Bridging the Poles: Education Linked with Research

A Report on the Workshop

23-25 June 2004
Washington, D.C.

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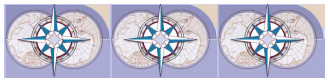


APPENDICES

Special thanks to all those in the polar/research/education communities who allowed their images to be included this report. For a list of credits for images not noted in the text please see Image Credits at the end of this report (p. 93-94).

Executive Summary

If the 65 educators, scientists and media specialists who gathered at the "Bridging the Poles" workshop in Washington, DC on June 23-25, 2004 have their way, a semi-trailer truck labeled "Got Snow?" would traverse the country during the International Polar Year (IPY) of 2007-2009 loaded with polar gear, interactive activities, and a snowmaker. We would significantly increase the number of Arctic residents—especially indigenous Alaskans—with PhDs. We would build exchange programs between inner city youths and polar residents. Polar exhibitions would open at natural history and art museums and zoos. And polar postage stamps, interactive polar computer games, national polar book-of-the-month recommendations, made-for-TV polar documentaries, and a polar youth forum, would bring the poles front and center to the public's attention. The goals of the NSF-sponsored workshop were to define strategies that will engage the next generation of polar scientists, engineers and leaders, and inspire the general public. Through a series of plenary talks and roundtable discussions, the workshop focused on: opportunities and needs for different levels, engaging diverse communities, leveraging the importance and excitement of polar science, and programs to feature nationally and internationally over the next 5 years. This workshop was the first major community effort to develop an integrated education and outreach program that would maximize the potential of the International Polar Year.

Discussions about opportunities and models for engaging different levels: grades K-5, 6-12, undergraduate non-science, undergraduate and graduate science majors, and the general public, emphasized capitalizing on the tremendous ability of polar themes to attract attention and the need for a broad, interdisciplinary approach. With their geographic foundation, the poles encompass multiple content areas ranging from science to culture and heritage. Workshop participants advocated capturing student interest and increasing science literacy in the general public by linking fascination with polar environments, to improving science, math, reading, and other skills, while integrating polar themes into state and national standards. Polar science can engage diverse groups of learners in science as a human endeavor, history and nature of science, science as inquiry, and science and technology. For advanced students, there are exciting opportunities in circumpolar distance learning with Web course delivery, as well as other programs such as the University of the Arctic's PhD networks and collaborative field courses. Beyond curricula, the use of polar themes in major competitions such as the National History Month, the National Ocean Sciences Bowl and Intel is a powerful way to expand attention on, and interest in, polar subjects. Other imaginative polar

Photo courtesy of science teacher Carol Landis (12/03) a mountain on the north rim of the Taylor Dry Valley, Antarctica, was framed by a hole in one of the wind-eroded rocks ventifacts) above Lake Bonney Camp.

education and outreach ideas discussed at the workshop include polar-themed McDonald's Happy Meals, circumpolar following of "A Day in the Life at the Poles," and junior Arctic and Antarctic councils.

Participants articulated the need of the polar science community to fully engage more diverse participation, including Arctic peoples and communities, underrepresented minorities, and women, as well as broadening economic and geographic involvement. Communication with Arctic indigenous people must extend beyond the simple transmittal of science results. Programs must advance the next generation of researchers from the Arctic who will investigate and communicate northern issues to global populations and decision makers. This theme of building capacity within communities, together with providing opportunities for personal contact and field experiences, making polar issues relevant at the community level, and developing mentoring and support systems was articulated by workshop participants for each target group. Common interests can bring diverse communities together. For example, Matthew Henson, the African American explorer who went to the North Pole with Robert E. Peary, played a crucial role in polar exploration at the turn of the last century, yet since his time minorities have remained underrepresented in polar science. A first step towards bridging the gap between inner city communities and communities in the Arctic was taken at the workshop when the leader of the Earth Conservation Corps' Matthew Henson Center in Washington DC established contact with Native Alaskans and together they began to plan exchange programs. Unlike many of the other sciences, user data collected through the experience of San Francisco's Exploratorium's Web-based "Live@", including "Science Live from Antarctica," indicates that polar themes, unlike many other science themes, draw a nearly gender-balanced audience. Polar education efforts should build on this latent interest to develop a more gender-diverse community.

Just as it is important to engage diverse audiences within their own community, establishing connections among local scientists, educators and informal outreach venues, can have long-lasting impacts. These connections build networks that sustain, and encourage further engagement on all sides. Especially important are providing opportunities for field experiences for students, teachers, and the media; these opportunities can build life-long advocates of the poles.

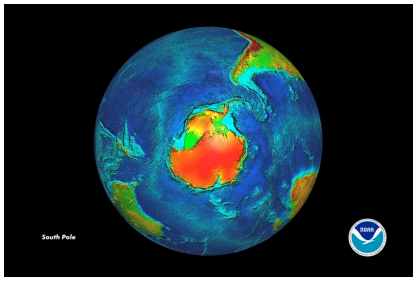
The group identified ways to leverage the importance and excitement of polar science, starting with what people think they know about polar organisms – and then moving beyond the charismatic megafauna of polar bears, penguins and whales to look at the diversity of adaptations to life in extreme environments. Participants discussed ways that major emerging science programs can be connected with meaningful education and outreach programming, and rolled out to the public as media events. Examples include: ANDRILL - drilling in the Ross Sea to recover key paleoclimatic records; and Ice Cube - a neutrino observatory at the South Pole. Polar environmental change, including SEARCH

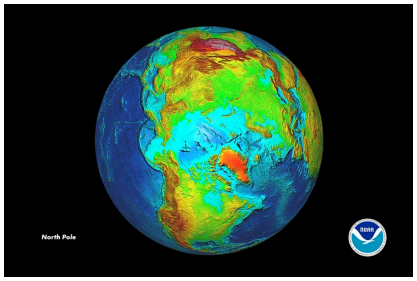
(Study of Environmental Arctic Change), links communities around the world with the worlds at the ends of the Earth, and underscores the feedback mechanisms of the poles on and also from the global system. “Think Globally/Act Locally” and the complementary “Think Locally/Act Globally” will be important themes for local, national and international IPY programming.

To ensure the success of polar education and outreach efforts, coordination of existing resources, linking communities and developing partnerships, access to data and content from the polar regions, securing funding to develop new programs, and sustaining programs after the conclusion of the IPY, are crucial. Education and outreach initiatives must be clearly defined with measurable outcomes so that IPY's promise in building capacity in Arctic communities, growing a new generation of polar researchers, and stimulating the public to know more — and care more — about the poles, is realized. Workshop participants recommended that interagency and international working groups on IPY education and outreach, with staff, be created to coordinate and leverage programs, and be integrated with research plans. A rich, sophisticated, multidisciplinary, international and multilingual one-stop Web portal should be developed to host research and education resources, opportunities, and advances, post reports from the field and curriculum material, serve as a central meeting point for a diverse suite of populations, and provide contacts for researchers, educators, the media, and the public at all levels. The media – television, radio and print – as well as educators, zoos and museums – are eager for timely, accessible, and meaningful content. Access to high quality content requires improved high bandwidth communications – this issue emerged repeatedly in the workshop as critical to timely and dynamic connections between the poles, the media and other communities.

In conclusion, to maximize the potential of the International Polar Year, workshop participants recommended integrating research, education and outreach efforts, at the international as well as national level, with the goal of building a coherent and exciting public presence during 2007-2009. Requests for proposals (RFPs) for the International Polar Year should encourage a broad spectrum of research, education, and outreach projects. The RFPs should be written to allow maximum flexibility in design and size: not all research programs need to have a major education component, and not all outreach programs need to have a major research component. Expensive, collaborative projects can have major national or even international impact when science programs are connected with press events, educational programming, and spin-offs of local programs. But small, individual projects can produce sustained transformation of local or target communities. There is a pressing need to start now to develop an integrated research/media/education strategy; establish partners among the research, media, and education communities; and diversify participation and audiences. Just as it takes time to define a research program and establish the logistics to carry it out, effective education and outreach programs take years to develop.

BRIDGING THE POLES





Introduction

The goals of the "Bridging the Poles" workshop of June 23-25, 2004 were to define strategies to engage the next generation of polar scientists, engineers and leaders, and inspire and educate the general public. The timeframe considered was the next five years, including maximizing the educational impact of the International Polar Year (IPY) in 2007-2009 (see inset below). The ca. 65 participants included K-12 educators, undergraduate professors, Arctic and Antarctic research scientists, Alaskan natives and residents, museum curators, representatives from agencies, the media and international programs.

The workshop focused on four major themes:
- Reaching different levels
- Engaging diverse communities
- Possibilities for thematic areas
- Programs to feature nationally and internationally

The 22 roundtable discussions on these topics resulted in numerous recommendations to engage both future scientists and the general public.

This report synthesizes opportunities for polar education and outreach identified at the workshop, recommends ways to maximize the impact of the IPY, and proposes "Next Steps" to develop polar education and outreach over the next five years.

Contributed ideas are compiled in an appendix (pgs. 50-64) as a resource for building communities and advancing common interests.

Polar Education and Outreach Objectives

Workshop participants identified major objectives of polar education and outreach that we believe can be achieved by 2010. These major objectives can be clustered into: targeting learners at all levels, engaging diverse communities, leveraging the importance and excitement of polar science, and creating infrastructure for effective education and outreach.

Objectives that **target learners at all levels** include:

- Increase and sustain public engagement in polar regions at all levels -- from kindergarteners to Elderhostel programs.
- Increase student achievement by linking fascination with poles to improving curriculum and other teaching resources, and improve students' science, math, and reading.
- Encourage lifelong scientific literacy through establishing an appreciation for science and nature by making connections between science and society early in life, and reinforcing those connections through varied media.

Objectives that involve **engaging diverse communities** include:

- Arctic residents, including indigenous populations, are meaningfully engaged in developing and implementing polar research, education, and outreach, including community concerns and traditional knowledge, with an increase in the number Arctic residents—especially indigenous Alaskans—with PhDs.
- The diversity of those interested in polar science is significantly broadened, to include Arctic indigenous peoples, minorities, women, elders, and youth.

Objectives that **leverage the importance and excitement of polar science** include:

- Students and the general public better understand the roles of the poles in global systems and recognize the relevance of polar processes to their lives.
- Rich combinations of qualitative and quantitative multidisciplinary and interdisciplinary polar data from diverse world views are accessible and used effectively in research and education.
- A new generation of polar scientists, engineers, and leaders is successfully engaged and researchers successfully communicate the human face of polar science.

Objectives for **effective education and outreach infrastructure** include:

- Dynamic, sustained, one-stop polar research and education web site is a central resource for content and contacts for all ages.
- Strong supportive partnerships evolve into a polar learning community with dynamic ongoing communication and collaboration among agencies, scientists, educators, media,

northern peoples, students, communities, different countries, and the general public, building on existing programs and networks and incorporating modern technologies, field experiences and innovative teaching methods.

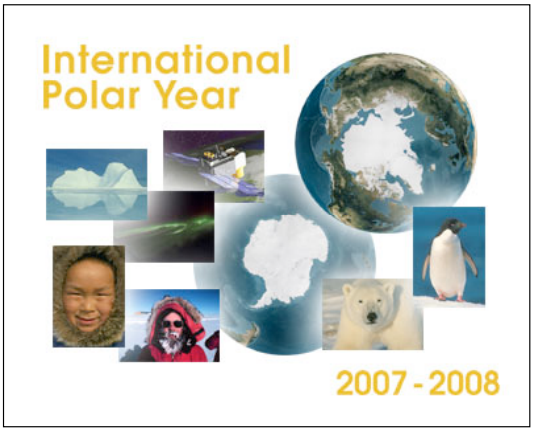
- Ensure the long-term involvement of educators and scientists, beyond the conclusion of the IPY, to sustain polar science and education at the mainstream.
- Develop research, education and outreach programs that are truly international and link communities around the globe through common interests.

A Vision for the International Polar Year 2007-2008 (2004)
Polar Research Board (PRB)
http://books.nap.edu/books/0309092124/html/pagetop

Environmental changes currently witnessed in the polar regions are vivid and in many cases greater than changes observed in the midlatitudes or tropics. The Arctic ice cover is decreasing in extent and area; some ice shelves in Antarctica are retreating and thinning; glaciers across the globe are shrinking; ecosystems are changing; Alaskan villages are being moved to higher ground in response to rising sea levels; and permafrost is causing the collapse of roads and buildings. We must understand these changes in the context of past changes in order to make decisions for the future. Yet we do not understand how or why many of the changes are occurring.

… IPY 2007-2008 [later extended to 2009] is envisioned to be an intense, coordinated campaign of polar observations, research and analysis that will be multidisciplinary in scope and international in participation. … It will be a watershed event and will use today's powerful research tools to better understand the key roles of the polar regions in global processes. Automated observatories, satellite-based remote sensing, autonomous vehicles, the Internet, and genomics are just a few of the innovative approaches for studying previously inaccessible realms. … Such a program will not only add to our scientific understanding, but also it will result in a world community with shared ownership in the results.

… It will serve as a mechanism to attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues. In addition, there clearly is an opportunity to organize an exciting range of educational and outreach activities designed to excite and engage the public, with a presence in classrooms around the world and in the media in varied and innovative formats.



Targeting Learners at All Levels

Discussions about opportunities and models for engaging different levels – grades K-5, 6-12, undergraduate non-science, undergraduate and graduate science majors, and the general public– emphasized capitalizing on the ability of polar themes to attract attention and the need for a broad, multi/interdisciplinary approach. With their geographic foundation, the poles encompass a range of content areas: from science to culture and heritage. Workshop participants advocated capturing student interest and increasing science literacy in the general public by linking fascination with polar environments, to improving science, math, reading, and other skills, and integrating polar themes into state and national standards. Polar programming can involve a diverse group of learners in multiple content areas: science as a human endeavor, history and nature of science, science as inquiry, and science and technology. Some projects have already prepared curriculum materials based on education standards using polar themes. For more advanced students, there are exciting opportunities in circumpolar distance learning with web course delivery, as well as other programs such as the University of the Arctic's PhD networks and collaborative field courses. Beyond curricula, the use of polar themes in major competitions such as the National History Month, the National Ocean Sciences Bowl and Intel is a powerful way to expand interest in, and attention on, polar subjects. To bring polar conditions to a wider audience, workshop participants came up with the idea of a semi trailer truck labeled: "Got Snow? – A Traveling Exhibition," outfitted with a snow making machine, polar gear and interactive activities, traveling around the country.

(image from AlaskaScienceOutreach.com: al-Ask-a-Scientist feature – designed for readers of all ages to submit questions.)

Just as it is important to engage diverse audiences within their own community, establishing connections among local scientists, educators and informal outreach venues, can have long-lasting impacts. These connections build a network that sustains, and encourages further engagement on all sides. Field experiences for students, teachers, and the media alike build life-long advocates of the poles. A rich, multidisciplinary and multilingual web portal where resources can be accessed and opportunities posted, would serve as a central meeting point for a diverse suite of populations and would provide the media – television, radio and print, as well as educators, zoos and museums – with timely, accessible, and meaningful content.

Grades K-5

The K-5 sector is important for polar education and outreach. Children of this age are fascinated with people and animals living in extreme conditions and they have not yet formed misconceptions/opinions about science. The integration of unique and unusual experiences like the polar sciences and the IPY is an excellent mechanism to engage youth. Connections between scientists and educators help make polar science come alive to students, and in turn, build a community of individuals involved in polar science. Scientists and educators need to be linked in such a way that they both see benefits from working together.

Specific Proposals:

- Build a community of polar researchers connected with teachers who can assist in outreach activities. Increase awareness that linking research with education and outreach is an integral part in the overall success of science education.
- Provide opportunities for different levels of commitment for scientists and involvement of educators (from emails to video clips to classroom visits and joint curriculum development) – individuals differ in their strengths, abilities and time – but establishing direct communications is important.

Students present their research to teachers at a regional workshop.

- Use graduate students as a bridge between scientists and educators: NSF Graduate Teaching Fellows in K-12 Education (GK-12) project a good resource.
- Networking is essential. Regional workshops – teacher to teacher, teacher with scientist and project – show teachers how to bring polar information to a local level.

Grades 6-12

Grades 6-12 are in a balancing state. In these grades, teachers need time to teach required material, both to meet standards and to prepare students for assessment. There is an opportunity to develop problem solving and inquiry-based units focused on polar themes that will help both students and teachers meet requirements in interesting ways. Polar themes can also be integrated into existing programs accepted by school districts, where standards are already aligned

Specific Proposals:

- Incorporate polar science into existing programs (GLOBE, CoVis, National Ocean Science Bowl).
- Engage more teachers. Expand Teachers Experiencing Antarctica and the Arctic (TEA) opportunities. Develop a listserv to provide units that teachers can use in the classroom.
- Balance "wow" factor of state-of-the-art technology used in polar science with students' understanding that technology is a tool, not a substitute for understanding science.

- Complement state standards assessments with polar problem solving units that demonstrate inquiry-based science.
- Attend professional meetings of educators with polar resources to display and give away (e.g. National Science Teacher's Association: NSTA).

Undergraduate Non-Science Students

Polar themes and activities can be included in undergraduate curricula in a number of way. Many undergraduate institutions require that students complete some sort of general science course. For most students, this is their last encounter with science. This is a perfect opportunity to explore polar issues since they can be broad in scientific focus and relate to large scientific questions that have relevance to the general population.

William H. Johnson. Cmd. Peary and Henson at the North Pole, c. 1945. Smithsonian American Art Museum

Polar themes can also be integrated into history, art, and intensive writing programs: reading the early polar exploration literature, reliving expeditions, understanding artists' representations of the known (e.g. by the Inuit) vs. the unknown (e.g. survival conditions).

Specific Proposals:

- Pose rich questions about broad connections to scientific issues, methods, etc. that educators can use internationally, as well as nationally, that help students learn science and help students make connections to their lives, culture, and communities.
- For undergraduate general science courses: develop curriculum elements that use polar themes to set an interesting context for learning science, help students see connections between science and the world around them, and help students to learn how science works (i.e. latent heat of melting and 0ºC summer temperature in central Arctic).
- Have educators and researchers provide resources to a central clearinghouse so that they can be used more widely. Provide materials to help teachers work with students on interdisciplinary classroom investigations that extends their own content knowledge.

Undergraduate Science Majors

Two major areas of opportunity for undergraduate science majors are incorporating more polar science into standard courses, and giving students either hands-on or virtual polar field experiences. Developing opportunities for introductory science courses is important, as this is where students often determine whether to continue in this career or pursue something else. Research and field experiences need to be created for the upper level students.

Specific Proposals:

- For the broad-brush introductory courses:
  - Create a web-based clearinghouse for polar opportunities and resources – field courses etc. and research opportunities. Develop online lectures with associated activities, e.g. "live from the field," targeted for use in specific introductory classes.
  - Provide financial incentives for polar researchers to work with educators to create modules for distribution and textbook inclusion, or stand-alone activities.

- For the focused upper year students the following opportunities should be enhanced:
    - Utilize NSF Research Experiences for Undergraduates (REU) opportunities.
    - Enhance information exchange about educational and research programs and other opportunities in the Arctic, Antarctic and the lower 48 states.

Graduate

Graduate students are a tremendous resource, but one that is somewhat limited. Polar field opportunities should be offered to undergraduates, or as short courses to post-baccalaureate students, so that potential graduate students are captured at that early stage. Engaging this community in field research as liaisons with education, outreach, and community relations is important.

Specific Proposals:

- Capture graduates through undergraduate and post-baccalaureate opportunities, including short courses, field opportunities, and internships.
- Enhance ongoing circumpolar research and education initiatives, like that of Barrow Arctic Science Consortium (BASC) and the University of the Arctic, especially the PhD networks, creative polar-related webcourse offerings, and opportunities for earning advanced degrees through part time study and research.
- Create a bi-polar portal to facilitate access to and development of polar opportunities, including listservs such as ANSWER (for the Antarctic) and ArcticInfo.
- Provide training in ethical conduct – for people and the environment: ensure that all who work in polar regions are aware of NSF, Inuit Circumpolar Conference, and Alaskan Native Knowledge Network guidelines.
- Educate graduate students about best practices in education and outreach.
- Polar research, because it is place-based and logistics often requires sharing by multiple disciplines, is often interdisciplinary. Are interdisciplinary graduate degrees viable? Systemic change would be required to realize this fully.

General Public – Informal Education

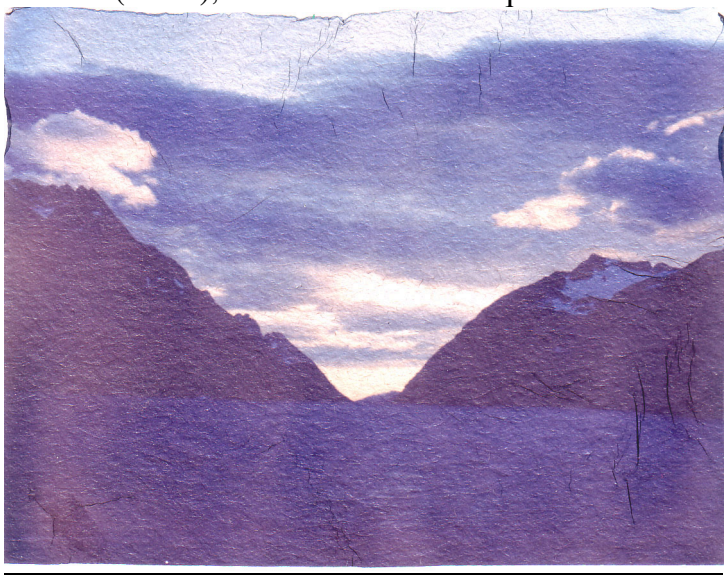
Polar topics have terrific public appeal. Outreach through informal education venues (museums, zoos, TV, radio, print media) should be pursued through a coordinated media strategy. But informal education of the general public through these venues typically reaches a self-selected audience. While many people are fascinated with polar themes, how do you draw others in, who are not currently interested in the poles, including the broader international community? Research is needed on how to broaden and diversify public interest.

Specific Proposals:

- Learn what the public understands currently, and identify their misconceptions. Do not ignore what people are curious about, even if it always starts out with penguins and polar

bears. Build from what engages attention. Develop universal messages, as well as information with targeted relevance: i.e. communicate the science process, not just the results.

- Examine the audience currently participating in programs focused on polar themes. Survey them to find out why those who participate, are there, and develop a strategy to gather others. Capitalize on female interest in polar regions.
- Coordinate a media strategy with general themes: make the poles feel real, personal, and dynamic. Make the poles "real" by providing a sense of place, using images and technology. Focus on people: residents, scientists, etc. to make poles "personal" – more than 50% of visitors surveyed in "Science Live from Antarctica" said they like to hear scientists speak about their work. Let scientists speak for themselves, and show the human interest stories too. Highlight dynamics and change: climate, environment, and society. A coordinated media strategy requires staff and materials designed for general public.
- Tap into the wide variety of available resources (images, stories, artifacts), and a distributed approach. Museum exhibitions on polar arts/scientists should be traveling shows. Public libraries should contain polar books on their summer reading lists.
- Target to have CNN, Fox, MSNBC etc. include a science news spot in their regular news program (a spot separate and distinct from medicine). Regular news broadcasts with science coverage would increase awareness and acceptance of science.
- Engage the media and informal educators: present polar materials at professional conferences (e.g. Association of Science and Technology Centers (ASTC), American Association of Museums (AAM), American Zoo and Aquarium Association (AZA).



Strategies to Engage Diverse Communities in Polar Science

Following investments in general science education stimulated by Sputnik and the International Geophysical Year of 1957, women emerged on the polar science scene in the 1980's. Seeking to understand changes in Arctic climate, ice and biota in the 1990's, researchers turned to native elders to learn from their observations and analysis. Despite these recent developments, women and indigenous peoples remain underrepresented in polar research. Workshop participants articulated the clear need of the polar science community to actively engage more diverse participation, including Arctic peoples and communities, underrepresented minorities, and women, as well as broadening economic and geographic involvement. Communication with Arctic indigenous peoples must include developing a new generation of researchers from the Arctic who actively investigate and communicate northern issues to global populations and decision makers. This theme of building capacity within communities, together with providing opportunities for personal contact and field experiences, making polar issues relevant at the community level, and developing mentoring and support systems, was articulated for each target group.

Networking diverse communities together through common interests can have long-lasting impact. For example, at the turn of the last century Matthew Henson played a crucial role in attempting to attain the North Pole, yet since that time minorities have remained underrepresented in polar science. A first step towards bridging the gap between inner city communities and communities in the Arctic was taken at the workshop where the leader of the Earth Conservation Corps' Matthew Henson Center in Washington DC established contact with Native Alaskans and began to plan exchange programs. Unlike many of the other sciences, user data collected through the experience of San Francisco Exploratorium's web-based "Live@" including "Science Live from Antarctica," indicates that polar themes draw a nearly gender-balanced audience. Polar education efforts should build on this latent interest to develop a more gender-diverse scientific community.

Arctic Natives and Residents

In order to engage Arctic Natives and residents, workshop participants recommended gaining their active involvement in future working group meetings, and working to develop the respect and confidence of the native community and its residents. Mutual respect is essential for the science community to work with them. Science capacity within indigenous communities must be expanded so that native persons design and conduct research projects for native populations.

Specific Proposals:

- Develop a better working relationship between the indigenous community and the science community by carefully planning the timing and cultural structuring of meetings and events,

and ensuring that researchers and planners have some background/training in cultural sensitivity and ethics such as existing guidelines from NSF, Alaska Native Knowledge Network (ANKN), and international first peoples organizations (http://www.ankn.uaf.edu, http://www.nsf.gov/od/opp/arctic/conduct.jsp). Highlight paradigmatic stories of respectful and successful collaborations between native communities and scientific communities. Develop a historical overview extending from the first IPY to the International Geophysical Year (IGY) and through current day.

- Focus on building capacity *within* indigenous communities for conducting research (including local collection of data) and education/outreach in both traditional and non-traditional venues. Community-based educational components should be developed for existing and planned long-term observation networks, structured like GLOBE projects and tailored by community members to address community relevant issues, and to involve both native elders and scientists. Arctic research projects by native people, for native people, will involve finding funding sources and connecting them with native communities. There can be varied tracks for community-based science education ranging from informal to certificate-track to graduate degree-track. Develop opportunities for all types of students.
- Recognizing that the Native peoples have knowledge and tradition to share with other populations is an important first step towards their involvement. Their presence in the field of education, both traditional and non-traditional will assist in encouraging more Natives, and in providing a bridge to other cultures. Science information existing in their people through their elders and collective knowledge and practices has a place in current and future research. Respect for preserving their traditions must be considered in any program.

