INTERNATIONAL POLAR YEAR 2007–2008

REPORT OF THE **IMPLEMENTATION** WORKSHOP

Committee on International Polar Year 2007-2008: Report of the Implementation Workshop
Polar Research Board
Division on Earth and Life Studies

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Although the reviewers listed above have provided constructive comments and suggestions, they did not see the final draft of the summary before its release. The review of this report was overseen by Irene Peden of the University of Washington. Appointed by the National Research Council, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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OVERVIEW

The International Polar Year (IPY)[1] 2007-2008 will be an intense, internationally coordinated campaign of polar observations, research, and analysis that will further our understanding of physical and social processes in the polar regions, examine their globally-connected role in the climate system, and establish research infrastructure for the future. Within this context, the IPY will galvanize new and innovative observations and research while at the same time building on and enhancing existing relevant initiatives. It also 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 the United States, The National Academies' Polar Research Board (PRB) established the U.S. National Committee for the International Polar Year (USNC) to outline a framework for U.S. participation in the IPY. The Committee authored a report entitled *A Vision for the International Polar Year 2007- 2008* (NRC, 2004) that identified five scientific challenges:

1. Assess large-scale environmental and social change in the polar regions;
2. Conduct scientific exploration of the polar regions;
3. Create multidisciplinary observing networks in the polar regions;
4. Increase understanding of human-environment dynamics; and
5. Create new connections between science and the public.

To further IPY planning, the PRB then created an IPY Implementation Workshop Committee (see Appendix B for committee biographies) to organize a 2-day workshop on July 8-9, 2004 in Washington, D.C. (see Appendix C for the Workshop Agenda), aimed at promoting discussions between the National Academy of Sciences (NAS) and federal agencies. The Workshop was attended by 47 agency representatives and scientists (see Appendix D for a participant list), to talk about how the United States might address these challenges and move ahead in the process of developing a suite of coordinated scientific activities in the context of known and potential international interests. This report outlines the results of that workshop, which provided specific discussions about potential activities and a

[1]A list of acronyms is provided in Appendix A.

forum for frank discussion of how different agencies might participate and what each envisions as possible goals during the IPY. It is important to note that these IPY discussions are still at a very early stage with regard to specific plans, and it is likely that other ideas and more specific program plans will emerge in the coming months. This report does not contain consensus findings or any recommendations; rather, it is a summary of key discussion items.

The workshop was organized around three main sessions—opening agency remarks made in the context of current understanding of international interests, discussion on possible U.S. and international IPY science and technology initiatives, and discussion of IPY implementation and next steps. The workshop began with prepared remarks from attending agencies[2] that outlined potential agency interests in the IPY. This gave the workshop participants a starting point for discussion.

Participants began the open discussion by focusing on polar environmental change. Participants noted that an internationally-coordinated study of environmental change would provide an understanding of rapid past changes and an account of current changes, and create a baseline for future comparisons. There also was discussion on studying the relationships of the polar regions to the mid-latitudes and tropical regions, and studying the polar regions as harbingers of change for the mid-latitudes and tropical regions. In the Arctic, a necessary component of the environmental change program would be to enhance the Arctic observing network, to create benchmark data sets, and to invest in data fusion, data assimilation, and modeling studies. In the Antarctic, key U.S. components would address ice sheet stability and climate history contained in high resolution ice and sediment cores, as well as develop targeted, internationally coordinated environmental studies.

There were many statements that the U.S. efforts to address coupled human-environment dynamics are not as well developed as ideas for studying environmental change, and that additional efforts are needed to develop the social science and humanities portions of the IPY plan. Some participants suggested that the U.S. effort should include studies on contaminants, as well as studies on the management of fisheries and marine ecosystems. With guidance from the National Institutes of Health (NIH) perspective, there was discussion on the need for studying health issues in the polar regions with an emphasis on the emerging issues in the north, such as the recent increase in diabetes and heart disease; the prevalence of alcoholism and abuse; mental health, particularly as it relates to the polar night; and vector diseases associated with environmental change. Related topics that received considerable discussions were human adaptation, "wellness,"

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[2]Agencies present included Department of Defense/Arctic Submarine Lab, Department of Defense/Office of Naval Research, Department of Energy, Department of Homeland Security/United States Coast Guard, Department of the Interior/U.S. Geological Survey, Environmental Protection Agency, National Aeronautics and Space Administration, National Institutes of Health, National Oceanic and Atmospheric Administration, National Science Foundation, Office of Science and Technology Policy, Smithsonian Institution, The National Academies, and U.S. Department of State.

sustainability, and polar engineering studies in the IPY. These concepts are well-recognized in Alaskan communities, but they are not yet fully integrated into the U.S. IPY plan.

The parts of the U.S. IPY program focusing on exploring new scientific frontiers will likely include exploiting new technologies and studying new or little-explored regions. Participants discussed that genomics is an incredibly powerful tool for understanding polar organisms and ecosystems, and that many aspects of polar biology represent emerging scientific frontiers. Participants also recognized the scientific community still knows relatively little about how organisms and ecosystems manage to survive in the extreme cold and dark of the long polar night. U.S. efforts focused on developing the capability for supporting biological research during the polar night would constitute a great accomplishment for the IPY. In addition, there is hope the IPY could be used to sequence a series of polar organisms for the first time. In terms of studying new and little-explored regions, some places the United States may try to explore include the Gakkel Ridge, Canada Basin, Eurasian Basin, continental shelves, East Antarctica, and the subglacial lake environments. Concern about accessing Lake Vostok (the largest known subglacial lake) during the IPY was expressed given the need for developing strong environmental safeguards and advancing drilling technologies and robotic sensors in the relatively short time remaining before IPY. The concept of studying a smaller subglacial lake was advanced.

The development of multidisciplinary observing networks was seen as an important component of a U.S. IPY program. Some participants noted that the Group on Earth Observations is developing a world-wide observing network, and that the IPY could be used to implement this network in the polar regions, particularly the Arctic. As part of developing the network, there was strong support for U.S. participation in taking a global “snapshot” of polar conditions, where Earth observing satellites from many nations would be coordinated and coupled to intensive surface and airborne-based observational campaigns. Additionally, as part of developing this network, some participants suggested a concerted U.S. effort could focus additional energy on autonomous vehicles and new sensors. Furthermore, efforts to refurbish the icebreaker fleet and upgrade research infrastructure would help ensure the long-term viability of polar science.

The workshop also examined data issues and education and outreach. There were many statements that data sharing, storage, and archival policies are not yet well-defined for the IPY, and that those need to be addressed, perhaps by a task force on data consisting of agency and data center personnel, and working scientists. In terms of education and outreach, a recent workshop on polar education was cited as an example of the level of effort to further IPY education and outreach. Again, discussion focused on mechanisms needed to organize the IPY education and outreach program, including the possibilities of an interagency working group or an education task force.

The workshop continued with a discussion of additional projects that might occur in a more ambitious IPY, should this be possible. Some of the ideas included a concentrated program on new technology, enhanced studies of global teleconnections, and the establishment of global infrastructure to create a legacy for generations to come. Some participants also discussed the steps needed to implement the U.S. IPY program, noting that, while the IPY is still three years away, planning must continue at a quick pace in order for the United States to be fully prepared. There was agreement that some important next steps include continuing to disseminate IPY information to the science community and facilitating their involvement; increasing attention on data, education, and outreach issues; and determining the future structure of IPY coordination.

The workshop then concluded with a discussion of the potential outcomes of the IPY. There was discussion that a successful IPY program would improve understanding of the key role of the polar regions in the global context, advance technology for polar science, and improve our ability to undertake interdisciplinary studies. The IPY also would be successful if it inspired the human spirit of discovery and improved the lives of residents across the globe. Some commentators mentioned that the IPY could foster the continued peaceful use of the poles, inspire additional nations to undertake science and technology studies in the polar regions, and lead to a more globally-engaged scientific workforce.

1

INTRODUCTION

WORKSHOP PURPOSE

Planning for the International Polar Year (IPY) 2007-2008 has progressed rapidly in the last year, moving from general dispersed discussions to an organized planning process with both national and international components. Some 20-25 nations are now committed to a coordinated campaign of interdisciplinary scientific research and observations in the polar regions. At the international level, planning is being led by the International Council for Science (ICSU) and the World Meteorological Organization (WMO), with strong involvement from other groups, such as the Scientific Committee on Antarctic Research (SCAR), the International Arctic Science Committee (IASC), and the Arctic Council. In 2003, ICSU appointed a Planning Group that proposed general concepts to guide IPY planners, and ICSU and WMO will create a new IPY Joint Committee in October 2004 to continue international coordination efforts. The ICSU Planning Group conducted outreach globally and based on this input developed the overarching vision that IPY will be an international program of coordinated research to explore the polar regions, deepen understanding of polar interactions including their role in global climate, expand our ability to detect changes, and extend this knowledge to the public and decision makers. The ICSU Planning Group further identified themes to (1) determine the present environmental status of the polar regions by quantifying their spatial and temporal variability; (2) quantify and understand past and present environmental and human change in the polar regions in order to improve predictions; (3) advance our understanding of polar-global teleconnections on all scales, and of the processes controlling these interactions; (4) investigate the unknowns at the frontiers of science in the polar regions; (5) use the unique vantage point of the polar regions to develop and enhance observatories studying the Earth's inner core, the Earth’s magnetic field, geospace, the Sun and beyond; and (6) investigate the cultural, historical, and social processes that shape the resilience and sustainability of circumpolar human societies, and identify their unique contributions to global cultural diversity and citizenship.

In the United States, the National Academies' Polar Research Board (PRB) established the U.S. National Committee for the International Polar Year to engage the science community in thinking about what IPY might accomplish. This committee conducted a number of activities to evaluate the merits of participating in IPY, identified and articulated the important scientific challenges, and developed an initial sense of how the United States might want to contribute. It published its findings in the report "*A Vision for International Polar Year 2007-2008*" which outlines a framework for U.S. participation in IPY, including discussions of the rationale, science challenges, technology needs, and public involvement opportunities (Box 1; NRC, 2004). This report identified five scientific challenges that could be pursued, with discussion of possible types of questions and activities for each. The five framework challenges are:

1. Assess large-scale environmental and social change in the polar regions;
2. Conduct scientific exploration of the polar regions;
3. Create multidisciplinary observing networks in the polar regions;
4. Increase understanding of human-environment dynamics; and
5. Create new connections between science and the public.

