 90 years and climate proxies indicate even greater Holocene climate variability. Despite this, little is known of sub-century-scale climate change and virtually nothing is known of decadal scale variability in this region. In this program, undergraduate students are conducting glacilacustrine research at Lake Linne, west of Longyearbyen, and pilot studies of glacimarine systems in Kongsfjorden, near Ny Ålesund, in order to establish linkages between climate, glacier mass balance, sediment transport, and lake and fjord sedimentation.

Our program provides genuine research experiences in arctic quaternary science. Students receive a total immersion experience and are surrounded by scientists and students from different nations and disciplines who are associated with the University Centre on Svalbard (UNIS) and the large international research center of Ny Ålesund. They interact with these scientists and among themselves to develop their own research plans, making decisions and modifying sampling schemes throughout the field season. Following summer fieldwork, we require that a strong home academic advisor guide the student through completion of the project during each student's senior academic year. Many students have continued on in graduate studies and consider their REU exposure to have been invaluable.

Key to the success of our field program are tight logistics and the integration of research objectives with UNIS. In the future, we plan to work more closely with a growing number of UNIS faculty developing stronger linkages for curriculum planning and summer fieldwork.

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The Search For a Past: The Prehistory of the Indigenous Saami of Northern Coastal Sweden

Noel D. Broadbent, Smithsonian Institution

The goal of this project has been to document and evaluate the long-term evidence for Saami settlement and land use on the Bothnian coast of northern Sweden. Archaeological, ethnographic, historical, and place-name evidence indicate that Saami territory once extended as far south as Oslo, Stockholm, and Helsinki. The Saami had been involved in widespread independent social and economic networks until the 14th century. By AD 1300 the Swedish State and Church had extended its influence into the far north, leading to the displacement of the Saami from the Bothnian coastal regions and into the interior. Taxation and ecological imperatives led to a greater reliance on reindeer. Agrarian and mercantile expansion, combined with the effects of the Black Death and Little Ice Age, transformed the Saami from a northern hunter-gatherer-based society into a nomadic herding society within a complex state system. Saami land rights are still tied to this historical transformation.

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Research Opportunities in the Barrow, Alaska, Area

Tim Buckley, Barrow High School

This poster outlines the research opportunities available in the Barrow area for visiting scientists. The variety of field data collection undertaken by scientists and support personnel is illustrated. A satellite image of the Barrow Environmental Observatory is also included and allows some of the equipment involved with the biocomplexity project to be seen. A recent picture of the Barrow Global Climate Change Research Facility is on the poster showing the steel framework already in place. A list of organizations and individuals with long-term involvement in Barrow area research projects is also provided.

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Planning the Barrow Cabled Observatory: Real-Time Oceanographic and Environmental Data for Northern Alaska

Dale N. Chayes, Lamont-Doherty Earth Observatory, Columbia University; Bernard Coakley; Richard Machida; Andrey Proshutinsky; and Thomas Weingartner

Study of the Arctic Ocean is limited by sea ice and harsh weather that restrict access using traditional methods for much of the year. This has limited data acquisition in the past and obscured understanding of events, processes, and variability of the environment over most of the Arctic Ocean. Breaching this isolation can be achieved through the use of cabled observatory technology and instrumentation to monitor the shelf and basin independent of surface conditions.

Located at the confluence of the Chukchi and Beaufort Seas, Barrow, Alaska, is an ideal location both to observe local phenomena and to address mixing issues having global significance. The Beaufort and Chukchi shelves are heterogeneous environments characterized by complex oceanography that dramatically impacts the local ecosystem and, ultimately, the communities that depend on this ocean. Because this region is particularly sensitive to climatically driven environmental changes, understanding the variability and the linkages between and within the atmosphere and the ocean is necessary to constrain change, to predict how it will evolve over time, and to develop plans to mitigate the consequences to local communities.

A design effort to address the science needs and technical issues associated with a cabled observatory at Barrow, Alaska, is well underway. A science workshop was held in Barrow in February 2005 with the results reported in *Eos*. A technical working group met in Monterey, California, in November 2005 to develop a conceptual design for a cabled seafloor observatory at Barrow. This poster reports on the results of these two workshops.

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Arctic Science Education: Partnerships Build Bridges Across the Learning Continuum

Renée D. Crain, National Science Foundation

The Arctic Sciences Section at the National Science Foundation supports the integration of scientific research with science education at all levels. Support from the Arctic Research and Education program has enabled arctic researchers to involve K–12 students, teachers, journalists, arctic residents, and the broader public in their research. Researchers, including graduate-level students, convey the latest theories and questions in arctic science in an active, inquiry-based way that engages learners. Researchers impart to their audiences the importance of the polar regions to the global system, act as role models for young people seeking career opportunities, and provide invigorating collegial interactions for teachers and other professionals. This poster describes some of the projects supported by the Arctic Sciences Section to involve students and the public in arctic research, with an emphasis on including and providing experiences for arctic residents. The results have provided thousands of students and many others with unique and informative experiences in arctic science. With support from the Arctic Sciences Section, researchers are finding new avenues to ensure the broader impacts of their research while they gain new perspectives about science teaching and learning through these enriching activities.

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Paleolimnological Perspective on Long-term Environmental Change in the Canadian High Arctic

Marianne Douglas, University of Toronto; Dermot Antoniades; Bronwyn Keatley; Darlene Lim; Neal Michelutti; Roberto Quinlan; and John P. Smol

High arctic lakes and ponds have been shown to be critical bellwethers of environmental change. Our limnological and paleolimnological data from the Canadian High Arctic show that lakes in different settings follow different ecosystem trajectories dependent on local and regional factors such as geological and climate characteristics. This poster reviews three case studies including marked limnological changes, global transport of pollutants, and archaeological applications. These demonstrate some of the exciting kinds of paleoenvironmental data that can be obtained from arctic freshwater sediments. Given the spatial and temporal coverage, much still remains to be completed, especially given the sensitive nature of these high latitude sites.

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Biomass-NDVI-LAI Relationships Along the Full Arctic Bioclimate Gradient

Howard E. Epstein, University of Virginia; Donald (Skip) A. Walker; Gensuo J. Jia; Alexia M. Kelley; and Martha K. Raynolds

A common methodology for assessing the potential effects of terrestrial ecosystems to environmental change is to develop present-day spatial relationships between environmental variables and ecosystem properties. Spatial relationships between climate variables and ecosystem variables should of course be used cautiously when extrapolating these patterns over time, i.e., space-for-time substitutions. Nevertheless, this approach has been extremely useful along regional climate gradients, in addition to providing support for vegetation dynamics models. We have developed several datasets of latitude, temperature, aboveground plant biomass, the NDVI (normalized difference vegetation index) and LAI (leaf area index) for arctic tundra ecosystems along an 1,800 km transect from the low arctic tundra in northern Alaska to the polar desert of the northern Canadian Archipelago. Another useful application of these data is the relationships between NDVI and aboveground plant biomass, which can allow for the conversion of satellite data to on-the-ground ecosystem properties.

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Trends in Circumpolar Photosynthetic Activity from 1982–2003

Scott Goetz, Woods Hole Research Center; and Andrew Bunn

Temperature increases in northern high latitudes over the past few decades have led to a wide variety of ecosystem changes, including modification of the productivity of plants as measured by ground cover (growth) and associated changes in global CO_2 exchange. Well-known studies of "greening" trends between 1982 and 1991 in high latitude vegetation indicate an earlier onset of growing season and more active photosynthesis in the mid-summer months. Our recent work indicates that these trends do not continue uniformly in time or space but instead vary between vegetation types and different periods of the growing season. These results provide some of the first evidence that high latitude forests may be in decline following an initial growth spurt associated with CO_2 and warming. The satellite observations are supported by a range of field observations and indicate that natural ecosystems may be responding to climate change in unexpected ways that will have significant further effects on the biosphere.