Minorities

Building involvement in polar activities by minority communities requires actively reaching out to them, and ensuring that research and activities have relevance to their specific interests. Existing community agencies and activities can be a vehicle for numerous and repeated exposures on their home ground. Locating these agencies and local needs will involve physically going to communities and exploring possibilities face-to-face. Ongoing support systems for engaged minorities need to be established that will sustain them throughout their involvement in research.

Specific Proposals:

- Focus groups can help in identifying ways to encourage minorities in their involvement in polar science and emphasize its relevance to them and their communities, and to develop local connections. Connect through professional minority associations. Find ways to offer hands-on, field participation by community members. Encouragement and recognition for

involvement in science and research can have a major impact, anything from offering day care and meals to a modest stipend. It is important not to set the level so high at the beginning that people without a strong background are intimidated and therefore unwilling to participate. Courses can be restructured so that they are designed to be more informative than evaluation oriented. Seminar series with following group discussions, or individual presentations might be an alternative design to courses focused on traditional testing and evaluation.


Matthew Henson Center, Washington D.C.

- Better preparation in math and science is essential, especially in the grades K-6 as this is when the foundation for future learning is established. Integrating science and math with other fields is one way to expand relevance and motivation.
- Once people are involved it is important to develop a network of mentors to serve as active role models. Develop vignettes on minorities involved in science – their background, accomplishments and challenges to share with newcomers. Train non-minority scholars in successful approaches to mentoring minority students.

Gender Diversity

Polar exploration and science has historically been a field comprised predominantly of males, but strong female engagement in programs like the Exploratorium's "Science Live from Antarctica," indicates that women have substantial interest in polar themes. This is a two-fold issue comprised of both the issues facing women choosing any science as a profession, as well as the issues facing woman who chose polar science. A change in the general culture and acceptance of science-oriented girls would address both issues. Systemic changes include broadbased goals such as: highlighting the successful women in science and encouraging them to serve as mentors to other women, more women in senior science positions to serve as role models, more support for women with children who must do polar field work, "Reprogramming" parents so that they encourage girls to play with Legos and other technical toys, and teaching math and science in context in middle schools so that females and minorities don't lose interest and miss out on building their foundation for college science. Addressing these and other items that have been raised in recent studies on women in science, will help with recruiting and retaining more women interested in polar science as well. Enhancing gender diversity also includes involving more male K-12 teachers as well as engaging more women in polar research.

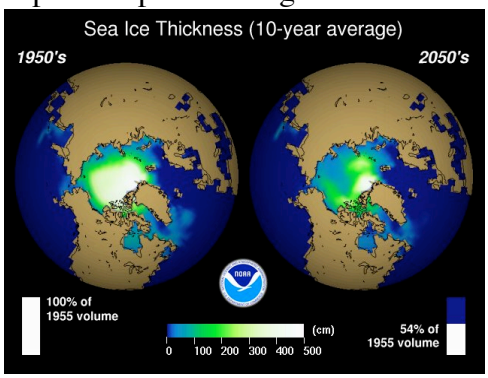
Specific Proposals:

- In order to understand what attracts women to polar science, collect data from the women presently in polar science. Survey female researchers to ask what inspired them to do what they do. Develop vignettes to share on these individuals, their background, accomplishments and challenges.

- Investigate why so many women are underemployed. Recognize contributions of part time employees and increase their status. Consider salary equity and benefits: offer benefits to part time employees and adjuncts. Examine ways to offer educational opportunities to people with a wider range of availability, for example, MA, MS and certificate programs that can be completed part time and after hours. Establish part-time science programs for nights and Saturdays, with childcare, so that working women can attend.
- Educational programs should deliberately attempt to engage the female population in science as well as the male population. Target middle schools with a focus to engage them in meaningful activities, and to teach more math. Middle school is a time when females and minorities lose interest in science, math, and technology so it is especially important to keep them engaged and not allow them to fall behind.
- Informal educational opportunities are often a good way to engage individuals who might otherwise not be involved. Provide materials for museums, and zoos to engage the female audience, and take advantage of "virtual" experiences. Teach youth to appreciate nature at an earlier age (organize field trips, bring snow-making machines in the South, polar-themed coloring books,.). Create materials for wide distribution: recommended polar reading list, film lists.
- Develop a mentoring and support system. Encourage networking. Provide opportunities for teachers to work closely with researchers so that they can be role models for their students.

Geographic Diversity

From Louisiana to the Middle East and Asia, what are the keys to engaging people in diverse geographic settings in understanding and appreciating the poles? Engaging geographically diverse communities will involve personally connecting them to the research so that they see the relevance to their community. Focus on the impacts on the poles of decisions made elsewhere or the impact of polar change on other communities. Studies/activities that can be done in any location allow all individuals to be a part of the science research experience.



Specific Proposals:

- Meet with communities to find out what is important to them, how they relate to specific issues, and then make it personal. Identify issues and values that communities have in common with the poles, compare and contrast. Focus on connections between each community and the poles. For example, a rise in sea level caused by melting glaciers and ice sheets could directly affect the 1/3 to 1/2 of the US population that lives in

the coastal zone. Provide an open framework so that communities can select what is important to them to focus on (climate, biology, etc.) – communities relate to specific issues and should be able to plug their projects into this interest. Emphasize that local policies and practices are relevant to the changes in the global system and affect the poles.

- Provide contact information so that communities can connect with scientists and other like-minded communities to set up projects.

Socioeconomic Diversity

Scientific research, often requiring a PhD, seems beyond the reach to many socioeconomic groups. And so polar regions, literally at the ends of the earth, becomes an esoteric subject. To reach economically diverse communities will necessitate the better use of media and public information systems. The media and non-traditional educational opportunities should be a primary focus for reaching economically disadvantaged communities. Misconceptions about where scientists come from can be addressed through biographies of scientists who come from non-academic, and lower economic backgrounds. These biographies should be provided to teachers, parents and students.

Specific Proposals:

- Make connections between environment and local community – make it all relevant. Develop programs and activities that are appealing to all socioeconomic backgrounds.
- Create dramatizations about polar science for wide distribution to teachers and children. Make short public TV sections (like Sesame Street or Bill Nye) that teachers can use directly in their classroom. Give away posters with facts about the poles to teachers for use in classrooms (as well as PDF files, etc to download). Develop inexpensive programs and activities: fast food children's meals with polar toys, explorer games and play cards, polar tic-tac-toe (if answer correctly can put down an X or an O), polar checkerboard. Engage scholastic publishing with polar topics and free books (containing polar information). Tap community/recreation centers and camps to diversify the outreach through informal science.
- Make polar research more accessible. Address the misconceptions about where scientists in academia come from. Publish the low-income success stories. Have an option to make an audio tape essay for applications to advanced degrees, since some applicants may be more articulate in speaking than in writing.
- Be vigilant – make sure that communities have proper resources (especially technology). Involve both students and parents. Make school resources available during non-school hours.

International Diversity

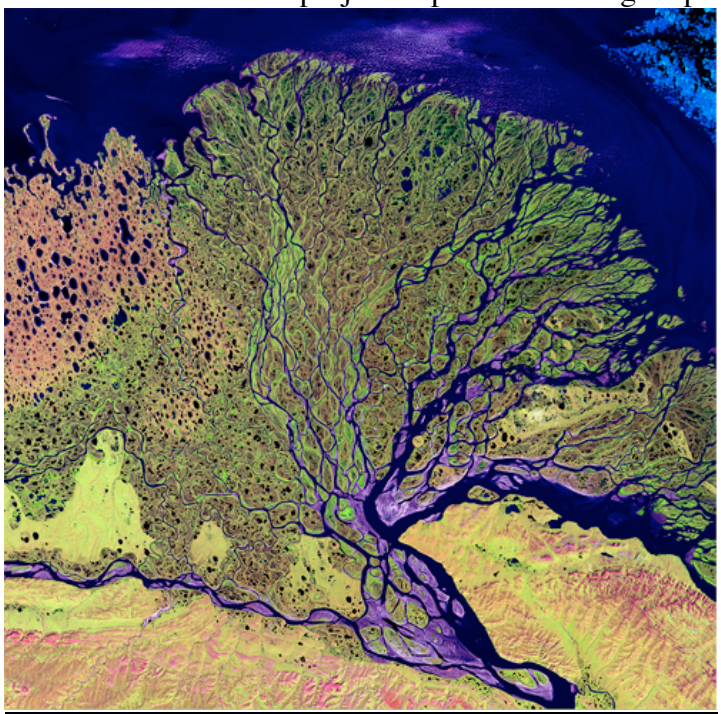
Existing international projects show the tremendous success of scientists around the world working together. Large-scale, far

International Research Council for Antarctica

reaching projects touch people around the world and highlight the fact that science is based on contributions from around the globe. The web and polar research, and specifically the IPY, all international by definition, are excellent vehicles for international outreach.

Specific Proposals:

- Focus on international issues that touch people across the world e.g., Antarctic Treaty, Ocean Drilling, Global Climate Change. Develop projects that allow citizens and/or students from around the world to contribute data or research (like project GLOBE), and then connect contributors with scientists, and provide them with information about how the data is being used, so they see that their contribution is valued. Work with large international groups who might be able to bring in financial support.
- Use communications that easily spans international boundaries. The web is global, and if language is a barrier, recruit young researchers from various countries to develop multilingual materials and translate for elders to break the barrier. Use non-Eurocentric language or symbols and photos and limited words (Japanese do this successfully). Use art and music to transcend language barriers.
- Engage international organizations, institutions and committees, for example, the Arctic Council, the University of the Arctic, the International Polar Foundation, Scientific Committee on Antarctic Research, International Arctic Sciences Committee.
- Promote and support the exchange of scientists and science students between countries for research and education. Prepare the scientists for the cultural differences they will face when they visit or relocate other countries. Increase international partnerships and understanding by encouraging students to study abroad as part of their science education and to collaborate in an international research project as part of their degree program.



Lena River Delta with Arctic Ocean on the top

Leveraging the Importance and Excitement of Polar Science

While much of the workshop discussion stressed the need for an interdisciplinary approach (see box), each discipline has its own attractions, which can be built on both in training the next generation of researchers and in engaging the general public. In a similar vein, while many programs can be bipolar, it is important to recognize, and capitalize on, differences between the poles. The Arctic has continents surrounding an ocean, and residents including indigenous peoples. The Antarctic is a continent shielded by vast fields of ice, with only a few logistics bases from which to launch programs.

Interdisciplinary Approach

Life, research, exploration, and discovery in the Arctic and Antarctic involve the intersection of many disciplines, spanning the complete range from anthropology to zoology. Field research requires sharing limited logistics platforms, base camps, and ships for extended periods of time, which facilitates interdisciplinary discussion and collaboration, and the opportunity for a "systems" approach to study in the polar regions. Because polar research encompasses such a range of disciplines, polar education and outreach is a perfect way to involve diverse groups of learners in multiple content areas. Future programs should build on this strength of polar research, cultivating a "sense of place" for researchers, educators, students and the general public, "pride of place" for Arctic residents—especially indigenous Alaskans, and a sense of connectedness, relevance, and impact on the poles/poles influence on the rest of the earth. Polar environmental change including SEARCH (study of environmental Arctic change) – understanding the feedbacks of the poles on and also from the global system – links communities around the world, with the worlds at the ends of the Earth.

An ice cave at Loudwater Cove on Anvers Island, near the Antarctic Peninsula.

There are many points of connection between these seemingly remote places and broad-ranging societal issues. Connecting global themes with local issues helps engagement at the community level. It is important that people in, for example, the Midwest, understand how their actions affect the poles and how they are affected by polar change. Develop initiatives with the thought "think globally/act locally" — international activities with national outlets. Make connections between protecting local environments by promoting healthy environments at the poles. Polar researchers and educators should learn about their own community and make connections with it to show how it impacts, and responds to polar regions.

People: Anthropology, Heritage, Society

Any focus on the people and heritage of the poles should be viewed in a holistic "wellness" approach. It is important to continually monitor and be aware of our impacts on each other and

to assess how to heal the land, relationships with different peoples, and communities. This will involve a systems-thinking approach that illustrates how all nationalities are connected, and how science, policy and human actions are connected.

Specific Proposals:

- Emphasize systems thinking and demonstrating the links between action and science and policies, and humans and natural systems. Monitoring the Earth's systems is how people stay connected with the impact we are having as a species. Develop programs that focus on monitoring as an activity that is normal to all people.
- Share seasonal changes, festivals, and unique events that occur in differing areas. Including the native customs as part of exhibits or tours is important in understanding their heritage and culture. "A day around the Poles" – a rotating spotlight on a normal day in specific areas: a snapshot of different people in differing locations, real people doing real things. Focus on similarities and differences. This could be linked with polar sunrise or sunset, and followed in a similar fashion as the turn of the Millennium.
- Look at change around the poles and examine what is different. Look at what life in the poles was like for indigenous populations and researchers during the first IPY more than 100 years ago, and the IGY 50 years ago.
- To have impact, coordinate efforts, develop synergy, look for ways to optimize activities on all levels, and work together – much as "tipping the boat" takes all parties working together.

Young student experiences dressing for field work in the Arctic

Biota

Start with what people think that they know about polar organisms – and then go beyond the charismatic megafauna of polars bears, penguins and whales to look at the diversity of adaptations to life in extreme environments. Take advantage of the "wow" factor of unusual biota and extreme conditions for life to entice the public.

Parborlasia corrugatus (Proboscis worm) - an example of Antarctic gigantism

Specific Proposals:

- Assess what people already know, what they don't know, and build from that. For example, what kinds of life exist under the ice?
- Emphasize diversity, abundance, and distribution of marine and terrestrial life; include fossil records such as Antarctic trees and Arctic dinosaurs. Examine fossil records from the

poles using ANDRILL and show how you can use biota as temperature proxies. Show how plate tectonics and isolation affected Antarctic development

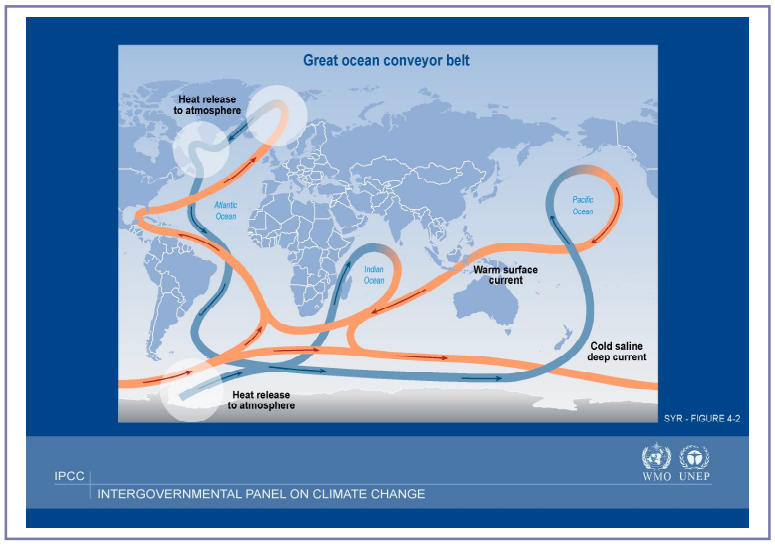
- Life in extreme environments: use this concept to hook the media. Explain interesting adaptations to survive – and thrive – in severe environments and links to climate change
- Use and re-release excellent materials that already exist: e.g. Audubon, National Geographic, Peterson's Guides. Involve tour companies/field guides for tourists and adventurers
- Create a polar postage stamp series with polar flora and fauna (as well as history and current research)

Ocean

How do the polar oceans affect the rest of the world? How do humans affect the polar oceans? What are the impacts of these changes? Show the connections between the Arctic, the Antarctic, and the rest of the world. Show how these connections have changed through time, and how much time they take to change.

Specific Proposals:

- Focus on the effects of changes in polar oceans: deep circulation and abrupt climate change, changes in sea levels and coastal ecosystems, their interconnection and impact on human societies and international security and commerce
- Encourage stakeholders to promote the important role of polar oceans to the broadest audience: industry, informal science community, professional organizations



- Encourage people with polar ocean resources and data to submit to Digital Library for Earth System Education (DLESE), National Science Data Library (NSDL) or other agent to make information widely available (see insert example).
- Develop curricula and activities that bring into the classroom the concepts of the layered ocean, and the importance of convection and thermohaline circulation.

Ice

Ice defines the poles: from permafrost and glaciers on land to sea ice in the ocean, ice is both a surface to walk on, live on, and a barrier to overcome. Because ice and snow are accessible to a majority of communities, local activities can be used to make connections to conditions at the

poles. Because it shifts phases so easily, ice is vulnerable to change. And ice has a sensory impact on people: they like to touch, see, and feel ice. Be creative with ice to bring it alive through exploration. Focus also on the power and danger that snow and ice can represent: the avalanche, the hidden glacier bas. These are all items that fascinate and thrill, offering an opportunity to engage the public.

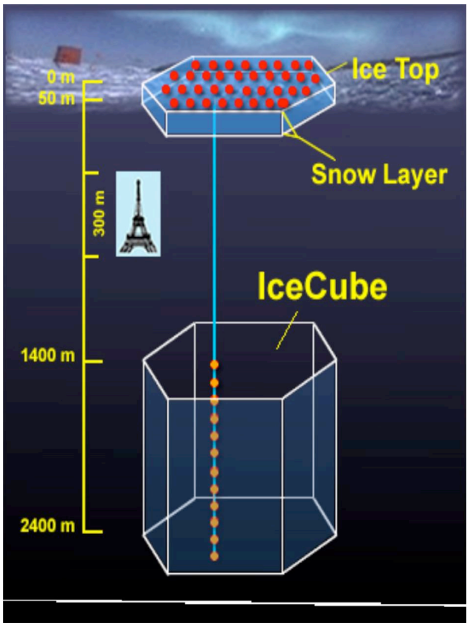
Specific Proposals:

- Focus on the link between surface run off (water) and snow precipitation. Seasonal storage of ice and snow and then a spring release. Place these local processes within a larger context
- Use the 5 senses to create hands-on approaches: take snow machines to southern areas to make snow for southerners, explore different types of ice that form locally and contrast them with ice in polar regions: lake, sea, glacier, etc. Make ice: freeze ice on cookie sheets or layer by layer in a tube to show how layers archive temporal changes

- Create problem-based learning units examining crystal growth, phase changes, glacier flow with silly putty. Integrate activities with learning standards
- Pair science and education together to provide a complete picture for students. Use maps, models, etc., to show how ice has affected the world we live in, including changes in climate and sea-level.
- Share personal experiences with students, i.e. Teachers and Researchers Exploring and Collaborating (TREC)) using webcams, journals, etc.

Geology, Geophysics, Meteorology, Space Science

From the solid earth to the atmosphere and space the poles play important roles in geodynamics and our understanding of earth and space systems. Many questions still remain: do the poles control climate? What really lies beneath the massive ice sheets of Antarctica, and the drift ice of the Arctic?



Specific Proposals:

- Use the poles as an observatory, i.e. messengers from space/ Ice Cube (international high energy neutrino observatory being built on the South Pole), Antarctic Muon and Neutrino Detector Array (AMANDA) and Balloon Observations of Millimetric Extragalactic Radiation and Geophysics

(BOOMERANG).

• Emphasize exploration of unknown territory (massive ice sheets hiding the Antarctic continent, mountain ranges and Lake Vostok; sea ice covering the Arctic and the Gakkel Ridge).

• Compare extreme environments with those on other planets and moons.

Maximizing the Impact of the IPY

To maximize the potential of the International Polar Year of 2007-2009, people need to work together to build a coherent and exciting public presence both locally and globally[1] Integration of research, education, and outreach efforts, at the international as well as national level, coordination of existing resources, linking communities and developing partnerships, access to data and content from the polar regions, securing funding to develop new programs, and sustaining programs after the conclusion of the IPY, are essential (international site - www.ipy.org; U. S. - www.us-ipy.org).

Leverage Polar Fascination

People of all ages and groups, are fascinated by the poles. The community can build excitement for science through the uniqueness of the poles and the international focus of the IPY. Charismatic wildlife, human resourcefulness in extreme environments, expansive fields of ice and snow, and daring explorers all capture the imagination. Linking this existing fascination with programs and activities developed in association with the IPY, can enhance knowledge of polar regions and interest in science. A diverse group of learners can be involved in science as a human endeavor, history and nature of science,

A Resolution in Celebration of the legacy of the International Geophysical Year of 1957, and the International Polar Years of 1932 and 1882 was submitted by Senator McCain and approved as Senate Resolution 466 - October 11, 2004.

The first IPY involving 12 nations, and the second IPY involving 40 nations, established internationally coordinated scientific campaigns. IGY, involving 66 nations and 60,000 scientists, was the largest international scientific endeavor undertaken to date, and left an ongoing legacy beyond measure.

Legacies of the IGY include satellite communications, modern weather forecasting and modern natural disaster prediction and management, from volcanic eruptions to El Nino. IGY included the launching of the first artificial satellites, Sputnik and Vanguard, founding the space age itself.

The decision to set aside Antarctica, an entire continent, for cooperative study, was the product of IGY. This pathbreaking decision of the IGY program alone– permanently institutionalized by the Antarctica Treaty–made the year a scientific triumph.

IGY clearly marked the development of international science through the unprecedented number of scientists from throughout the world who banded together to implement the IGY. Globally coordinated activities that today save millions of lives–such as the campaigns to contain and find cures for SARS and AIDS–owe their inspiration and working model to IGY. Scientific findings from thousands of locations, ranging from world research centers to remote field stations, were collected and organized by this global team, resulting in an unprecedented range of discoveries for human benefit.

There is a coming together in the study of our planet and its diverse inhabitants through new integrative linkages that are being established among mathematics, physics, the geosciences, the life sciences, the social sciences, as well as the humanities. The potential scope and significance is only beginning to be perceived.

Therefore, the Senate resolves to endorse the concept of a worldwide campaign of scientific activity for 2007-2008 emphasizing activities directed to global environmental research, education, and protection…

Part of this wording is taken from House Rtp.108-422- "International Geophysical year 50th Anniversary " http://thomas.loc.gov/cgi-bin/cpquery/?anddb_id=cp108andr_n=hr422.108andsel=TOC_4

[1] Albert, M. et al., 2004, A Vision for the International Polar Year 2007-2008, U.S. National Committee for the International Polar Year 2007-2008, National Research Council, p. 112.

science as inquiry, and science and technology. The IPY is a perfect way to approach science education for school systems and the general public; the effort already aligns with education standards. Tapping into people's appreciation for nature and interest in nature/society interactions will help improve science literacy, promote understanding of heritage, develop community and "pride of place," gain an appreciation for environmental variability and change, link policy with stewardship, learn about technological advances, focus on the concept of Earth as a system, and see how predictions about future environmental conditions are developed from observations and models.

Meaningful Engagement

Education and outreach efforts should ensure that the IPY is truly meaningful to a diverse suite of communities. The IPY should be structured so that it is responsive to the interests and concerns of indigenous Arctic peoples, minorities, women, and people from developing countries – see earlier "Targeting All Learners" and "Engaging Diverse Communities" for specific proposals. Meaningful engagement of indigenous and non-indigenous residents of the Arctic is critical so that they are enthused to launch their own IPY-related efforts. To engage people in less developed countries, perhaps the community could establish a fund for their researchers, educators, and media representatives to participate in the IPY. Putting a face on polar researchers – those active during the first IPY of 1881 and the later International Geophysical Year (IGY) of 1957, as well as those conducting research today – makes their research more accessible, personal, and meaningful.

Education and outreach initiatives must be clearly defined with measurable outcomes so that IPY's promise in building capacity in

IPY Education and Outreach Infrastructure Needs

An IPY **education and outreach headquarters,** with a staff and a central office, should be created to coordinate and leverage programs. Linked with the headquarters should be an Interagency Working Group on IPY Education and Outreach, which also connects with international efforts. Continue coordination of polar education and outreach after the end of the IPY. In order to have impact beyond the conclusion of the IPY, we need to establish and maintain networks among scientists, educators, students, and communities, grow associated communities beyond Arctic regions, and involve all levels, from k through gray.

A **sophisticated one-stop web portal** should be developed for the IPY and beyond to serve polar content and contacts for researchers, educators, the media, and the public at all levels. It should be served through a vetted source, perhaps with an IPY brand. The site should collect education and outreach resources, highlight research and educational advances. Educational resources include curricula that are easily accessible, developed for all levels, linked to recent events and research programs, suits state/national standards, and maximizes the integration of research with education. The web portal should promote individual as well as group efforts and contacts, catalogue polar research, researchers, educators with identifiers for local contacts for setting up joint projects, and connect with data resources like DLESE. There need to be regular reports from the field, including research news and stories. Access to high quality content requires improved high bandwidth communications – this issue that emerged repeatedly as critical to timely and dynamic connections between the poles, the media and other communities. We need to plan for maintaining website after the IPY so that there is value added and enduring effect.

IPY **observatories** located at the poles are essential: there should be shared platforms for varied sciences and nations to pursue scientific inquiry, and host media and educators. We can build on existing observatories and networks, i.e. circumpolar environmental observatories, ocean observatory network, census of marine life. Existing stations need to be modernized to make them more environmentally friendly, and with better technology, i.e. high bandwidth communication capability. And we need to establish Arctic and Antarctic on site communications offices to support polar experiences for a diversity of participants: science writers, journalists, and educators.

Arctic communities, growing a new generation of polar researchers, and stimulating the public to know more – and care more – about the poles, is realized. For example, over the next 5-10 years, there should be a measurable increase in the number of Arctic residents completing graduate study in IPY-related fields.

Educational opportunities need to be explored at informal venues, such as museums, zoos, TV, radio, print media, and meetings of professional societies, as well as through traditional classrooms. There are different opportunities and needs for different levels, K-5, 6-12, undergraduate non-science majors, undergraduate science majors, and the general public. The general public can be engaged with made-for-TV documentaries, exhibitions at zoos and museums, and multilingual coffee table books.