To continue making progress, the PRB organized a 2-day workshop on July 8-9, 2004, held at the National Academy of Sciences in Washington, D.C. The goal of this 2-day workshop was for federal agency representatives, members of the PRB, and members of the U.S. National Committee for the IPY to talk about how the United States might address these challenges and move ahead in the process of developing a suite of coordinated scientific activities. The fundamental premise was that active engagement of federal agencies with polar-related responsibilities is critical to the success of IPY. This workshop provided a forum for frank discussion of how different agencies might participate and what each envisions contributing to the IPY. In essence, it was time to move from a broad framework to more specific discussions about implementation of potential activities.

Box 1
An Excerpt from "A Vision for IPY 2007-2008"

At its most fundamental level, IPY 2007-2008 is envisioned to be an intense, coordinated field campaign of polar observations, research, and analysis that will be multidisciplinary in scope and international in participation. IPY 2007-2008 will provide a framework and impetus to undertake projects that normally could not be achieved by any single nation. It allows us to think beyond traditional borders—whether national borders or disciplinary constraints—toward a new level of integrated, cooperative science. A coordinated international approach maximizes both impact and cost effectiveness, and the international collaborations started today will build relationships and understanding that will bring long-term benefits.

Within this context, IPY will seek to galvanize new and innovative observations and research while at the same time building on and enhancing existing relevant initiatives. IPY 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, IPY is clearly an opportunity to organize an exciting range of education and outreach activities designed to excite and engage the public, with a presence in classrooms around the world and in the media through varied and innovative formats. The IPY will use today's powerful research tools to better understand the key roles of the polar regions in global processes. Automatic observatories, satellite-based remote sensing, autonomous vehicles, Internet, and genomics are just a few of the innovative approaches for studying previously inaccessible realms. IPY 2007-2008 will be fundamentally broader than past international years because it will explicitly incorporate multidisciplinary and interdisciplinary studies, including biological, ecological, and social science elements.

WORKSHOP CONTEXT

On three occasions during the last 125 years, nations around the world united to advance scientific discovery in ways that single countries or scientists could not do alone. These multi-national scientific endeavors were called International Polar or Geophysical Years. The fundamental concept of the International Polar Year (IPY) in 1882-1883 was that geophysical phenomena could not be surveyed by one nation alone; rather, an undertaking of this magnitude would require a global effort. Twelve countries participated, and 15 expeditions to the polar regions were completed (13 to the Arctic, and 2 to the Antarctic). The U.S. contribution included establishing a scientific station at Point Barrow, the northernmost point in Alaska and the continental United States, and a field expedition to Lady Franklin Bay in Canada. Beyond the advances to science and geographical exploration, a principal legacy of the first IPY was setting a precedent for international science cooperation.

The second International Polar Year in 1932-1933, even in the midst of the Great Depression, included participants from 40 nations and brought advances in meteorology, atmospheric sciences, geomagnetism, and radioscience. The U.S. contribution was the second Byrd Antarctic expedition, which established a winter-long meteorological station approximately 125 miles south of Little America Station on the Ross Ice Shelf at the southern end of Roosevelt Island. This was the first research station inland from Antarctica's coast.

The International Geophysical Year (IGY) in 1957-1958, in which 67 nations participated, was conceived as an effort to use technology developed during World War II, such as rockets and radar, for the advancement of scientific research and human-kind. The IGY brought many "firsts," such as the launch of the world's first satellites. IGY also included a number of important activities in the polar regions, especially in the Antarctic where our first research stations were established. Even in the midst of the Cold War, differences were set aside and the international

Antarctic Treaty was ratified in 1961 establishing Antarctica as a place for peace dedicated to the furtherance of science. Antarctica remains the only continent managed by international agreement and cooperation. This history provides a precedent of remarkable scientific collaboration among nations.

WORKSHOP AND REPORT ORGANIZATION

The workshop was organized around three main sessions—formal remarks from the 14 agencies in attendance, open discussion of U.S. IPY science and technology initiatives based on the NRC (2004) report[3], and an open discussion of IPY implementation and next steps. The morning of the first day began with a report on IPY 2007-2008 planning activities and the history of previous IPYs/IGY, and then focused on formal keynote remarks from agency representatives (Chapter 2), which allowed the agencies to outline their key interests and goals, as well as possible ideas for IPY studies. The afternoon of the first day and the morning of the second day focused on discussing agency interest in the key recommendations from the *Vision report* (NRC, 2004), and included discussions of U.S. IPY science and technology initiatives (Chapter 3), as well as data accessibility/management and education/outreach (Chapter 4). The final session focused on determining "next steps" for the U.S. IPY program, including important issues for implementation and a list of key tasks to be accomplished in the next few months (Chapter 5). This workshop report is a summary of major discussion items, and according to Academy rules about workshop reports it does not contain consensus findings or recommendations. It is not a workshop transcript. The full transcript will be available for the IPY 2007-2008 historical record. A list of discussion topics is presented in the Workshop Agenda (Appendix C).

[3] Hereafter, NRC (2004) will also be termed the *Vision report.*

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OPENING REMARKS

Robin Bell, chair of the Polar Research Board (PRB) and research scientist at Lamont-Doherty Earth Observatory of Columbia University, William Wulf, President of the National Academy of Engineering, Chris Elfring, Director of the PRB, and Mary Albert, Chair of the U.S. National Committee for the IPY delivered welcoming remarks. These were followed by remarks from all the agencies present, highlighting their interests and hopes for the IPY. This chapter outlines key remarks from each agency.

THE NATIONAL ACADEMIES

Dr. William Wulf, President of the National Academy of Engineering (NAE), presented the first talk on behalf of the NAE, the National Academy of Sciences (Bruce Alberts, President), and the Institute of Medicine (Harvey Fineberg, President). Dr. Wulf noted that the National Academies were pleased to have been instrumental in guiding the planning for International Polar Year to its present stage. The recent *Vision report* was developed in a “bottom up” fashion, with wide input from the science and engineering communities and from the government agencies with responsibilities in the polar regions. This report is an important first step in creating what will become the U.S. IPY program and also an important contribution to the international IPY campaign. It is clear that IPY 2007-2008 will take place in some shape or form, but it is time for the next step in IPY planning: to move from vision to implementation. It is time to talk in more concrete terms about actual activities and the resources needed to make them happen.

The National Academy of Sciences was instrumental in planning and executing the highly successful International Geophysical Year (IGY) in 1957-1958. And when the field activities concluded, in 1958 and continuing into 1959, the NAS building was the venue for negotiations between the U.S. government and the 11 other nations with Antarctic IGY programs that ultimately became the Antarctic Treaty. It is natural, therefore, for the National Academies to take a strong interest in a program like IPY 2007-2008 that will both advance polar science and enhance international cooperation. The upcoming IPY has an important parallel to IGY; in both instances, important technological and engineering advances will allow scientists to do truly innovative work that can lead to major scientific findings. In the 1950s, the tools came from World War II: rockets, the prospect for satellites, and advances in instrumentation. The tools available today are equally striking: unmanned robotic vehicles that can explore beneath the sea ice, an array of new sensors and automatic sensor networks, and advanced computing and telecommunications capabilities that could not have been imagined even a few decades ago.

Ms. Chris Elfring, Director of the the National Academies' Polar Research Board (PRB), followed Dr. Wulf with some additional comments on the Academies' goals for the IPY. The first National Academies goal was to get a sense of whether IPY 2007-2008 had considerable scientific merit. The IGY was held only 25 years after the second IPY because there was an incredible suite of new scientific tools available and it was clear that a coordinated international campaign held significant potential. In order to determine whether a new IPY was appropriate for 2007-2008, the PRB polled NAS and NAE members, hosted an interactive web discussion over a series of weeks, and talked to scientists at more than a dozen conferences. The answer was a resounding "yes," there is a compelling rationale for an IPY in 2007-2008.

The Academies second goal was to help get IPY planning started at the international level. To succeed, IPY must be a truly international effort. First, the PRB worked with colleagues in England to put the idea before the International Council for Science (ICSU). The PRB helped ICSU establish an international IPY Planning Group and worked to have strong U.S. leadership in the group. With Robin Bell (the PRB chair) appointed as vice-chair of the Planning Group and Bob Bindschadler (PRB committee member) as another U.S. member, the PRB helped the ICSU Planning Group write a strong rationale for IPY and the first guidance they distributed to get other nations involved. The PRB continues to serve as a liaison to the international group so that the United States has a real leadership role in the international setting.

The Academies third goal was to ensure that IPY 2007-2008 was planned using a transparent process and with strong "bottom-up" input from the science community and agencies. The recent NRC *Vision report* is the result of significant outreach to the U.S. science community. The report articulates what could be accomplished during IPY, and as a result, real excitement is building in the community, evidenced by over 400 preliminary submissions of IPY ideas to the ICSU IPY Planning Group.

The Academies would be pleased to have a continued role in IPY 2007-2008, and the PRB envisions at least three "next" concrete goals. The first is to continue acting as a conduit for communication and coordination with the international planning effort; the second is to continue in a communication and coordination role with the U.S. science and agency communities; and the third is to help facilitate the transition from vision to implementation. What will these goals entail? Some things are clear—the ICSU international Planning Group (which will become a joint ICSU-WMO Joint Committee in October 2004) has requested that each nation have a National Committee as a point of contact and the Academies would be pleased to continue in that role. The PRB structure is also well suited for facilitating meetings like this workshop to help with decision-making and coordination of efforts, for continuing to help articulate science goals, and for producing documents needed to articulate IPY ideas and justify activities.

Beyond these rather process-oriented goals, the PRB stresses that the overall goal of IPY 2007-2008 should be to improve life for people through increased understanding of the polar regions and their global connections. We should all keep that in mind as we move ahead in our planning.

NATIONAL SCIENCE FOUNDATION

Dr. Arden Bement, Acting Director of the National Science Foundation (NSF), gave the first agency remarks. Dr. Bement noted that both the NAS and ICSU have made a compelling case for an IPY in 2007-2008, and that NSF is in full agreement. In the polar regions, environmental change is observable in reduced sea ice extent, retreating glaciers, shifting patterns in flora and fauna, and environmental observations by Arctic natives. These changes—whether environmental, biological or social—have implications for the rest of the globe. Polar change ripples across the planet on a spectrum of time scales, through the atmosphere, oceans, and living systems.