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Preparing for IPY in Canada

David Hik, University of Alberta

International Polar Year 2007–2008 will expand our understanding of the polar regions, especially the complex interactions between physical, biological, and human dimensions. Canadian participation, planning, and support for IPY activities is advancing rapidly, and this poster highlights recent developments in science and research projects, community partnership, private sector participation, youth engagement, education, and outreach programs.

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Migration in the Arctic: Subsistence, Jobs, and Well-Being in Urban and Rural Communities

Lee Huskey, University of Alaska Anchorage; Matthew Berman; Lance Howe; Wayne Edwards; Robert Harcharek; Jack Hicks; and Stephanie Martin

This project studies patterns of migration of North American arctic indigenous people between rural communities, larger regional centers, and urban areas over the past several decades. It has four primary research objectives:

- develop improved methods for analyzing migration decisions of individuals participating in mixed subsistence and cash economies;
- apply these methods to improve understanding of Inuit migration decisions in a comparative multi-decadal study of Alaska and arctic Canada;
- develop and make available to other researchers metadata for research and policy applications; and
- involve arctic communities in policy-relevant research.

We address questions about the causes and consequences of migration, such as the roles of subsistence opportunities and community quality of life amenities, gender differences, and national policies on migration decisions. Comparing the Iñupiat regions in Alaska to the Nunavut Territory of Canada, we ask whether Canadian Inuit are less mobile than Alaska Iñupiat and, if so, to what extent can this be attributed to differences in policies in the two nations? We also investigate the long-term consequences of migration decisions: is mobility on balance improving living conditions in arctic communities, especially the poorest places, or is it draining leadership to larger settlements and exacerbating inequalities?

We are analyzing microdata collected from the late 1970s to the present, including the U.S. Census, Survey of Living Conditions in the Arctic, North Slope Borough Censuses, Statistics Canada Aboriginal People's Survey, and other household survey data from Nunavut and Alaska. In the first year of the project, we have

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created a new large-sample household-level dataset from 1990 and 2000 Decennial Census Long Form data, in cooperation with the U.S. Census Center for Economic Studies. Our preliminary findings for Alaska Iñupiat from the 2000 Census dataset include:

- Overall, the largest migration flows from 1995–2000 occurred to and from urban areas.
- Migration among arctic villages occurs primarily among places in the same census regions.
- Migration patterns are consistent with a "stepping stones" migration hypothesis. That is, the highest village out-migration rates are to regional centers; regional center out-migration is greatest to Alaska urban centers; out-migration from Alaska urban centers is greatest to other U.S. states.
- Net out-migration rates from arctic regional centers to urban areas are higher for women than for men, but net out-migration rates are higher for men from urban Alaska to other states. College-educated Iñupiat moved from arctic places to Anchorage at considerably higher rates than those with less formal education.

Learning from the Past: Archaeology of Nuvuk

Anne M. Jensen, Ukpeagvik Iñupiat Corporation; Dennis H. O'Rourke; and Shawn Miller

North America's northernmost village, Nuvuk, was once located at the tip of Point Barrow, Alaska. Erosion has been exposing ancient human remains at an alarming rate. A National Science Foundation-funded survey of the area revealed that there are a large number of old unmarked graves in severe danger of erosion. Many cultural features, including work areas and apparent tent sites, are also threatened with erosion.

This project, with funding from the U.S. Department of Education's "Education through Cultural and Historical Organizations (ECHO)" grant, is involving students in all phases of a major archaeological project to excavate these threatened cultural resources and save the data they contain about the past 1,100 or 1,200 years of history at Nuvuk.

Several additional research projects have developed in connection with this excavation, including skeletal morphometrics, a specialist analysis of wood and woodworking, and geophysical site mapping. Projects involving ancient human DNA and a controlled intercomparison of additional geophysical techniques are proposed and seeking funding. Additional projects being considered include a geomorphological study of the Point Barrow spit and ancient DNA from faunal remains.

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Northern Material Culture Through International Polar Year Collections, Then and Now: In the Footsteps of Murdoch and Turner

Anne M. Jensen, Ukpeagvik Iñupiat Corporation

This poster describes a developing project based on the encyclopedic ethnological reports resulting from expeditions to Point Barrow, Alaska, and Fort Chimo in the Ungava District (now northern Quebec), which are perhaps the most lasting products of the scientific output from the first International Polar Year (IPY). Together, Murdoch's Ethnological Results of the Point Barrow Expedition (1892) and Turner's Ethnology of the Ungava District (1894) form the intellectual bedrock of northern native studies in their respective regions. These publications are likely the only research results from the original IPY, which still are consulted routinely by researchers.

We will be undertaking a modern version of these ethnological collecting projects. Using the categories developed by Murdoch and Turner, with appropriate additions (e.g., communications equipment, navigation devices), the project will document modern equivalents of the items they collected and their uses. Project documentation will provide a valuable resource for comparative studies of Iñupiat material culture change through time. The project's value will be enduring and will only grow through time, as happened with the material collected during the first IPY, leaving a legacy for future generations of researchers.

Similar programs will be carried out in other northern communities. There are reportedly some collections and photographs from other original IPY sites. However, this program need not be limited to those locations. It can be undertaken in any interested community. A K–12 educational component involving partnerships between northern and southern schools has also developed in connection with this project.

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Village-Based Monitoring of Coastal Dynamics Along the Beaufort Sea in Northern Alaska

Torre Jorgenson, ABR, Inc.; Jerry Brown; Tim Buckley; and Chien-Lu Ping

A village-based network for monitoring coastal dynamics along the Beaufort Sea coast of northern Alaska was initiated in 2004 to provide local residents, the science community, industry, and policy makers information on changes along the coast. The network of four key sites at Barrow, Nuiqsut, Kaktovik, and Beaufort Lagoon is designed to monitor sea level and storm surges, wave dynamics, coastal erosion, sedimentation, and permafrost temperatures. Local teachers, students, village representatives, and scientists collaborate to collect the data that are available to students for use in classroom exercises and science fair projects. Information from the local network is provided to the circumarctic network of the Arctic Coastal Dynamics program. The village-based monitoring is supported by the National Science Foundation's Study of the Northern Alaska Coastal System (SNACS), Barrow Arctic Science Consortium, and Experimental Program to Stimulate Competitive Research (EPSCoR) programs; the North Slope Borough School District and Department of Wildlife Management; U.S. Fish and Wildlife Service; ConocoPhillips Alaska, Inc.; International Permafrost Association; and ABR, Inc.

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Climate Warming Greatly Restricts Growth and Recovery of Lichens Following Heavy Grazing by Reindeer on a Bering Sea Island

David R. Klein, University of Alaska Fairbanks

Lush, lichen-dominated plant communities on St. Matthew Island in the northern Bering Sea were markedly altered by grazing pressure following introduction of reindeer there in 1944. The reindeer were introduced by the U.S. Coast Guard to provide an emergency food source for their personnel operating a LORAN navigational aid station during the latter part of World War II. The Coast Guard abandoned the island after the end of the war in 1945 and the reindeer increased from 29 animals in 1944 to 6,000 in 1963 in the absence of humans and other potential predators. By 1963, lichens, the primary winter food of the reindeer, had been virtually eliminated in the previously lichen-dominated plant communities on the island. In late January and early February of the following winter, an anomalous weather event of extreme cold and heavy snowfall resulted in a massive and near total die-off of the reindeer, with less than 50 animals surviving. No viable males survived, thus in the absence of breeding by the few remaining females, extirpation of the population followed. By 1963, those plant communities that had been lichen-dominated prior to the population explosion of the reindeer had become dominated by vascular plants, mainly sedges (*Carex* spp.) and willows (*Salix arctica*).