Build Communities

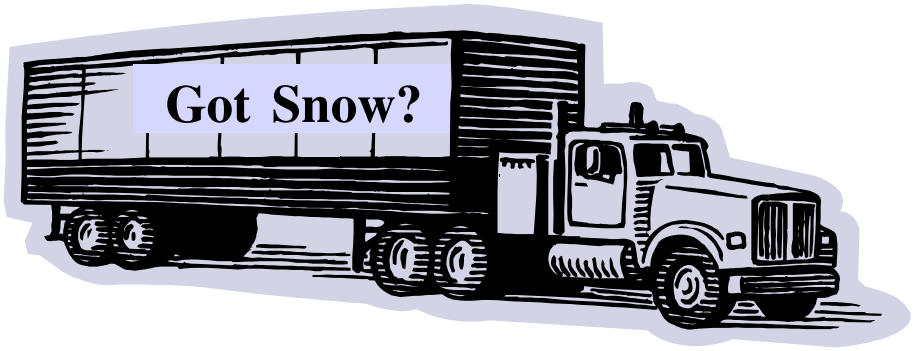
While the number of people living in, teaching about, and researching the polar regions is not large, the workshop brought together many people who had not previously met. Effective education and outreach requires establishing and maintaining connections among these disparate communities through joint programs and regular meetings, extending up to, through, and beyond the IPY of 2007-2009.

Both in the national and international arenas, attention should be paid to reaching diverse groups: ethnic minorities, girls/women as well as boys/men, and those from different geographic, socioeconomic, and cultural backgrounds. To increase interest in polar regions and polar science, and enhance the diversity of those interested, it is essential to meet with different groups, face-to-face, and determine how the poles are relevant to each group. Melting of polar glaciers will cause sea level to rise in New Orleans – a topic of interest to Louisianans. Black American Matthew Henson's journey inspires young adults in the Earth Conservation Corps along the Anacostia River in Washington, DC. Following a day in the life of a polar resident promotes awareness of distant locales, the people living and working in those places, while at the same time makes a personal connection for a variety of learners. To date the international community has not been tremendously successful in reaching groups not traditionally engaged in polar research and education. The US is in the position to take a leadership role on this issue.

Link Research and Education

To inspire interest in the poles and maximize the impact of the IPY, research needs to be linked with education and outreach. The IPY poses a rich suite of questions about scientific issues, methods, and themes that educators can use internationally, as well as nationally. IPY questions should be used to help students learn scientifically and help students make connections to their lives, culture, and communities. Through the IPY, students and the public can explore the rich heritage and history of poles, identify changes, consider societal issues with the potential to affect and interact with the polar regions, and learn what the polar regions can teach us about our Earth and Universe. Specific projects and activities can be created (i.e. comparison of artifacts from the first IPY,

IGY and today) to showcase just during the IPY, while others can become part of standard curricula. Issues like climate change and polar amplification of contaminants show connections between individual actions and the poles. Some other ideas include circumpolar focus on specific events such as solstices or equinoxes; creating "A day in the Life of the Poles" that lets students track "their" animals from day to day; a polar school blitz to have as many polar scientists visit as many schools as possible nationwide in a single day; a semi-truck labeled "Got Snow?" traversing the country loaded with polar gear, interactive activities and a snowmaker; interactive polar computer games; national polar book-of-the-month recommendation, a polar youth forum. See sections above and "Contributed Ideas" in the Appendix for more possibilities and contact information.

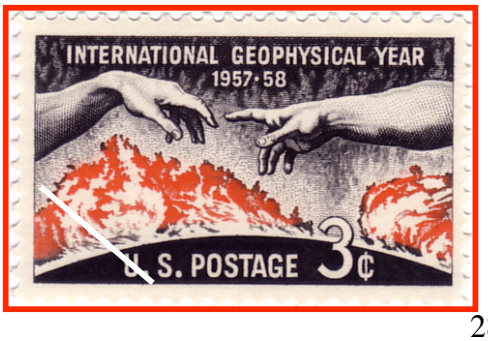


Partner with Media and Marketing

Given public interest in polar themes, the media should be a willing partner in focusing attention on the IPY – if they are provided with timely and high-quality content. An active and coordinated research, education, outreach and public relations effort should hold a major, simultaneous international launch event in March 2007, followed by a series of "splash" events. The IPY should get as much coverage as Mars Rover landings. How can this be achieved? One recommendation is to have a polar media conference, a science writer's conference, and/or a joint science writers and scientists conference and ask: How would you showcase IPY? Media engagement should tap all available resources including NSF Antarctic Artists and Writers, Department of Fisheries and Oceans journalists, educational journalists, public television and radio. A general marketing strategy should focus on joint exhibitions or exhibitions at high profile locations.

An IPY brand (seal of approval) and awards should be established. Marketing professionals should be engaged to develop and market the IPY brand. A brand, or logo, can catch the eye and from there build an understanding of what is behind the brand/logo – what it stands for. From educational resources to polar postage stamps, the IPY brand/logo could signify quality and connections with this international endeavor. Similarly, awards for exemplary IPY participation, could go to students, teachers, community organizers, the media and researchers. Connections with industry could broaden awareness through commercial outlets such as MacDonald's Happy Meals and Barbie dolls.

In addition to a brand/logo, a slogan should be adopted for IPY. The slogan should be part of all advertising for IPY events, and also part of a crop of environmental ads.



Next Steps

The community needs to start now to develop an integrated research/education/media strategy that will lead up to, and then be implemented during, the IPY of 2007-2009. Securing funding, establishing meaningful links with research programs and communities, constructing a portal/clearinghouse, involving agencies and industry, and developing exhibitions and documentaries all require substantial lead time. As a strategy is developed, the community needs to consider what education and outreach programs we want to remain in place in 2010 and the years following. First, both community and agency leaders need to be identified and working groups set up. Then these working groups should engage the community in identifying priorities and major collaborative programs. Concurrently, the community needs to work with the agencies to secure funding. From these ideas an implementation strategy can be developed, and Requests for Proposals distributed. Finally, the community needs to submit proposals, followed by implementation and evaluation.

Leadership, Community Building and Management

The "Planning for International Polar Year of 2007-2005" workshop on July 8-9, 2004, agreed that a crucial next step for the IPY was to increase the planning, including the possibility of a working group involving all the interested agencies. This action was taken in direct response to a recommendation from the Bridging the Poles workshop. Participants at the Bridging workshop also recommended establishment of an International Working Group on Polar Education and Outreach. Both of the national and international education and outreach committees need to work closely with planning efforts for the major science initiatives[2].

Through follow up workshops and communications, the education and research communities need to advertise the potential of the IPY and of polar education and outreach, and to start developing programmatic recommendations from the broad suite of options identified in this report. Educators and researchers should promote IPY to the broadest audience: industry, informal science and media communities, and professional organizations. Researchers and educators, including informal educators, should host special sessions at professional meetings on realizing the potential of the IPY.

Internationally, education and outreach efforts will be coordinated both through an Education and Outreach Task Force that will report to the overarching ICSU-WMO Joint International Polar Year Committee and through the International Polar Year Program Office. The Program Office will serve as a communication hub and hence will be a crucial link in developing integrative international education and outreach programs. With respect to national management, a central education and outreach body is needed with responsibility for coordinating among diverse communities, among agencies, among national and international science based committees. It should ensure regular communications with the broader polar community, through

[2] Bell, R. E. et al., 2004, planning for International Polar Year 2007-2008: Report of the implementation workshop, National Research Council, p. 51.

annual meetings, and a monthly/bi-monthly newsletter leading up to and during IPY. The US Interagency Task Force could agree to set aside support for such a coordinating effort.

Identify Programs and Priorities

Through follow up workshops and community proposals, the community should identify major collaborative programs to feature both nationally and internationally, and agree on a way to sequence and market their rollout. Programs to focus attention on the IPY need to be substantive, imaginative, and engaging to a broad audience. Events should be planned to complement research milestones, and to awaken public interest. The community should work towards establishing partners among the research, media, and education communities; and diversifying participation and audiences.

Develop an Implementation and Evaluation Strategy

As a community consensus emerges, it should be translated into an implementation and evaluation strategy, with a time line – just as it takes time to define a research program and establish the logistics to carry it out, effective education and outreach programs take years to develop. Communities need to work with institutions and agencies to fit polar education and outreach into their program plans for the next 5 years. It is important to think about how success will be measured, and so that baseline data can be collected before major programs begin.

Get Funding

To realize the potential of the IPY and polar education and outreach in general, requires funding, including support for new initiatives that join research, education and outreach projects, and support to maintain initiatives after the conclusion of the IPY. High-quality education and outreach programs are not cheap. A preliminary estimate would be 5-10% of the science budget of $10-60 million dollars. For example traveling museum exhibitions cost $2-3 million each, and factoring in logistics, a polar documentary can cost $1 million.

Recommendation for an Integrated IPY RFP

Requests for the proposals for the International Polar Year should encourage a broad spectrum of research, education, and outreach projects. The RFPs should be written to allow maximum flexibility in design and size: not all research programs need to have a major education component, and not all outreach programs need to have a major research component. Expensive, collaborative projects can have major national or even international impact when science programs are connected with press events, educational programming, and spin-offs of local programs. But small, individual projects can cause sustained transformation of local or target communities.

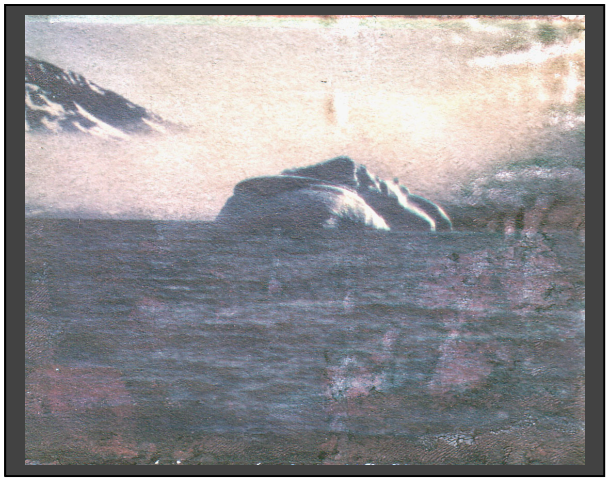
Implementation and Evaluation

It is important that the implementation of the IPY education and outreach activities be evaluated so that this experience can serve as a model that informs other such science and education initiatives. We must be able to look back at our objectives and measure our progress. Did we –

polar scientists and educators – succeed in reaching learners at all levels, engaging diverse communities, leveraging the importance and excitement of polar science, and establishing infrastructure for effective education and outreach? Do people know more – and care more – about the poles? Have we inspired a new generation of polar scientists?

Acronyms

AAM	American Association of Museums
ALISON	Alaska Lake Ice and Snow Observatory Network
AMANDA	Antarctic Muon and Neutrino Detector Array
ANDRILL	Antarctic Drilling
ANKN	Alaska Native Knowledge Network
ANSWER	Antarctic mailing list maintained by the Texas A&M University
ArcticInfo	Arctic mailing list maintained by the Arctic Research Consortium of the United States
ASTC	Association of Science and Technology Centers
AZA	American Zoo and Aquarium Association
BOOMERANG	Balloon Observations of Millimetric Extragalactic Radiation and Geophysics
BASC	Barrow Arctic Science Consortium
CoVis	Learning through Collaborative Visualization
DLESE	Digital Library for Earth System Education
IGY	International Geophysical Year
IPY	International Polar Year
GLOBE	Worldwide, hands-on science and education program
Ice Cube	International high energy neutrino observatory being built on the South Pole
NSDL	National Science Digital Library
NSF GK-12	NSF Graduate Teaching Fellows in K-12 Education
NSTA	National Science Teacher's Association
REU	NSF Research Experiences for Undergraduates
SEARCH	Study of Environmental Arctic Change
TEA	Teachers Experiencing Antarctica and the Arctic Program
TREC	Teachers and Researchers Exploring and Collaborating



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Appendices

Bridging the Poles Workshop
AGENDA

June 23-25, 2004, Washington DC

Wednesday June 23, Day 1

8:00 Continental breakfast

8:30 Stephanie Pfirman – Welcome, workshop goals and structure
Karl Erb, Director, NSF Office of Polar Programs – Linking Research and Education
Robin Bell, LDEO – International Polar Year

9:10 Plenary: three minute, one slide presentations by all on "Best polar ideas to inspire and educate the public and the next generation of researchers"

10:15 Break

10:45 Continue "Best polar ideas"

12:00 Other introductions

12:10 Lunch

1:00 Plenary presentations by Media Experts on Pacing/Rollout Strategy: Audience, Attention Span, Sequencing, Good Models
Andrew Revkin, NYT Science Times (could not attend)
Evan Hadingham, Senior Science Editor, NOVA, WGBH
Curt Suplee NSF Director of the Office of Legislative and Public Affairs

1:45 Roundtable Discussion: We will be successful by 2010 if what 3 things are accomplished?

2:15 Report back to group

2:45 Break

3:15 Plenary presentations on community perspectives:
David Smith, ECC/Matthew Henson Center
Jana Harcharek, North Slope Borough School District (could not attend)
Glen Sheehan, BASC

4:00 Roundtable Discussion: Opportunities and ways to engage diverse communities
- Table 1 Arctic natives and residents
- Table 2 Minorities
- Table 3 Gender diversity
- Table 4 Geographic diversity
- Table 5 Economic diversity
- Table 6 International diversity

5:00 Report back to group

5:30 Wrap up and End day 1

Thursday June 24, Day 2

8:00 Continental breakfast

8:30 Plenary presentations on approaches and tools to facilitate learning:
Susan Doubler, TERC – The Study of Place
Richard Duschl, Rutgers – Connecting Classrooms and Supporting Students' Science

Reasoning
Ross MacPhee, American Museum of Natural History – "*The* Endurance: *Shackleton's Legendary Antarctic Expedition*" and the role of Natural History Museums

9:30 Roundtable Discussion: Opportunities and needs for different levels
- Table 1 K-5
- Table 2 6-12
- Table 3 Undergraduate science majors
- Table 4 Undergraduate non-science majors
- Table 5 Graduate
- Table 6 General Public and Continuing Education

10:20 Break
10:50 Report back to group
11:20 Plenary presentations by Science/Data/Connectivity Specialists:
Sean Topkok, Alaskan Native Knowledge Network
Don Perovich, CRREL – Arctic Change
12:00 Lunch
1:00 Science/Data/Connectivity Specialists continued:
Tamara Ledley, TERC – DLESE
Bob Bindschadler, NASA – Antarctic Change
Mary Miller, Exploratorium – "Live from Antarctica"
Rick Caulfield, Univ. of Alaska Fairbanks – U Arctic, Distance Learning
2:10 Plenary discussion of remote participatory experiences and use of computers/data/graphs/images/animations/models
2:45 Break
3:15 Roundtable Discussion: Opportunities and needs to represent thematic areas
- Table 1 People: History and Heritage
- Table 2 Core to Inner Space
- Table 3 Ocean
- Table 4 Ice
- Table 5 Biota
- Table 6 People: Society and Development

4:15 Report back to group
5:30 End day 2

Friday June 25, Day 3

8:00 Continental breakfast
8:30 Roundtable Discussion: Programs to feature nationally/internationally over the next 5 years
9:30 Report back to group
10:15 Break
10:45 Plenary discussion of next steps and implementation time line
12:00 End of meeting

Presentation Summaries

Introductory Remarks

Stephanie Pfirman and Robin Bell – Workshop Co-Chairs

The goals of the "Bridging the Poles" workshop are to define strategies to engage the next generation of polar scientists, engineers and leaders, and inspire and educate the general public. The agenda is structured with introductory presentations followed by roundtable discussions. We will focus on four major themes: engaging diverse communities, opportunities and needs for different levels, possibilities for thematic areas, and programs to feature nationally and internationally over the next 5 years, including maximizing the educational impact of the International Polar Year (IPY) in 2007-2009.

Karl Erb – Director, NSF Office of Polar Programs

Education and outreach activities associated with the research programs of the IPY can link with NSF goals by: implementing better ways to learn science, understanding the science of learning, bringing science to a more diverse community, and encouraging broader involvement in science. NSF's growing leadership in these issues is evidenced by NSF now requiring an assessment of the broader impacts of each proposal, new "Science of Learning" centers supported by NSF, and support for workshops to integrate research and education. But NSF is now facing assessment challenges: how do you know what you have accomplished? See "On Evaluating Curriculum Effectiveness" by William Schmidt, 2004.

Robin Bell – The International Polar Year

The IPY should excite and engage the public, and increase awareness and understanding of the poles. Since winter 2003, international and national committees have been meeting to establish goals and themes for the IPY. US national recommendations include: initiating a sustained effort at understanding large scale environmental change; coupling studies of societal, economical, and strategic impacts with physical science research; exploring new scientific frontiers; examining how the IPY opportunity can be used to design and implement multidisciplinary networks for long-term perspective. The US should invest in physical and human infrastructure including education and outreach. Recommendations from this workshop will assist in the design and implementation of the US and international IPY education and outreach programs.

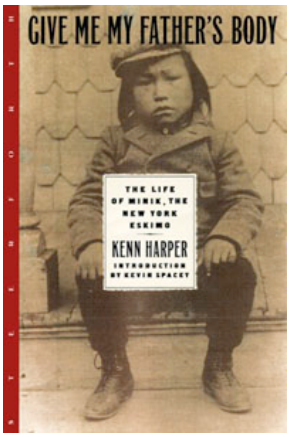
Media Perspectives

Evan Hadingham: **NOVA, PBS, WGBH Science series**

The average NOVA is seen by 6 million people in US and 100 countries worldwide, with websites having 1 million hits a month. An IPY documentary series focused on cutting edge polar research could debut in 2007 with the initiation of IPY, could then be replayed 3-4 times

over the next two years, with an extensive website presence. We have an opportunity coming up with NOVA's "Leading Edge" science news magazine series which will begin next year on a two-year grant from NSF.

What works are stories presented by a charismatic, naturally enthusiastic person that makes topics exciting and what the media group refers to as D.W.E. (dead white explorers) and survivors of adversity (Shackleton, Krakauer, Scott, Amundsen, Franklin Expedition). Find a creative way to dramatize history/science (such as poles warming faster than any other place in the world) to attract the audience. The poles are attractive to people, investigating the unknown is exciting. The process is important: how do we get data? – compare present approaches with those used in the past. Conflict and controversy also engage interest. In developing programs for TV, titles very important, you need an effective hook to get people to watch a show at the end of the day, and you need to assess how to divide the show up thematically. Most viewers prefer a story with a beginning, middle and end, but most science does not follow that structure. A charismatic scientist or host can make science more meaningful.



Challenges for polar programming and funding, timing, and partnerships: The typical show is ca. a half million to air but, because of logistics difficulties a polar show is $800,000 minimum for one hour. We must start now as it can take 2-3 years to develop a show. No one broadcaster can put up a series, you need partners. The UK is a good partner but they are moving from documentaries to science movies. General environmental pieces are not popular although archeology and natural disasters are popular.

A compelling program could be telling the story of Arctic native encounters with other cultures, through their own eyes, not through those of DWE's: the Franklin expedition as documented by local Inuit, or a dramatization of "Give Me My Father's Body: The Life of Minik, the New York Eskimo" by Kenn Harper, the Inuit story of a group of Inuit taken to New York to be studied.

Curt Suplee - NSF Director of the Office of Legislative and Public Affairs

Polar science has many advantages. The public has a large thirst for polar themes, so exploit the interest and enthusiasm of the general public by tapping into their fascination with "charismatic megafauna" and extreme environmental conditions. Another advantage is the 24/7/6-month polar summer. If polar resources are brought together on a bipolar website that shares science, education, and outreach and is maintained daily, the media and the public will be engaged. Establish a *Northern Hemisphere Journal* and a *Southern Hemisphere Journal* on the web to help bring the poles closer to the public. Create a "top 10 things to know about the poles" (like David Letterman). Develop interactive web activities to engage the public. Running webcams at each pole is an uncomplicated way to share their changing conditions with the public and to maintain an updated website. A successful example of engaging the public through media is the NASA website, as it changes every day, from its pictures to featured articles.

Approaches and Tools to Facilitate Learning

Sue Doubler, Valerie Martin and Tamara Ledley (Katherine Paget) - Study of Place: Antarctica Exploration website by TERC

An integrated curriculum website demonstrates how interactive web activities can be used in the classroom to provide a meaningful education. "Study of Place" is a middle-school level web-based curriculum designed to integrate science, history, geography, and basic mathematics. The website uses different perspectives and tools to ensure that the majority of the students understand the concepts, and educators have flexibility in teaching and applying them.

Richard Duschl- Earth Systems- Learning System

Geoscience is moving away from mapping and mining into discovery science with a "global change" and "earth systems" focus. Technological innovations, such as computers and TERRA satellite data, and learning programs, such as GLOBE and CoVis, can be used to design efficient learning environments.

CoVis

WorldWatcher:
A Global Visualization Environment for Education

According to cognitive and social psychology theory, there are different types of knowledge. Declarative knowledge is "what," procedural is "how," schematic answers "why," and strategic is "reflection." Educators need to understand students' prior knowledge. *How People Learn* by Bransford, *Knowing What Students Know* by Pellegrino, Chudowsky and Glaser (Eds.), and *Inquiry and the National Science Education Standards* by Loucks-Horsley are three resources that research and reflect learning. *Everyday Assessment in the Classroom* by Duschl is a good resource describing the three domains of thinking and listening: conceptual, epistemological, and social.

Ross MacPhee- American Museum of Natural History

Learning through informal educational mechanisms has a different challenge and focus than classroom learning. Image is the key to a presentation. For informal education, the exhibit must grab the visitors' interest quickly: ideas must be bold, and get both adults and youth interested. Example of the process: select charismatic megafauna as an attention grabber; then note how it is being impacted by local behavior (to allow each person to connect to it); then show how it can be corrected; and end with messages that describe what actions the individual visitor should take to correct the situation. For youth, learning materials like games are most effective, while adults find humanistic artifacts with a story attached the most compelling. Sometimes teaching the science is a byproduct of the main exhibit. In the Shackleton exhibition at the AMNH, the science of navigating using a sextant was taught in connection with following Shackleton on his sea voyage.

Community Perspectives

Glenn Sheehan- Barrow Arctic Science Consortium, Executive Director

The locals in Barrow and Alaska have made important contributions to polar science research. The Arctic people, with thousands of years of observing climate change, have shared their knowledge and opened their land for research. Barrow was one of the original IPY sites, and a source for Murdoch and Ray's 1881- 1883 documentation of material cultural.

Two important pieces that summarize the climate change from the local perspective are *The Whale and the Supercomputer* -"What's going on in the Arctic?" which describes the struggles of two cultures to reconcile their vastly different ways of understanding the environment and *New York Times* Magazine's "Watch the World Melt Away," which describes the future through the eyes of a lonely scientist.

The Iñupiat Heritage Center of Barrow Arctic Science Consortium has various community-building programs to try and engage students and other members of the community in polar science and projects. One example is schoolyard Saturdays, a program in which speakers come to speak about components of the Northern Regions to the youth and adults.

David Smith- Matthew Henson Earth Conservation Center, Site Manager

Like Matthew Henson, inner city youth in Washington DC are filled with promise but need an opportunity to develop their potential – it is not the destination that is important, it is the journey. It is easy to teach science, but harder to get the point across, so they have tried to create meaningful opportunities to involve the youth in science work in their community. Historically, the Anacostia River, rich in resources, helped create the District of Columbia area that exists today. However, the river became badly polluted over time. The Earth Conservation Center, located right on the river, was originally the Pepco Pumphouse and a huge dump site. By working with disadvantaged youth who are helping clean up and rejuvenate the area, the center is teaching the community how the environment around them is impacting them, and they are developing "pride of place." The youth are learning how to focus on "we" the community, not "me." The seaboard education program, has involved 10,000 kids. The riverkeeper program connects the youth back to the river and provides hands-on experience and education. Passing on the history of Henson, who has become a central part of the community, is a vital part of that learning process, which doesn't stop at the youth.

<u>Science/Data/Connectivity Perspectives</u>


Sharing Our Pathways

A newsletter of the Alaska Rural Systemic Initiative

Alaska Federation of Natives • University of Alaska • National Science Foundation • Rural School and Community Trust

The Hills on the Telaquana Trail

by Frank Hill

Growing up, my Dena'ina grandmother, Mary Ann Trefon, lived with our family periodically in Iliamna and spoke of walking the Telaquana Trail. She, with others, would travel from the community on Telaquana Lake to Kijik to trade furs for staple goods like flour, sugar, tea and tobacco. Entire families, or groups of families, traveled together. In the summer, they would walk the Telaquana Trail, carrying their supplies on backpacks. Dogs also wore backpacks in summer and in winter were used with sleds and harnesses. The Lake Clark area Dena'ina were aptly called the

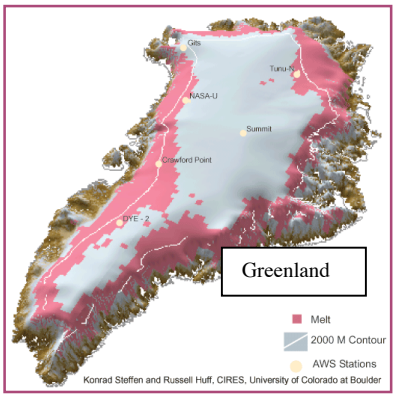
(continued on next page)

Sean Topkok - Alaska Native Knowledge Network

The Alaska Native Knowledge Network serves as a resource for compiling and exchanging information related to Alaska native knowledge systems and ways of knowing. In order to preserve and document indigenous knowledge of Alaska native people, the website is helping students learn from tribal elders to correct misconceptions and teach about deep culture, which is little known to westerners. They are developing culturally responsible units for instruction, with a goal of increasing respect for the

culture, increased pride, and preserving cultural knowledge. Working with elders teaches that the outcome is not as important as the process. Studies show that when native knowledge is used in class, test scores increase, and more students go on to the university.

Don Perovich – CRREL, Arctic Change



Although charismatic megafauna have appeal, the poles are themselves a good hook for gaining public attention. If the public knew that the Arctic may be the canary in the coal mine and how climate change impacts everyone, they would be engaged in polar research. Indicators can be examined to determine the rate of change and potentially to predict the future. Satellite images monitoring the Arctic since the 1970's, demonstrate a reduction in ice cover, and biological data show changes in the percent of shrubs in the tundra.

Bob Bindschadler - NASA, Antarctic Change

Continental warming in Antarctica can cause thick ice sheets to disintegrate, releasing ice bergs to the ocean and raising sea level. This is a direct tie to the general public because the majority of people lives near, relies on, and enjoys, the coastline. You can lead from this framework of broad societal relevance to discuss glacier flow acceleration, ice sheet disintegration, and thinning towards coastline.