We do not yet fully understand the causes of what we are observing. Now is the time to change this, for new tools make possible the needed observations and synthesis. They range from satellites to ships to sensors, and from genomics to nanotechnology, information technology, and advances in remote and robotic technologies. The NSF is especially pleased at this new opportunity, offered by IPY, to advance fundamental science, alongside the mission activities of our fellow agencies. Although the Office of Polar Programs would naturally take the NSF lead, a number of NSF directorates—bio- and geosciences, education and human resources, engineering, and social and behavioral sciences—also have potential roles.

One of the main emphases for the IPY from NSF's perspective includes the Study of Environmental Arctic Change (SEARCH). SEARCH will explore the causes of Arctic environmental change and its relationship to global climate, biogeochemical cycles, ecosystems, and human populations. Understanding the biological and social consequences of and adaptations to change is integral to this program. In conjunction with the science, the Smithsonian Institution will launch an exhibition on Arctic change in May, 2005, called "The Arctic: A Friend Acting Strangely." NSF is enthusiastic about the interest on the part of the Arctic nations and the international community in transforming SEARCH into a truly international effort, under a new name: The International Study of Arctic Change (ISAC).

Another proposed NSF focus for IPY science—in potential partnership with NASA, USGS, and other agencies—is the large ice sheets, both north and south. While we know enough to recognize that we cannot yet model their behavior, their dynamics and fate are of direct consequence to human beings around the globe. The West Antarctic ice sheet, grounded below sea level, may be especially prone to instability. The analysis of finer temporal resolution ice cores drilled in West Antarctic will help fill in the details of climate history, which are now gleaned mainly from the Greenland ice cores. A field camp in West Antarctica would have potential to support activities beyond drilling, depending on scientific and international interest. We also need to study the bedrock beneath the ice sheets, which strongly influences ice stability. Geological drilling, such as in the Ross Sea, will also advance insight on critical climate junctures of the past.

A third high priority will be to focus genomics technology on life in the extreme conditions of polar regions. This is an area of potential collaboration with the Department of Energy. Genomic tools that can sample organisms directly in the natural environment and help trace complex environmental relationships are coming on-line. Some startling insights about how organisms interact with, and influence, their physical environment have already come to light. More polar scientists need training in these technologies. Polar ecosystems rank among the least known on earth, yet these systems—often simpler than those in the rest of the world—can serve as testbeds for genomics. Also, the study of how polar organisms react to higher temperatures and ultraviolet radiation may provide insight into how organisms in other ecosystems may react to future changes.

Other areas ripe for exploration in IPY include extending observations at the polar Long-term Ecological Research (LTER) sites into the winter season. Increasing cooperation with Arctic peoples and increasing research efforts that are of interest to northern residents are also needed. Additional activities could include establishing systems to record and share data around the world, exploring the Arctic Ocean’s Gakkel Ridge, and investigating ecosystem changes in the Bering Sea.

All of these are exciting scientific frontiers, and exploring them will rely upon maintaining the polar science infrastructure built through U.S. investment dating back to the IGY. In Antarctica, the new South Pole Station will be completed in 2007, offering a premier laboratory for astrophysics, among other disciplines. Added to that are the state-of-the-art Crary Laboratory at McMurdo Station, facilities at the Palmer Station, and NSF’s ability to erect large, temporary field camps for particular studies. Broad success of IPY activities at these facilities relies upon Coast Guard icebreakers, which in turn hinges upon securing funding to keep the icebreakers operational. Logistics capabilities are critical to the success of the IPY and will need to be included in our planning.

NSF also stressed the importance of international planning. International collaboration made IGY a success, and it spawned structures for peaceful scientific cooperation, like the Antarctic Treaty, that endure today. A lasting legacy of IPY will be a portrait of the “state of the poles”—a benchmark of the atmosphere, oceans, land, and ecosystems at both ends of the globe for future studies. The polar science communities have a spectacular scientific history, and it is the right time to move forward on this International Polar Year, which is sure to accelerate discovery for the benefit of this nation and the world.

DEPARTMENT OF HOMELAND SECURITY/UNITED STATES COAST GUARD

RADM Dennis Sirois, Assistant Commandant for Operations, highlighted U.S. Coast Guard (USCG) interest in the IPY. The USCG mission includes providing logistics support for re-supply of McMurdo Station in Antarctica, and the USCG looks forward to providing logistics support for IPY activities with key partners. The USCG takes the polar logistics mission very seriously, and they encourage IPY participants to think “out of the box” to maximize the use of available resources. For instance, many opportunities exist for Coast Guard vessels and aircraft to make contributions in the sub-polar regions in the course of their normal operations. The USCG is faced with some daunting challenges though; three difficult years of ice breaking have damaged the two polar-class icebreakers, Polar Sea and Polar Star. In particular, the Polar Sea will be unavailable for Operation Deep Freeze 2005 (re-supply of Antarctica). Repairs to the Polar Sea are scheduled to take 1-2 years, although an influx of new funds could accelerate this timetable. In concluding, the USCG noted that the IPY could serve as the impetus for focusing attention on the critical needs we face relating to our aging icebreaker fleet.

DEPARTMENT OF ENERGY

Dr. Jerry Elwood, director of the Climate Change Research Division in the Office of Biological and Environmental Research (Office of Science), provided formal remarks for the Department of Energy (DOE). The DOE’s interest in the polar regions largely is in the global climate system, in particular how the global climate system is affecting the arctic region, and in turn how the polar regions affect the climate system. While no new DOE initiatives currently are planned for the IPY, changes in programmatic priorities are possible. DOE is actively looking to participate in IPY by collaborating with other agencies and nations. DOE has three main areas of interest:

1. Arctic Climate Research: The main focus for DOE efforts in Arctic climate research are climate modeling and climate process studies. DOE is interested in regional climate, ocean circulation, sea ice, and coupled climate-bio-geo-chem models. Most of DOE’s climate process studies involve the DOE Atmospheric Radiation Measurement (ARM) program facility in Barrow, Alaska (http://www.arm.gov/instruments/static/ bmet.stm), which includes a Cloud and Radiation Testbed (CART). The Barrow ARM/CART site is one of three in the

United States, and these sites provide some of the most detailed information for climate process studies available. DOE also is deploying a mobile ARM/CART, which could be utilized in the IPY, and possibly available for Antarctic studies. The DOE also has an unmanned aerial vehicles program, and they can deploy UAVs over the sites for intensive campaigns.

2. Greenhouse gas sources and sinks in the Arctic: DOE is the primary sponsor of AmeriFlux (http://public.ornl.gov/ameriflux/index.html) an instrumented network of research sites in North, Central, and South America that provides continuous measurements of ecosystem level exchange of CO_2, energy, and water with the atmosphere at diurnal, synoptic seasonal, and interannual time scales using the eddy correlation method. Three currently active AmeriFlux sites are located in the Arctic region of Alaska at Atquasuk, Barrow, and Upad. Since each AmeriFlux station operates using with similar instruments, the network may be a good data source for polar-mid-latitude-tropical comparison and/or teleconnection studies.

3. Characterizing life in extreme environments: DOE has substantial genome sequencing capabilities that could be brought to bear on the polar environments, to characterize life forms to understand the communities and the diversity of communities in Arctic environments. To this end, the DOE operates the Joint Genome Institute (JGI) in Walnut Creek, California (http://www.jgi.doe.gov/) which provides the research community at large with access to the high throughput sequencing capabilities at the JGI.

ENVIRONMENTAL PROTECTION AGENCY

Dr. Gary Foley, Director of the Environmental Protection Agency's (EPA) National Exposure Research Laboratory, provided remarks on behalf of the EPA. Dr. Foley noted that 75 percent of U.S. coastline is in Alaska, and that Alaska has unique issues and problems requiring special focus. For instance, Alaskan ecosystems are different from the rest of the 49 states. The EPA focus for IPY could be centered on three objectives:

1. Improve basic knowledge about Arctic stressors and effects: EPA activities related to this objective include the Arctic Monitoring and Assessment Programme (AMAP) Phase II assessment (heavy metals); transformation of mercury at the Arctic sunrise; PBTs (PCBs, dioxins, heavy metals, pesticides), ramification of the Persistent organic pollutants (POPs) treaty; and the Environmental Monitoring and Assessment Program (EMAP) coastal and fresh water monitoring assistance. The EMAP effort is particularly interesting for the EPA, and they hope that the IPY might spur Alaska to implement EMAP and lead to efforts to develop a monitoring grid of the entire circumpolar (circumarctic) region for establishing the baseline condition. EPA is planning to approach AMAP to see if they have an interest in EMAP.

2. Understand and reduce risk to Arctic residents and the Arctic environment: EPA interests in this objective include an Alaskan native fetal cord blood monitoring study (a project to increase the ability of tribes to assess environmental threats) and a study of the benefits and risks of a traditional diet, in particular heavy metals and Persistent organic pollutants (POPs) in traditional foods and in seagull eggs.
3. Implement innovative technologies to solve environmental problems: EPA efforts in this objective may include a reduction of atmospheric mercury releases from Arctic nations, reducing PCBs in Russia, grants to tribes to develop sustainable technologies, and EMAP support of innovative monitoring technologies.

The EPA is also very interested in using the IPY to contribute to a number of international projects, including the Global Earth Observations System of Systems (GEOSS), which needs a stronger polar focus; ratifying the treaty for the Long Range Transport of Air Pollution (LRTAP)/POPs, and coordinating emissions inventory and technology assistance for United Nations Environment Programme (UNEP) and Alternative Cover Demonstration Project (ACAP) mercury studies (EPA has the U.S. lead).