A factor contributing to the loss of lichens, in addition to grazing by the reindeer, was the strong wind common on the island that resulted in large amounts of lichens fractured by grazing and trampling being blown to sea, rather than potentially serving as living propagules for lichen re-growth. When the island was re-visited in 1985, little lichen recovery had occurred in the 22 years following the reindeer die-off. In vegetation plots established in 1957, re-growth of lichen biomass, primarily by “pioneering” species, accounted for less than 10% of lichen biomass in plant communities on adjacent and un-grazed Hall Island where “climax” lichen species predominated in the thick lichen mats. When these vegetation plots on St. Matthew Island were again examined in 2005, 42 years after the reindeer die-off, we were surprised to find no significant changes in lichen biomass as well as species composition within the vegetation plots. A major climatic regime shift in the northern Bering Sea in recent decades, accounting for warming, reduced summer fog, and associated drying, is believed responsible for greatly reducing favorability for lichen growth on St. Matthew Island. Thus, the warming climate has stabilized change in plant community structure brought about by the relatively short presence of a large herbivore species on the island.

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Scientific Diving Under Ice: A 40-Year Bipolar Research Tool

Michael A. Lang, Smithsonian Institution; Adam G. Marsh; and Martin D. Sayer

The 40-year history of scientific diving under ice validates its effectiveness as a research tool in increasing our knowledge of polar science. The conduct of underwater research in extreme environments requires special consideration of scientific diving equipment design and maintenance, diver training and operational procedures, and human physiological factors. National scientific diving programs of the U.S., U.K., Canada, Australia, New Zealand, Norway, Sweden, and Germany share a common risk management approach in this regard and will likely increase their research diving activities and network in support of the International Polar Year.

In 2003 and 2005, under-ice training courses for diving scientists were conducted in Ny Ålesund, Svalbard, and will continue in March 2007. Formalized scientific diving drysuit training in the U.S. is conducted through the Smithsonian Institution and Scripps Institution of Oceanography, and is available in the U.K. through the National Facility for Scientific Diving. The U.S. Antarctic Program (National Science Foundation) and the British Antarctic Survey (Natural Environment Research Council) scientific diving exposures in support of underwater research enjoy a remarkable safety record and scientific productivity. A greater understanding and mitigation of the physiological impacts of cold-water diving and advances in diving equipment technologies have evolved to support underwater polar scientific research. Overall, diving in extreme polar environments is challenging and underwater research beneath the ice is only possible with a significant allocation of logistical support and resources to ensure personnel safety. Scientific diving has been an essential research tool in the production of some of the milestone polar publications of the past 40 years.

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The People of Point Hope: Their Past and Their Present

Karlene B. Leeper, U.S. Air Force; Aanauraq Lane; and Mark S. Cassell

As part of its federally mandated role as resource steward of lands it manages, the U.S. Air Force in Alaska has taken a broad-based contextual approach to cultural resource management. A manifestation of this approach was the March 2005 collaborative cultural heritage workshop it sponsored in Point Hope, an Iñupiat Eskimo village on the Chukchi Sea coast of northwestern Alaska where archaeologists have been working since the 1930s. Point Hope Eskimo elders, high school students, interested community members, and a small group of northern-oriented archaeologists spent two days engaged in a thoughtful, heartfelt, and occasionally somewhat confrontational discussion of the region's archaeological past, its heritage concerns, and the social present.

In those early days of archaeology around Point Hope, professional investigators did not trouble themselves much with self-critical notions of living Eskimos as objects or subjects in their archaeological research. Living Eskimos were thus the objects—their past and the course to their present given meaning by archaeologists through artifacts and archaeological sites. In recent years, archaeologists working among Eskimos have come to realize that not only is the Eskimo present alive, but also that their pasts are very much alive. Eskimos themselves are thus subjects, active attributors of meaning to material culture, to Eskimo pasts, and to the development of Eskimo society. This poster looks at the varied paths traveled during the workshop and illustrates the active signification by the people of Point Hope regarding their past and their present and, indeed, their future.

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The Canadian Circumpolar Institute at the University of Alberta

Elaine L. Maloney, Canadian Circumpolar Institute; and Ryan Danby

Established on 1 July 1990, the Canadian Circumpolar Institute (CCI) was founded on a 30-year tradition of excellence in northern research fostered by its predecessor, the Boreal Institute for Northern Studies. The institute builds on the continuing involvement of northernists and northerners from around the world and has been involved with numerous important initiatives, from the development of a world-class northern library collection to establishing and sustaining a number of north-south links with a diverse set of client communities. The CCI is a multi-disciplinary research institute whose role is to foster northern studies in a wide range of academic and professional faculties at the University of Alberta. Its role is to foster scholarly activity related to the circumpolar North, to be responsive to calls for research on northern issues, and to encourage northerners to participate in research development and execution. It fulfills its mandate in a number of ways, but primarily through a program of grants and scholarships, and encouraging communication through workshops, seminars, conferences, newsletters, and the publication program of CCI Press.

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Arctic Science Discoveries

National Science Foundation

The past five decades of intense research have increased our understanding of the Arctic, but much remains to be learned. The Arctic Sciences Section of the National Science Foundation (NSF) funds basic research on the Arctic through the Arctic Natural Sciences, Arctic Social Sciences, and Arctic System Science programs, with field research support from the Research Support and Logistics program. Some recent research results are presented both as answers to important questions and leads to future research directions.

Studying Arctic Change: The Study of Environmental Arctic Change (SEARCH) is an interagency, interdisciplinary, multiscale program to study changes occurring in the Arctic and their potential impacts.

Ringed Seal Migration: Working with Alaska Native hunters, researchers attached a satellite tracking device to follow a ringed seal as it migrated northward with the melting ice of the Chukchi Sea in spring.

Photochemistry in Greenland Snow: Light-mediated chemical reactions (photochemistry) occur at the air-snow interface and significantly impact the chemical composition of air trapped in ice and of the air overlying the snow.

Small Streams on the Move: Small streams contribute more to removing nutrients such as nitrogen from water than do their larger counterparts. Based on data collected initially from streams in NSF's Arctic Tundra Long-Term Ecological Research site in Alaska, the findings were confirmed by data from 12 sites across the country.

Living Conditions in the Arctic: This international effort involves a partnership of researchers and indigenous organizations across the Arctic to advance our understanding of changing living conditions among Inuit and Saami peoples and the indigenous peoples of Chukotka.

On the Gakkel Ridge: The Gakkel Ridge is the slowest spreading center in the world, giving scientists the opportunity to explore Earth's inner layers as the mantle spreads at about 1 cm per year onto the ocean floor near the North Pole.

Understanding the Arctic Ocean: The Western Arctic Shelf Basin Interactions (SBI) project is investigating the impact of global change on physical, biological, and geochemical processes over the Chukchi and Beaufort Sea shelf basin in the western Arctic Ocean. The closely affiliated Chukchi Borderlands project studies the region where relatively cold, fresh, and nutrient-rich water from the Pacific Ocean meets warmer, saltier, and deeper water from the Atlantic Ocean over a bottom tortuously rife with slopes, ridges, and deep-sea plateaus.

National Science Foundation, Office of Polar Programs, 4201 Wilson Boulevard, Arlington, VA 22230, USA, www.nsf.gov/od/opp/

The International Polar Year 2007–2008

National Science Foundation

The International Polar Year 2007–2008 (IPY) will extend from March 2007 through March 2009. IPY is envisioned as an intense scientific campaign to explore new frontiers in polar science, improve our understanding of the critical role of the polar regions in global processes, and educate the public about the polar regions. Projects are expected to involve a pulse of activity during the IPY period, have multi- and inter-disciplinary scopes, leave a legacy of infrastructure and data, expand international cooperation, engage the public in polar discovery, and help attract the next generation of scientists and engineers.