Tamara Ledley - DLESE

The use of data in classrooms requires student access to data seamlessly embedded in an interesting context; teachers finding data in education modules that are easily accessible, at low cost and fit the curriculum; and developers locating data and gaining access to it. Data services of the Digital Library Earth Science Education (DLESE) in cooperation with the National Science Digital Library (NSDL) include access to raw data, activities, workshops, and teaching tips. DLESE data partners include the National Snow and Ice Data Center, NCAR, Federation of Earth Science Information Partners. Students, teachers, and developers will find the data archives, digital libraries, and data portal useful.

Mary Miller- San Francisco Exploratorium

The Exploratorium "Explore Live" Series has 17 million visitors/yr (total visitors to the museum are 600,000/yr). Although most of their series had substantially more male than female visitors, the Antarctica Live series had a 1 to 1 male to female ratio of website searchers, indicating substantial public

interest in Antarctic themes. Lessons learned from this experience: In order to engage the public, do not ignore what people are curious about, even if it just starts out being penguins and polar bears. Communicating the process of science, not the product, is important so letting scientists speak for themselves with humanized stories, will further engage the audience. Providing access for improved communications, such as increased bandwidth, and building an NSF Polar News Website are important.

Rick Caulfield- University of Arctic, Distance Learning

Although the poles are remote they are not isolated. Their remote setting provides a prime opportunity for distance education programs. Two effective programs are the UAF Rural Development BA and MA program and the University of the Arctic. The goals of these programs are to serve non-traditional students by providing circumpolar access and incorporating place-based history, science and culture in the curriculum to produce lifelong learners. By using technology as a tool, adapting to community schedules, using video conferencing, providing hands-on experience, and approaching learning in different ways, distance education can develop into meaningful learning. Extending these approaches to more Arctic people and the general public will better educate them about the history of science and cultures of the Arctic.

UNIVERSITY OF THE ARCTIC
Circumpolar study for distance learning

Bridging the Poles Workshop Participants
Washington, DC
June 23-25, 2004

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Compilation of Contributed Ideas

Workshop participants and other interested individuals were asked to submit their Best Polar Ideas to advance polar education and outreach. These responses have been categorized below by general subject area. The names of the individuals submitting comments are listed for each category. It is our hope that many of these ideas will be further developed by either attendees of the workshop or the users of this document.

CATAGORIES LIST:

1. GENERAL ADVICE SUMMARIES
A. Polar Outreach/Education Overview
a. Incorporate modern technologies
b. Humanize polar researchers
c. Use the systems approach to learning
d. Educate our scientists and our government

2. SPECIFIC TARGET GROUPS
A. Indigenous Communities
B. K-12th – Overview
C. K-5th
D. 6-12th
E. Student Competitions
F. Undergraduate
G. Graduate
H. Programs for Teachers and Researchers
I. Scientists
J. Research Summaries
K. Informal Education Outreach
L. Websites
M. Additional Web Uses
N. Data Summaries
O. IPY
P. International

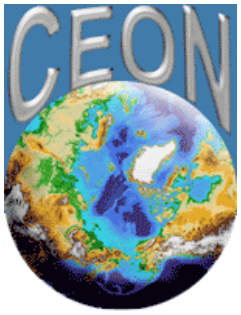
SECTION 1:
GENERAL ADVICE SUMMARIES (Warnick, Caulfield)
It should be our goal to ***encourage lifelong scientific literacy*** through establishing values and attitudes early and providing long term support. Polar education should be an integral part of K-12 schooling, higher education, and a recognized presence in informal venues. Education about the poles should have a strong presence at all three levels of focus:

- ***Locally*** with Arctic residents meaningfully engaged in developing and implementing polar research and education that addresses community concerns and traditional knowledge
- ***Nationally*** with US citizens informed and knowledgeable about polar research questions, findings, and significant policy issues
- ***Internationally*** with US institutions and initiatives at the forefront of collaboration in international research, education, and outreach relating to the Arctic and Antarctic

A. Polar Outreach/Education Overview - (Topkok)
We should embrace the "Stone Soup" approach, where everyone contributes and this summation of the different contributions enhances the whole, we need to build on existing programs and networks to build supportive partnerships (a learning community) between - northern people, scientists, educators, media.

- A part of this community building process is to focus on promoting diversity through natives, minorities, women, elders, and youth
- Add or increase the presence of native people as instructors at universities around the globe to improve educational exchange moving both directions.

Incorporate modern technologies **- (Tweedie)**
We should incorporate modern technologies, field experiences and innovative teaching methods to enhance interaction among scientists, students, and educators.



- Establish databases of polar projects identifying gaps in knowledge
- Shock/immersion teaching or saturated learning
- Focus on wildly contrasting experiences and environments to the norm – compare and contrast
- Use cyber-infrastructures - interactive GIS http://ims.arcticscience.org and Circumarctic Environmental Observatories Network http://ceonims.org)
- Outer Pole experiences – cultural and educational exchanges between poles and elsewhere

Humanize polar researchers **– (Kolb, Beitler, Vogel)**
Give the Poles a face and image - interpersonal connections are crucial to engaging the wider community.

- Polar researchers have an obligation to share their story and adventure in order to both inspire and educate others. Direct communication between researchers and scientists in the field and students in classrooms will generate public interest in the Poles.
- Focus on human aspects of research in the poles
- To reach the broadest audience, include staff and technicians as well as scientists

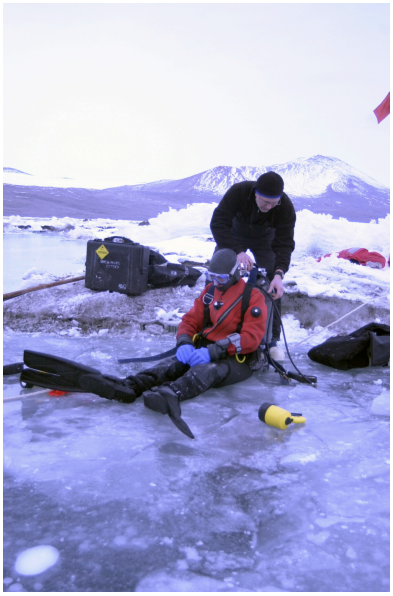
• Use various approaches - emails to online journals to videos to lectures

• Embed scientists – bring scientists into the community for a year to better understand the cultural life, and build better community acceptance. Early adventurers, like Perry and Henson actually resided in the community. This sets up opportunity for exchange in both directions, a promising potential to enhance diversity.

• Profiles of polar scientists and researchers (field and office) – modern day versus historical differences.

• Wonderwise: (videos and associated activities highlighting women researchers)

• Stories on polar life



Biologist Dr. Sam Bowser and Diver Karen Sterling in McMurdo Sound, diving for foraminifera.

• ***Use the systems approach to learning*** **– (<u>Beitler, Holmes, Rudolph, Vogel)</u>**

Emphasizing cross-disciplinary views of the polar sciences will assist in connecting the poles to a wider group of researchers and educators. Additionally it will increase awareness of poles and their role in the Earth system.

• Focus on Arctic as big multinational and multicultural area – think pan-Arctic and multi national - from scientific questions, to sociological to cultural.

• Offer professional development, ranging from workshops to conferences for teachers to provide them support in systems education on the poles

• More cross-disciplinary interaction and resource sharing

• Require PhD candidates to spend 6 months to a year at a foreign university and perhaps incorporate an international research perspective into their analysis

• Integrated, collaborative methodology to regularly monitor knowledge and respond quickly to change

• ***Educate our scientists and our government*** **<u>(Mahootian, Erickson, Kelley, Duffy, Sajor)</u>**

The effect that political decisions have on environmental consequences must be constantly emphasized through increased effort to offer higher education courses and degrees in science and policy. Scientists must connect themselves to the media and communities so that the government is regularly reminded of the impact of changes in the environment.

• Scientists should be educated to make better economic and political choices, not only to be good scientists.

• Through polar science, the science community can better understand the past terrestrial changes.

• SPENCER – Science Education for New Civic Engagements and Responsibilities – exploring science and policy interface in the Arctic through interdisciplinary inquiry and student involvement in monitoring and assessment, e.g. the nuclear legacy

• Protection of the poles from exploitation and too much interest/traffic needs to be addressed

• Antarctica remains common patrimony of humanity

SECTION 2
SPECIFIC TARGET GROUPS

A. <u>Indigenous Communities</u> - **<u>(Alessa, Sheehan, Topkok, Sparrow)</u>**

Arctic residents must be involved in developing and implementing research – effective partnerships are important.

- Especially focus to include indigenous culture-bearers
- Encourage education and outreach of northern people – target increase of indigenous students and scholars in polar science
- Collaborations between scientists and Arctic residents, first created in 1881 during the initial IPY in Barrow, are integral parts of research and preservation of the north. Murdoch's 1892 report of the 1881-83 Expedition to Point Barrow is a lasting science contribution that can be used as a contrast piece for life today in the Arctic
- Evaluate how knowledge influences behavior – studies show increased 'knowledge' by natives leads to depreciative behavior (reduced respect for the native way of life and the environment) – this must be addressed
- *OLGC* – Observing Locally/Connecting Globally – An example of a successful program: used by 60 Alaska teachers in rural and urban Alaska: work with elders and native experts as well as scientists and educators to conduct climate and environmental change studies.

B. <u>K-12 School Groups – Overview</u> - (<u>Sparrow, Warnick, Beitler, Albert, Caulfield, Jeffries, Holmes, McMullen, Bruccoli)</u>

Successful education programs must inspire, engage and connect.

- A rich polar curriculum (including research and climate change) should be assimilated into National Teaching Standards and each state's science framework should have at least one major polar theme for each grade level K-12. Membership on State Curriculum Committees would help achieve this.
- Develop a level-specific Arctic/Antarctic curriculum for use in K-12 classrooms using innovative best practices that aligns with national science standards, is relevant, and is inquiry based. The poles provide opportunity to integrate multiple subject areas: geography/physical features; social studies; science; literature. Student web scavenger hunt on polar features creatively blends technology and polar education in a game-like activity.
- Showcase compelling polar themes – human element, sudden climate change, charismatic megafauna, and confirm that Poles are not just empty space

- Must involve students and teachers in science from the start – conception and preparation of proposal – so shape full process
- Experiential i.e. **hands-on field experience** is best way to promote active learning and enhance students' critical thinking skills. Create hands-on opportunities for students to do their own science in conjunction with researchers in the Arctic and Antarctic; special emphasis on students in polar communities. Include field experience for K-12 students and other diverse communities.

An example of a successful hands on education project is the *Schoolyard Long Term Ecological Research (SLTER*) Project at the Univ. of Alaska Fairbanks: LTER scientists and educators have engaged K-12 students in long term ecological research/climate change studies at or close to their schools.

- Continue communications after research experience – scientist can attend teacher's class, teacher can co-author paper, attend conferences together, or teacher can lead regional workshops cover their polar research experience with scientist facilitating
- Polar Bears International (PBI), in partnership with Tundra Buggy® Tours and regional zoos, has created a distance learning program where students participate in activities geared to increase science literacy, create environmental awareness, promote environmental conservation, web journaling, and provide a strong, nationally accepted science and technology curriculum for schools. (www.polarbearsinternational.org/)
- Classrooms around the country engage in parallel and complementary science projects with researchers and classes in the American Arctic
- Kids around the country follow progress of polar projects on daily multi-media basis, keep in touch with scientists through e-mail, journal entries etc.

C. K-5 (Clapp, King, Petula, Sheehan, Robertson)

Polar science and education needs to begin at the early ages to take advantage of youthful enthusiasm for the extreme and unfamiliar. Polar education can be incorporated into multiple curriculum areas.

- Use research projects taking place at the poles as models to develop age-specific curriculum in order to help students understand why polar science is important and how it relates to their life. Projects, such as PARTNERS, help educators break down polar research projects into parts to teach students at age-appropriate times (water cycle, density, convection currents, chemistry, elements and compounds, meteorology and oceanography.
- Target child to connect to the broader family - People need a "hook" to pull them into science research
- Workshops targeting untenured teachers who are looking for workshop hours – use AMNH Seminars in Science courses taught through the internet.
- Network teachers to scientists

- Students should make presentations on what they have learned and discovered to ensure complete understanding.
- Use students to educate the public through on-line research projects and power point presentations.
- Internet journals, online broadcasts, face-to-face presentations, lectures, and conferences .
- Collaboration with English and Journalism educators to author articles and broadcast them.
- Organize field trips, incorporate polar science in the curriculum, and teach the basic scientific method
- Barrow students are recreating cultural material that Murdoch collected in traditional and current form. Students elsewhere could do this (fishing gear, clothing, food etc.). Plan, catalogue, describe, research, etc. In order to ensure polar passion in the future, students must learn about Arctic residents.

C. 6-12th (Scott, Perovich, Sparrow, Scott, Barber, Stevenowski)

At the middle school and high school level, linking students to real scientists, and including some type of field experience, are both key ingredients.

- Use model like EPSCoR Alaska Rural Research Partnership (ARRP) -ARRP is a collaboration of pre-college students, teachers and scientists:
  1) Individual or a small group of high school students partner with a University of Alaska scientist on a research project (related to the on-going research of the scientist partner)
  2) Class(es) of K-12 students are partnered with a scientist and engaged in earth system science or environmental research using the GLOBE program. Topics include: genetics of the immune system of caribou, dogs, and whales; feeding ecology of seals; effects of power plant hot water discharges on dissolved oxygen levels of a river.
- Summer field experience for students working with a teacher and scientist (added data collector).
- Network teachers together to build a support community…establish mentoring between HS and MS teachers (NASA Explorer's Schools Program)
- Real time access to data and imagery
- Pre-developed polar science units of study – teachers just pick up and use.

Polar Bear International Science Camp
Student Summer Research Experience

- Researcher clearinghouse – directory of polar researchers and their teaching experience for teachers to use to identify potential classroom visits by researchers
- Hire teachers in various parts of country to serve as teacher/coordinators to
  * Assist researchers with outreach programs
  * Develop and manage IPY activities
  * Run summer field experience program
  * Maintain clearinghouse
- Need to connect investigators/researchers with NSF-funded internet and curriculum sites –to develop polar modules for existing investigative approach learning sites. Use the

internet linked to current curriculum already developed, published and in the classroom. Student focused/inquiry based activities such as the EarthComm series, NSF funded for Earth Science developed by American Geological Institute for High Schools. Middle School program is Investigating Earth Systems. On line data used to solve real world problems.

• Science webcasts -_streaming audio and video from remote polar field sites should be provided. A couple times a week, a broadcast from the fields transmitted via internet. In order for this to occur, a polar connect website must be constructed and maintained.

• Focus on specific events that are unique or unusual such as solstices or equinoxes

• *Schools On Board* model in Canada – hands-on experience for limited number of high school students and teachers–students do a multidisciplinary project, give presentations, and meet northern residents. Hands-on experience with world-renown scientists and graduate students.

Students shown measuring bear tracks

D. <u>Student Competitions</u> <u>(Sugai, Kolb, Barber, Geisbush, Stevenoski, Renouf)</u>

Student competitions are an excellent way to set up cross cutting research, and possibly include some field work for the students.

• A competition for science projects that predict the map of Antarctica without ice should be created.

• National Ocean Science Bowl (NOSB). Student ocean-related science competition can use polar theme

• Intel International Science and Engineering Fair (Intel ISEF) is the world's largest pre-college celebration of science. Held annually in May, the Intel ISEF brings together over 1,300 students from approximately 40 nations

• Toshiba/NSTA Exploravision awards (<u>www.exploravision.org</u>)

• CYBERMSSION web based science, math and technology competition for 6-9th grade teams. Teams propose a solution to a real problem in their community – could link the think locally-act globally theme to this.

• National History Day Competitions – This competition could include an in-depth look at polar explorers, IGY, polar scientists, polar women and any number of other topics.

• American Museum of Natural History Young Naturalist Awards (select a polar theme or IPY theme)

•☐*ARCUS award for Arctic Research Excellence* –international undergrad and grad student research paper competition.

• Establish a new **youth forum** (Jr. Arctic Council; junior Antarctic Treaty Consultative Meetings) for students with wide coverage in age and geographic region would be an excellent way to involve education and youth and has multiple opportunities. Create a big, splashy international youth forum (U.N.-like) combining scientists, educators and students. Youth forum would have wide coverage (age and geographic). Idea is to include discourse and debate. The forum could span beyond science with key questions that students are to evaluate and study. The discussion on these questions can start at the local level, and move to regional, national and then international. The forum could be linked with museum exhibits, GLOBE testing etc.

Some additional suggestions on this Youth Forum included:

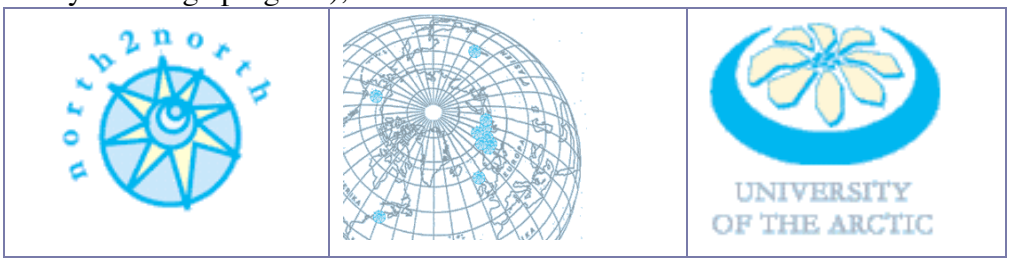
•Roll out with opening of a museum exhibition:

* Facilitate forum by graduate students
* Create school kits accessible on the internet
* Hold debates, contests, etc.
* Involve circumpolar network
* Provide opportunities for northern students
* Key theme: climate change - because it links the work together, as well as creates an interdisciplinary curriculum (social studies, social science, science, politics, psychology)
* Have incentives for teachers to register
* Don't limit questions to just science…include politics, culture, perhaps a National Polar History Month
* Use zoos and museums for a family opportunity

D. <u>Undergraduate Education</u> <u>(Pundsack, Maksym, Goroknovich, Atwood, Caulfield, Albert, Janes, Levy, Kitts, Vogel)</u>

Essential components of undergraduate educational opportunities are interdisciplinary courses and field work.

•☐Build international IPY education/outreach programs using the University of the Arctic's circumpolar PhD networks, north2north student/faculty mobility (northern latitude student and faculty exchange program), and online courses



•☐International exchanges can be life-changing, and work best when students are placed in a heterogeneous group that includes at most one other student from their institution or country.

•☐Develop interdisciplinary courses and activities that are relevant to questions society faces today, and that require the students to role-play various points of view in the decision-making processes.

• Mentorship program for aboriginal youth to participate in research and attend college and grad school.

• Field courses – for all disciplines – on- and off-ice research experience for science majors - Active undergraduate polar observational research opportunities are important at all stages - Use polar issues as a template to assist in inquiry-based learning. Students must have ownership of the research to minimize disconnect. The research experience is contagious and essential to encouraging others to become involved in research and educating the public on it. Need funding opportunities for these.

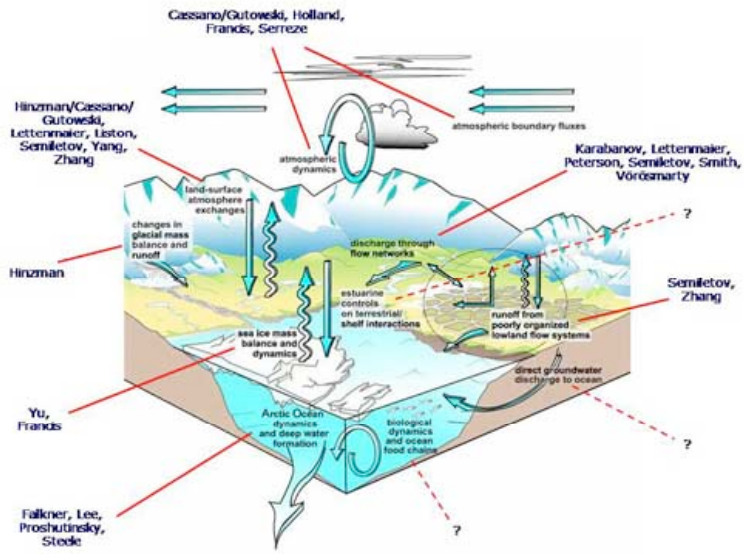
• "The Ends of the Earth" college course developed by Raytheon Polar Services, Fresno State University, the UAF Geophysical Institute, and Interior Aleutian Campus of the University of Alaska to teach students about both ends of the Earth – uniqueness of poles.

• Uses distance learning; geographical and cultural diversity; science through relevant observations; thematic approach to Earth; ready availability of polar researchers

• Field work for students in Kangerlussuaq (Greenland) International Science Support (KISS) or a 1-2 week field trip. There, students will earn about glacial environments and ecology, have live contacts with scientists in Greenland, attend workshops and conferences, and actively participate in the research data-colleting process.

• Need synthesis education – NSF-ARCSS Freshwater Cycle Program (aka Freshwater Initiative or FWI) is excellent vehicle for synthesis education.

• Develop a curriculum for a series of international courses, cross-disciplinary short courses related to science in polar regions, and link curriculum with similar courses in other countries participating in polar region research activities – International Science Course Series (ISCS). Broaden curriculum and enhance international collaboration. Focus is on undergraduate students in order to encourage them to pursue a wider collaborative focus in their studies.



Conceptual model from Arctic Community-wide Hydrologic Analysis and Monitoring Program highlighting key linkages among land, ocean, and atmosphere noting researchers for each area. Synthesis and integration activities are central to the effort to learn more about the connections of these important processes.

G. Graduate Education (Alessa, Robertson, Caulfield, Pundsack, Vogel)

A targeted doctoral degree program should be developed to increase the number of indigenous and Arctic residents. An additional focus should be to train students with an interdisciplinary focus.

• Develop a targeted doctoral degree program for Alaska Natives and Arctic residents that

significantly increases the number of indigenous scholars across the disciplines by the year 2010

- Develop a program that focuses on the complexity of Arctic environmental change issues by promoting synthesis training through planned student interactions with peers and faculty members. This will encourage training of the next generation of polar scientists through an integrated educational program.
- The transition from PhD student to professional researcher is challenging, particularly for those engaged in interdisciplinary activities such as polar research. After years of disciplinary specialization, graduates must quickly develop collaborations across disciplinary, institutional, and international boundaries. Other sciences have a tradition of symposia for young investigators, designed to enhance interdisciplinary understanding and collegial peer networks. Such symposia, designed for new polar investigators should be developed.
- On- and off-ice research experience
- Increase the number of women in graduate work
- Train graduate students in media relations and match them with a scientist/educator to do outreach
- Develop a curriculum for a series of international courses, cross-disciplinary short courses related to science in polar regions, and link curriculum with similar courses in other countries participating in polar region research activities – Proposed International Science Course Series, designed to broaden curriculum and enhance international collaboration. One focus is on graduate students in order to establish international collaboration as a standard research practice.

H. <u>Programs for Teachers and Researchers (Warnick, Clapp, Pagenkopp, King)</u>

Programs for teachers that build awareness, understanding, hands on field work, and connections with science researchers are essential for developing the enthusiasm that will create a student base to become the next wave of science researchers. For researchers, connections to teachers are an important means of outreach and education that allows current research findings to be shared with the community.

- Build, expand and re-establish programs, such as TEA, TREC, REU, STEM (Teaching and Learning Through Arctic Connections), ARMADA, IDEAL, GLOBE –
- Link people together with common polar learning objectives
- Need proper logistical support to be successful
- On- and off-ice research experiences for teachers
- Partnerships with schools for both teacher in-service and classroom visits
- Teachers assist researchers in writing grants with integrated education

- Provide access by local educators to local researchers.
- Develop a curriculum for a series of international courses, cross-disciplinary short courses related to science in polar regions, and link curriculum with similar courses in other countries participating in polar region research activities – International Science Course Series (ISCS). Designed to broaden curriculum and enhance international collaboration. One focus area is science teachers so that they can assist in reaching the next generation of science researchers.
- *Science in the Ice* is an initiative to develop a coherent presentation to introduce cutting edge research from multiple disciplines – glaciology, geology, and astrophysics – with polar science as a unifying theme. Stresses science as a human construct that must evolve and change to remain vital. Partnering National Science Foundation-supported **AMANDA** (Antarctic Muon and Neutrino Detector Array) and its successor, **IceCube**, **TEA** (Teachers Experiencing Antarctica and the Arctic) and MSP **SCALE** (System-wide Chance for All Learners and Educators) it brings together master teachers and active researchers – designed to integrate materials that convey the content and process of these disciplines.

Logo of AMANDA-II

I. <u>Scientists and Research Initiatives</u> <u>(Robertson, Madsen)</u>

Scientists must strive to ensure that polar research remains a central focus at conferences, and in the media. It is through this commitment to keeping polar science in the public's eye that a wider base of understanding and support will be generated. Research is the basis of continued growth of science and education initiatives.

- Media-relations courses/training for scientists – focus on communication
- Promote polar research at meetings NSTA, NABT, SACNAS, AWG, NAGT, etc.
- Survey current researchers to find out how they became "inspired"
- Better Arctic and Antarctic researcher collaboration
- More diversity in polar researchers and logisticians so they better represent general society
- *Census of Marine Life* –(through 2010) global network of researchers in over 50 nations examining the diversity, distribution and abundance of marine life in the oceans – past, present and future – Arctic focus in 2004…continue the emphasis of this topic.

CENSUS OF MARINE LIFE

- Publicize the NSF program for researchers to submit a small education and outreach supplement proposal with or shortly after the submission of a research proposal, usually in collaboration with schools and/or museums. Can also be submitted on the second or third anniversary of research funding. Targeted funding allotments provide an entrepreneurial incentive to doing outreach.

J. <u>Informal Education and Outreach</u>

Do not overlook informal science education venues as they can reach vast numbers of individuals.

Publications ***(Janes, Kitt, Levy, Linder)***

- *Science Work and Super Science* – classroom magazines include polar features
- Children's books
- Coffee table books containing photographs and essays, such as those of legendary photographer Galen Rowell, provide both creative, informal educational material, as well as a keepsake memory of the International Polar Year.

Museums **(Reddy-Vitale, MacPhee, Hutchinson, Pfirman, Bell, Janes)**

- Work with Association of Children's Museums – create traveling polar exhibit – interactive (e.g. kiosk) for formal (e.g. museums) and informal educational settings (e.g. mall)
- Go Polar! Part of EdVenture Children's Science Museum in Columbia, SC – layered program with multiple entry points: monthly newsletter, passport, special honors course, Arctic activities.
- Major Traveling Museum exhibition "Exploring the Changing Poles" – linked to IPY, 50th Anniversary of IGY, 100th anniversary of the Peary-Henson North Pole attainment, and opening of new US South Pole Station in 2007.