DEPARTMENT OF THE INTERIOR/UNITED STATES GEOLOGICAL SURVEY

Dr. Jerry Mullins, Manager of Polar Programs and Canada for the Department of the Interior/United States Geological Survey (DOI/USGS) Office of International Programs, presented the DOI/USGS interests in the IPY. The USGS stressed the importance of participating in the IPY as a unified agency, rather than having each office participate individually. The USGS is broadly interested in studies pertaining to change in the cryosphere and utilizing satellites and autonomous vehicles. The USGS also is particularly interested in data issues pertaining to the IPY and in broadening national and international collaboration on their IPY efforts. During the IPY, USGS Arctic interests include glacier studies, especially re-visiting glaciers surveyed in the IGY; ice coring/climate history studies; the biology impacts of de-glaciation; earthquakes; permafrost; minerals and energy assessment; borehole temperature measurements; migratory birds; polar bear habitat; and marine mammals. In the Antarctic, the USGS is interested in seismology; geodesy, especially autonomous measurements and aerogeophysical observations in the interior; establishing a geomagnetic observatory at the South Pole; improving GIS/on-line data delivery, and helping to develop an air geophysics science platform. Dr. Mullins also noted that the USGS runs the U.S. Data Center in Sioux Falls, South Dakota, where they archive satellite and airborne imagery. The USGS is specifically interested in establishing an enhanced seismic array at the South Pole station.

DEPARTMENT OF DEFENSE/ARCTIC SUBMARINE LAB

Mr. Jeff Gossett, Technical Director at the Arctic Submarine Lab (ASL), stated that although the ASL has no specific IPY plans, several current projects are relevant to the IPY. For example, the Navy routinely de-classifies environmental data and may use the IPY to release additional data. Bathymetric data from 1999 through 2002 should be released prior to the IPY, and upward-looking sonar data may be available. Furthermore, the Navy is planning ice camps near Prudhoe Bay for five weeks (beginning late March/early April) in the spring of 2007 and 2009, and the Navy has committed to making two to three weeks available for scientific experiments. Finally, the Navy previously operated several dedicated Scientific Ice Expeditions (SCICEX) cruises to the Arctic. While the likelihood for dedicated science submarine cruises during IPY is low, programs on a cruise staffed exclusively by navy personnel is possible (SCICEX accommodations, where samples will be collected by navy personnel, but no civilian scientists will be on board).

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Dr. James Mahoney, Assistant Secretary of Commerce for Oceans and Atmosphere and the National Oceanic and Atmospheric Administration (NOAA) Deputy Administrator, presented for NOAA. As a representative of the Climate Change Science Program (CCSP), Dr. Mahoney emphasized that the IPY is an opportunity to further polar research and understanding if stronger links are made between the IPY, CCSP, and the GEO efforts. NOAA believes the IPY is an ideal opportunity to advance observations of the polar region, and NOAA noted that “observations” include not only the original acquisition of data, but also archiving and long-term stewardship of the data and its application to societal needs. NOAA stressed that the IPY is an ideal time for advancing observations of sea ice, polar oceans and seas, and biological variables, and for vigorous efforts to provide ground-truth for satellite instrument-derived data sets. Establishing a baseline to assess future change, both physical and biological, could be a lasting legacy of the IPY.

NOAA suggests that an effort to improve decision-support systems in the Arctic be a focus for the IPY. Recent changes and model projections, if realized, will require significant adaptive response by Arctic residents, and new management approaches for species that are or may become exploited or endangered. An emphasis on biological observations to detect climate impacts and identify new management approaches requires an initial exploratory survey in under-studied regions such as the polar regions. NOAA also advocates an increased effort on impacts of “space weather” during the IPY, which could extend our knowledge of the space frontier and pay benefits in protecting people and infrastructure.

As probably all agencies will do, NOAA has evaluated its participation in IPY along three lines: (1) what is NOAA already doing that would contribute to the IPY; (2) what current activities could be modified to better meet IPY objectives; and (3) what new activities might NOAA consider for the IPY period and beyond. To evaluate the IPY-relevance of current activities, NOAA has completed an inventory of its ongoing activities in the polar regions; all five of NOAA's line offices have some level of polar activity. The vast majority of NOAA's current polar programs are in the broad category of environmental observations, either by satellite or in situ means. Most of these observations are conducted by operational programs supporting one or more of NOAA's strategic missions. Activities such as satellite operations, weather station operations, living marine resource assessment, trace gas monitoring, nautical charting, sea ice forecasting, data management, and others will continue during and beyond the IPY period. Some of NOAA's observational programs (e.g., sea ice thickness, atmospheric observatories, ocean observations) are still in their early development and may evolve somewhat before the IPY begins. NOAA has several campaign-style programs that are likely to have a polar expression during the IPY. These include the Ocean Exploration and Undersea Research Programs and the Weather Research Program.

Among the activities NOAA will consider for its FY2007 budget are several that relate to recommendations of the U.S. National Committee:

NRC Recommendation 1: Initiate a sustained effort to assess environmental change and variability

- Extend GOOS/GEO to the Arctic Ocean—sea ice thickness, snow cover, motion, and energy balance; Arctic Ocean structure and circulation; Bering Strait Observations
- Begin Arctic System Reanalysis—high resolution Arctic coupled ocean-ice-atmosphere model with data assimilation to produce uniform gridded fields from non-uniform observations
- Capture historical polar data sets, construct data atlases, and make available to public through web-based means
- Implement North Pacific and Arctic Observing Enhancement (THORPEX) leading to first ever verification of Arctic weather forecasts

NRC Recommendation 2: Study of coupled human-natural systems

- Enhance decision-support capabilities in Alaska through exchange of information with users on application of climate data for their benefit; work with Arctic countries to develop circumpolar decision-support capabilities
- Develop a circumpolar map of resources at risk from oil spills in the Arctic
- Undertake research to improve short-term Arctic sea ice forecasting to improve navigation and subsistence activities

NRC Recommendation 3: Explore new frontiers

- Enhance research in Alaska on biological and biogeochemical responses to climate change in the Arctic Ocean and in permafrost areas
- Enhance research on marine mammal (e.g., Right Whale, Steller Sea Lion, Ice Seals) population dynamics in the Bering, Beaufort, and Chukchi Seas
- Begin research on air/sea coupling east of Greenland and its influence on ocean thermohaline circulation (both weather and climate influence)

NRC Recommendations 4 and 5: Create observing networks and improve science infrastructure

- Accelerate Alaskan coastal bathymetry and shoreline mapping
- Add real-time water level stations in Alaska
- Accelerate application of NOAA satellites, ships, and aircraft to observation of polar regions

U.S. DEPARTMENT OF STATE

Mr. Ray Arnaudo, Deputy Director of the Office of Environmental Sciences/Ocean Affairs, spoke on behalf of the U.S. Department of State. Although the State Department is not typically thought of as a research-granting agency, they do provide some limited funds for studies on international issues. Nonetheless, the main resource that the State Department has is international outreach, connection, and cooperation through U.S. embassies. These embassies are a major network already in place for dissemination of IPY information. For instance, the Public Affairs Bureau in the Department is a simple and effective method to get resources and information out to other countries. The State Department also leads U.S. delegations to the Antarctic Treaty, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), AMAP, the Arctic Council and others, where it can urge support for the IPY. The State Department has some specific interests in IPY research including refurbishing icebreakers, strengthening the polar focus in the GEO effort, enhancing continental shelf research, improving ecosystem management via CCAMLR, utilizing the GLOBE program as a vehicle for getting students involved in research, and further incorporating EMAP.

THE SMITHSONIAN INSTITUTION

Dr. William Fitzhugh, Director of the Smithsonian Arctic Studies Center, presented on behalf of The Smithsonian Institution. The Smithsonian Institution recognizes three primary areas where it may make substantial contribution to the

IPY via its science, collections, and public education. In the realm of polar science, the Smithsonian Institution has a relatively small operation, compared to other major agencies; it is most actively engaged in anthropological and human-environment research in the Arctic through its Arctic Studies Center. The Smithsonian is perhaps better known for its collections, and it has a vast repository of artifacts from previous U.S. IPY expeditions, as well as Antarctic meteorite collections, and additional polar materials in the fields of botany, zoology, and paleoecology. The Smithsonian might use the forthcoming IPY as an opportunity for an enhanced effort to preserve instrumentation and other records of the IPY-1 and of IGY, as well as of the new IPY. The Smithsonian is also well-known for public education and is already planning a small display on arctic climate change in 2005. It is possible that a Smithsonian contribution to the IPY could be a larger public education display, including a major exhibit (with potential traveling venues), additional science projects with public outreach, and more integration of current climate change projects already on-going.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. Jack Kaye, Director of the Earth Science Enterprise Research Division, presented for the National Aeronautics and Space Administration (NASA). Potential NASA contributions to IPY cut across multiple NASA enterprises (pre-transformation), including the Office of Earth Science, the Office of Space Science, and the Office of Biological and Physical Research. NASA’s contributions likely will involve ongoing activities (operating satellites, continuing ground networks, and scientific research), some episodic activities (satellite snapshots and field campaigns), and possibly some new satellites. Currently, NASA operates nearly 20 satellites that collect information about the polar regions. Some, such as IceSat, provide unique polar information not available from other sensors. NASA emphasized the need for surface (ground and ocean surface) and airborne observations to complement their satellite based sensors in order to do proper calibration/validation work and achieve the best scientific results.

NASA also has polar missions that reach beyond Earth, including the PHOENIX Mission that will land near Mars North Pole in 2008, the Lunar Recon Orbiter that will map Lunar polar regions for the first time in 2008, and the Mars Recon Orbiter (MRO) that will explore Martian polar regions from orbit. NASA stressed that polar analogues in Mars exploration are vital; for instance, scientists have used Earth’s polar regions to simulate Mars for over 30 years. For instance, the Dry Valleys of Antarctica are the best “Mars analogue” known on Earth. The ASTEP Program (astrobiology) uses polar activities in Antarctic, Axel Heiberg, Svalbard, Siberia, and in the future potentially Iceland. In summary, NASA is using the polar region analogues as we prepare to explore “beyond”, where astronauts and robotics emulate future deep space mission scenarios. NASA also noted that the new NASA Science Mission Directorate (Earth and Space sciences) can help extend the “reach” of IPY to science-relevant polar regions of Mars, the Moon, and beyond.