In anticipation of IPY, the Office of Polar Programs and the Directorate for Education and Human Resources have identified special emphasis areas that will require preparation in advance of IPY. The research emphasis areas are: ice sheet history and dynamics, biological adaptations at the cellular and genomic level to life in extreme cold and prolonged darkness, and the arctic observing network.

The IPY web page maintained by OPP is located at www.nsf.gov/od/opp/ipy/ipyinfo.jsp.

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The Circumpolar Active Layer Monitoring Network

Frederick E. Nelson, University of Delaware; Nikolay I. Shiklomanov; Kenneth M. Hinkel; Jerry Brown; and Galina Mazhitova

The Circumpolar Active Layer Monitoring (CALM) program is one of several global-change programs affiliated with the International Permafrost Association (IPA). CALM was initiated in the early 1990s to track possible changes and trends in the seasonally frozen (active) layer in the permafrost regions. Widespread, large-magnitude increases in the thickness of the active layer induced by climatic warming could liberate carbon sequestered in near-surface permafrost, create irregular topography (thermokarst terrain) in areas of ice-rich permafrost, damage human infrastructure on the surface, and induce pronounced ecological changes.

CALM is a hypothesis-driven program that monitors active-layer thickness and shallow ground temperature, coordinates field experiments, and provides data for use by investigators involved in a wide range of cold-environment research and modeling activities. The CALM network is currently comprised of more than 125 sites distributed throughout the Arctic, parts of Antarctica, and several mountain ranges of the mid-latitudes. Efforts to expand the number and capabilities of sites in the Southern Hemisphere (CALM-S) are underway. Instrumentation and data-acquisition methods include monitoring the soil thermal and moisture regimes with automatic data loggers, mechanical probing of the seasonally thawed layer at specified spatial and temporal intervals, frost/thaw tubes, and a variety of instruments for measuring frost heave and thaw subsidence. Several groups of sites have been used to create maps of active-layer thickness and estimates of the volume of thawed soil at regional scales. The CALM network has also provided a large amount of data pertaining to cryostratigraphy, cryoturbation, and soil carbon. Data obtained from the network have been used in validation procedures for hydrological, ecological, and climatic models at a variety of geographic scales. Data are archived at the Frozen Ground

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Data Center (http://nsidc.org/fgdc/) in Boulder, Colorado.

CALM is sponsored by the U.S. National Science Foundation's Office of Polar Programs. CALM is linked with many other global-change programs through the network of observatories known collectively as the Global Terrestrial Network for Permafrost (GTN-P), a network under the WMO Global Climate Observing Network (GCOS). With its sister programs, Thermal State of Permafrost (TSP), Antarctic Permafrost, Periglacial, and Soil Environments (ANTPAS), Carbon Pools in Permafrost Regions (CAPP), and Arctic Coastal Dynamics (ACD), CALM forms a comprehensive effort on the part of the IPA to monitor, understand, and predict the effects of environmental change in the world's permafrost regions. CALM is a major component of the IPA's coordinated program for the International Polar Year.

Detailed information about the CALM program can be found at www.udel.edu/Geography/calm/.

The U.S. Permafrost Association

Frederick E. Nelson, University of Delaware; Jon E. Zufelt; Kenneth M. Hinkel; Michael R. Lilly; Vladimir E. Romanovsky; Larry D. Hinzman; J. David Norton; and Jennifer Harden

Permafrost is an important component of the cryosphere, hydrosphere, and biosphere and exerts a significant influence in the natural and human systems of cold regions. Interest in permafrost and related topics has been growing steadily in concert with concerns about the impacts of global climate warming. The U.S. Permafrost Association (USPA), incorporated in Alaska as a not-for-profit organization, promotes scientific, engineering, and educational investigations and activities on all aspects of frozen ground. An important component of the USPA mission is to promote awareness about permafrost among the public and training of new generations of scientists, engineers, and other professionals to work in fields related to permafrost. USPA acts as the U.S. representative to the International Permafrost Association.

USPA functions as the parent organization for the Ninth International Conference on Permafrost (NICOP), to be held 29 June–3 July 2008 on the campus of the University of Alaska Fairbanks. The conference will include a full complement of paper and poster sessions, a large number of local and regional field excursions, and a series of publications. A U.S. National Committee for NICOP has been established under USPA to assist the university's local organizing committee. Further details are available at www.nicop.org. Memberships in USPA are available in three forms: individual, corporate, and institutional. Detailed information about USPA can be found at www.usperma-frost.org.

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Inuit and Scientific Descriptions of the Narwhal: Connecting Parallel Perceptions

Martin Nweeia, Harvard School of Dental Medicine; Frederick Eichmiller; Cornelius Nutarak; Jack R. Orr; James Mead; and Peter Hauschka

To discover the purpose and function of the erupted tusk of the narwhal, a multinational team has been established using an interdisciplinary approach that crosses borders of biologic, chemical, physical, and social science. Thus far, 27 institutions worldwide and over 48 scientists have combined their insights and backgrounds with 32 Inuit elders from the Canadian High Arctic and Greenland to assemble the pieces of this marine mammal puzzle that has eluded scientific discovery for hundreds of years. Investigators with myriad backgrounds in cellular biology, histology, anatomy, marine mammal science, dental medicine, evolutionary genetics, and mathematics are currently analyzing narwhal teeth and their associated structures. Inuit elders, who have experienced decades of intimate interactions with narwhals, are providing their knowledge and experiences to help researchers understand the whale's behavior and social characteristics. Each of these parallel perceptions has shared points that contribute to, guide, and challenge past studies and current findings. For example, Fourier transform infrared fluorescent micro-spectroscopy results on the flexibility and strength of the tusk hard tissue scientifically confirms what Inuit elders have known for years. Currently underway are studies involving CT and MRI imaging of anatomical head specimens, electron microscopic and cellular examinations of hard and soft tissue associated with narwhal teeth, mathematical modeling of tusk spirals in relation to function, collection and compilation of digital audio, video interviews recording traditional knowledge, and arctic ice formation examination from satellite records. Realizing the evolutionary precedents for the expression of the narwhal tusk are limited, tooth microstructure studies of *Odobenoceptops* and other animals in the fossil record will be investigated.

These broad based evaluations have led to significant findings about tusk function. Among them is an unusual anatomic expression of

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sensory tubules extending from the tooth pulp to the outer tusk surface and a reverse hard tissue architecture. Both of these findings are unique in the expression of teeth. These studies bring scientists face to face with Inuit elders on a common platform that integrates observation and scientific findings to establish a better understanding of the narwhal and its extraordinary tooth.

Six Weeks in the Arctic: A Teacher Research Experience in Svalbard, Norway

Robert S. Oddo, Horace Greeley High School

During the summer of 2005, Robert Oddo, a high school science teacher at Horace Greeley High School in Chappaqua, New York, participated in Teachers and Researchers Exploring and Collaborating (TREC), a program that pairs teachers with researchers to improve science education through arctic field experiences. Through TREC, K–12 teachers embark on scientific expeditions as part of a program that strives to make science in the Arctic a "virtual" reality. TREC builds on the scientific and cultural opportunities of the Arctic, linking research and education through topics that naturally engage students and the wider public.

Robert Oddo joined the Svalbard Research Experiences for Undergraduates Program, which focuses on understanding how high latitude glaciers, melt-water streams, and sedimentation in lakes and fjords respond to changing climate (www.mtholyoke.edu/go/svalbard). Robert accompanied researchers Steve Roof from Hampshire College and Mike Retelle from Bates College and seven undergraduates to investigate processes associated with a glacier-river-lake system on the island of Svalbard, Norway, to understand Holocene climate change. The 2005 expedition was the second of three summer field seasons for the National Science Foundation-sponsored program, which provides undergraduate students genuine field and research experience in the remote Arctic.