NAS Koshland Museum
Environmental Change

- NAS Koshland Museum – New exhibit on impact of environmental change on the poles. This will help to connect science in the Arctic and Antarctic to the public's daily life. Exhibits that consider "science issues in the public policy context" should be developed.
- Smithsonian new Arctic exhibition opening in fall 2005: "A Friend Acting Strangely" Part of "Forces of Change" Smithsonian exhibition. Looks at changes: in land through caribou; in coast through erosion; in sea-ice through warming; "we have seen it before – this is not new". Wanted to make it traveling exhibit but lacked funding.
- Polar museum established with a polar library to house videos and books etc.
- "The Frozen Sublime," – artists exploring the poles – proposal for a temporary traveling exhibition, over 80 paintings, photographs, graphic works, and sculptures that describe American exploration in the Arctic and Antarctic – includes landscapes, explorers, Arctic peoples, polar animals.


Admiral Byrd During BAE II

Films **(Hadingham, Krahmann, Miller, Pfirman, Bell, Sheehan)**

- *Nationally televised*
  - Highlighting major historical expeditions to the poles and connecting to existing research and

researchers: showcase environmental change and variability

• Highlighting scientific research in the poles – example or model is 1st Earth Film festival organized by 32nd International Geological Congress in Florence

• US contribution to first IPY in 1881

• On 1909 Peary and Henson expedition

- *Amateur level films*

  • Digital video camera and software to create short amateur level documentaries on science research in the poles.

  • Use of funding agency public relations depts. to create and disseminate movies

  • Offer classes or workshops on how to create them

  • Student film competition

- *Digital Films*

  • Stories with options for on-screen vocabularies, maps, thumbnail explanations of concepts. Set up at community centers or schools. Example is American Museum of Natural History's "Biobulletins:" creates 5-10 short science features each year. Filmed in HD.

  • Digital classroom (K-12) on WGBH website (starts 2005-2006) - Provides small bits of video (including textual contexts) that teachers can use in a class period

***Communities* (Janes, Bell, Pfirman)**

• Design polar education campaign – kids and communities commit to doing something specific at a given date and time…perform an experiment, record weather etc.

• Promote sister cities – set up educational, business and personal assoc.

• Annually designate "Polar Week" – encourage through UN etc. involvement

• Create lecture circuit for "extreme scientists" – speaker bureaus

• Engage parents and community through "science nights"

• Establish a sister Matthew Henson Center in Manhattanville in 2007 – focus on community involvement in environmental research, education and outreach.

• Education and outreach activities for Elder Hostels – Eco-tourism

***Toys/purchase items* (Levy, Kitts)**

• 'Educational toys' – (e.g. crayons, coloring books, Lego – drilling system, Playmobile, remote controlled skidoos, Dora the Explorer, video games)

• Snow-making machine rental and 'quiz show game'

• Sounds of the poles – recording of sounds

***Broadcasts* (Miller, Perovich, Sheehan, Caulfield, Levy, Kitts)**

• Weekly webcasts and press conferences, and posting journals, streaming video, with larger bandwidth, the McMurdo lectures, articles, and photographs that the audience can follow. Combine film, real-time and virtual resources. Whenever possible, let scientists tell their own story.

• Develop television programming focusing on high-profile polar research issues of relevance to US society; make these available for classroom and other educational purposes

• Aside from family interactions, popular TV series, movies and pop idols have the largest influence on societal values. Focus a TV series and movies on science and environmental awareness.

• Survivor Antarctica and reality shows to engage the teens and young adults!!

• Network program on the poles like Rainey's weekly "What in the World?"

Radio **(Hadingham, Petula)**

• PSA – Polar Science Announcements – small capsules of information plugged into breaks - Based on NOVA news minutes (1-2 minutes) which cost $30,000, or do 1-2 minutes on AM radio

• NPR mechanism to explore polar issues and peoples

• National Geographic radio expeditions has only done 3 on polar areas - encourage more

Scouts **(Elfring)**

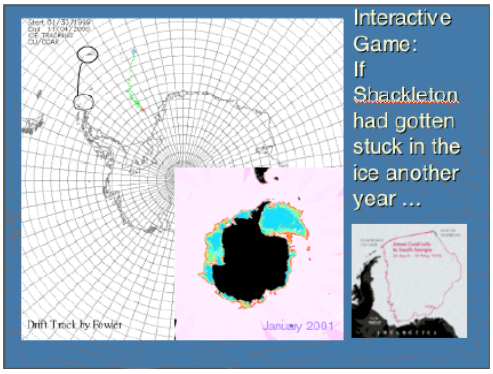
• Boy Scout participation was an important aspect of the last International Geophysical Year. For the upcoming International Polar Year, scientists work with scouts to design an IPY merit badge for both Girl and Boy Scouts.

• Focus on scout science badges – use these to segue into polar themes. Look at wider opportunity experiences for scouts where individual scouts apply for unique a career exploration or life experience opportunities

Zoos **(Foat)**

• Develop more opportunities like Polar Bears International (PBI) (in partnership with Tundra Buggy® Tours and regional zoos) a distance learning program where students participate in activities geared to increase science literacy, create environmental awareness, promote environmental conservation, web journaling.

• National Bear Awareness Week supported through Defenders of Wildlife, American Zoo and Aquarium Association' Bear Taxon Advisory Group (BEAR TAG focuses on the special needs and conservation issues of the world's eight bear species, both in zoos and the wild) and Polar Bears International.



Interactive Game (Pfirman/Bell)

Interactive Games **(Albert, Pfirman)**

• Curiosity-driven interactive activities and electronic games that teach science as a by-product, require critical thinking, and can include groups of kids interacting and chatting.

• Interactive computer game "Polar Explorer" based on simulations and role playing – focus on actual environmental conditions, physics of snow, ice and air, decision making.

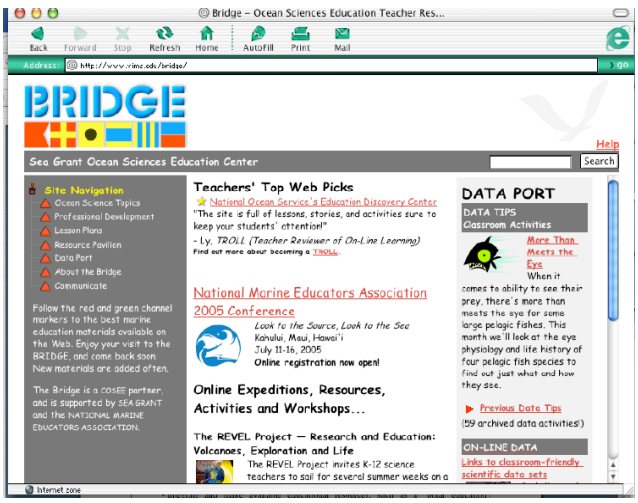
Courses – General Interest for the Public **(Caulfield)**

- Develop quarterly online short courses through University of the Arctic on polar issues of high interest: e.g., climate change, contaminants, polar tourism, conservation of flora and fauna, indigenous cultures and languages, environment and development in polar regions, polar history, polar resource regimes, polar transportation and logistics, telemedicine
- Field experience courses for students, educators, film makers, journalists, artists

K. Website (Suplee, Berger, Cook)

Suggest creation and active maintenance of a website with the following features:

- Build polar news/interactive/coordinated/managed polar research web portal designed for community access covering multitude of topics – "BiPolar.org" – with scientists, teachers, data sets from research, information pages and activities, textbook web-pages linked to in-place lesson plans, science education links, links through NSF, NASA, AGI, AAAS, Exploratorium, museums, zoos.
- Web accessed "contact-clearinghouse" – connect local educators to local researchers by providing a clickable United States map with researcher sidebars, link to research institutions with active field work by name and topic
- An interactive website containing nested and linked maps that students can navigate – both an educational and fun tool for students to use. Baseline "knowledge map" by region, scale and culture



http://www.vims.edu/bridge

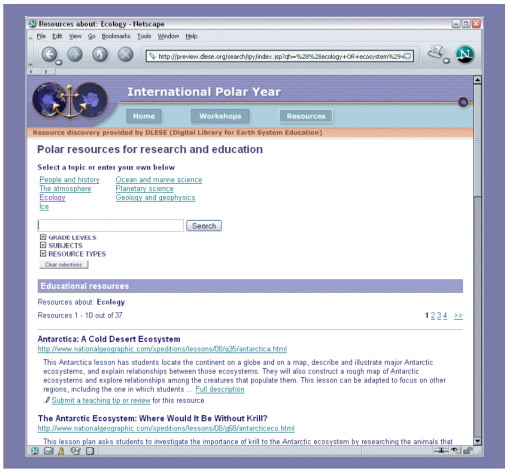
- Advertise with article in Chronicle of Higher Education and other teacher-frequented venues
- Web-connected student-driven in-situ experiments
- Model websites: http://www.vims.edu/bridge (BRIDGE website of marine education materials- a COSEE partner) (e.g. CHRONOS [Also on CD for school systems with limited bandwidth access])

L. Additional Uses of the Web (Cook, Doran)

- Online polar science courses, seminars and symposiums to explore local connections and impacts on polar regions.
- Access to current research on the web – video-clips, links to web etc.
- Develop listserv for students and teachers similar to ARCUS list of Arctic researchers.
- Use NSTA as means to publish, present at conferences, online and/or strand training
- Point to point video conferencing - Provide facilities and band-width at USAP field hubs
- Provide funds to equip classrooms with Polycom stations at universities doing polar research; also to K-12 institutions who commit to using a polar curriculum

M. Data Summaries (Suitor, Ledley, Beitler)

The creative use of data in helping people to understanding of the poles offers unique opportunities to enhance learning and build excitement.



- ***Access to data through Digital Library System (DLESE)*** (Ledley, Sauter)
  • Use the Digital Library for Earth System Education (DLESE) and National Science Digital Library (NSDL), to facilitate polar science communication.
  * Develop a "Polar Science Collection".
  * Integrate and make available educational resources, such as a "polar education package."

- ***Comprehensive Information database*** (Hickox)
  • Develop infrastructure to compile and maintain comprehensive web-based catalogue and schedule of current and future polar research initiatives (national and international), and associated education and outreach programs
  * Initial reference point for researchers, media, educators, students, and the general public – bring the whole community together
  * Update frequently and serve live data streams where possible

- ***Use of NASA data*** (Drobot)
  • NASA has developed a strategy for long-term monitoring of some key parameters needed for answers regarding climate change and its relation to social systems. This technology consists of a group of six satellites that can make a suite of earth observations referred to as the "A-Train". Data from this group of polar orbiting satellites, as well as from the Orbital Carbon Observatory (OCO), and older Quikscat and new Seawinds radar missions, can provide focus for an education program based not only on the acquisition of polar data but also on how these data correlate with global observations.
  • Use NASA TV network available 24 hours a day on the web

- ***Data and Learning*** (Rapp)
  • To provide better conceptual understanding, polar scientists could use visualizations systems and computer driven simulations. Visualizations have been offered as worthwhile tools for helping students understand complex systems and processes in science classrooms. Multimedia visualization systems can be interactive and dynamic; they can provide students with hands-on experiences that would be impossible given pragmatic limitations (e.g., expense associated with travel, or danger associated with actual exploration).
  • Collaboration with the GEOWALL group (www.geowall.org) currently investigating whether 3-dimensional presentations of geoscientific information facilitate learning.

N. IPY (Jeffries, Renouf, Levy, Sheehan)

The International Polar Year is an extraordinary outreach opportunity to celebrate science in the polar regions. IPY provides opportunities for K-12 educators and scientists to collaborate in beneficial research experiences to improve science education and awareness, and help bridge gap between K-12 and higher education. IPY is a chance to entrain more students into thinking science, especially polar science, is "cool". As part of the IPY kick-off a major, simultaneous international launch event should be held in March 2007.

Polar Postage Stamps (Jeffries & Petula)

Have a stamp design contest. At the workshop it was also suggested that the design contest could include schoolchildren: the First Day of Issue ceremonies for the stamps could occur simultaneously at an Arctic (Barrow) and Antarctic (McMurdo or South Pole) location with an official US Post Office, and the successful young stamp designers attend these ceremonies.

MUST START NOW TO BUILD FOR IPY (Petula)

Develop an integrated plan with a "how to" guide and funding for polar research, education, and outreach in conjunction with IPY that addresses needs of: a) *undergraduate and graduate students, b) K-12 education, and c) the broader public*

School Groups Could Compare IPY's

- Transform materials and resources (photos and diaries) from IGY into community education resources
- Create specific projects to compare IPYs
- Develop and deliver IPY packets to K-8 teachers prior to the start of IPY school year
- An important and practical objective of IPY educational outreach is to recognize that the earth is a system and that it is best to acquire seasonal and secular atmospheric, terrestrial and oceanic environmental data from space.
- Successful only if the media, educators, and scientists work together to reach students and the general public
- Array of activities - such as ongoing informative website, background information, live web cams and e-mails from poles, educator participation in field studies, and public lectures provided by scientists.
- Dedicated time and effort for face-to-face interaction
- International/National "stamp of approval" mechanism set up to authorize official IPY materials

IGY Books

Set up a series of Immersive-Interactive Polar Experiences (Renouf, Kitts, Levy)

- A freezer where you could create the experience of pulling a sled
- IPY semi trailer truck traveling around the United States with "Got Snow?" on the sides - a traveling exhibit

• Taking star readings to fix your position in a simulated "rough and freezing" sea
• Restaurant recreate the diet of early polar explorers
• Data collection project that schools or individuals can bid to run – assist with large projects where there are lots of data that are easy to monitor (runoff from Greenland's ice sheet)
• Bid for a chance to remotely use equipment at the poles – lease research time

O. <u>International</u> (Johnson-Amine, Barber, Gatti, Cook, Bell)

The National efforts for polar science education and for IPY should mirror and enhance International efforts.

• Multi-pronged, long-termed initiatives (ANDRILL, cross-cutting, etc)

• Integrate international projects - showcase key projects with major press events
• Promote the exchange of scientists between foreign universities to study and/or collaborate in international research.
• Link networks and observatories network and satellite
  * Census of marine life
  * Circumarctic environmental observatories network and satellites
  * Ocean observatory network
• Youth forum (Jr. Arctic Council; junior Antarctic Treaty Consultative Meetings) that has wide coverage (age and geographic)
• Develop an international catalogue of polar researchers and research projects
• Publish multilingual material so that we reach a broad audience
• Funds to support polar researchers in poor countries/communities
• Coordinate centralized activities (control what goes out)
• Value added of enduring effects – for Arctic rim population/science supports
• Modernize existing stations to make them more environmentally friendly (better technology)
• International polar-focused programs should be developed and available on line (target higher education as well as community level education). Think globally – act locally as a way to connect people and local actions to the larger picture. Underpin by overarching themes (such as climate change, contaminants, microbiota, etc.)
• Build on existing *GLOBE* program for an international science/education program– (currently managed by UCAR and CSA , funded mainly by NASA and NSF) – Norway developed special program for Arctic environments looking at persistent organic pollutants (GLOBE Arctic POPs). GLOBE is an international science and education program. There are 107 GLOBE countries to date. The GLOBE Arctic POPs project had at least two High Schools from 7 countries in the Circumpolar North [US, Norway, Finland, Sweden, Iceland, Russia, Canada] that participated. Students conduct studies and gather data

close to their school and share it online with a central data repository for worldwide comparison for use by scientists and others including students.

* Two Alaskan schools (Kodiak and Polaris HS) represented the US in this international school project. Elena Sparrow, coordinator of the Alaska GLOBE Program and the Alaska GLOBE Arctic POPs, provide contacts in Nordic communities.

• Make better use the International Polar Foundation (IPF) – which informs the public on the research being carried out in the Poles. Some programs:

* EONS, the Earth Observation Network for Schools provides students with hands-on projects that demonstrate the scientific method and have useable results. Idea for a project: construct an environmental observation station from everyday objects

* Series of Polar Science and Adventure Expeditions organized to look at historical vs. current conditions

* The Polaris Climate Change Observatory (PCCO), a base to run IPY activities – exhibitions, live communication events, traveling exhibitions, polar film festival.

* Arctic Drift Project – International Polar Foundation 2 year long drift in the Arctic Ocean – opportunity for collaboration with 2007 options. Icebound ship will be used as floating research platform.

Beginning in June 2006, in collaboration with Alain Hubert, the International Polar Foundation (IPF) and the team of the schooner Tara will re-enact an epic Arctic journey and operate an Arctic research station while doing so. In the summer of 1893, Fridtjof Nansen set off from Norway with a twelve man crew, aboard the Fram, a three-masted sailing vessel designed to withstand the crushing power of the ice pack. The Fram expedition lasted three years, after which the ship, the crew and the captain returned safely to port in 1896.

Resource List for Polar Education and Outreach

Pedagogical Resources

Integrating Research and Education
Bridget Avila, 2003
http://www.nap.edu/catalog/10627.html

Summary report of a workshop providing guidance for researchers applying to the National Science Foundation (NSF) for funding. NSF guidelines require applications to address the "broader impact" of the proposed research. Presentations at the workshop provided ideas on how to do this by engaging in undergraduate education, K-12 education or public outreach via museums or journalists. The workshop summary discusses issues to consider in choosing an appropriate collaborator for the education or outreach component of the project and how to build in methods for assessing the success of the project. It also provides lists of resources helpful in writing education proposals and discusses the similarities between research in education and scientific research.

How People Learn: Brain, Mind, Experience, and School
National Research Council, J. Bransford, A. Brown and R. Cocking, Eds. 2000
http://www.nap.edu/books/0309070368/html/

How do experts learn and how is this different from non-experts? What can teachers and schools do–with curricula, classroom settings, and teaching methods–to help children learn most effectively? This book offers exciting new research about the mind and the brain that provides answers to these and other questions. New evidence has significantly added to our understanding of what it means to know, from the neural processes that occur during learning to the influence of culture on what people see and absorb.

How People Learn examines these findings and their implications for what we teach, how we teach it, and how we assess what our children learn. The book uses exemplary teaching to illustrate how approaches based on what we now know result in in-depth learning. Topics include:

- How existing knowledge affects what people notice and how they learn.
- What the thought processes of experts tell us about how to teach..
- The relationship of classroom learning and everyday settings of community and workplace.
- Learning needs and opportunities for teachers.
- A realistic look at the role of technology in education.

Bringing Research on Learning to the Geosciences
Cathy Manduca, David Mogk, and Neil Stillings, 2004
http://www.johnsonfdn.org/confpub.html

A workshop report - twenty leaders from geoscience education, learning science, and the application of learning science to STEM (Science, Technology, Engineering and Mathematics) disciplines gathered to initiate the development of a community engaged in applying learning science to the geosciences.

Discussion concentrated on six areas, from development of geoscience learning goals to application of pedagogical models. Each discussion session is summarized in PDF format. Each of the participants also contributed an essay, which are available for download in PDF format. The Final Report is now available. For more information, http://serc.carleton.edu/research_on_learning/.

Knowing what students know: The science and design of educational assessment,
J. Pellegrino, N. Chudowsky and R. Glaser, Eds. National Academy Press 2001
http://www.nap.edu/catalog/10019.html

While there are many strategies for improving the educational process, we need a way to find out what works and what doesn't work as well. Educational assessment seeks to determine just how well students are learning and is an integral part of our quest for improved education.

The nation is pinning greater expectations on educational assessment than ever before. We look to these assessment tools when documenting whether students and institutions are truly meeting education goals. But we must stop and ask a crucial question: What kind of assessment is most effective?

At a time when traditional testing is subject to increasing criticism, research suggests that new, exciting approaches to assessment may be on the horizon. Advances in the sciences of how people learn and how to measure such learning offer the hope of developing new kinds of assessments-assessments that help students succeed in school by making as clear as possible the nature of their accomplishments and the progress of their learning.

Knowing What Students Know explains how expanding knowledge in the scientific fields of human learning and educational measurement can

form the foundations of an improved approach to assessment. These advances suggest ways that the targets of assessment-what students know and how well they know it-as well as the methods used to make inferences about student learning can be made more valid and instructionally useful. Principles for designing and using these new kinds of assessments are presented, and examples are used to illustrate the principles. Implications for policy, practice, and research are also explored.

Inquiry and the National Science Education Standards,
NRC, National Academy Press 2000
http://www.nap.edu/catalog/9596.html

Inquiry and the *National Science Education Standards* is a practical guide to teaching inquiry and teaching through inquiry, as recommended by the National Science Education Standards. This will be an important resource for educators who must help school boards, parents, and teachers understand "why we can't teach the way we used to."

"Inquiry" refers to the diverse ways in which scientists study the natural world and in which students grasp science knowledge and the methods by which that knowledge is produced. This book explains and illustrates how inquiry helps students learn science content, master how to do science, and understand the nature of science.

This book explores the dimensions of teaching and learning science as inquiry for K-12 students across a range of science topics. Detailed examples help clarify when teachers should use the inquiry-based approach and how much structure, guidance, and coaching they should provide.

The book illuminates the subtle interplay between concepts, processes, and science as it is experienced in the classroom. Inquiry and the *National Science Education Standards* shows how to bring the standards to life, with features such as classroom vignettes exploring different kinds of inquiries for elementary, middle, and high school and Frequently Asked Questions for teachers, responding to common concerns such as obtaining teaching supplies.

Turning to assessment, the committee discusses why assessment is important, looks at existing schemes and formats, and addresses how to involve students in assessing their own learning achievements. In addition, this book discusses administrative assistance, communication with parents, appropriate teacher evaluation, and other avenues to promoting and supporting this new teaching paradigm.

Boys and Girls Learn Differently: A Guide for Teachers and Parents
Michael Gurian, John Wiley and Sons, ISBN 0787961175, 2002. (not available on line)

Many of us have felt instinctively that boys and girls don't learn in the same way or at the same rate. Now, we have the scientific evidence to document and understand their many biological gender differences. For instance, girls talk sooner, develop better vocabularies, read better, and have better fine motor skill. Boys, on the other hand, have better auditory memory, are better at three-dimensional reasoning, are more prone to explore, and achieve greater abstract design ability after puberty. In this profoundly significant book, Michael Gurian synthesizes this current knowledge and presents a new way to educate our children based on brain science, neurological development, and chemical and hormonal disparities.

Catalogue of Pedagogies
Project Kaleidoscope Volume IV: What works, what matters, what lasts, 2004 catalogue
http://www.pkal.org/template2.cfm?c_id=1294

PKAL Volume IV describes some of the pedagogies changing the undergraduate STEM learning environment.

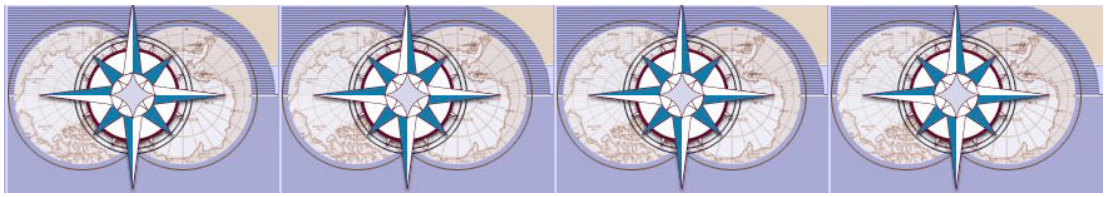
Even a quick survey of these various approaches reveals several prominent themes:

- *the community of learners*, in which students are enmeshed in a healthy social interaction that creates a sturdy sense of identity
- *the personal character of learning*, calling for students to absorb ideas and learn to apply them in his or her own way
- *the connectedness of knowledge*, providing a frame of reference in which ideas can be examined, tested, and put to work.

These qualities meet the test of diffusibility; thus, these pedagogies can be incorporated into the work of colleagues on campuses of all sizes and circumstances.

Wingspread Conference Report
http://www.johnsonfdn.org/confpub.html
http://serc.carleton.edu/research_on_learning/

The Wingspread Conference Report site provides various resources, including the final report called “Bringing Research on Learning to the Geosciences”, of the Wingspread Conference. See both website links.



Umbrella Organizations/Association

American Association of Museums (AAM)
http://www.aam-us.org/
The American Association of Museums (AAM) is dedicated to promote and advance the museum community. AAM is the only organization representing the entire scope of museums, professionals, and non-paid staff who work for and with museums. Advocacy programs, professional education, information exchange, and focused guidance have helped museums across the country better serve the public.

American Zoo and Aquarium Association
http://www.aza.org
The American Zoo and Aquarium Association is a non-profit organization dedicated to advance zoos and aquariums and to create a world where humans respect all living things. It hosts an annual national conference, as well as workshops, education programs, and grants, in order to achieve its goals.

Arctic Research Consortium of the United States (ARCUS)

http://arcus.org
The Arctic Research Consortium of the United States, ARCUS, is a non-profit organization that consists of and connects various educational, professional, and scientific institutions dedicated to the purposes of Arctic research. A recent addition to ARCUS's commitment to education is TREC, Teachers and Researchers Exploring and Collaborating, a network between the science and education fields improving and strengthening science education. TREC allows K-12 teachers participation in Arctic research by working closely with scientists. An interactive program for students as well, providing links to educational games and interactive programs that explore the Arctic.

Association of Children's Museums (ACM)
http://www.childrensmuseums.org
The Association of Children's Museums (ACM) is an international association dedicated to bringing together children and families to encourage lifelong learning. Its efforts include expanding beyond the walls of museums and into day care centers, schools, and homes of children and families.

Association of Science and Technology Centers (ASTC)
http://www.astc.org
The Association of Science and Technology Centers (ASTC) is dedicated to expand the public's knowledge of science through informal education. In addition to its annual conference, the ASTC's services include workshops, a website, various conferences, and traveling exhibitions.

Building a Presence for Science (BAP)- part of National Science Teachers' Association (NSTA)
http://ecommerce.nsta.org/bap/coordinators.asp
The site provides a list of state coordinators across the country from whom information for upcoming events and opportunities spreads. Each school, in turn, has a "point of contact" to help pass the information on.

Digital Library for Earth System Education (DLESE)
http://www.dlese.org/
DLESE is a resource dedicated to Earth system education for the entire community, ranging from educators to developers. For undergraduate and K-12 educators, DLESE features a variety of information, including data (factual information), tools (interactive and collaborative), and themed collections on a variety of subjects. The library is designed to integrate Earth research and education.