NASA is well-known for cutting edge technology, and they envision using the IPY to test new tools and techniques, including UAVs. NASA also anticipates a field campaign during 2006-2007, looking at Greenland outlet glaciers. NASA plans to enhance coordination in the IPY, particularly through complementary surface-based observations, integrated modeling, and involvement in major government-wide activities (SEARCH, CCSP, GEO). Some potential NASA science, technology, and outreach elements include:

NRC Recommendation 1: Initiate a sustained effort to assess environmental change and variability

- Polar feedbacks (CCSP): Satellite derived albedo
- Polar snapshot: Work with other agencies that have sensors with limited duty cycles (e.g. SAR) to cover polar regions, in an effort to maximize repeat coverage. This should occur in conjunction with field activities.
- Targeted airborne laser surveys of polar ice sheet elevation changes: Repeat Canada, Greenland, and Antarctica surveys of the 1990s and 2002 for revised mass balance assessment, in particular to determine if mass loss is accelerating.
- Surveys of ice thicknesses around the perimeter of Antarctic and Greenland grounding lines with ice-penetrating radar

NRC Recommendation 2: Study of coupled human-natural systems

- Ozone observations and process studies

NRC Recommendation 3: Explore new frontiers

- Polar Regions as stepping stones to planetary environment
- Polar analogies to other planets, including surface and environmental characteristics, and paleo-environmental proxies

NRC Recommendations 4 and 5: Create observing networks and improve science infrastructure

- New observation networks that are stepping stones to exploring other planets. Sensor networks, intelligent data collection (e.g. artificial intelligence), and power management are particular interests.
- Surface rovers: Transition currently passive rovers such Tumbleweed to a steerable design
- UAVs: Develop a UAV SAR, or UAV laser altimetry to survey targeted areas of polar ice

NRC Recommendation 6: Education and outreach

- Wide-band data transmission for virtual presence
- Challenges for instrumentation development to meet observational challenges

NATIONAL INSTITUTES OF HEALTH

Dr. Sharon Hrynkow, Acting Director of the Fogarty International Center (FIC), presented for the National Institutes of Heath (NIH). FIC has recently been designated the NIH focal point on Arctic issues. Under the direction of NIH Director, Dr. Elias Zerhouni, the NIH is initiating new ways of thinking and operating, specifically highlighting interdisciplinary teams. For the IPY, FIC/NIH envisions an opportunity to highlight human health and suggested that the World Health Organization also be asked to co-sponsor the IPY. NIH ideas for consideration include polar human health studies of infectious and chronic diseases and mental health and suicide, and training northern residents, particularly girls, in medicine and public health.

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Dr. Kathie L. Olsen, Associate Director for Science, indicated that Office of Science and Technology Policy (OSTP) is supportive of IPY and its wide range of exciting scientific questions covering many disciplines and providing opportunities for advancing interdisciplinary sciences of north and south polar regions. OSTP acknowledges the lead Federal agency role of NSF in Arctic research, as specified in the Arctic Research and Policy Act of 1984. Should the need arise for involvement of the National Science and Technology Council (NSTC), OSTP is willing to assist in this process. Dr. Olsen also noted that the Global Earth Observation System of Systems (GEOSS) is a high priority for the Administration, and it is being developed around the global observations needed to study scientific questions. Many of these questions, from climate change to health to the environment, involve concepts of the IPY.

DEPARTMENT OF DEFENSE/OFFICE OF NAVAL RESEARCH

Dr. James Andrews highlighted the Office of Naval Research (ONR) interest in IPY. Although ONR has had a long history of science and research in the polar regions, the High Latitudes Program has come to an end, and ONR participation likely will be on an individual principle investigator basis, either through various environmental studies or for sensors and remote systems.

SESSION SUMMARY: A FRAMEWORK FOR THE IPY

At the conclusion of the agency presentations, workshop committee member Mr. Phil Smith proposed a framework for the IPY, which incorporated the ideas from the *Vision report* and most of the major initiatives discussed by the agencies and in the ensuing group discussions. The tentative "Framework for IPY" includes eight objectives (Table 1). During discussion of the framework, it became clear that the potential activities described by the agencies tracked well to the main themes of the *Vision report* and that the agencies had many concrete ideas for IPY activities that would be in line with the international context, and at the same time, further U.S. interests.

TABLE 2.1 A Framework for the IPY*

1. Enhancement of observations at existing stations, including the use of new technologies and multidisciplinary approaches
2. Consideration of special observing days/periods, as in the IGY
3. A set of programs that will discuss, analyze, and research environmental change
4. Exploration of new frontiers
    a. New science (e.g., genomics)
    b. New regions (e.g., Arctic Basin, Bering Sea, WAIS)
5. New observational networks (which would create a post IPY)
6. Human-environment interactions
    a. Cold region engineering
    b. Human health (environmental health and diseases/addictions, etc.)
    c. Tapping native knowledge
7. Public understanding
8. Data management
    a. Re-examination of existing data
    b. Reintegration of networks
    c. Improving modeling
    d. Handling new data
    e. Protocols for international data access

*New technologies, sensors, telecommunications, UAVs, etc., run across all of these 8 points.

3

SCIENCE AND TECHNOLOGY INITIATIVES

Following the agency remarks, members of the International Polar Year Implementation Workshop Committee led a discussion on each of the five science and technology recommendations from the *Vision report*[4]. The sessions began with a brief statement summarizing the recommendations, followed by general discussion. This summary is based on comments expressed by participants and documents handed out at the workshop.

ENVIRONMENTAL CHANGE AND VARIABILITY IN THE POLAR REGIONS

The discussion on IPY science issues was moderated by Dr. David Bromwich, from the Ohio State University, and Warren Zapol, M.D., from Harvard Medical School and the Massachusetts General Hospital. The initial discussion focused on environmental change. It is well recognized that environmental change and variability are part of the natural pattern on Earth, but changes currently witnessed in the polar regions are in many cases more pronounced than changes observed in the midlatitudes or tropics (NRC, 2004). Participants noted that the polar regions are part of a globally-linked system, and encouraging IPY studies that focus on global teleconnections would be beneficial. The recently-established World Meteorological Organization (WMO) Implement North Pacific and Arctic Observing Enhancement (THORPEX) program could be one mechanism to develop these global teleconnection studies. THORPEX is an international research program to accelerate improvements in the accuracy of 1- to 14-day weather forecasts for the benefit of society, the economy, and for residents of the polar regions.

In the Arctic, participants noted that U.S. interests might include internationally-coordinated studies of environmental change and further development of an international observing network. Environmental change crosses all national boundaries, and the underlying mechanisms driving change are pan-

[4] The full text of the *Vision* report (NRC, 2004) recommendations are listed in Appendix E.

Arctic and global, necessitating a coordinated, international effort. Several initiatives to study change already exist or are proposed (e.g., Study of Environmental Arctic Change (SEARCH), International Study of Arctic Change (ISAC), and the IPY) can provide additional benefits to these programs by facilitating international collaboration. Various workshops (NSF, 2002; NSF, 2004a) have recently discussed the development of a more robust Arctic observing network, as has the SEARCH implementation plan (SEARCH, 2003). However, participants stressed that all nations must agree to develop an international network in order to ensure a more successful effort. Along this front, a new NRC study, *Designing an Arctic Observing Network*, may be valuable, because the committee developing this report will consist of U.S. and foreign representation and will include a mix of science and implementation experts. More details on polar observing networks are presented in the next chapter. In addition to developing a more robust network, efforts to recover past data and create better models will be important efforts during the IPY. Participants also noted that the Arctic Climate Impact Assessment (ACIA), which is an international project to assess knowledge on climate variability, change, and increased ultraviolet radiation and their consequences, will contain extensive scientific recommendations, where the IPY could provide the in-depth understanding needed to enact ACIA recommendations by stressing a period of maximum effort by all the interested countries. It was also noted that one of the untapped sources of in-depth data on Arctic environmental change are daily observations and ecological knowledge of northern residents. Many participants felt that development of special programs engaging local environmental experts and subsistence users in IPY-related observational networks, both on the national (Alaska) and international levels, would be a valuable IPY contribution.

In the Antarctic, discussion focused on studies of environmental change, measuring discharge of ice off the Antarctic continent, and linked traverses in East Antarctica. To document environmental change, participants highlighted the need to develop an Antarctic counterpart to Arctic efforts such as SEARCH or ISAC, which could include an extension of the West Antarctic Ice Sheet (WAIS) efforts already underway. For example, several nations are planning to collaborate on a WAIS drilling project during the IPY to obtain a 100,000 year record. Because this will require significant resources, there may be opportunities for developing other studies in West Antarctica in coordination with this drilling program. The IPY is therefore a chance to develop an internationally-coordinated observational and modeling plan to understand past changes (including rapid changes), measure the present, and prepare for the future. To guide the IPY effort efficiently, participants discussed the possibility of focusing on the interaction of ice sheets, the underlying lithosphere, and the atmosphere and oceans, which would have interagency and international interest. By studying the current environmental conditions in Antarctica, data from the IPY also could be used to further understanding of feedbacks between Antarctica and lower latitudes.

Discussion on measuring the discharge of ice off the Antarctic continent noted the major logistic challenges associated with this endeavor, highlighting the need for international collaboration. While the United States cannot undertake this effort alone, it possibly could be accomplished through a collaborative international effort, where different countries take different pieces of the perimeter. This type of activity also is very true to the spirit of IPY, and there has already been some discussion at the international level about the possibility of partitioning Antarctica into "slices" and having countries lead the efforts for infrastructure and science in a particular area. Some discussion focused on the possibility of focusing U.S. effort in the Ross Sea sector where U.S. logistical capability is centered. The Antarctic Regional Interactions Meteorology Experiment (RIME) is an example of this approach.

COUPLED POLAR HUMAN-NATURAL SYSTEMS

Workshop participants discussed how the U.S. and international science communities could use the IPY to pioneer new polar studies of coupled human-natural systems and encourage research to understand the impacts of environmental-technological-cultural change on daily life and society at the community, regional, and global levels**.** Participants commented that more studies are needed to examine the effects of polar environmental change on the human-built environment, including new research in polar engineering, sustainable land and resource use, social policies, and the sustainability of northern communities. There also was discussion on initiating new interdisciplinary studies of past and present human and societal adaptations in the polar regions and exploring new strategies and holistic approaches to communicate the polar regions' unique contribution to global cultural and ecological diversity.

Many participants felt that these new approaches will advance the scientific use of traditional ecological knowledge and concepts developed by polar residents; pioneer the systemic value of the indigenous concept of "wellness"[5]; advance studies in community sustainability, subsistence, and co-management strategies; promote studies of ecosystem health and spiritual and environmental healing; encourage culture, heritage, and language preservation; and promote scholarly cooperation between polar researchers and local environmental experts.