This six-week field experience in the Arctic gave Robert an authentic research experience that allowed him to think about scientific inquiry differently and examine different ways to teach science. This knowledge has changed the way that he thinks about science and how he shares science with his students. Robert's poster will provide an overview of TREC as well as highlight how this unique research experience impacted him both personally and professionally.

TREC is funded by the National Science Foundation Office of Polar Programs and administered by the Arctic Research Consortium of the U.S. (ARCUS). Logistical support is provided by VECO Polar Resources. More information about TREC can be found online at www.arcus.org/trec.

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Coastal Erosion Across Northern Alaska and Community Action

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Over the past decades, the accelerated erosion of the arctic coastline has been the focus of scientists, land managers, policy makers, and Native communities along the arctic coast. The retreating of the coastline along the Beaufort Sea in northern Alaska has been monitored for the past decade. The objectives of this National Science Foundation project are to monitor the erosion rates, estimate the amount and fate of the organic carbon in the tundra soils and underlying permafrost eroded into the Arctic Ocean, and involve coastal communities in awareness and partnership development in the research and land-use planning. The estimated average erosion rate along the 1,800 miles of Beaufort Sea coast from Point Barrow to the Alaska-Canada boundary is 6 feet per year. This transforms to about 2,000 acres of land lost to the Arctic Ocean per year. Based on first year measurements, the average ice content of the soils measured to 6-foot depth is 55% ice and carbon content of 120 pounds per cubic yard, which amounts to 750,000 tons of carbon entered into the biogeochemical processes and cycling in the Beaufort Sea and Arctic Ocean. During thawing and erosion into the Arctic Ocean, the thawed permafrost soils release CO_2 and methane into the atmosphere, and the carbon eroded into the ocean will further decompose and release more gases. The fate of the eroded carbon is being studied through our ongoing field and laboratory experiments. A good model of partnership with the Native community has been established in the project. Community residents of Barrow, Nuiqsut, and Kaktovik have participated in monitoring the coast erosion and provided logistic support and the researchers presented their findings to local schools and communities.

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Multidecadal Variability in the Arctic/North Atlantic Climate System

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Over the past several decades, the Arctic and North Atlantic have undergone substantial changes. Enhanced transport of warmer air from lower latitudes led to increased arctic surface air temperature associated with decreased arctic sea-level pressure and increased polar atmospheric cyclonicity, which led to reductions in arctic ice extent and a decrease of ice thickness. Changes in the Arctic Ocean are also significant. Positive temperature anomalies in the intermediate Atlantic Water (AW) layer of the Arctic Ocean were found in the 1990s and 2000s. Freshwater content in the upper layer of the Arctic Ocean was also reduced dramatically over the recent decades. Concurrent with these high-latitude changes are North Atlantic warming and salinification in the upper 300 m layer (except the subpolar North Atlantic) and widespread cooling and freshening in the 1,000–3,000 m layer. We suggest that both long-term climate trend and low-frequency variability play a substantial role in shaping these recent changes in the arctic/North Atlantic climate system. Understanding the key factors influencing the arctic/North Atlantic multi-decadal variability may provide a reasonable means for developing climatic forecasts of widespread persistent anomalies.

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Barrow Sea Ice Observatory: Online, Near-Real-Time Delivery of Ice Conditions

Daniel Pringle, University Alaska Fairbanks; Andy Mahoney; Hajo Eicken; and Patrick W. Cotter

As part of the developing Alaska Ocean Observing System (AOOS), we have established online, near-real-time delivery of landfast sea ice conditions in Barrow, Alaska (www.gi.alaska.edu/BRWICE). A webcam and radar mounted on a four-story building in Barrow provide views of the near-shore ice in the visible and microwave, and a radio-equipped ice mass balance site transmits half-hourly measurements including the air-snow-ice-water temperature profile, snow depth and ice thickness, and local sea level.

There are both scientific and public safety objectives of this work. The webcam and radar allow us to record near-shore ice dynamics, including seasonal landfast ice formation and break up. Scientific objectives of the mass balance site include the identification of small-scale seasonal processes such as sea ice response to onshore surges and the occurrence of convective brine motion within the ice triggered by spring warming. In keeping with the enhanced public safety objective of AOOS (www.aoos.org), a key aspect of this work is to collaborate with the local community to provide useful information in regards to on-ice safety. In addition to the webcam, this currently includes hourly online updates of local sea level variations and ice thickness.

Here, we describe our measurements and advertise the available results and data online. We welcome feedback on the web delivery and suggestions for other potentially useful measurements for both the local community and scientific users.

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A Small Diameter CTD Rosette for Sampling Through Sea Ice from Aircraft

William M. Smethie, Jr., Lamont-Doherty Earth Observatory, Columbia University; Dale N. Chayes; Richard S. Perry; Peter Schlosser; and Robert T. Williams

Some polar regions are difficult to sample from ships or ice breakers because of thick multi year ice ridges. These regions are accessible by aircraft, submarines, and drifting ice camps. However, these working environments preclude the use of large conductivity, temperature, density (CTD) rosette systems typically used in oceanographic research. We have developed a lightweight vertical CTD rosette that can be deployed through a 12-inch hole in sea ice. The rosette is modular, consisting of one CTD module and multiple water sampling modules. The CTD module includes a SeaBird 19 plus CTD with a SBE 43 Dissolved Oxygen sensor and a modified SeaBird rosette controller. Each water-sampling module has four 4-liter bottles and the associated release mechanism for each bottle. The modules are about 1 m high and 27.9 cm (11 inches) in diameter. The CTD module is attached to the end of the conducting cable and one, two, or three water-sampling modules are attached above it. The modified rosette controller and cabling between the water sampling modules and the CTD module enable selective closing of each sampler by command from the surface. Temperature, salinity, and oxygen are acquired in real time and displayed on a laptop computer and bottles are tripped on the up cast as in a typical CTD rosette cast. At the completion of a station, each module is placed in an insulated container to prevent heating or freezing and the modules are returned to a base camp for sampling of a variety of substances under well-controlled conditions. The system has been used from Twin Otter aircraft on the Switchyard Project, which is coordinated with the North Pole Environmental Observatory program and samples a section between Alert and the North Pole each year. It has provided high-quality data for salinity, oxygen, nutrients, CFCs, helium isotopes, oxygen isotopes, barium, and ^{129}I demonstrating its capability to collect high-quality water samples for a variety of measurements, as well as to make high-quality CTDO measurements. Data collected during the Switchyard 2005 and possibly 2006 field season will be presented.This project is funded by NSF OPP02-30238.

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Changes In Arctic Tourism and the Need for a New Outlook on Collaboration

John Snyder, Strategic Studies, Inc.

Tourism is now the single largest human activity in the Arctic. The number of tourists visiting the Arctic each year far exceeds their host populations. Additionally, polar tourism is the fastest growing segment of the world tourism market in percentage terms and arctic economies are increasingly reliant on the revenues, jobs, and personal income derived from it. As a result of these circumstances, changes in the Arctic's climate will have potentially significant effects upon the arctic resources and its people. Examples include decreased arctic sea ice cover that will facilitate improved tourist access; alteration of wildlife habitat and animal behavior that will influence both resource and tourism management practices; and transformation of ecological zones and seasonal characteristics that will affect both tourist and Native people's use of the Arctic. This presentation will briefly identify key relationships between tourism and its environmental, cultural, and economic setting. It will describe the most probable ways in which those relationships will be significantly influenced by arctic climate change. Based on this review, it will be evident that the Arctic is experiencing a new resource management paradigm that deserves an innovative collaborative response. Collaborative initiatives designed to meet that challenge will be presented.