Geological Society of America, The
http://www.geosociety.org/
The Geological Society of America is a scientific society that provides grants, awards, conferences, and publications to advance human understanding of Earth and enhance the professional growth of its members.

GLOBE Program
http://www.globe.gov/fsl/welcome.html
Educators, scientists, and the general public can join this national and international program. There are

various resources for everyone, such as a teacher's guide that includes lessons, activities, protocols, labs, etc. for all the components of the Earth's system. For scientists, there is a "scientist corner," in which site visitors can meet the scientists participating in this program, view and learn about the instruments used, and read various articles about the research being conducted at the Poles.

International Council of Museums (ICOM)
http://www.icom-oesterreich.at/2007/en-format.html
The International Council of Museums (ICOM) is committed to conserving the world's cultural heritage. It hosts conferences to discuss advancements and improvements of museums. In August 2007, Vienna is hosting ICOM's 21st conference.

International Polar Foundation (IPF)
http://www.internationalpolarfoundation.org
The goal of this foundation is to raise public awareness about polar science by providing various activities and educational programs to the public. These range from films, newsletters and museums, to an educational program that develops educational modules and activities specifically for primary and secondary schools.
(http://www.polarfoundation.org/old/www_educapoles/)

International Polar Year (IPY) 2007-2009
http://us-ipy.org/
The US IPY website for IPY information. A summary of the "A Vision for the International Polar Year 2007-2008"--outlines its "vision of key science challenges, enabling technologies, and public outreach opportunities" is downloadable at http://us-ipy.org/download/IPY_Summary.pdf

National Aeronautics and Space Administration (NASA)
http://quest.arc.nasa.gov/arctic/
NASA Quest's goal is to provide resources to students, educators, and the general public about space. Working with the United States Coast Guard, NASA created an interactive website allowing its audience to explore the Arctic region, as well as experience it through a select group of people living in that region.

NASA Sponsored Universities Space Research Association's Earth System Science Education (ESSE) Program
http://www.usra.edu/esse/essonline/)
ESSE 21 is a collaborative undergraduate/graduate education program offering small grants to colleges and universities to engage a diverse interdisciplinary community of faculty and scientists in the development of courses, curricula and degree programs and sharing of learning resources focused on the fundamental understanding and application of Earth system principles for the classroom and laboratory. In addition, it provides dozens of news-related, scientific, and educational links for educators and students alike to learn more about all of the components of Earth, from space science to life science to everything in between.

National Association of Geoscience Teachers (NAGT), The
http://www.nagt.org/
The National Association of Geoscience Teachers, established in 1938, seeks to improve earth science teaching in both formal and informal instruction. Technical sessions, workshops, field trips, and an annual meeting are among the events NAGT sponsors to achieve its goal.

National Oceanic and Atmospheric Administration (NOAA)
http://www.arctic.noaa.gov/index.shtml
The National Oceanic and Atmospheric Administration (NOAA) created an Arctic theme page that provides information about all things Arctic. It includes current events in the Arctic, laboratory and science links, as well as educational links for educators, students, and the general community. The links range from facts about glaciers to the activities about the Arctic flora.

National Optical Astronomy Observatory
http://www.noao.edu
The National Optical Astronomy Observatory of the National Science Foundation is a website that provides research, information, and support for astronomical science.

National Science Foundation (NSF); Office of Polar Programs
http://www.nsf.gov/od/opp/
The Office of Polar Programs (OPP) manages, and initiates NSF funding for basic research and its operational support in the Arctic and the Antarctic. The OPP support of research in the Antarctic and the Arctic acknowledge the need to understand the relationships of these regions with global processes and the need to understand the regions as unique

entities. OPP provides support for investigations in a range of scientific disciplines. In addition to funding and proposal information the website has links to polar news, polar research both past and present, and polar reports.

Oceanography Society (TOS), The
http://www.tos.org
The Oceanography Society's goal is to disseminate knowledge of oceanography and its importance in the future. TOS accomplishes this through its publication *Oceanography*, a series of meetings, including the annual International Ocean Research Conference (co-hosted by UNESCO's Intergovernmental Oceanographic Commission), and awards given to recognize important oceanographic research being conducted.

University of the Arctic
http://www.uarctic.org
The University of the Arctic organization is a network of universities, colleges, and other organizations that are committed to Northern education and research. Educators can use this website to gain access to the programs offered by the University of the Arctic, as well as information about current events in the North.

Polar Organizations/Institutions

Alaska Native Knowledge Network
http://www.ankn.uaf.edu
The Alaska Native Knowledge Network is a resource created to share knowledge about the cultural experiences of Alaska Natives, including a section designated to science and mathematics education. The section contains Alaskan and non-Alaskan links, such as to Alaska Science Forum, which provide both pictures and written explanations of various components of Alaska's environment.

American Society of Limnology and Oceanography (ASLO)
http://aslo.org/phd.html
The American Society of Limnology and Oceanography provides programs for recent PhD's to participate in that involve the environment and education.

Antarctica: ITASE
http://www.secretsoftheice.org/
The Secrets of the Ice is an organization sponsored by the Museum of Science, National Science Foundation, and the Institute for Quaternary and Climate Studies. It displays information about the exploration of Antarctica, the ice core research being conducted there, and the scientific expeditions of the past. In addition, learning resources such as books, laboratory activities, and videos are provided to help students and communities discover the Antarctica.

ArcticCHAMP- Community-wide Hydrologic Analysis and Monitoring Program
http://ArcticCHAMP.sr.unh.edu
Arctic CHAMP provides all factual, educational, a research-based information about the hydrology cycle of the North. Its education and outreach section encourages educators and students to bring science into the real world.

Arctic Research Consortium of the United States (ARCUS)
http://www.arcus.org/
The Arctic Research Consortium of the United States, ARCUS, is a non-profit organization that consists of and connects various educational, professional, and scientific institutions dedicated to the purposes of Arctic research. A recent addition to ARCUS's commitment to education is TREC, Teachers and Researchers Exploring and Collaborating, a network between the science and education fields improving and strengthening science education. TREC allows K-12 teachers participation in Arctic research by working closely with scientists. An interactive program for students as well, providing links to educational games and interactive programs that explore the Arctic.

Byrd Polar Research Center
http://www-bprc.mps.ohio-state.edu
Ohio State University's Byrd Polar Research Center encourages polar research. Educators of high school and undergraduate students can use this source to teach more about research in general, as well as encourage polar research education, to their students. Various resources, such as polar and weather pointers, are also included in this website to supplement research.

Barrow Arctic Science Consortium (BASC)
http://www.arcticscience.org
Barrow Arctic Science Consortium is dedicated to integration of research and education in Alaska, Russia, and the Arctic Ocean. The site lists the facilities BASC provides, as well as information about the research conducted in the various programs, such as its educational outreach program.

IceCube
http://icecube.wisc.edu

University of Wisconsin's website provides information about IceCube, which is a one-cubic-kilometer international high energy neutrino observatory being built on the South Pole. The site provides construction information, IceCube's goals, as well as career opportunities and publications that the public may be interested in.

Murie Center
http://www.muriecenter.org/alaska.htm
This website celebrates the 1956 Murie Sheenjek Expedition, a defining moment for American Conservation. In honor of the 50th anniversary of the expedition, the Arctic National Wildlife Refuge Expedition is being celebrated in 2006. Additionally, the Murie Center, an organization located in Alaska, was created to inspire people to respect and appreciate the wilderness of the Arctic, as the Murie's have done. The center provides group sessions, community celebrations, symposiums, and more to promote spirit and respect of the wild.

National Ice Center
http://www.natice.noaa.gov/
The National Ice Center provides an archive that educators and the community alike may access to learn more about the history of Antarctica, Arctic, the Great Lakes, and other water regions of the country. Educators of all levels will find this source useful in order to find factual information of the various regions.

Office of Marine Programs
http://omp.gso.uri.edu
Office of Marine Programs (OMP) website includes links to education programs, publications, programs, and activities that visitors may participate in. Its goal is to integrate environmental education with science communications.

Scott Polar Research Institute - Directory of Polar and Cold Regions Organizations
http://www.spri.cam.ac.uk/lib/organ/keyindex.htm
The Scott Polar Research Institute of the University of Cambridge provides a directory of Polar and Old Region Organizations in most major countries. Educators in these countries are able to gain access to these organizations, which can send educational information (from documentaries to pamphlets) that may be good supplements to polar education.

Secrets of the Ice
http://www.secretsoftheice.org
The Secrets of the Ice is an organization sponsored by the Museum of Science, National Science Foundation, and the Institute for Quaternary and Climate Studies. It displays information about the exploration of Antarctica, the ice core research being conducted there, and the scientific expeditions of the past. In addition, learning resources such as books, laboratory activities, and videos are provided to help students and the community discover the Antarctica.

University of Alaska Northern Studies
http://www.uaf.edu/northern
The University of Alaska provides information about Alaska, their students, and most importantly, the Northern Studies Program. The program is an interdisciplinary program in which students study the problems and policies of the North. Educators should encourage students interested in Alaskan history and public policy to apply to this program to further their Alaskan education.

U. S. Fish and Wildlife - Arctic National Wildlife Refuge
http://arctic.fws.gov/index.htm
The United States Fish and Wildlife Service of Alaska has established an Arctic National Wildlife Refuge to preserve the wildlife of the region. Educators teaching wildlife conservation and extinction will find the factual information helpful. Educators of middle schools are especially the target audience because the refuge provides science and math lessons and activities for students to learn more about the Arctic refuge.

General Resources/Databases

70South
http://www.70south.com/links/edu_links
70South is a resource that provides articles, as well as other resources, about everything concerning Antarctica, from its birds to stations to maps. Educators of all levels will find this site useful because it provides both articles *and* pictures.

Aerospace Engineering Sciences
http://snowwhite.colorado.edu/
Part of the University of Colorado at Boulder, the Aerospace Engineering Sciences program combines both research and education for undergraduate and graduate students interested in the various components of aerospace engineering.

Alaska Native Knowledge Network
http://www.ankn.uaf.edu/
The Alaska Native Knowledge Network is a resource created to share knowledge about the cultural experiences of Alaska Natives, including a section designated to science and mathematics education. The section contains Alaskan and non-Alaskan links,

such as to Alaska Science Forum, which provide both pictures and written explanations of various components of Alaska's environment.

Alaska Native Science Commission
http://www.ankn.uaf.edu/ansc.html
One can access information about the Alaska Native Science Commission through the Alaska Native Knowledge Network. ANSC supports scientific research that perpetuates Alaska Native cultures, as well as protects the indigenous property.

ANDRILL
http://andrill-server.unl.edu
ANDRILL (Antarctic Drilling) is an initiative taken by various countries across the world to investigate Antarctica's role in the global environmental change. The drilling will provide clues to determine the climatic, volcanic, and tectonic history of the region.

Antarctic Images
http://www.nsf.gov/od/opp/antarct/imageset/start.htm
The National Science Foundation provides updated, detailed pictures of various geographical and scientific components of Antarctica, from its size in comparison to that on the United States to the microorganisms found in the waters surrounding Antarctica to the different satellite communications' technology. These pictures may help students, as well as the public at large, better understand the various physical concepts of Antarctica.

ArcticCHAMP
http://ArcticCHAMP.sr.unh.edu
Arctic Community-wide Hydrologic Analysis and Monitoring Program (CHAMP) provides all factual, educational, a research-based information about the hydrology cycle of the North.

Arctic Coring Expedition (ACEX)
http://www.ecord.org/acex/acex.html
This expedition drills to the deepest of Arctic cores in order to examine and learn about the past in order to help solve the mystery of the recent climate changes.

Arctic Environmental Atlas
http://maps.grida.no/arctic/
An interactive map of the various landcovers (forest, grassland, permafrost) of all regions of the world is one of the key features of the Arctic Environmental Atlas. Students and educators will find this site's visual representations of the world at various views and depths useful.

Arctic Region Climate System Model (ARCSyM)
http://cires.colorado.edu/arcsym/
The Polar Climate and Meteorology group studies the climate and meteorology Arctic and Antarctic using various system models. The site also provides various projects, published and current, that educators may find useful when teaching.

Barrow Area Information Database-Internet Map Server (BAIDS-IMS)
http://ims.arcticscience.org/
It provides both current and historical data for teachers, students, and scientists to use. This database may be geared towards higher institutions (undergraduate and graduate levels), but all educators may find it useful for students to learn geography.

Canadian Arctic Shelf Exchange Study (CASES)
http://www.cases.quebec-ocean.ulaval.ca/school.asp
Canadian Arctic Shelf Exchange Study (CASES) is a national program that integrates Arctic science research into schools.

Census of Marine Life
http://www.coml.org/coml.htm
This network enables researchers to share information about marine life, from its history to current projects to future predictions. This also includes outreach projects on various topics of marine life.

Circumarctic Environmental Observations Network-Internet Map Server (CEON-IMS)
http://ceonims.org/
This database provides interactive maps and data that all educators may find useful for geographical study to help enable visualization. Higher institutions, such as undergraduate and graduate levels, may find the data that is available most helpful.

Cold Regions Research and Engineering Laboratory (CRREL)
http://www.crrel.usace.army.mil/
The goal of this laboratory is gaining knowledge of the cold regions through research and engineering. This laboratory conducts military-based research to characterize constraints placed on army material and operations in a cold, realistic environment and determine the impact of the cold on construction, operations, and human activity.

Colorado Center for Astrodynamics Research (CCAR)
http://www-ccar.colorado.edu

The Colorado Center for Astrodynamics Research is a space science program dedicated to research astrodynamics, satellite meteorology, oceanography, geodesy, and terrestrial vegetation. Educators may use this resource to contact various scientists, as well as guide students interested in astrodynamics to further their education.

DLESE
http://www.dlese.org/
DLESE is a resource dedicated to Earth system education for the entire community, ranging from educators to developers. For undergraduate and K-12 educators, DLESE features a variety of information, including data (factual information), tools (interactive and collaborative), and themed collections on a variety of subjects. The library is designed to integrate Earth research and education.

Earth Exploration Toolbook (EET)
http://serc.carleton.edu/eet
Earth Exploration Toolbook presents case-study educational uses of Earth Science datasets and scientific tools.

Ecosystems
http://ecosystems.mbl.edu/partners
Ecosystems provides information about the Arctic environment, which is sensitive to climate change. It also provides education and outreach information, data about the Arctic system, photography, publications, and more.

Houston Advance Research Center (HARC)
http://www.harc.edu/harc
Houston Advance Research Center is a non-profit organization dedicated to improve human and ecosystem well-being. It provides information about components of the environment, health, and society in order to educate the public about the Earth.

IceCube
http://icecube.wisc.edu
University of Wisconsin's website provides information about IceCube, which is a one-cubic-kilometer international high energy neutrino observatory being built on the South Pole. The site provides construction information, IceCube's goals, as well as career opportunities and publications that the public may be interested in.

Institute of Social and Economic Research (ISER)
http://www.iser.uaa.alaska.edu/
The Institute of Social and Economic Research (ISER) provides information on all current and past research projects. In addition, it provides information on various environmental studies and their impact on the environment.

International Arctic Research Center (IARC)
http://www.iarc.uaf.edu
IARC was established to promote international cooperation and coordination of Arctic climate change research. Scientists from around the world work together to study Arctic climate change, the causes of these Arctic climate changes and try to reduce uncertainty of climate change prediction.

Mathematics and Science Initiative
http://www.ed.gov/rschstat/research/progs/mathscience/sciencesummit04.html
The Mathematics and Science Initiative site provides a list of the presentations of the Science Summit and the Mathematics and Science Initiative, as well as links that provide further information on the presenter and presentations.

MMAB Sea Ice Analysis History Page
http://polar.ncep.noaa.gov/seaice/Historical.html
This Sea Ice Analysis History Page from the Marine Modeling and Analysis Branch pictorially shows the development and reduction of sea ice of the past decade in both the North and South Poles. Students and educators may use this website to track their personal expeditions through the North and South Pole.

National Geographic
http://www.nationalgeographic.com/
National Geographic provides concise articles and maps about all components of society, including people, culture, environment, animals, and nature, in all different parts of the earth. Educators may be able to use National Geographic as a source of current events for their students.

National Science Digital Library (NSDL)
http://www.nsdl.org/
This online library provides resources for science, technology, engineering, and mathematics education.

National Science Foundation - Polar Related Links
http://www.nsf.gov/od/opp/wwwsites.htm
The National Science Foundation has created a website containing various Antarctic, Arctic, and Polar Region links that those interested in discovering information about the regions may access. Information includes facts of the regions from various United States government agencies, historical information, and research programs.

National Snow and Ice Data Center (NSIDC)
http://nsidc.org
The National Snow and Ice Data Center provides information about the current research being conducted on the Earth's cryosphere, as well as data already collected about the Earth's cryosphere. The data was collected after conducting research with other centers and programs around the world, ranging from NASA to the International Arctic Research Center. In its effort to educate the community about the Earth's surface, NSIDC has also created various educational sites that teach students about the different types of forms water takes on the Earth's surface.

Nunavut Planning Commission Environment Database
http://npc.nunavut.ca/eng/index.html
The Nunavut Planning Commission (NPC) is responsible to develop plans, policies, and objectives for land use. Educators of public policy will find this a useful real-world example of how policies affect the environment.

Online Learning Center, The
http://www.geometry.net/earth_sciences/polar_regions_education_and_research.html
This online educational center includes earth science education and research on the polar regions. The site provides numerous links for individuals to learn about the research conducted at specific sites and the technology being used.

Open Directory Project (DMOZ), The
http://dmoz.org/Regional/Polar_Regions/Science_and_Environment/
This directory provides a list of sources that the community may browse in order to learn more about science and the environment. Educators may use this directory as a preliminary source to learn about the polar regions.

Polar Libraries Colloquy
http://www.acs.ucalgary.ca/~tull/polar/plcmain.htm
The Polar Libraries Colloquy website contains polar information accessible to the public. Students writing reports on the various components of the polar regions will find this website an ideal source to find information.

Polar Radar for Ice Sheet Measurements (PRISM)
http://ku-prism.org/resources/BearsOnIce/index.html
PRISM, Polar Radar for Ice Sheet Measurements, is dedicated to determine the thickness and bedrock conditions below the ice sheets in Greenland and Antarctica. The site includes news of the polar regions, including resources and lessons for K-12 students.

Polar Research and Cold Climate Technology (link from EELS)
http://www.luth.se/foundations/coldtech/coldeel.html
The Polar Research and Cold Region Technology is an online database connecting users to written journals and publications, as well as access to the various institutes and research programs around the world.

Publication: Overcoming the Challenges of ICT
http://www.uarctic.org/documents/genpub16.pdf
"On Top of It: Overcoming the Challenges of ICT and Distance Education in the Arctic" is University of the Arctic's new publication concerning the potential of information and communications technology (ICT) in bringing higher education to the population in the peripheral areas.

Reference.com
http://www.reference.com/Dir/Regional/Polar_Regions/Education_and_Research/
This online reference web directory provides a list of sources that integrate education and research of the polar regions. Educators can use these sources to teach about the various Polar explorers or the different types of research projects being conducted in the region today.

Satellite Imagery of Antarctica
http://TerraWeb.wr.usgs.gov/TRS/projects/Antarctica/AVHRR.html
Using advanced technological sources, the United States Geological Survey displays current satellite images of the Antarctic landscape. Educators may use this website as an interactive tool for which students may observe the Antarctic continent in various resolutions and sizes to attain a better understanding of the continent's true landscape.

http://www.south-pole.com/homepage.html
The primary aim of this website is to provide information about the history of the Antarctic continent, especially the polar heroes who dared to explore the area. Because the website contains tools such as detailed timelines, maps, and biographies, educators of all levels will find this website helpful when teaching about the Antarctic history.

Science Centre World Congress
http://www.questacon.edu.au
http://www.museudavida.fiocruz.br/4scwc

The Science Centre World Congress is an international meeting with events discussing programs for education and outreach, research, and business administration relating to science. The National Science and Technology Centre of Australia hosted the third Science Centre World Congress. The fourth congress will be held in Brazil in April 2005.

Science Magazine
http://www.sciencemag.org/cgi/content/full/304/5670/521
Science Magazine provides summaries and full-length articles about science today in order to integrate and encourage science and education in classrooms and at home.

Sea Ice Page NCEP Ocean Modeling Branch
http://polar.wwb.noaa.gov/seaice/
The NCEP MMAB Sea Ice Page provides various sources displaying the sea ice formations throughout various time periods, as well as mathematical data analyzing it. Educators and students alike may find this site useful because it provides pictorial representations of how the sea ice forms and alters.

Teachers Experiencing Antarctica and the Arctic (TEA) Program
http://tea.rice.edu/tea_kolbfrontpage.html
This website provides information about Sandra Kolb and her journey to the Arctic, along with activities, journals, and other links that educators will find useful.

Thematic Realtime Environmental Distributed Data Systems (THREDDS)
http://my.unidata.ucar.edu/content/projects/THREDDS/index.html
THREDDS is a data portal that connects people to the data.

University of Colorado
http://polarbear.colorado.edu
Part of the Colorado Center for Astrodynamics Research at the University of Colorado, this site provides an in-depth look into various Polar research projects currently being conducted, as well as those conducted in the past. Higher level educators may find this site useful to demonstrate the components of a research project, as well as to use the projects as educational tools.

Utah Education Network
http://www.uen.org/themepark/html/exploration/polar.html
This resource provides a variety of information about the polar regions, from links to places, people, and things, as well as resources educators can use to engage their students in physical activities. These activities range from building igloos to taking a virtual tour to observe the animals of the Arctic.

VECO Polar Resources
http://www.vecopolar.com
VECO Polar Resources is the National Science Foundation's Arctic Logistics contractor, which supports grants and scientists working in the polar regions. The site includes science and research information about all Northern countries, as well as logistical information about how things are done.

West Antarctic Ice Sheet Research Information
http://itll.colorado.edu/ITLL/Templates/AntarcticResearch/Research/index.html
The website provides information on the West Antarctic Ice Sheet Research from the field season 2001-2002. The site includes a link for teachers, as well as journal entries and photographs of the various people involved in this project.

Woods Hole Oceanographic Institution – Edge of the Arctic Shelf
http://www.whoi.edu/arcticedge/
The website provides information on a three year Arctic research project. An education piece with excellent photography and images.

Arctic Natives

Alaska Federation of Natives
http://www.nativefederation.org/flash.html
The goal of the Alaska Federation of Natives is to encourage and advance the voice of the Alaska Native community. Advocating the cultural, economic, and political rights of the Alaska Native community through conventions and publications is one part of their mission.

Alaska Fish and Wildlife Service
http://alaska.fws.gov/internettv/fisheriestv/mmmtv/partnersinfo.htm
The Alaska Fish and Wildlife Service is part of the United States Fish and Wildlife Service. Its mission includes marine mammal protection and determination of the impact of climate change on both marine mammals and subsistence projects.

Alaska Native Knowledge Network: Fairbanks, Alaska
http://www.ankn.uaf.edu/

The Alaska Native Knowledge Network is a resource created to share knowledge about the cultural experiences of Alaska Natives, including a section designated to science and mathematics education. The section contains Alaskan and non-Alaskan links, such as to Alaska Science Forum, which provide both pictures and written explanations of various components of Alaska's environment.

Alaska Native Regional Corporations
http://www.arcticgaspipeline.com/first%20peoples.htm#alaska%20non-profits
The website provides information about the Northern Gas Pipeline. Additionally, it serves as a contact to various Native Regional Corporations, from Ahtna to Bristol Bay to Sealaska.

Alaska Native Science Commission (ANSC)
http://www.nativescience.org
The Alaska Native Science Commission seeks to support science research that preserves and enhances all components of Alaska Native culture, from nutrition to the environment. By building a network between researchers and the Native community, as well as a clearinghouse for proposed research, the ANSC has been successful perpetuating and protecting native cultures.

"When an elder dies, a library burns."
Alaska Native Science Commission website

Alaska Native Student Wilderness Enrichment Retreat (ANSWER Camp)
http://www.serrc.org/AnswerCamp/
ANSWER Camp is a two-week cultural and educational retreat for seventh- and eighth-grade students in rural Alaska. This project's goal is to enrich the mathematical and scientific skills of the students through exploration of life and have a positive impact on students' future aspirations.

Alaska Native Studies Curriculum and Teacher Development: Fairbanks, Alaska
http://www.alaskool.org/
The goal of the Native Studies Curriculum and Teacher Development Project (NSCTD) is to bring together all components of a community, especially its educators and elders, to develop a curriculum that educates the community on all aspects of Alaska Native culture, from its social issues to its education.

Alaska Native Tribal Health Consortium
http://www.anthc.org/
The Alaska Native Tribal Health Consortium is a non-profit organization that provides various medical and community health services for Natives in the state of Alaska. It also provides a variety of programs, from research to safety to job training, in order to strengthen the community

Alaska Partnership for Teacher Enhancement
http://apte.alaska.edu/
The Alaska Partnership for Teacher Enhancement is a five-year grant awarded by the United States Department of Education. Its purpose is to prepare better-quality and experienced teachers to advance public education and create successful students. It does so by providing various partnerships with Alaskan universities, researching, and hosting events.

Alaska Reform in the Classroom through Technology Integration and Collaboration (ARCTIC): Marion, Ohio and Alaska
http://www.treca.org/m_home.html
ARCTIC's goal is to improve the way that teachers teach and students learn by integrating technology into the educational field. To use technology as a tool in the classroom, educators can participate in this training and support program.

Alaska Rural Systemic Initiative (RSI): Fairbanks, Alaska
http://www.ankn.uaf.edu/arsi.html
The focus of this initiative is to integrate the indigenous knowledge of Alaska natives into their educational programs, especially their scientific knowledge, in efforts to obtain solutions to the human problems in the Arctic environment.

Alaska Science Outreach
http://www.alaskascienceoutreach.com
The Alaska Science Outreach website is an independently produced service of Alaska Writer. It provides online science outreach for children and the general public. Its services range from articles to press releases to "ask the scientist" sessions.

Alutiiq Museum
http://www.alutiiqmuseum.com/
The Alutiiq Museum and Archaeological Repository displays and shares the unique culture of the Alutiiq people of Kodiak, Alaska. Educational programs, exhibitions, publications, and anthropological research are among the ways the museum is both preserving and sharing the culture's traditions.