Discussion on coupled human-environment dynamics also focused on human physical and mental health. In particular, most participants agreed that medicine and public health studies driven by National Institutes of Health (NIH) scientists and examining the recent increase in Arctic resident heart, lung, and blood diseases, as well as mental health studies in terms of suicide and understanding the affect of darkness and other environmental stressors on mental health, would be valuable

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[5] "Wellness" is a popular term among the arctic residents, and it encourages a holistic view of the Arctic as an environment—a system where humans and biological species live together.

additions to the IPY program. There also was interest in research on alcoholism and abuse, diabetes due to changing diets, social change, and the arrival of vector diseases to the Arctic.

Concern over the effects of environmental change on the human-built environment led to discussion on cold-weather engineering. Engineering research is critical for cold regions, and proponents stressed that research is needed to find out what "safe" engineering means in the Arctic, particularly in a time of rapid environmental change. There was also discussion of the necessity of an engineering program to cope with the effects of thawing permafrost and increased storm-induced coastal erosion, and in particular what this will mean for buildings, roads, harbors, and community infrastructure.

Some participants also thought studies on pollution would be important for the IPY, particularly to understand the effects of contaminants on humans and ecosystems. In addition, some participants noted that fisheries and ecosystem management in the polar regions is challenging because in many cases we do not fully know the inter-species dynamics in polar ecosystems, nor how the ecosystems function in rapidly changing conditions. The Census of Marine Life project (http://www.coml.org) is an international program to catalog the marine ecosystems, and the IPY could help initiate a census for polar regions.

Participants recognized that significant involvement of the social science community is essential for dealing with issues such as the human dimensions of climate change, wellness, and sustainable land use. These comments are echoed by many other discussions with the science community, both nationally and internationally. Most of the discussions focusing on the need to integrate physical and social sciences note the difficulty in this task and this workshop did not spend considerable time discussing mechanisms to increase the role of social scientists in IPY activities. However, it was noted that a recently formed International Arctic Social Science Association (IASSA) IPY team might facilitate involvement of this community in the IPY.

EXPLORING NEW SCIENTIFIC FRONTIERS

As noted in the *Vision report*, exploration of the unknown has been a vital part of humanity's interaction with the polar environment for thousands of years. In earlier IPY and IGY research programs, science-driven exploration of new geographical regions was a major activity. In the IPY 2007-2008, only limited regions of the Earth's surface, such as parts of East Antarctica, remain to be explored in the traditional geographic sense. But new scientific frontiers and challenges loom as exploration activity takes advantage of new disciplines and technologies. Discussion during the workshop highlighted four main themes for scientific exploration: genomics, life in extreme environments, geographic places, and the polar night.

We know very little about the most prominent species in the polar regions—the microbes (NRC, 2003). These species are involved in virtually all biogeochemical transformations in terrestrial, freshwater, and marine ecosystems of the polar regions. Without better knowledge of the microbial world at the polar regions, we lack the basis for a comprehensive understanding of the functions of polar ecosystems and their susceptibility to climate change and pollution. Genomic methodologies, which are defined in NRC (2003) as “the study of the structure, content, and evolution of genomes, including the analysis of expression and function of both genes and proteins,” allow identification of species and elucidation of the types of functions their genes and proteins enable them to perform. These new DNA-based methods now provide microbiologists with tools to determine what microbes are out there and what roles they play in ecosystems. An emphasis on genomic sequencing of polar organisms or communities during the IPY would open up important new understanding of the pivotal role that microbes play in all polar ecosystems.

Genomic techniques also will help scientists understand life in extreme environments, including how polar organisms adapt to physical extremes. As noted in the NASA remarks, the polar regions are proxies for other worlds, and this research might help us understand life beyond Earth. At the same time, it may help us develop new bio-medical remedies for humankind.

Exploration in the traditional sense of going to (relatively) new places still has a role in the next IPY. Recent expeditions to the Gakkel Ridge revealed surprisingly abundant hydrothermal and volcanic activity, highlighting that we do not fully understand Arctic basins. These long-lived hydrothermal ecosystems may have been cut off from the rest of the oceanic ecosystem for a long time, since the ridge segments are isolated, so these ecosystems may contain a large number of endemic species and provide constraints on the genetics and evolution of seafloor organisms. Other potential expeditions to the Canadian and Eurasian Basins during IPY likely will reveal surprises. Although the continental shelves are areas where relatively more exploration has been undertaken, there are few cores of the shelves. The technology is now available to sample these regions with cores.

There was also discussion of exploration of East Antarctica and the bedrock conditions of the ice sheet, as well as subglacial lakes. Buried miles beneath the Antarctic ice sheets are subglacial lakes ranging in size from Lake Vostok, a body the size of Lake Ontario, to shallow frozen features the size of Manhattan. Scientists have now identified over 100 lakes, and these unique environments are found nowhere else on Earth. Sealed from free exchange with the atmosphere for 10 million to 35 million years, subglacial environments are the closest Earth-bound analogs to the icy domains of the planet Mars and the moon Europa, and discoveries about life and climate on Earth in the subglacial lakes may have implications for other planets. Nonetheless, subglacial lake exploration poses one of the most challenging scientific, environmental, and technological issues facing polar science today. Therefore, drilling into Lake Vostok as part of the IPY may be difficult due to the technical and environmental challenges, but the IPY could serve as a testbed for subglacial lake drilling technologies. It is possible that a small, isolated lake could be reached during the IPY time frame.

In addition to spatial exploration, the IPY could improve our ability to observe conditions during the polar night. This is a time when few scientists operate in the field and when visible satellites cannot provide much information. There is general agreement in the science community that the polar night is not a time of hibernation, but we have not thoroughly investigated processes during the polar night to know much about what happens during this period.

POLAR OBSERVING NETWORKS

Workshop participants recognized that observations of many significant components of the polar regions remain extremely limited and nonstandardized, due to the small, scattered human populations, limited scientific infrastructure, and inherent difficulties of working in cold, remote environments year-round over sustained periods of time. Additionally, observation infrastructure and records are being lost, reduced, or eliminated in some countries, further restricting our ability to understand these complex regions. There was a strong feeling that the IPY can make a major contribution to science and society by intensively observing the polar regions, undertaking international data rescue efforts, and setting in place an observation network to enable ongoing observations of the polar regions in the decades to come.

The development and installation of international, long-term, multidisciplinary observing networks could be a particularly significant legacy of the IPY 2007-2008. It is important to remember that IGY efforts were not confined to the 18-month timeframe; the long-term data collection started in the IGY produced many key and still-continuing data series, such as the famous CO_2 records from Mauna Loa and the South Pole. The aspiration for developing a better polar observational network is well-timed for integration with other systems currently in development. For example, the Group of Environmental Observations (GEO) project currently is developing a 10-year implementation plan for designing a global observing network. The IPY can play an important role in the GEO effort by facilitating the development of the polar network, and the participants noted that connections between GEO and IPY need to be strengthened in the coming months in order to realize the potential. The Ocean Research Interactive Observatory Networks (ORION) project also is developing an oceans observing project, which could be cloned to both poles; plans for a cabled observatory off of Barrow would facilitate this during the IPY. The Circumpolar Environmental Observations Network (CEON), which currently is a compilation of present-day observing efforts, also could be expanded through the IPY. Some discussion focused on the role local residents could play in an expanded network. Using their ecological knowledge, this would be a powerful and plentiful resource. There also was extensive discussion of the need to develop sensors and power systems to operate autonomous observatories over the polar night, particularly in the interior Antarctic.

Most participants strongly endorsed the concept of a "polar snapshot" during the IPY, when nations would focus their satellite assets on coordinated campaigns of obtaining information across the electromagnetic spectrum. Coordination of satellite observations from this ever-growing international suite of sensors and additional focus by higher data rate sensors that do not collect data continuously would secure valuable benchmark datasets and advance the effort to assess the ongoing polar change. Participants also noted the value of the polar snapshot idea would be maximized with intensive field campaigns during the IPY, to compare satellite observations with in situ measurements. It is unlikely that new satellites will be built for the IPY, but there is some hope that NASA can push along a salinity sensor for launch during IPY. There also were discussions about employing commercial satellites or utilizing high-resolution military satellites in a similar manner to the Surface Heat Budget of the Arctic Ocean (SHEBA) effort.

CRITICAL INFRASTRUCTURE

Participants began the discussion of critical infrastructure by noting that one of the IGY's great legacies was the valuable scientific and geopolitical infrastructure (e.g., research stations and the Antarctic Treaty) left behind, and that hopefully the coming IPY could have similar impacts. In particular, discussion focused on the potential for new international policies, better infrastructure, and innovative technologies that will be instrumental for collecting and analyzing data during the IPY and for disseminating IPY research to the broader public. There was concern that without some expanded and new international agreements, new pan-arctic observing networks that currently are being discussed will be at best very difficult, and perhaps impossible, to implement. The new science and development of expanded polar observing networks also will require better infrastructure to deploy, service, and maintain functionality in the system. Innovative sensors, better equipped to handle the polar night and take advantage of communications bandwith, also could be a fundamental part of the IPY.

Many participants expressed interest in capitalizing on the IPY to increase base infrastructure and revitalize the U.S. icebreaker fleet, which is moving toward obsolescence and requires attention soon if we are to be able to fulfill our scientific and geopolitical obligations in the polar regions. These infrastructure upgrades would facilitate research during the IPY and into future decades.

The multidisciplinary observing network mentioned above will improve spatial and temporal coverage and provide a critical benchmark dataset for assessing the state of the polar environment (NRC, 2004). While current technologies would provide a good basis for development of the network, new sensors and autonomous vehicles could greatly expand the value of the observing network. For instance, sensors that vary observational parameters or temporal sampling rates, or sensors that interact with each other in a “sensor web” would greatly expand the utility of the observing networks. These “smart” sensors also could last longer by better utilizing power, for instance by remaining dormant until the phenomenon they are programmed to measure occurs. The polar environment is an ideal testing ground for advancing these concepts, with tangible benefits from improving the relative proportion of valuable data that are collected to the more efficient use of available power (NRC, 2004).