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Alaska's North Slope Science Initiative: Managing Oil and Gas Development Through Science on Alaska's North Slope

Kenton P. Taylor, Bureau of Land Management; John F. Payne; and Ann Claerbout

The mission of the North Slope Science Initiative (NSSI) is to enhance the quality and quantity of scientific information available for aquatic, terrestrial, and marine environments on the North Slope and to make this information available to decision makers, governmental agencies, industry, and the public.

Formalized in the Energy Policy Act of 2005, the NSSI is composed of the land and resource management agencies at the local, state, and federal level. The Oversight Group includes: mayor, North Slope Borough; president, Arctic Slope Regional Corporation; commissioners of the Alaska Department of Fish and Game and the Alaska Department of Natural Resources; state director, Bureau of Land Management; and regional directors, Fish and Wildlife Service, Minerals Management Service, National Park Service, National Marine Fisheries Service, and U.S. Geological Survey. The U.S. Arctic Research Commission and U.S. Department of Energy serve in an advisory capacity to the group. A Science Technical Group was established by the Secretary of the Interior to advise the Oversight Group on science needs.

NSSI objectives include:

- Develop an understanding of information needs for regulatory and land management agencies, local governments, and the public.
- Identify and prioritize information needs for inventory, monitoring, and research activities to address impacts of past, ongoing, and anticipated development activities on the North Slope.
- Coordinate ongoing and future inventory, monitoring, and research activities to minimize duplication of effort, share financial resources and expertise, and assure the collection of quality information.
- Identify priority needs not addressed by existing agency science programs and develop a funding strategy to meet these needs.
- Maintain and improve public and agency access to accumulated and ongoing research, and to contemporary and traditional local knowledge.
- Ensure through appropriate peer review that the science conducted under the oversight of the NSSI and by participating NSSI agencies and organizations is of the highest technical quality.

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An Accessible Arctic: Arctic Education and Outreach

Juanita Urban-Rich, University of Massachusetts Boston

For those who work there, the Arctic is a fascinating place and one of vital importance to global systems. For many other people, however, the Arctic is a remote, desolate place that has no connections to their daily lives. In order to try and overcome these beliefs and to help make the Arctic more accessible and "alive," we have developed several arctic education programs: a website diary, hands-on investigations, and an interactive web-based exchange program. Each of the programs is designed to engage both the general public and elementary school students and teachers. The programs provide opportunities for inquiry-based learning and, by using different methods, they attempt to bring a distant place into our daily lives. Come and see how technology and the Internet can bring places closer together. See the Arctic through a day or a year in the Windows Around the World program (www.windowsaroundtheworld.org). Travel down the Mackenzie River to the Beaufort Sea and hear what the scientists were doing and how a teenager from the Arctic saw our work (http://jurban.es.umb.edu/ardex_home.aspx). Come watch how children can explore a simulated Arctic Ocean and observe climate change effects (http://jurban.es.umb.edu/estme/2005).

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Greening of the Arctic: An IPY Initiative

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A primary objective of IPY is to characterize and model circumpolar patterns of carbon, water, and energy and how these interact with the human component of the arctic system. The Greening of the Arctic (GOA) IPY initiative will examine the spatial and temporal variability of ongoing changes to the abundance and distribution of plant biomass in the Arctic. The initiative's central theme is to explore the potential linkages and feedbacks between changes in sea ice distribution and the changes to tundra biomass. GOA consists of four separately funded projects (components) that in total are addressing IPY themes 1 (Current State), 2 (Change), 3 (Teleconnections), 4 (New Frontiers), and 6 (Human Societies).

Component I: Synthesis and models to examine the effects of climate, sea ice, and terrain on circumpolar vegetation change. This component examines the 24-year record of greenness across the entire Arctic as measured by the normalized difference vegetation index (NDVI) and how these covary with climate, changes in sea ice distribution, land-surface-temperatures (LSTs), snow cover, bioclimate subzones, vegetation type, glacial history, and other variables in a circumpolar GIS database.

Component II: Human dimensions of greening on the Yamal Peninsula, Russia. A major focus of this project is the analysis of changes to the patterns of forage conditions of the Nenets reindeer herds, including patterns of greening, shrubification, grassification, and desertification, and how these affect the culture of the Nenets people.

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Component III: Arctic Geobotanical Atlas (AGA). This project is an outreach/education component of the GOA initiative to develop a web-based AGA using Internet map server software and other web-based GIS tools.

Component IV: The North American Arctic Transect (NAAT). This proposed project will establish a string of satellite terrestrial observatories in all five bioclimate subzones in North America as part of the Arctic Observatory Network.

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Downscaling Characteristics of Sea Ice and Ocean Circulation in the Beaufort-Chukchi Seas Simulated by an IARC Coupled Ice-Ocean Model

Jia Wang, University of Alaska Fairbanks; Haohuo Hu; Kohei Mizobata; and Meibing Jin

We applied an International Arctic Research Center regional Coupled Ice-Ocean Model (CIOM; Wang et al. 2002, 2005) based on the Princeton Ocean Model to simulate the downscaling ice and ocean processes with a 4-km resolution. The Beaufort CIOM was nested to the CCSR/NIES/FRCGC high-resolution (1/6Ext.1/4 degrees) global coupled atmosphere-sea ice-ocean model. Atmospheric forcing data were derived from the NCEP reanalysis. Simulation of seasonal cycle was conducted. In the Chukchi Sea, the Bering inflow separates into three branches: the first main branch flows along the Alaska coast, that is the Alaska Coastal Current (ACC); the second branch flows northward and turns to the right, joining the ACC along the Beaufort coast; and the third branch flows toward the Northwind Ridge. The Beaufort Gyre is well reproduced, superimposed by numerous mesoscale eddies, with anticyclones outnumbering cyclones. We also investigated downscaling sea ice dynamics, such as sea ice ridging, rafting, leads, and landfast ice, which are not resolved in the previous coarse resolution model (Wang et al. 2002, 2005). This approach combining the global model for the 20th century climate simulation with the regional downscaling/nesting simulation helps understanding of both large-scale sea ice variability and small-scale sea ice dynamics. Sea ice breaks up offshore piece by piece with landfast ice untouched along the Beaufort Sea coast. Sea ice cracks from pack ice with irregular shapes due to 1) complex ocean circulation, coastal current, and mesoscale eddies, 2) multi-category sea ice dynamics, and 3) complex and high-resolution geometry and topography. Sea ice ridging, rafting, and openings/leads can be well reproduced in sea ice thickness and concentration. Model validation using in situ observations, satellite measurements, and historical datasets is underway.

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Simulating the 20th Century Arctic Sea Ice and Ocean Circulation Variability Using a Global Coupled Atmosphere-Ice-Ocean Model

Jia Wang, University of Alaska Fairbanks; Meibing Jin; Jun Takahashi; Tatsuo Suzuki; John E. Walsh; and Hiroyasu Hasumi

The simulations of the arctic ice-ocean circulation using the high resolution global coupled atmosphere-ice-ocean model with 1/6Ext.1/4 degrees and 48 vertical layers on the "Earth Simulator" supercomputer were evaluated to determine the model performance, physics soundness, and its sensitivity to different process parameterizations. The model was parameterized by GM (Gent McWilliams 1990) parameterization to the north of 45 N. The statistical time series of the total oceanic and ice kinetic energy and ice areas suggest that the model reaches an equilibrium without any T/S restoring or flux adjustment and no model drifting is found. The model climatology (mean over all the model years) and variability were examined and compared with the available observations, such as ice area, temperature, and salinity at certain key depths and transects. Several important physical features in the Northern Hemisphere, such as the thermohaline structure in the Arctic Ocean, Atlantic water, meridional overturning, transports from Bering Strait, Fram Strait, etc., were examined to determine physical soundness of the model. An important achievement is that the Atlantic layer in the Arctic can be reasonably reproduced with no restoring temperature and salinity to observations. An important criterion of reproducing the Atlantic layer variability is measured by the core (max) temperature of the layer of 500–1,500 m. The model reproduces, reasonably, the Atlantic water core temperature in the 20th century that compares well with the observation by Polyakov et al. (2004). The model catches the 1930–1940s warming and the 1990s warming, similar to the observations. These results indicate that this coupled global model captures most important dynamic and thermodynamic processes in the Arctic Ocean. Further analyses of the model performance is underway.