American Indian Science and Engineering Society (AISES)
http://www.aises.org/
The American Indian Science and Engineering Society is a non-profit organization promoting science and technology education in traditional Native communities. Education programs for students of all ages are among the opportunities AISES provides.

Bristol Bay Native Association
http://www.bbna.com/
The Bristol Bay Native Association website is a resource that members of the community may access to check current weather conditions and updated news information. It links the tribe, communities, and the state together to promote Native voice, culture, and unity.

First Alaskans Institute
http://www.firstalaskans.org/aboutus/index.cfm
This non-profit organization, founded in 1989, is dedicated to advance education for Alaska Natives in order to inspire today's youth to become leaders of tomorrow. Education summits and literacy research programs are among some of the institute's initiatives to educate and inspire.

Hawaiian Studies Program: Waianae, Hawaii
http://www.k12.hi.us/~waianaeh/HawaiianStudies/main.html
The Hawaiian Studies Program seeks to help students of the Waianae High School learn more about their culture and surroundings to strengthen and promote future career skills and aspirations.

Iñupiat Heritage Center
http://www.north-slope.org/IHCsite/
Designed to preserve and promote the Iñupiaq culture, the Iñupiat Heritage Center offers classes, constructs exhibits, arranges performances, and organizes educational activities.

Murie Center
http://www.muriecenter.org/alaska.htm
This website celebrates the 1956 Murie Sheenjek Expedition, a defining moment for American Conservation. In honor of the 50th anniversary of the expedition, the Arctic National Wildlife Refuge Expedition is being celebrated in 2006. Additionally, the Murie Center, an organization located in Alaska, was created to inspire people to respect and appreciate the wilderness of the Arctic, as the Murie's have done. The center provides group sessions, community celebrations, symposiums, and more to promote spirit and respect of the wild.

Old Minto Cultural Heritage and Education Institute (CHEI): Minto, Alaska
http://www.ankn.uaf.edu/chei
The goal of the Cultural Heritage and Education Institute is to share the culture of Alaska Natives with the community, educate the youth about it, and restore the spirituality of the area. In order to educate the youth, as well as the community at large, programs and summer camps are available.

Rural Alaska Honors Institute (RAHI): Alaska
http://www.uaf.edu/rahi/
In order for rural Alaskan students to make an easier transition from high school to college, Rural Alaska Honors Institute provides an academic and social bridging program.

Simon Paneak Memorial Museum
http://www.north-slope.org/nsb/55.htm
Located in the village of Anaktuvuk Pass, Alaska, the Simon Paneak Memorial Museum is both a local history and ethnographic museum. The museum focuses on the history of the Nunamiut people, from their history to culture to daily lifestyle. By organizing showcase exhibits, building a library, and creating various community-building programs, the museum and the community is preserving its cultural traditions.

Formal Educational Resources
General Education

Adventure Learning Program
http://www.tundrabuggy.com/web/images-alp.shtml
The Adventure Learning Program is a part of the Tundra Buggy Adventure. It seeks to link students from afar to the center of polar bear research. Video conferences and interactive tours are also available for those who cannot experience the actual adventure.

Alaska Native Studies Curriculum and Teacher Development: Fairbanks, Alaska

http://www.alaskool.org/
The goal of the Native Studies Curriculum and Teacher Development Project (NSCTD) is to bring together all components of a community, especially its educators and elders, to develop a curriculum that educates the community about all aspects of Alaska Native culture, from its social issues to its education.

Alaska Reform in the Classroom through Technology Integration and Collaboration (ARCTIC): Marion, Ohio and Alaska
http://www.treca.org/m_home.html
ARCTIC's goal is to improve the way that teachers teach and students learn by integrating technology into the educational field. To learn how to use technology as a tool in the classroom, educators can participate in this training and support program.

Alaska Rural Research Partnership (ARRP): Alaska EPSCOR Education Outreach Program
http://www.alaska.edu/epscor/
The goal of ARRP is to enrich science education in rural schools, encourage rural students to consider science and engineering careers, and involve more rural students in scientific research activities in their villages. Students or classes of students are partnered with University of Alaska scientists and other scientists as they conduct research projects. EPSCOR is NSF funded.

Alaska Rural Systemic Initiative (RSI): Fairbanks, Alaska
http://www.ankn.uaf.edu/arsi.html
The focus of this initiative is to integrate the indigenous knowledge of Alaska natives into their educational programs, especially their scientific knowledge, in efforts to obtain solutions to the human problems in the arctic environment.

Alaska Science Outreach

http://www.alaskascienceoutreach.com
The Alaska Science Outreach website is an independently produced service of Alaska Writer (LLC). It provides online science outreach for children and the general public. Its services range from newspaper features, columns and press releases to fieldwork websites and blogs, to an online "ask the scientist" feature.

Alaska Lake Ice and Snow Observatory Network (ALISON)
http://www.gi.alaska.edu/alison
Based at the Geophysical Institute, University of Alaska Fairbanks, the ALISON project provides opportunities for K-12 teachers and students to practice real science and learn in the local context by measuring lake ice thickness, and the depth, density and temperature of the snow on the ice, and deriving the conductive heat flow through the ice and snow.

American Society of Limnology and Oceanography
http://aslo.org/phd.html
The American Society of Limnology and Oceanography provides programs for recent PhD's to participate in that involve the environment and education.

American Society of Limnology and Oceanography
http://www.aslo.org/mas.html
The American Society of Limnology and Oceanography also provides minority students an opportunity to participate in aquatic science research and activities.

AMNH Shackleton Exhibition
http://www.amnh.org/exhibitions/shackleton/
The American Museum of Natural History has created an exhibit and expedition guide celebrating Shackleton's legendary Antarctic expedition. For educators, this detailed guide of the expedition may be the perfect, concise substitute to the expedition's detailed biographies. Visits to the exhibit at the Museum of Natural History may also be a great educational and entertaining addition.

"Antarctica: The Farthest Place Close to Home" developed and produced by the American Museum of Natural History in collaboration with GLACIER
http://www.amnh.org/education/resources/antarctica/credits.php
The American Museum of Natural History created an educational resource about the Antarctic continent that contains information about geography, organisms, maps, meteorology, and explorers of Antarctica. It also provides activities and curriculum materials targeted to a specific (and listed) audience that educators may find educational and entertaining.

Arctic Circle
http://borealis.lib.uconn.edu/arcticcircle/
The goal of the Arctic Circle program is to expand knowledge about the circumpolar North to other parts of the community, including students, educators, and policy makers. A virtual classroom with syllabi,

problems, and activities provides a method of integrating polar education into the science curriculum for educators.

Arctic Ecological Laboratory (AEL)
http://www.ael.msu.edu/projects/antarctica.html
The Arctic Ecological Laboratory provides study abroad field courses and research on regional changes in the ecosystems for students and educators of all levels to participate in.

Arctic Research Consortium of the United States (ARCUS) Education Project
http://www.arcus.org/Education/index.html
The Arctic Research Consortium of the United States, ARCUS, is a non-profit organization that consists of and connects various educational, professional, and scientific institutions dedicated to the purposes of Arctic research. A recent addition to ARCUS's commitment to education is TREC, Teachers and Researchers Exploring and Collaborating, a network between the science and education fields improving and strengthening science education. TREC allows K-12 teachers participation in Arctic research by working closely with scientists. An interactive program for students as well, providing links to educational games and interactive programs that explore the Arctic.

Barrow Arctic Science Consortium (BASC)
http://www.arcticscience.org/
http://www.sfos.uaf.edu/basc/
This non-profit organization is dedicated to researching Alaska's North Slope and adjacent portions of the Arctic Ocean. It includes the BASC Educational Outreach, which provides resources for educators and students to further investigate the Arctic interact with scientists by reading journals and performing experiments.

Bridge- Ocean Sciences Teacher Resource Center
http://www.vims.edu/bridge/
This center provides a resource for educators and students to learn more about the ocean sciences. It is an interactive website as well, organizing conferences, online fieldtrips, online expeditions, activities, and workshops for its visitors.

Consortium for Oceanographic Research and Education (CORE)
http://www.coreocean.org/Dev2Go.web?id=209384andrnd=26809
A Washington, D.C. based association of U.S. oceanographic research institutions, universities, laboratories, aquaria and industry. The 82 members represent the nucleus of U.S. research and education about the ocean.

Elementary, Secondary, and Informal Education (ESIE) Program
http://www.ehr.nsf.gov/esie/programs/nsee/workshop/richard_duschl.pdf
The ESIE Program site provides a PowerPoint presentation summarizing key ideas and objectives of Centers for Learning and Teaching. A reference list is also provided, which educators may find useful.

GLACIER
http://www.glacier.rice.edu/
Rice University has created a detailed curriculum for educators, students, and the community to learn more about the Antarctic glacier and its components, specifically the expeditions, weather, ice, oceans, and global connections. Curriculum targeted towards educators, called the Teachers Experience Antarctica and the Arctic (TEA). The TEA program allows K12 teachers to participate in a polar expedition, where he/she works closely with scientists and researchers. The objective is to bring increased knowledge and experience into classrooms.

Into the Arctic
http://arcss.colorado.edu/data/arcss069.html
Into the Arctic is a CD-ROM, which contains educational material about the historical climate of the Arctic that educators may order. In addition, it contains activities that educators may incorporate into their daily lessons to help the students understand the Arctic more clearly.

JASON Project
http://www.jasonproject.org
This organization provides a curriculum for numerous topics in different academic subjects, ranging from science to mathematics to English to technology. The curriculum, which is available online for purchase, encourages experience-based learning for science educators.

Live From the Poles: Nationwide
http://www.passporttoknowledge.com/ptk_poles.html
This website features live broadcasts from the Poles of real scientists, their Polar experiences, and the life, land, and atmosphere of the Poles. Students can interact directly with scientists to enhance their knowledge of the polar regions by following the scientists' work and experience.

New South Polar Times, The
http://205.174.118.254/nspt/home.htm

The *New South Polar Times* is an online archive and newsletter that provides its audience, teachers and students with information about the scientific research taking place at the South Pole.

Observing Locally, Connecting Globally (OLCG) also known as Global Change Education Using Western Science and Native Knowledge
http://www.uaf.edu/olcg
OLCG provides Alaska teachers and students the opportunity to engage in original global change research based on local observations and knowledge and western science (GLOBE and other climate change research in Alaska), and to translate such research into meaningful classroom activities and student learning. Native elders and other local experts, scientists and educators are also involved in this NSF-funded program.

Old Minto Cultural Heritage and Education Institute (CHEI): Minto, Alaska
http://www.ankn.uaf.edu/chei
The goal of the Cultural Heritage and Education Institute is to share the culture of Alaska natives with the community, educate the youth about it, and restore the spirituality of the area. In order to educate the youth, as well as the community at large, programs and summer camps are available.

Partners in Science: Fairbanks North Star Borough School District (FNSBSD), Alaska
http://www.northstar.k12.ak.us/
http://www3.northstar.k12.ak.us/
Educators and classes can link to the GLOBE network, which allows students to interactively investigate science by completing activities.

Polar Expeditions
http://school.discovery.com/lessonplans/programs/polarexpeditions/
The Discovery Channel provides a resource for educators of all levels to engage in polar education. By creating lesson plans with specific objectives, materials, procedures, and evaluations, students and teachers can engage in micro-research experiments in their own classrooms.

Prince William Sound Science Center (PWSSC): Alaska
http://www.pwssc.gen.ak.us/pwssc/pwssc.html
The Prince William Sound Science Center conducts studies on the ecology in southeastern Alaska. It has recently expanded to educate students and the general public, offering monthly elementary education programs that include field trips, projects, and lectures.

Resources for Involving Scientists in Education (RISE) Program
http://www.nas.edu/rise/
Resources for Involving Scientists in Education (RISE) Program is for scientists who would like to contribute to a program that encourages science education in elementary, middle, and high schools.

Schoolyard Long Term Ecological Research (SLTER) Project at Bonanza Creek LTER
http://www.lter.uaf.edu/sylter/schoolyard.htm
http://www.lter.uaf.edu
K-12 students are involved in long-term ecological research providing unique experiences inside and outside the classroom in this NSF funded program.

Schools on Board Network
http://www.cases.quebec-ocean.ulaval.ca/school.asp
This network, part of Canadian Arctic Shelf Exchange Study (CASES), links schools to various research programs for on- and off- location education. It prepares students by providing courses, activities, forums, monitoring systems, and presentation opportunities to enrich their education.

Science Education for New Civic Engagements and Responsibilities (SPENCER)
http://www.aacu-edu.org/SENCER/index.cfm
Created by the Association of American Colleges and Universities (AACandU), this program connects students and teachers to several higher-education institutions. It puts students' scientific knowledge to immediate use by providing courses, project activities, and other various resources.

Smithsonian Arctic Exhibits
http://www.mnh.si.edu/arctic/
The Smithsonian National Museum of Natural History has created an Arctic Studies Center in which educators, students, and the public can explore the history of the people, the environment, issues, and culture of the Arctic. Educators and students alike will learn more about the Arctic by reading the detailed explanations and observing the vibrant photographs the center provides.

System-wide Change for All Learners and Educators (SCALE)
http://scalemsp.wceruw.org
Funded by the National Science Foundation (NSF), SCALE's goals are to provide high-quality scientific and mathematical K-12 teaching and learning, as well as to improve K-12 collaborations with higher institutions by providing activities, forums, events, grants, and more to accomplish their goals.

Primary Education

Antarctic Exploration
http://studyofplace.com
Middle-school students can access this website to:

- use a route map of Shackleton's expedition to navigate to investigations
- study a time-line of Antarctic Explorers
- study maps and aerial views of Antarctica in an online image gallery, individually or in a side-by-side view (Investigation 1, Exploring and Discovering)
- measure seasonal change in sea ice using an online grid (Investigation 2, Exploring and Discovering)
- watch a quick-time movie of seasonal change in sea ice (Investigation 2, Extension Activity)
- use an online solar calculator to obtain data and an online tool to graph the angle of the sun in their home town over a year's time compared to data from Antarctica (Investigation 2, Looking Closer)
- graph cooling and heating curves derived from insulation and reflectivity experiments (Investigation 4, Exploring and Discovering)
- type their answers on line for all record sheets

Teachers can:

- Access and print all the science content and technology background they need for teaching
- Evaluate student assessments that accompany each investigation with scoring rubrics
- Print all record sheets, readings and assessments from PDF downloads

Alaska Rural Research Partnership (ARRP): Alaska EPSCOR Education Outreach Program
http://www.alaska.edu/epscor/
The goal of ARRP is to enrich science education in rural schools, encourage rural students to consider science and engineering careers, and involve more rural students in scientific research activities in their villages. Students or classes of students are partnered with University of Alaska scientists and other scientists as they conduct research projects. EPSCOR is NSF funded.

Ecology Curriculum Reform: Integrating innovative teaching and global change technology: San Diego State University (see also the PISCES program)
http://www.sdsu.edu
http://www.sdsa.org/pisces/
The Center for Research in Mathematics and Science Education includes links to the PISCES, Partnerships Involving the Scientific Community in Elementary Schools, program in San Diego, California and Barrow, Alaska. The goal of the center is to improve elementary science with specific activities for educators of kindergarten through eighth grade students.

GLOBE Program
http://www.globe.gov/fsl/welcome.html
Educators, scientists, students and the general public can join this national and international program. There are various resources for everyone, such as a teacher's guide that includes lessons, activities, protocols, labs, etc. for all the components of the Earth's system. For scientists, there is a "scientist corner," in which site visitors can meet the scientists participating in this program, view and learn about the instruments used, and read various articles about the research being conducted in the Poles. Archived GLOBE data on various areas of investigations are available to everyone.

Observing Locally, Connecting Globally (OLCG) also known as Global Change Education Using Western Science and Native Knowledge
http://www.uaf.edu/olcg
OLCG provides Alaska teachers and students the opportunity to engage in original global change research based on local observations and knowledge and western science (GLOBE and other climate change research in Alaska), and to translate such research into meaningful classroom activities and student learning. Native elders and other local experts, scientists and educators are also involved in this NSF-funded program.

Prince William Sound Science Center (PWSSC): Alaska
http://www.pwssc.gen.ak.us/pwssc/pwssc.html
The Prince William Sound Science Center conducts studies on the ecology in southeastern Alaska. It has recently expanded to educate students and the general public, offering monthly elementary education programs that include field trips, projects, and lectures.

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http://www.lter.uaf.edu
K-12 students are involved in long-term ecological research providing unique experiences inside and outside the classroom in this NSF funded program.

Secondary Education

Alaska Native Student Wilderness Enrichment Retreat (ANSWER Camp): Alaska
http://www.serrc.org/AnswerCamp/
ANSWER Camp is a two-week cultural and educational retreat for seventh- and eighth-grade students in rural Alaska. This project's goal is to enrich the mathematical and scientific skills of the students through exploration of life and have a positive impact on students' future aspirations.

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Hawaiian Studies Program: Waianae, Hawaii
http://www.k12.hi.us/~waianaeh/HawaiianStudies/main.html
The Hawaiian Studies Program seeks to help students of the Waianae High School learn more about their culture and surroundings to strengthen and promote future career skills and aspirations.

Observing Locally, Connecting Globally (OLCG) also known as Global Change Education Using Western Science and Native Knowledge
http://www.uaf.edu/olcg
OLCG provides Alaska teachers and students the opportunity to engage in original global change research based on local observations and knowledge and western science (GLOBE and other climate change research in Alaska), and to translate such research into meaningful classroom activities and student learning. Native elders and other local experts, scientists and educators are also involved in this NSF-funded program.

Rural Alaska Honors Institute (RAHI): Alaska
http://www.uaf.edu/rahi/
In order for rural Alaskan students to make an easier transition from high school to college, Rural Alaska Honors Institute provides an academic and social bridging program.

Schoolyard Long Term Ecological Research (SLTER) Project at Bonanza Creek LTER
http://www.lter.uaf.edu/sylter/schoolyard.htm
http://www.lter.uaf.edu
K-12 students are involved in long-term ecological research providing unique experiences inside and outside the classroom in this NSF funded program.

Sea Education Association (SEA)
http://www.sea.edu/
In Woods Hole, Massachusetts, the SEA program provides diverse opportunities and experience for high school and undergraduate students in hopes that they will become educated and passionate about the sea. Additionally, it provides a selective summer program for educators, who can then take their experience into the classroom.

Toolik Field Station: University of Alaska Fairbanks
http://www.uaf.edu/toolik/
The Toolik Field Station (TFS) supports research and education to create a better understanding of the Arctic and its relationship to the global environment. TFS works with different levels, from high school to graduate students, to expand its educational component.

Undergraduate Education

Antarctica Field Course
http://www.ael.msu.edu/projects/antarctica.html
The link provides information about the Antarctica Field Course for students who are interested in studying the components connected to the Earth System.

Geosciences at Purchase

http://www.ns.purchase.edu/geo/greenland.html
This website, part of the Environmental Sciences Board of Study of SUNY, provides numerous links to the courses and research publications offered by SUNY. Educators and students may access this site to observe the various projects SUNY students are participating in, as well as research for jobs/internships that the board offers.

G L O B E P r o g r a m
http://www.globe.gov/fsl/welcome.html
Educators, scientists, students and the general public can join this national and international program. There are various resources for everyone, such as a teacher's guide that includes lessons, activities, protocols, labs, etc. for all the components of the Earth's system. For scientists, there is a "scientist corner," in which site visitors can meet the scientists participating in this program, view and learn about the instruments used, and read various articles about the research being conducted in the Poles. Archived GLOBE data on various areas of investigations are available to everyone.

Hamilton College Antarctic Program
http://www.hamilton.edu/news/exp/antarctica/2004/
The Hamilton College Antarctic Program website contains journals from the most recent expedition, short biographies of the students and faculty participants, and a summary of the project. Information on past Antarctic cruises is also accessible from the site.

Institute for Field Education: Boulder, Colorado
http://www.muskox.com/
The Institute for Field Education allows undergraduate and graduate students to explore science outdoors. Under the guidance of scientists, students gain valuable research skills and knowledge through direct experience.

International Field Trips from Iowa State University
http://www.biology.iastate.edu/intop/FieldTrip.html
Iowa State University offers students to take international field trips in biology to combine education and outdoor experience. This is a great opportunity for students to experience biology first hand and travel the world.

International Science Course Series (ICSC)
http://bprc.mps.ohio-state.edu/~svogel/IPY/AITI-summary.php
Proposal aimed to develop curriculum for a series of courses related to science in polar regions and to link this curriculum with similar courses in other countries participating in Polar Region research activities. Designed to provide education and training to the next generation of students, teachers and researchers, create international partnerships, create awareness for polar regions, encourage minority participation and gender diversity.

Into the Arctic
http://arcss.colorado.edu/data/arcss069.html
Into the Arctic is a CD-ROM, which contains educational material about the historical climate of the Arctic that educators may order. In addition, it contains activities that educators may incorporate into their daily lessons to help the students understand the Arctic more clearly.

Long Term Ecological Research (LTER)
http://www.lternet.edu/
The Long Term Ecological Research (LTER) Network involves over 1800 scientists and students working together to observe and study the ecological processes over numerous time scales. Undergraduate and graduate educators interested in research and ecological preservation should encourage their students to participate in this network.

North2North
http://www.uarctic.org/north2north/index.html
North2North is a student mobility (student exchange) program sponsored by the University of the Arctic that gives students the opportunity to live, study, and research in the Arctic.

Ohio State: ASPIRE
http://polarmet.mps.ohio-state.edu/ASPIRE_99/introasp/aspmenu.htm
The goal of this site is to integrate science into education to encourage and strengthen critical thinking, creative, and problem-solving skills in students, thus enabling students to approach situations in various ways. The site provides links to various science-based programs that promote education.

Polar Driver of Thermohaline Circulation
http://www.ldeo.columbia.edu/dees/ees/climate/labs/circ/index.html
This source, provided by the Columbia University's Earth Observatory, provides a laboratory that helps students of high education learn how to drive ocean circulation. Because this is a hands-on activity, educators and students alike will find this source beneficial.

Sea Education Association (SEA)
http://www.sea.edu/
In Woods Hole, Massachusetts, this program provides diverse opportunities and experience for high school and undergraduate students in hopes that they will become educated and passionate about the sea. Additionally, it provides a selective summer program for educators, who can then take their experience into the classroom.

Solar-Terrestrial Physics
http://www.polar.umd.edu/~allanw/
Allan T. Weatherwax of the University of Maryland has created this site to present much of the research he has been conducting on upper atmospheric physics. The information includes explanations on various components of atmospheric physics, as well as detailed pictures, that are geared towards individuals with an intense (and high) educational background in physics.

Space Science and Engineering Center
http://amrc.ssec.wisc.edu
The Space Science and Engineering Center provides opportunities for scientists and students of the University of Wisconsin-Madison to participate in various Antarctic projects. The site also provides additional links containing contacts of people, meetings, and new information about the meteorology of the environment.

Toolik Field Station: University of Alaska Fairbanks
http://www.uaf.edu/toolik/
The Toolik Field Station (TFS) supports research and education to create a better understanding of the Arctic and its relationship to the global environment. TFS works with levels from high school to graduate students, to expand its educational component.

U Conn: Arctic Circle
http://arcticcircle.uconn.edu/
The goal of the Arctic Circle program is to expand knowledge about the circumpolar North to other parts of the community, including students, educators, and policy makers. A virtual classroom with syllabi, problems, and activities provides a method of integrating polar education into the science curriculum for educators.

The *Inuksuk* [plural: *inuksuit*] has long been recognized as the 'compass' of the Arctic. Stones are placed in such a manner to resemble a human figure. The orientation of the stones also gives guidance by marking a trail on the tundra for hunters. Inksuk are still used today by Inuit hunters throughout the Arctic.
From U. Conn: Arctic Circle Website

Graduate Education

Institute for Field Education: Boulder, Colorado
http://www.muskox.com/
The Institute for Field Education allows undergraduate and graduate students to explore science outdoors. Under the guidance of scientists, students gain valuable research skills and knowledge through direct experience.

Long Term Ecological Research (LTER)
http://www.lternet.edu/
The Long Term Ecological Research (LTER) Network involves over 1800 scientists and students working together to observe and study the ecological processes over numerous time scales. Educators with undergraduate or graduate students interested in research and ecological preservation should encourage their students to participate in this network.

Student Competitions

Alaska Statewide High School Science Symposium (ASHSSS)
http://www.uaf.edu/csem/ashsss
The Alaska Statewide High School Science Symposium (ASHSSS) provides information about past science project winners, as well as a step by step guide to creating a research project. The site includes "how-to's" for all components of a science project, as well as online forms that students need to fill out.

ARCUS Award
http://www.arcus.org/award/

Undergraduate and graduate researchers are eligible for ARCUS's annual award for Arctic Research Excellence. Financial rewards are awarded based on each student applicant's research paper.

eCYBERMISSION
http://www.ecybermission.com
eCYBERMISSION is a web-based math, science, and technology competition supported by the United States Army for students in grades 6-9. Teams of students propose a solution to a real problem in their community and compete for regional and national awards.

ExploraVision Awards
http://www.exploravision.org
Toshiba and the National Science Teachers Association host the ExploraVision Awards. Students in grades K-12 participate in a competition that encourages scientific and technological creativity, as well as teamwork.

NAGT's Awards
http://www.nagt.org/awards.html
The National Association of Geology Teachers (NAGT) supports students with a variety of summer field programs and awards.

National History Day
http://nationalhistoryday.org
National History Day (NHD) is a yearlong history education program created to facilitate students' active learning. A National History Day contest, which includes dramatic performances, exhibits, documentaries, and research papers, is held every June.

National Ocean Sciences Bowl
http://www.coreocean.org/Dev2Go.web?id=208648&rnd=10712
The Consortium for Oceanographic Research and Education (CORE) administers national competition to high school students on topics related to oceanography. The National Ocean Sciences Bowl, held annually in April, was created to increase knowledge, understanding, and interest in the study of oceans.

National Science Teachers Association Awards
http://www.nsta.org/awardscomp
The National Science Teachers Association provides various awards, grants, and competitions to both students and educators throughout the year. These honors are provided for a variety of students, faculty, and staff.

Odyssey of the Mind
http://www.odysseyofthemind.com
Odyssey of the Mind is an international problem-solving program that provides five problems for students of all ages to solve. The problems cover a vast number of science fields and various types of talents. Additionally, the competition encourages both team work and creativity. The site also includes classroom activities for educators from Odyssey and NASA.