Innovative technologies, in the form of autonomous vehicles, could provide additional observations between observing nodes, and they can be utilized to perform some functions that other ships and planes cannot (NRC, 2004). For instance, unmanned aerial vehicles (UAVs) can remain aloft for long time periods (more than 24 hours) and have tremendous range. Autonomous underwater vehicles (AUVs) are the subsurface complement to UAVs and share many of the same advantages—for example, long mission times and range with no risk to human life. Another promising strategy for obtaining significant surface and near-surface observations is the deployment of instrumented rovers, such as those in design and consideration for use on Mars. Although still in their infancy, the potential research applications for autonomous vehicles are numerous, and their continued adaptation for polar operations would be greatly advanced by a concerted IPY research program.

Many participants also noted the need to upgrade infrastructure to develop more comprehensive polar education programs, in particular enhancing bandwith and wireless capabilities in remote northern communities. Improving this infrastructure would also be instrumental in improving outreach efforts and better integrating native knowledge into observing networks.

A BROADER SCOPE

The above discussion on science and technology items focused on attainable, realistic goals, often based on existing or planned activities. Participants then brainstormed for “dream items” that they would like to see in a more ambitious IPY, should this be possible. The following list does not convey a ranking or importance, nor is it intended to be complete or comprehensive.

- Performing regional reanalyses of the coupled atmosphere-ocean-sea ice-land system of both polar regions to describe and understand contemporary climate variability and change
- Generating a genomic fingerprint of several polar organisms, including a microbe, fish, bird, and mammal
- Utilizing a movable array of seismographs, notably in Antarctica
- Accelerating icebreaker repair, in particular the Polar Sea
- Emphasizing an engineering program for cold regions
- Purchasing commercial satellite data (e.g., RADARSAT)

- Developing and adapting new technologies to the polar regions, such as rovers, UAVs, and drilling probes
- Using a steerable ice drill
- Equipping a long-range research aircraft capable of flights to East Antarctica
- Extending geodic infrastructure to the Antarctica interior
- Developing an inward-looking telescope
- Enhancing global teleconnections studies
- Revisiting glaciers studied during IGY
- Obtaining polar operations past the traditional season (e.g., polar night)
- Defining a policy of free global data during IPY, for the benefit of all, not the profit of some
- Establishing global infrastructure to create a legacy for generations to come
- Re-affirming easy access to other country zones for research purposes
- Proclaiming an international statement for the polar regions as “zones of peace”
- Developing international agreements for cooperation in future Arctic activities in a similar way that the Antarctic Treaty developed out of the IGY
- Encouraging countries who are not currently heavily involved in polar research to participate in the IPY, in particular, encouraging areas that are in conflict to participate
- Preserving the IPY legacy through logbooks, instruments, and photographs
- Collecting samples for study in years after the IPY
- Repeating laser altimetry studies in Greenland
- Surveying ice shelves to create better topographic maps
- Enacting sustained weather station measurements
- Laying out the strategy for an Icesat follow-on
- Creating a more spatially-representative marine-based Long Term Ecological Research (LTER)
- Finding a surplus submarine for polar research

4

DATA, EDUCATION, AND OUTREACH INITIATIVES

DATA ACCESSIBILITY AND MANAGEMENT

The discussions on data accessibility and management were moderated by Dr. Douglas Wiens (Washington University at St. Louis) and Dr. Peter Schlosser (Lamont-Doherty Earth Observatory of Columbia University). The session began with a presentation on the National Spatial Data Infrastructure (NSDI) by Dr. Alan Stevens of the United States Geological Survey (USGS). The NSDI is a committee of 19 Cabinet level agencies who are charged with overseeing data and data standards, and Dr. Stevens' presentation stressed the importance of using common standards and techniques to collect, process, and archive geospatial information and data.

For the IPY, the developing Global Spatial Data Infrastructure (GSDI), which is an international extension of the NSDI, could be helpful for managing the anticipated large amount of data. Important considerations for data policies are related to standards, metadata, and data interoperability. The GSDI has published a "cookbook" dealing with each of these components, and IPY researchers could use this information to incorporate data specifications and standards into proposals. By adhering to the policies, researchers can help ensure efficient data handling, sharing, and archiving during and after the IPY.

Participants then discussed some examples of data sharing successes, but noted that timely data sharing remains problematic in many international projects owing to differences in culture. Additionally, due to privacy laws, data sharing for some social science projects may not be applicable. Nonetheless, there was discussion that the IPY could be seen as an opportunity to further international data sharing and data policy standards. An easy step could be encouraging investigators to submit metadata well ahead of actually giving the data. This would inform other researchers of what is being collected and where information is available, which may open the possibility for more collaborative research and data exchange during the IPY. There were comments that enforcing data sharing policies is difficult. Most U.S. agencies already have data policies, but ensuring compliance is sometimes difficult because investigators often do not feel that it is to their interest, and it takes considerable time and effort to comply. In fact, a disincentive is that there is rarely credit for sharing with a data center, and researchers, especially younger investigators, have little incentive to work on the data because their career promotions are based on what they publish scientifically, not on whether they place their data into long-term archives.

After the data sharing discussion, comments focused on data management and what the appropriate structure for data storage might be in terms of a centralized archive or distributed archive network. Most participants felt a distributed network is the better option for the IPY, and comments then discussed using existing data centers, which already have the expertise and facilities to manage data. Comments also noted that creating new data structures would be expensive and inefficient. The discussion then concluded by noting that most decisions about IPY 2007-2008 data protocols, both with the United States and internationally, remain to be made. In the United States, the formation of a working group or task force, comprising representatives from agencies, data centers, and the science community, might be a way to further advance discussion of IPY data issues.

EDUCATION AND OUTREACH INITIATIVES

Following the data discussion, Drs. Schlosser and Wiens moderated the session on IPY education and outreach opportunities. Most workshop participants were not experts in education and outreach, but they recognized its importance. Preliminary discussion noted that education and outreach are small investments compared to some of the other activities proposed for the IPY, yet they will be a significant legacy that the IPY leaves to future generations.

The discussion continued with a presentation from Ms. Reneé Crain (NSF/OPP), who spoke about a recent NSF-sponsored workshop on IPY education and outreach. Participants at that workshop stressed that the IPY could be used to increase public knowledge and interest of the polar regions, engage northern residents more fully in outreach activities, increase the use of polar research examples in math and science classes, enhance polar science influence on policy, and help internationalize polar science. The workshop also noted that the IPY community will need to marshal a wide range of tools to accomplish these goals. High bandwidth communications will be important for live feeds from the field. These live feeds can highlight so-called “splash-events”, which draw considerable public interest. In the IGY, one splash-event was the satellite launch; a more recent example is the Mars rover. The workshop also suggested museums and zoos could be a means of engaging the public, particularly by showcasing charismatic polar mega faunas and paleofaunas, explaining why they are important, and discussing how they have changed historically and how they are changing currently. Marketing, industry, and professional societies are another tool that might help scientists make the polar regions relevant to people across the globe. Foundations might even be able to provide some funds for education/public outreach.

Following from Ms. Crain's presentation, Dr. Peter West, from the NSF Office of Legislative and Public affairs, provided some further remarks on outreach. Dr. West noted that the public is inherently interested in polar regions, and that there already exists a cadre of well-placed and influential reporters that are aware of the IPY. In comparison with the IGY, one major difference in working with the media is that it is now physically possible to broadcast live television from, for example, the dry valleys, the South Pole, or the waters under the Arctic ice cap.

After Dr. West's remarks, participants noted that regardless of the specific education and outreach approaches to the IPY, it will be crucial to design these programs concurrently with the science, and also engage Alaskan residents more explicitly. There was some discussion that the IGY outreach effort was staffed by a small team, but because that outreach was their sole focus, they were able to make significant contributions. For the IPY, discussion centered on the possibility of forming an interagency task force to address the issue of coordinated education and outreach efforts. There are international bodies that also are interested in education and outreach, such as the Arctic Council, and the U.S. efforts would benefit from engaging them early. As with data management, many decisions regarding education and outreach remain to be answered.

5

NEXT STEPS

This session was moderated by Mr. Phil Smith, the former Executive Officer of the National Research Council (NRC). The discussion noted that although the start of the IPY is still three years away, planning must continue at a quick pace in order for the United States to be fully prepared. Much remains to be done to articulate a clear interagency science plan, create opportunities for scientists to propose concrete activities, develop funding mechanisms, develop international partnerships, and ensure provision of the necessary logistics and infrastructure. The next steps highlighted at the workshop include:

- Continuing dissemination information about IPY planning to the science community and facilitating their involvement.
- Developing mechanisms for input: Scientists and science teams are developing, and mechanisms need to be established for interfacing with these groups.
- Integrating IPY goals with goals of Climate Change Science Program, Group on Earth Observations, etc.
- Articulating and communicating the overall compelling science issues: This includes short-term and long-term benefits that matter to Congress and the public. To market the IPY, some participants suggested that we need to capitalize on inherent public interest, appeal to the pragmatic side of Congress, and ensure IPY is about good science.
- Determining how something becomes part of “IPY” and what it means to be an “IPY” activity.
- Increasing planning discussion for a wide variety of education and outreach activities: One possible idea would be to form a working group to continue the dialog about strategies for education and outreach; the agencies and the PRB should be involved in the continuing discussions.
- Focusing more attention on data: Some participants suggested formation of a working group that includes members from agencies, data centers, and the science community. Participants noted that early leadership by the United States in

data management issues would help guide the eventual ICSU-WMO IPY plans in this area.

- Developing an IPY timeline: This timeline needs to list IPY tasks, with options for how various responsibilities could be filled.
- Advancing agency participation and coordination: The workshop is a good start, but continuing efforts are needed; particularly, mechanisms encouraging agencies to begin seeking ways to get IPY-related activities developed (such as interagency agreements, proposal processes, and budget discussions).
- Determining the future structure of national coordination: Many practical questions about process need to be answered and communicated. One solution discussed is that the Office of Science and Technology Policy (OSTP) and the National Science Foundation (NSF) continue to develop links and coordination mechanisms for agencies to make progress on IPY planning.
- Determining the future structure of international coordination: International coordination is necessary and all key U.S. parties have to agree on how U.S. interests will be represented in the international realm. The PRB, as the body that represents the U.S. at SCAR and IASC, can continue to play an important role in developing IPY internationally. As the U.S. representative to WMO, NOAA can also provide guidance.