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Teachers and Researchers Exploring and Collaborating (TREC)

Janet Warburton, Arctic Research Consortium of the U.S. (ARCUS); Wendy K. Warnick; Helen V. Wiggins; B. Zeb Polly; and Sarah Behr

In Teachers and Researchers Exploring and Collaborating (TREC), K–12 teachers participate in arctic field projects, working closely with researchers to improve science education through experiences in scientific inquiry. TREC builds on the scientific and cultural opportunities of the Arctic to link research and education through topics that naturally engage students and the wider public. In addition to arctic field research experiences, TREC supports teacher professional development and a sustained community of teachers, scientists, and the public through workshops, Internet seminars, an e-mail listserve, and teacher peer groups.

TREC immerses teachers in scientific research across the Arctic. The program enables teachers to work side-by-side with researchers on arctic field projects investigating topics such as tundra and wildlife ecology, marine biology, atmospheric chemistry, and long-term climate change. Locations of field sites vary—TREC teachers participate in arctic research aboard the U.S. Coast Guard Cutter *Healy* in the Arctic Ocean; at scientific research stations on the Alaskan tundra, the Greenland Ice Sheet, and in the Svalbard Archipelago; at remote field camps in Russia; and at numerous other arctic locales.

While in the field, teachers and researchers communicate extensively with their colleagues, communities, and students of all ages across the globe, using a variety of tools including satellite phones, online journals, and interactive "webinars" (web-based seminars). The online outreach elements of the project convey these experiences to a broad audience far beyond the classrooms of the TREC teachers.

Currently in its third year, TREC is funded by the National Science Foundation Office of Polar Programs and managed by the Arctic Research Consortium of the U.S. (ARCUS) with logistical support from VECO Polar Resources.

Researchers, educators, classrooms, and the public are encouraged to visit the TREC website (www.arcus.org/trec) to learn more about calls from the field, online message boards and presentations, photo albums, and learning resources.

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Community Needs Assessment and Portal Prototype Development for an Arctic Spatial Data Infrastructure

Wendy K. Warnick, Arctic Research Consortium of the U.S. (ARCUS); Helen V. Wiggins; Lamont C. Hempel; Jordan Henk; Mark Sorensen; Craig Tweedie; and Allison Gaylord

As the creation and use of geospatial data in research, management, logistics, and education applications has proliferated, there is now a tremendous potential for advancing science through a variety of cyberinfrastructure applications, including Spatial Data Infrastructure (SDI) and related technologies. SDIs provide a necessary and common framework of standards, securities, policies, procedures, and technology to support the effective acquisition, coordination, dissemination and use of geospatial data by multiple and distributed stakeholder and user groups. Despite the numerous research activities in the Arctic, there is no established SDI and, because of this lack of a coordinated infrastructure, there is inefficiency, duplication of effort, and reduced data quality and search ability of arctic geospatial data. The urgency for establishing this framework is significant considering the myriad of data that is likely to be collected in celebration of the International Polar Year (IPY) in 2007–2008 and the current international momentum for an improved and integrated circumarctic terrestrial-marine-atmospheric environmental observatories network. The key objective of this project is to lay the foundation for full implementation of an Arctic Spatial Data Infrastructure (ASDI) through an assessment of community needs, readiness, and resources and through the development of a prototype web mapping portal.

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The Arctic Research Consortium of the U.S.

Wendy K. Warnick, Arctic Research Consortium of the U.S. (ARCUS)

The Arctic Research Consortium of the U.S. (ARCUS) is a nonprofit membership organization composed of universities and institutions that have a substantial commitment to research in the Arctic. ARCUS promotes arctic research by improving communication among the arctic research community, organizing workshops, and publishing scientific research plans. ARCUS was formed in 1988 to serve as a forum for planning, facilitating, coordinating, and implementing interdisciplinary studies of the Arctic; to act as a synthesizer and disseminator of scientific information on arctic research; and to educate scientists and the general public about the needs and opportunities for research in the Arctic.

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Arctic Sea Ice Simulations in the 20th Century and in Global Warming Scenarios

Xiangdong Zhang, University of Alaska Fairbanks

Sea ice is an essential component of the climate system and an outstanding indicator of global climate change. Recent dramatic shrinking of arctic sea ice cover has drawn much attention scientifically and societally. Remarkable global warming has been manifested in the polar region, which may continue and be further amplified, leading to a rapid decrease of sea ice cover or an ice-free summer in the Arctic Ocean, as projected in global warming scenarios.

The decreased sea ice cover would naturally result in significant climate consequences by changing energy budgets and hydrological cycle, for example, altering atmospheric circulation regimes and impacting the North Atlantic deep convections and Meridional Overturning Circulation. In this study, we analyzed changes of the arctic sea ice cover based on the multiple model outputs for the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4), which was archived by the Program for Climate Model Diagnosis and Intercomparison (PCMDI).

We first examined the arctic sea ice simulations for the climate of the 20th century (20c3m) and validated the model's performance against observations. Considering availability of accurate sea ice measurements by satellites, we selected a period of 1979–1999 from ensemble means of each model's simulations and compared model results with observational data. We then investigated changes of sea ice area in the 20th century and in the 21st century under global warming scenarios (SRES A1B, SRES A2, and SRES B1). The results demonstrated various capabilities of the participating models in simulating sea ice climatology. A number of models relatively captured realistic sea ice climatology, while a few models noticeably overestimated or underestimated sea ice cover. Nevertheless, most models show encouraging results in portraying decreasing sea ice during 1979–1999. In the global warming scenarios, all the models indicated a pronounced reduction of sea ice cover from 2000 to 2100 throughout the Arctic Ocean. Generally, the strongest sea ice decrease occurs in the SRES A1B and A2 scenarios and the weakest occurs in SRES B1. Close examination shows that an ice-free Arctic Ocean in the summer can be expected in the later 21st century in a number of models, while sea ice is relatively stable and can survive in summer in other models.

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Teachers and Researchers Exploring and Collaborating (TREC) Poster Abstracts

TREC teacher Amy Clapp and her 6th grade students from Salisbury Community School in Salisbury, Vermont, submitted the following poster abstracts from the Polar Symposium, a community event held at their school. These abstracts highlight classroom experiments the students conducted in conjunction with the 2006 TREC expeditions. For more information about TREC, please see the TREC abstract on page 64.

Water Sampling

Mattea Bagley, Salisbury Community School; Ashley Macy; and Torbrafe Ley

In December of 2005, Shannon Gmyrek came to our school and talked to us about pollution in the water and how it can kill fish. She also talked to us about pH, dissolved oxygen, phosphorus, and nitrate.

This poster presentation will explain what three 5th grade students from Salisbury Community School learned about water sampling and how water was analyzed in the Arctic as part of the PARTNERS project. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Animal Adaptations in the Arctic

Brooke Burlett, Salisbury Community School; and Maria Ploff

In December of 2005, we studied animal adaptations in the Arctic with a college student. We worked with Shannon Gmyrek and she taught us about polar bears and their adaptations. She made a PowerPoint presentation, and she had us do an experiment with blubber.