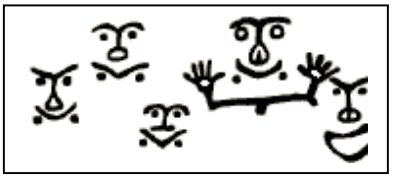
United States Academic Decathlon
http://www.usad.org/
The United States Academic Decathlon is an annual scholastic competition for high school students that teaches participants various subjects of school curriculum and teamwork and sportsmanship. The super quiz portion of this decathlon is on one of the various components of science, from astrology to biology.

Vermont State Science and Math Fair
http://www2.norwich.edu/hoppe/scifair/home.htm
Sponsored by the Vermont Principals' Association, in affiliation with the Intel International science and Engineering Fair, the Vermont State Science and Math Fair is an annual state-wide fair allowing high school individual students, as well as teams, to participate. Judges are provided and monetary prizes are awarded to the winners.

Young Naturalist Awards
http://www.amnh.org/nationalcenter/youngnaturalistawards/
In order to promote science participation, the American Museum of Natural History, along with J.P. Morgan Chase, have created an annual research-based essay contest for students in grades 7-12 called the Young Naturalist Awards. This competition allows students to expand their knowledge of science, as well as become creative since the theme of the contest, "Science Discovery Begins with Expeditions!," does not change.

Informal Education & Educational Centers

Alutiiq Museum
http://www.alutiiqmuseum.com/



The Alutiiq Museum and Archaeological Repository displays and shares the

unique culture of the Alutiiq people of Kodiak, Alaska. Educational programs, exhibitions, publications, and anthropological research are among the ways the museum is both preserving and sharing the culture's traditions.

American Zoo and Aquarium Association
http://www.aza.org
The American Zoo and Aquarium Association is a non-profit organization dedicated to advance zoos and aquariums and to create a world where humans respect all living things. It hosts an annual national conference, as well as workshops, education programs, and grants in order to achieve its goal.

American Museum of Natural History (AMNH)
http://www.amnh.org/
The American Museum of Natural History is a center for research, education, exploration, and self-guided web-based programs. The museum has had an active history with polar programs and exhibits. Some of the exhibits and programs include: Ocean exhibits on protecting polar seas, polar bears, and a web-based learning program on Antarctica, the farthest place from home.

Association of Children's Museums (ACM)
http://www.childrensmuseums.org
The Association of Children's Museums (ACM) is an international association dedicated to bring together children and families to encourage lifelong learning. Its efforts include expanding beyond the walls of museums and into day care centers, schools, and homes of children and families.

Association of Science and Technology Centers (ASTC)
http://www.astc.org
The Association of Science and Technology Centers (ASTC) is dedicated to expand the public's knowledge of science through informal education. In addition to its annual conference, the ASTC's services include workshops, a website, various conferences, and traveling exhibitions.

EdVenture Children's Museum
http://www.edventure.org
The EdVenture Children's Museum provides hands-on experience for children, families, and teachers in efforts to learn about everything science. It includes special programs (outreach and early childhood), as well as laboratory activities, afterschool programs, and summer camps to increase children's science participation and education.

International Council of Museums
http://www.icom-oesterreich.at/2007/en-format.html
The International Council of Museums (ICOM) is committed to conserve the world's cultural heritage. It hosts conferences to discuss advancements and improvements of museums. In August 2007, Vienna is hosting ICOM's 21st conference.

Iñupiat Heritage Center
http://www.north-slope.org/IHCsite/

Designed to preserve and promote the Iñupiaq culture, the Iñupiat Heritage Center offers classes, constructs exhibits, arranges performances, and organizes educational activities.

Matthew Henson Center
http://www.earthconcorps.org/mathewhenson.html
The Matthew Henson Earth Conservation Center was originally a Pepco Pumphouse on the Anacostia River in the District of Columbia. It has been restored and converted into the Matthew Henson Center to teach the local, disadvantaged youth about how the environmental and the rich resources found in the Anacostia river impact their own environment.

Museum Loan Network (MLN) at Massachusetts Institute of Technology (MIT)
http://loanet.mit.edu/
The Museum Loan Network helps fund long-term loan of art and cultural objects in order to make it more accessible to all communities. The MLN grant programs, funded by a variety of foundations and trusts, foster cultural education and collaborations to encourage understanding and appreciation of cultures.

National Geographic
http://www.nationalgeographic.com/index.html
The National Geographic web-site offers a whole range of educational information and experiences. Interactive maps offer personal exploration opportunities, historical information, cultural exploration, lesson plans, encyclopedias and more. Specially designed "kids" pages and activities are available as well.

Simon Paneak Memorial Museum
http://www.north-slope.org/nsb/55.htm
Located in the village of Anaktuvuk Pass in Alaska, the Simon Paneak Memorial Museum is both a local history and ethnographic museum. The museum focuses on the history of the Nunamiut people, from

their history to culture to daily lifestyle. By organizing showcase exhibits, building a library, and creating various community-building programs, the museum and the community is preserving its cultural traditions.

Smithsonian National Museum of Natural History
http://www.mnh.si.edu/
The Smithsonian has over one and a half centuries of experience in providing natural history to the nation. This is assisted through traveling exhibits, outreach programs and websites allowing them to have a physical presence in millions of classrooms and homes. One of the Smithsonian's Polar features is the Arctic Studies Center
http://www.mnh.si.edu/arctic/
The Smithsonian National Museum of Natural History has created an Arctic Studies Center in which educators, students, and the public can explore the history of the people, the environment, issues, and culture of the Arctic. Educators and students alike will learn more about the Arctic by reading the detailed explanations and observing the vibrant photographs the center provides.

Polar Bears

Adventure Learning Program
http://www.tundrabuggy.com/web/images-alp.shtml
The Adventure Learning Program is a part of the Tundra Buggy® Adventure. It seeks to link students from afar to the center of polar bear research. Video conferences and interactive tours are also available for those who cannot experience the actual adventure.

Bear Taxon Advisory Group (Bear TAG)
http://www.bearden.org/beartag.html
Bear Taxon Advisory Group (Bear TAG) was created by the American Zoo and Aquarium Association (AZA) to cater to the needs and conservation of the eight bear species in the world today.

Polar Bears International
http://www.polarbearsinternational.org
This not-for-profit organization for polar bears provides information about polar bears and their habitat.

Polar Bear Tracking
http://www.panda.org/polarbears/
The WWF Conservation Organization created the Polar Bear Tracker to educate the entire community about preservation of all living things, and in this case, polar bears. Two polar bears, Samantha and Marianne, were tagged so that the public can track the polar bears' movements and lifestyle. Other information about their habitat and diet is also provided to create a fun, interactive method of learning.

Opportunities and Courses for Educators

ARMADA Project
http://www.armadaproject.org
The ARMADA Project provides an opportunity for K-12 educators to participate in ocean science research and mentor students in order to bring experience into the classroom. Links of past summer experiences, applications, and journals are also provided.

LEARNZ: Christchurch, New Zealand
http://www.learnz.org.nz/
LEARNZ, the online education program for New Zealand students, gives educators opportunities to take field trips with their classes to experience the environment directly. These trips teach students about various components of the environment and how to preserve them.

NAGT's Outstanding Earth Science Teacher Award
http://www.nagt.org/awards.html
The National Association of Geoscience Teachers (NAGT), established in 1938, seeks to improve earth science teaching in both formal and informal instruction. NAGT supports educators who have made exceptional contributions to stimulate earth science interest.

National Council for the Social Studies (NCSS)
http://www.ncss.org/conference/
The National Council for the Social Studies (NCSS) hosts an annual conference to help educators inspire their students to imagine and believe. Educators can participate in a variety of events at the conference, from visiting exhibit booths to professional development sessions to clinics, to have the "ultimate experience."

National Earth Science Teachers Association Awards
http://www.nestanet.org/awards.html
The National Earth Science Teachers Association offers many awards to its members, ranging from service awards to awards for fellows to awards for appreciation. The organization holds conferences, meetings, and seminars to improve and advance Earth Science education at all levels.

National Science Teachers Association (NSTA)
http://www.nsta.org/conventions
Members and nonmembers of the National Science Teachers Association (NSTA) can learn about the latest science content, teaching strategies, and research to bring into the classroom at NSTA conventions. These educational conventions are held at various times throughout the year, depending on the regional location from which the educators reside.

National Science Teachers Association Awards
http://www.nsta.org/awardscomp
The National Science Teachers Association provides various awards, grants, and competitions to both students and educators throughout the year. These honors are provided for a variety of students, faculty, and staff.

The Polar Regions: Role in Global Change Studies
http://bprc.mps.ohio-state.edu/workshops/Chautauqua/

A 4 day short course targeting college teachers of all disciplines started at the Byrd Polar Research Center in 1998. Funding dried up but this could be revived for IPY. The main Byrd Polar Research Center webpage is a useful teacher tool.
http://www-bprc.mps.ohio-state.edu/

TAPESTRY Grant Program
http://fdncenter.org/pnd/rfp/rfp_item.jhtml?id=67000009
The Toyota TAPESTRY Grant Program, sponsored by Toyota and NSTA, includes various grants, ranging from $10000 to $2500, for K-12 science teachers. The site also includes other grants that deal with components of science, humanities, and politics, both nationally and internationally.

Teachers Experiencing Antarctica and the Arctic: Nationwide
http://tea.armadaproject.org/
The Teachers Experience Antarctica and the Arctic was a NSF program allowing K-12 teachers to participate in a polar expedition, where he/she worked closely with scientists and researchers, with the objective of bringing increased knowledge and experience into classrooms. While the program is no longer funded the website exists as an archive of teacher diaries, activities and education resourced.

Teachers and Researchers Exploring and Collaborating (TREC)
http://www.arcus.org/TREC

A recent addition to ARCUS's commitment to education is TREC, Teachers and Researchers Exploring and Collaborating. A network between the science and education fields is further created by this program, improving and strengthening science education. TREC allows kindergarten through twelfth grade teachers to participate in Arctic research by working closely with scientists. It is an interactive program for students as well, providing links educational games and interactive programs that explore the Arctic.

Renowned Individuals

Amundsen (1909)
The South Pole, Amundsen

Why Amundsen Killed his Dogs
http://tea.rice.edu/activity/rose/whyamundsenkilledhisdogsalessonfromtheheroicage_main.pdf
Rice University provides a brief explanation and an activity for students to participate in. Educators will find this activity beneficial in order to help their students understand Amundsen's actions towards his dogs.

Byrd (1934)
http://www.pbs.org/wgbh/amex/ice/index.html
The Public Broadcasting Service organization created this source targeting younger children (3-8) as their audience. The source contains brief, colorful timelines, maps, and biography of Byrd's expedition to Antarctica. Educators will find this site intriguing as well because of the details it provides, from Byrd's shack at Advance Base Camp to a teacher's guide including activities for students.

Cook (1906)
http://www.cookpolar.org/about.htm
The Frederick A. Cook Society is a nonprofit organization dedicated to educate the community about the life of Cook, as well as polar education in general. Educators interested in the life of Cook, polar research, polar literature, and polar exploration will find this site useful because it provides an abundant amount of information on each these topics.

Franklin (1849)
http://www.ric.edu/rpotter/SJFranklin.html
This website is dedicated to Sir John Franklin. It provides links to various components of Franklin's expedition, from his research to the search for him. Students will find this mystery intriguing and educational.

Henson (1909)
http://unmuseum.mus.pa.us/henson.htm
The Virtual Exploration Society provides a detailed account of Henson's race to the North Pole. Educators will find this site useful because it provides educational information, while students will enjoy the drama and adventure of this biography.
http://www.matthewhenson.com/
This resource provides information about Matthew Henson, the co-discoverer of the North Pole with Peary. All information about his life, from his childhood to his adventures to movies and books, is available in this resource.

Nansen (1896)
Farthest North, Nansen

The Life of Fridtjof Nansen
http://www.mnc.net/norway/Frit-nan.htm
This website provides four sources that detail the life of Fridtjof Nansen. Educators may use this source to attain either concise or detailed biographies of the explorer.
http://www.ub.uit.no/northernlights/eng/nansen.htm
This site gives a short, concise biography of Nansen's expedition to the North Pole. It also includes an expandable map of Nansen's route that educators will find helpful to track Nansen's journey.
http://members.aol.com/jstuster/boldendeavors/fnansen.htm
This site contains a brief biography of Nansen's life, as well as a concise background on the author's life.

Nansen's oceanographic data
http://www.nsidc.org/data/docs/noaa/g02120_fram_hydro
This website provides the oceanographic data collected by Nansen's crew. Educators will find this resource useful because it provides both the actual data and analysis of the data collected, which supplies a model for students to better understand the impact of critical thinking and analysis skills.

Meteorological data
http://www.nsidc.org/data/g01938.html
This resource is part of the Arctic Climatology Project, which created this Arctic Meteorology and Climate Atlas. The atlas includes a brief summary of the research, as well as all of the data used to provide the analysis. Educators will find this source useful in order to display the steps of data analysis and documentation.

Franz Josef Land
http://www.visibleearth.nasa.gov/data/ev160/ev16007_FranzJosef.A2002120.1010.1km.jpg
This link provides an enlargeable image of Franz Josef Land. Educators and students alike will be able to better observe its landscape.
http://chemsrv0.pph.univie.ac.at/ska/fjl.htm
This image is of the map of the Franz Josef Land and its surrounding Northern Europe countries. Educators may use this image to display the size of the lands in comparison to countries that are more familiar.
http://www-bprc.mps.ohio-state.edu/Icecore/FranzJosefLand.html
This source provides a topographical map of Franz Josef Land. Earth Science educators may find this site especially useful to incorporate into their own topographical lessons in the classroom.

Peary (1909)
http://www.pbs.org/wgbh/amex/ice/sfeature/peary.html
The Public Broadcast Service provides brief biographies on Peary, in addition to special features, timelines, and maps of Peary and other famous polar explorers, including Amundsen and Byrd. Educators may find the teacher's guide especially useful because it provides discussion questions and other features for student participation.

Scott (1909)
• *Scott's Last Expedition,* Scott
• *The Worst Journey in the World,* Aspsley Cherry Garrard
• 90 Degrees South: With Scott to the Antarctic (1933), DVD

Terra Nova Expedition
http://www.south-pole.com/p0000090.htm
The South Pole site provides an in-depth, detailed summary of Robert Falcon Scott's *Terra Nova* Expedition with a handful of pictures to add to the text. This is ideal for higher-level educators and students interested in the specifics of expedition and polar education in general.

http://www.nmm.ac.uk/education/fact_files/fact_scott.html
The National Maritime Museum and the Royal Observatory in Greenwich have created a fact file about the polar expedition leaders. Educators with

younger students will find this site useful because it provides all basic background information about Antarctica (i.e., What is Antarctica?; How did it get it name?) that younger students may be curious about.

Brief overview of Scott and his voyages
http://www.enchantedlearning.com/explorers/page/s/scott.shtml
The Enchanted Learning Center provides a brief, colorful biography for younger students interested in the life of Robert Scott.

Scott vs. Amundsen
Last Place on Earth, Huntford

Judgment over the Dead: The Screenplay of The Last Place on Earth (London: Verso/New Left, 1986) Scott and Amundsen, T. Griffiths a dramatic series on Masterpiece Theatre, a PBS television series produced by WGBH-TV, Boston, made possible by a grant from Mobil Corporation

The Coldest March, Solomon

Susan Solomon's web link
www.coldestmarch.com
This source provides a brief summary of Susan Solomon's *The Coldest March*, as well as her goal in writing this book and critical reviews. Educators who are contemplating sharing this book with their class may want to visit this site in order to make a well-informed decision.

PBS Secrets of the Dead
http://www.pbs.org/wnet/secrets/case_southpole/interview.html
In the Public Broadcasting Service organization's Secrets of the Dead series, the "Tragedy at the Pole" was further investigated. The episode contains background information on Scott and Amundsen, as well as clues and evidence to what may have happened. An interview with Susan Solomon, author of *The Coldest March*, is also part of this episode. Educators may find it useful to order or view this episode in class because it is both educational and engaging for students.

Polar Race Offers Leadership Lessons
http://www.uscg.mil/hq/g-w/g-wt/g-wtl/news/winter99/polar.htm
Robert Gunther provides a list and brief explanations of leadership qualities that every good leader should have. Educators of all level will find this an ideal method of teaching students of today to be leaders of tomorrow.

http://www.cep-dc.org/testing/testtalkoctober2002.htm
This "TestTalk for Leaders" issue, written by Nancy Kober, from the Center of Education is an in-depth guide for educators and parents to understand the limitations of tests on an individual's character. Educators with students who feel pressured by tests should read this issue in order to comfort and encourage students that tests are not the determinant factor for one's future.

Shackleton
South: A Memoir of the Endurance Voyage by Ernest Henry Shackleton, 380 pages (selections)
http://etext.library.adelaide.edu.au/s/s52s
This source is a 380-page selection of Shackleton's story of his last expedition. Educators and students of higher level may appreciate this source more because it is a very detailed personal account of his expedition, in addition to reviews and reactions by experts of the field.

• *Shackleton's Way*
• *Endurance*
• Shackleton - The Greatest Survival Story of All Time (3-Disc Collector's Edition), DVD
• South - Ernest Shackleton and the Endurance Expedition (1919), DVD
• Shackleton's Antarctic Adventure (Large Format) (2001), DVD
• Shackleton's Voyage of Endurance documentary, PBS Nova (2002)
• Shackleton miniseries, AandE (2002)
• Shackleton IMAX

Shackleton's Antarctic Odyssey
http://www.pbs.org/wgbh/nova/shackleton/
The Public Broadcasting Service organization highlights NOVA's film "Shackleton's Antarctic Adventure." Educators who want to teach Shackleton's expedition, as well as survival stories from other members of his crew, will find this source valuable and engaging for students.

Endurance Expedition timeline in paragraph form:
http://www.south-pole.com/p0000098.htm
The South Pole program provides an in-depth biography of Shackleton's trans-Antarctic expedition. Educators with high-level students will find this source useful because of the detail and length of this literature.

Timeline of the Endurance voyage (by date)
http://www.pbs.org/wgbh/nova/shackleton/1914/timeline.html

NOVA provides a detailed, but concise, timeline of Shackleton's voyage on the *Endurance*. Educators of all levels will find this source useful because it organizes the sequence of events that most students will easily comprehend and be engaged.

Elephant Island
http://www.visibleearth.nasa.gov/cgi-bin/viewrecord?3007
NASA provides a directory of various images and animations of the Earth. This source is a satellite image of Elephant Island and a brief description of what is seen for educators and students to observe familiar or unfamiliar land in different ways.

Navigating on the open sea
http://www.pbs.org/wgbh/nova/shackleton/navigate/escapewave.html
NOVA online provides technical information for those who would like to learn more about Shackleton's expedition to Antarctica. This source includes how a sextant works and Shackleton's escape from Antarctica. Educators of middle school and high school students may find this source useful in order to expand their naval education.

South Georgia
http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=10312
NASA's Earth Observatory provides new, detailed images of South Georgia Island, as well as brief explanations of what is observed. Students interested in topography and earth science may find this source engaging.

Maritime Information

How Icebreakers Break Ice
http://ourworld.compuserve.com/homepages/mnpowers/howicebr.htm
This site provides both pictorial and verbal explanations of how icebreaking ships are able to crush ice. Students who are new to the field of Polar Science will find this site very useful.

Naval Historical Center
http://www.history.navy.mil/branches/teach/ends/poles.htm
The Naval Historical Center in conjunction with the Navy Museum provides a brief background of the Navy's travels to the polar regions. Additionally, educators may find the links to timelines, maps, and activities useful in the classroom.

PORT- Maritime Information Gateway
http://www.port.nmm.ac.uk/ROADS/subject-listing/trav.html
This travel and exploration directory provides a list of topics that educators may observe to determine what topics are most suitable in their classroom. Each topic provides an alternative title, the author, and a brief description of the article. It also provides a URL for educators and students to gain access to additional information.

Media

National Association of Science Writers (NASW)
http://www.nasw.org/
The National Association of Science Writers was created in 1934 to strengthen and improve science reporting in order to better inform the public. Science reporters and public information officers on science are invited to join the association, which provides contact information of other science reporters, organized regional meetings, quarterly newsletters, and financial sponsorships.

Society of Environmental Journalists (SEJ)
http://www.sej.org/
The Society of Environmental Journalists is a United States-based organization dedicated to advance environmental reporting. It provides a better-educated network of professional journalists and editors who seek to improve public understanding of environmental journalism. For journalists, publications, conferences, and memberships are among SEJ's efforts to achieve its goals.

Recommended Sources:

Personal WebPages or Recommendations of Workshop Participants not included in the above listings

Lucette Barber
http://www.arcticnet.ulaval.ca/index_en.asp
-The ArcticNet is a network of natural, medical, and social sciences that provides research opportunities for scientists and educational tools for the public, as well as determines the impact of policies on the environment.

Peter Doran:
http://www.uic.edu/~pdoran/home.htm
-Personal webpage of associate professor Peter Doran, which includes his current research interests, published papers, and related links to other institutions.

Richard Duschle:
http://www.ehr.nsf.gov/esie/programs/nsee/workshop/richard_duschl.pdf
-PowerPoint presentation that summarizes key ideas and objectives of Centers for Learning and Teaching. Also includes other references that educators may find useful.

http://www.nas.edu/rise/
-Resources for Involving Scientists in Education (RISE) Program is for scientists who would like to contribute to a program that encourages science education in elementary, middle, and high schools.

Sarah Hickox:
http://omp.gso.uri.edu
-Office of Marine Programs (OMP) website includes links to education programs, publications, and program sand activities that visitors may participate in. Its goal is to integrate environmental education with science communications.

Max Holmes:
www.mbl.edu/inside/what/news/press_releases/2004_pr_5_18.html
-The Marine Biological Laboratory provided a press release on 18 May 2004 on "Ecosystems Center Researcher and Science Teacher Visit Siberia to Study Climate, Excite School children About Science." This article describes Holmes' goals for his visit to Siberia with school-teacher Amy Clapp.

http://ecosystems.mbl.edu/partners
-Provides information about the Arctic environment, which is sensitive to climate change. It also provides education and outreach information, data about the Arctic system, photography, publications, etc.

Sandra Kolb:
http://tea.rice.edu/tea_kolbfrontpage.html
-website provides information about Sandra Kolb and her journey to the Arctic, along with activities, journals, and other links that educators will find useful.

Heike Robinson:
http://www.mentorhigh.com/teacher/robinson
-Site provides information about the Expedition to Antarctica, a trip in a kayak promoting science education. The site includes information about Greenland, journals of the voyagers, biographies, and the science of the regions.

Susan Sugai:
http://www.uaf.edu/seagrant/nosb/index.html
-site provides information about the Alaska Regional National Ocean Sciences Bowl.

http://www.uaf.edu/seagrant/nosb/2005/research-project05.html#project
research project description for 2005

http://www.uaf.edu/seagrant/nosb/papers/index.html
archives on the projects from previous years.

Andrew Sajor:
http://www.perucsd.org/hsearthscience
-The Earth Science Homepage of the Peru Central School provides information about all things Earth Science, including the various educators' WebPages, reagents prep activities, and online labs.

Craig Tweedie:
http://www.ael.msu.edu/projects/antarctica.html
-The link provides information about the Antarctica Field Course for students who are interested in studying the components connected to the Earth System.

Personal WebPages or Recommendations from Non-Workshop Contributors

Gordon Bain:
http://ku-prism.org/resources/BearsOnIce/index.html
-PRISM, Polar Radar for Ice Sheet Measurements, is dedicated to determine the thickness and bedrock conditions below the ice sheets in Greenland and Antarctica. The site includes news of the polar regions, including resources and lessons for K-12 students.

Breck Bowden:
http://www.uvm.edu/~wbowden
-Personal webpage of Dr. Bowden, a professor at University of Vermont, which includes his biography, research, and education.

Howard Conway:
http://itll.colorado.edu/ITLL/Templates/AntarcticResearch/Research/index.html
-The website provides information on the West Antarctic Ice Sheet Research from the field season 2001-2002. The site includes a link for teachers, as well as journal entries and photographs of the various people involved in this project.

http://www.geophys.washington.edu/Surface/Glaciology/glac_proj.html
-This link provides access for educators, students, and the general public to learn more about various research projects being conducted in glaciology.

Diane Hirschberg:
http://www.iser.uaa.alaska.edu/
-The Institute of Social and Economic Research (ISER) provides information on all current and past research projects. In addition, it provides information on various environmental studies and its impact on the environment.

Matthew Lazzara:
http://amrc.ssec.wisc.edu
-The Space Science and Engineering Center provides opportunities for scientists and students of the University of Wisconsin-Madison to participate in various Antarctic projects. The site also provides additional links to come in contact with other people, meetings, and new information about the meteorology of the environment.

Chris Linder:
http://www.whoi.edu/science/PO/people/clinder/
-The website provides information about Chris Linder, Research Associate of the Physical Oceanography Department of the Woods Hole Oceanographic Institution. The information includes his research interests, as well as publications from the past.

Paul Mayewski:
http://www.secretsoftheice.org
-The Secrets of the Ice is an organization sponsored by the Museum of Science, National Science Foundation, and the Institute for Quaternary and Climate Studies. It displays information about the exploration of Antarctica, the ice core research being conducted there, and the scientific expeditions of the past. In addition, learning resources such as books, laboratory activities, and videos are provided to help students and the community discover the Antarctica.

Stephen Pompea
http://www.noao.edu
-The National Optical Astronomy Observatory of the National Science Foundation is a web site that provides research, information, and support for astronomical science.

Susan Weiler
http://aslo.org/phd.html
-The American Society of Limnology and Oceanography provides programs for recent PhD's to participate in that involve the environment and education.

http://www.aslo.org/mas.html
-The American Society of Limnology and Oceanography also provides minority students an opportunity to participate in aquatic science research and activities.

Jason Davis
http://geog-www.sbs.ohio-state.edu/grads/jdavis/index.html
-This is a personal webpage of Jason Davis, which provides a quick summary of his educational and scientific studies thus far, as well as links to related sources.

Carol Scott
http://www.agu.org/meetings/meetings_past.html
-This website provides information about past AGU meetings that have been held with associated links to talks and posters. There are education and outreach links that educators may find helpful, as well as information about the speakers and speeches that were given.

Carol and David Vleck
http://www.biology.iastate.edu/intop/FieldTrip.html
Iowa State University offers students to take international field trips in biology to combine education and outdoor experience. This is a great opportunity for students to experience biology first hand and travel the world!

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- Alaska Native Knowledge Network "Sharing Our Pathways" Newsletter

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