This poster presentation will explain what two 5th grade students from Salisbury Community School learned about animal adaptations in the Arctic. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Aquatic Invertebrates

Amy Clapp, Salisbury Community School

In November 2005, our class worked with some students from the University of Vermont who were working to improve our nature trails. One day, the UVM students brought some of their equipment to our school and we went down to the pond and trails to look for aquatic invertebrates.

This poster presentation will explain what several 5th grade students from Salisbury Community School learned about aquatic invertebrates. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Sediment Coring!

Elizabeth Dwire, Salisbury Community School; and Jesse Otis

In November 2005, Shannon Gmyrek from Middlebury College came to our class to work with us. We got to see a sediment corer and a sediment grabber. Shannon brought in a 3D map of Lake Champlain and its depths.

This poster presentation will explain what two 5th grade students from Salisbury Community School learned about sediment coring in the Arctic. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Jesse Otis, Salisbury Community School, 642 Monument Hill Road, Castleton, VT 05735, USA, aclapp@acsu.k12.vt.us

Grow

Seth Fisher, Salisbury Community School; and Dino Jandric

In November, Shannon Gmyrek came to our class and she told us about the different colors in white light. She said if you have something that is a color all the different colors would absorb into that thing except the color it is.

This poster presentation will explain what two 5th grade students from Salisbury Community School learned about plant growth in the Arctic. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Plots and Transects

Morgan LaRoche, Salisbury Community School; Wren Hobbs; and Jennifer Rich

Back in October, a Middlebury College student named Shannon gave us a PowerPoint presentation about plots and transects. We went out on the nature trail and learned about what plots and transects are. Some of the tools that we were introduced to are a tape measurer and a meter stick.

This poster presentation will explain what three 5th grade students from Salisbury Community School learned about plots and transects and observing growth of vegetation. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Arctic Plants

Sean MacCallum, Salisbury Community School; and Allison Haskell

In the fall of 2005, Shannon came into our class and taught us about growing plants and what they need to live. She gave us a PowerPoint presentation on how you see color and what plants need to grow and germinate.

This poster presentation will explain what two 5th grade students from Salisbury Community School learned about arctic plants and how they grow. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Arctic Weather

Heather Ploof, Salisbury Community School; Hailey LaFavel; and Devon Artis-White

In the fall of 2005, Shannon Gmyrek introduced us to the weather station where we collected data. For example, we measured precipitation, cloud cover, wind speed (knots), snow fall, and temperature. We used a wind speed measurer on the weather station to collect the weather data.

This poster presentation will explain what three 5th grade students from Salisbury Community School learned about weather and climate change in the Arctic. Their teacher, Amy Clapp, participated in Teachers and Researchers Exploring and Collaborating (TREC) in 2004 and 2005. These posters are part of a unit she taught in her classroom about the Arctic.

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Arctic Forum Program

Thursday, 25 May 2006

1:00 p.m. Welcome and Introductions — *Arctic Forum Co-Chairs: Volker Rachold, International Arctic Science Committee; Craig Tweedie, University of Texas at El Paso*

1:10 p.m. Polar Politics: The Marriage of Scientists, Stakeholders, and Policy Makers — *Fran Ulmer, University of Alaska Anchorage*

1:50 p.m. New Approaches to Understanding a Changing Arctic — *Peter Schlosser, Lamont-Doherty Earth Observatory*

2:15 p.m. Panel Discussion: Challenges and Needs of System-Scale Science

Moderator: John Walsh, International Arctic Research Center

- *Tore Furevik, Bjerknes Center for Climate Research*
- *Julienne Stroeve, National Snow and Ice Data Center*
- *Jörn Thiede, Alfred Wegener Institute*
- *Cynthia Tynan, School of Oceanography, University of Washington*

3:20 p.m. Break

3:40 p.m. Panel Discussion: Challenges and Needs of Stakeholder and Community Partnerships

Moderator: John Crump, United Nations Environment Programme/GRID-Arendal

- *Hadi Dowlatabadi, Institute for Resources, Environment, and Sustainability, University of British Columbia*
- *Kristina Lasko, The Centre for Research in International Migration and Ethnic Relations, University of Stockholm*
- *The Honorable Paul Okalik, Premier of Nunavut*
- *Frances Raskin, Trustees for Alaska*

5:00 p.m. International Policy Cooperation in the Arctic — *Scott Barrett, Johns Hopkins University*

5:30 p.m. Overview of Arctic Organizations —Who is Who? *Volker Rachhold*
International Arctic Science Committee
Craig Tweedie
University of Texas at El Paso

5:45 p.m. Poster Session: Presenting a wide range of arctic research, education, and outreach activities

6.30 p.m. ARCUS Annual Reception

Friday, 26 May 2006

8:00 a.m. Continental Breakfast

8:30 a.m. Welcome *Arctic Forum Co-Chairs: Volker Rachold*
International Arctic Science Committee
Craig Tweedie
University of Texas at El Paso

8:40 a.m. Beyond 2009: Broadening the Legacy of the International Polar Year
Karen Kraft Sloan
Canadian Ambassador for the Environment

9:20 a.m. Case Study 1: The Need for Technological and Scientific Collaboration: Arctic Upper Atmospheric Research *John Kelly*
SRI International

9:50 a.m. Case Study 2: Science-Industry Partnerships: Planning and Management Using Information Technology *Mark Sorensen*
Geographic Planning Colloborative Inc.

10:20 a.m. Break

10:50 a.m. Case Study 3: International Education Collaboration: Research Experiences for Undergraduates *Julie Brigham-Grette*
University of Massachusetts Amherst

11:20 a.m. Case Study 4: Planning and Cooperation for Multinational Field Projects
Heidemarie Kassens
The Leibniz Institute of Marine Sciences

11:50 a.m. Establishing Successful Community-Research Partnerships *Craig Fleener*
Council of Athabascan Tribal Governments

12:20 p.m. Light Lunch Buffet and Special Film Presentation *Arctic Rush*
Andrew C. Revkin
The New York Times

2:00 p.m. Panel Discussion: Managing Challenges Facing the Arctic Research Community

Moderator: Andrew C. Revkin, The New York Times

- *Paul Egerton, European Polar Board*
- *Shari Gearheard, Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder*
- *Susanne Moser, Institute for the Study of Society and Environment, The National Center for Atmospheric Research*
- *Andy Mahoney, University of Alaska Fairbanks*
- *Simon Stephenson, National Science Foundation*
- *John Crump, United Nations Environment Programme*

3:30 p.m. Break

4:00 p.m. Concluding Keynote: Advancing Arctic Research Through Policy and Science Advocacy *Lisa Murkowski*
U.S. Senator, Alaska

4:40 p.m. Concluding Remarks and Participant Discussion
Arctic Forum Co-Chairs: Volker Rachold
International Arctic Science Committee
Craig Tweedie
University of Texas at El Paso

5:00 p.m. Adjourn

6:00 p.m. Guided Tour of the Exhibit *"The Arctic: A Friend Acting Strangely"*

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Special Tour

A guided tour of the exhibit "The Arctic: A Friend Acting Stangely" was offered to Arctic Forum participants by Igor Krupnik, Arctic Ethnology Curator at the Smithsonian National Museum of Natural History.

This exhibit, part of the new Smithsonian environmental series "Forces of Change," was prepared by a team of Smithsonian arctic specialists and exhibit developers, in partnership with NOAA, NASA, and NSF. Unveiled to the public on April 15, 2005, it examined the dramatic changes that have taken place in the Arctic's climate and environment during the past 50 years. The exhibit told the story of a changing arctic seen through the eyes of northern residents and polar scientists alike.