POTENTIAL OUTCOMES OF THE IPY 2007-2008

The final session of the workshop, led by PRB Chair Dr. Robin Bell, discussed some possible outcomes of the IPY. Workshop participants identified outcomes that can be grouped into four categories: intellectual, societal, international, and agency/U.S. government. Results from this discussion are highlighted in Table 2.

At the conclusion of the workshop Dr. Bell thanked all the IPY workshop participants for their participation, saying that the two days had been highly productive because of the superb contributions all had made to the discussions.

TABLE 5.1 Potential Outcomes of the IPY 2007-2008

Intellectual	• Creating a polar legacy for the next 50 years
	  o New data that is accessible to all interested persons and institutions
	  o Advances in scientific understanding
	  o Observational infrastructure for ongoing polar research
	• Understanding teleconnections and roles of polar processes in global climate/weather
	• Improving understanding of human impacts on polar regions
	• Advancing technology for polar science
	• Improving the breadth and number of interdisciplinary studies

	• Improving data sharing and data management through creation of accessible metadata systems
Societal	• Inspiring spirit of discovery • Improving understanding of processes of change, how society is influencing change, and how changes will affect society • Improving environmental predictions • Training next generation of engineers, scientists and leaders • Improving the lives of northern residents by advancing studies of human health • Enhancing management and safety of fisheries • Understanding implications of Arctic Basin ice retreat for shipping and economic development
International	• Fostering the continued peaceful use of the poles • Advancing international cooperation • Engaging new partners and additional nations to engage in polar science • Leveraging resources to enhance science through international scientific collaborations
Agency/U.S. Government	• Enhancing agency synergisms • Improving management of fisheries • Renewing existing infrastructure and developing new infrastructure • Strengthening U.S. position in the Arctic Council and Antarctic Treaty

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APPENDIX A

Acronyms

ACAP	Alternative Cover Demonstration Project
ACIA	Arctic Climate Impact Assessment
AMAP	Arctic Monitoring and Assessment Programme
ARM	Atmospheric Radiation Measurement
ASL	Arctic Submarine Laboratory
AUV	autonomous underwater vehicle
CART	Cloud and Radiation Testbed
CCAMLR	Commission for Conservation of Antarctic Marine Living Resources
CCSP	Climate Change Science Program
CEON	Circumpolar Environmental Observations Network
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
EMAP	Environmental Monitoring Assessment Program
EPA	Environmental Protection Agency
FIC	Fogarty International Center
GEO	Group of Environmental Observations
GEOOS	Global Earth Observations System of Systems
GLOBE	Global Learning and Observations to Benefit the Environment
GOOS	Global Ocean Observing System
GSDI	Global Spatial Data Infrastructure
IASC	International Arctic Science Committee
IASSA	International Arctic Social Science Association
ICSU	International Council for Science
IGY	International Geophysical Year
IPY	International Polar Year
ISAC	International Study of Arctic Change
JGI	Joint Genome Institute
LRTAP	Long Range Transport of Air Pollution
LTER	Long-term Ecological Research

MRO	Mars Recon Orbiter
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NRC	National Research Council
NSDI	National Spatial Data Infrastructure
NSF	National Science Foundation
NSTC	National Science and Technology Council
ONR	Office of Naval Research
ORION	Ocean Research Interactivc Observatory Networks
OSTP	Office of Science and Technology Policy
PBTs	persistent, bioaccumulative, and toxic pollutants
PCBs	polychlorinated biphenyls
PI	Principle Investigator
POPs	persistent organic pollutants
PRB	Polar Research Board
RADARSAT	Radar Satellite
RIME	Antarctic Regional Interactions Meteorology Experiment
ROV	remotely operated vehicle
SAR	Synthetic Aperture Radar
SCAR	Scientific Committee on Antarctic Research
SCICEX	Scientific Ice Expeditions
SCOR	Scientific Committee for Oceanic Research
SEARCH	Study of Environmental Arctic Change
SHEBA	Surface Heat Budget of the Arctic Ocean
THORPEX	Implement North Pacific and Arctic Observing Enhancement
UARCTIC	University of the Arctic
UAV	unmanned aerial vehicle
UNEP	United Nations Environment Programme
USCG	United States Coast Guard
USGS	United States Geological Survey
USNC	United States National Committee
WAIS	West Antarctic Ice Sheet
WMO	World Meteorological Organization

APPENDIX B

International Polar Year Committee Biographies

Robin Bell, *chair,* is a Doherty Senior Research Scientist at the Lamont-Doherty Earth Observatory of Columbia University where she directs research programs on the Hudson River and in Antarctica. Dr. Bell is a geophysicist who earned her Ph.D. in 1989 from Columbia University. Her research interests are in linking the Earth's physical processes with the impacts on biota. These interests range from linking glacial and tectonic process to subglacial ecosystems, to understanding the ecosystem services provided to humans by rivers, estuaries and coastal environments. She is currently the U.S. representative to the Working Group on Geophysics of the Scientific Committee on Antarctic Research (SCAR) and vice-chair of the ICSU Planning Group for the International Polar Year.

Mary Albert is a senior research scientist at the U.S. Army Engineer Research and Development Center Cold Regions Research and Engineering Laboratory. She is also adjunct professor at the Thayer School of Engineering and the Environmental Sciences Department at Dartmouth College. Her research interests include flow and transport in porous media, surface-air physical and chemical exchange processes, snow physics, numerical modeling, effects of post depositional processes in snow and firn on ice core interpretation and on atmospheric composition. She has spent many field seasons conducting research in the deep field in Greenland and Antarctica and is a member of the National Research Council's Polar Research Board. Dr. Albert earned her Ph.D. in applied mechanics and engineering sciences in 1991 from the University of California, San Diego. Dr. Albert is chair of the U.S. National Committee for the International Polar Year.

David Bromwich is a senior research scientist and director of the Polar Meteorology Group at the Byrd Polar Research Center of the Ohio State University. He is also a professor with the Atmospheric Sciences Program of the Department of Geography. Dr. Bromwich's research interests include the climatic impacts of the Greenland and Antarctic ice sheets; coupled mesoscale-global circulation model simulations; the atmospheric moisture budget of high southern latitudes, Greenland, and the Arctic basin using numerical analyses; and the influence of tropical ocean-atmosphere variability on the polar regions. Dr. Bromwich has served on the

National Research Council's Committee on Geophysical and Environmental Data and was previously a U.S. Representative of the Scientific Committee on Antarctic Research. He is a member of the American Meteorological Society, the American Geophysical Union, the Royal Meteorological Society, and the American Association of Geographers. Dr. Bromwich earned his Ph.D. in meteorology from the University of Wisconsin, Madison, in 1979.

Richard Glenn is the vice president of lands for the Arctic Slope Regional Corporation. His professional experience includes petroleum geological studies, field geological mapping, structural geological and seismic interpretation, permafrost, methane hydrate, and borehole temperature profile research. Other specialties include year-round studies of the physical properties of sea ice near Barrow, Alaska; and temperature, salinity and crystallographic profiles of first- and multi-year sea ice and documentation of freeze-up, ice movement events, and spring thaw. He has served as director of the Department of Energy Management, North Slope Borough; general manager of Barrow Technical Services, a technical firm that provided project management consulting and geological and scientific research support services; and a geologist for the Arctic Slope Consulting Group. Mr. Glenn is a member of the Ilisagvik College Board of Trustees, board president of the Barrow Arctic Science Consortium, and former member of the U.S. Arctic Research Commission. Mr. Glenn is an Alaska native and earned his master's in geology from the University of Fairbanks.

David Karl is a professor of oceanography at the University of Hawaii. His research interests include marine microbial ecology, biogeochemistry, long-term time-series studies of climate and ecosystem variability, and the ocean's role in regulating the global concentration of CO_2 in the atmosphere. Dr. Karl is a member of the Polar Research Board. He earned his Ph.D. in oceanography from the Scripps Institution of Oceanography, University of California, San Diego, in 1978.

Peter Schlosser is the Vinton Professor of Earth and Environmental Engineering and professor of Earth and Environmental Sciences at Columbia University and senior research scientist at the Lamont-Doherty Earth Observatory. He also is the associate director of the Earth Institute at Columbia University. He received his Ph.D. in Physics from the University of Heidelberg, Germany, in 1985. Dr. Schlosser's research interests include studies of water movement and its variability in natural systems (oceans, lakes, rivers, groundwater) using natural and anthropogenic trace substances and isotopes as "dyes" or as "radioactive clocks"; ocean/atmosphere gas exchange; reconstruction of continental paleotemperature records using groundwater as an archive; and anthropogenic impacts on natural systems. He participated in seven major ocean expeditions, five to the polar regions. He was or presently is a member or chair of national and international science steering committees, including the World Ocean Circulation Experiment, the Climate Variability and Predictability Experiment, the World Climate Research

Program, the Surface Ocean Lower Atmosphere Study, and the Study of Environmental Arctic Change.

Philip M. Smith consults on science policy and management. As an organization executive, chair, or member of advisory committees, and a science and technology policy consultant, he is a leader in developing effective national and international science and technology policies and an expert in theory and practice of providing scientific advice to governments and international organizations. Dr. Smith was executive officer of the National Research Council for 13 years. He previously held senior positions in the White House Office of Science and Technology Policy, the Office of Management and Budget, and the National Science Foundation. He participated in the International Geophysical Year (IGY) and was involved in the organization and management of the U.S. Antarctic Program that followed the IGY. From 1995 through 2003 he consulted through the partnership McGeary and Smith. He served on several recent NRC committees, which reviewed the science, technology, and health aspects of the foreign policy agenda of the United States, the science advisory mechanisms of the United Nations system, and the role of science and technology in countering terrorism. Dr. Smith led a review of the mission, organization, and operating practices of the Scientific Committee on Antarctic Research and, with Michael McGeary, evaluated the organization and function of seven U.S. national committees for the international unions in the mathematical and physical sciences of the International Council for Science. He was awarded a D.Sc. (honoris causa) by North Carolina State University in recognition of his public service in science and technology policy.

Douglas Wiens is a professor of earth and planetary sciences at Washington University in St. Louis. His research interests include the structure of island arcs and oceanic spreading centers, anisotropy and flow patterns in the mantle, and the crustal and upper-mantle structure of Antarctica. He has directed field instrumentation programs in the Antarctic Peninsula and Trans-Antarctic Mountains. Dr. Wiens has served on the executive committee of the Incorporated Research Institutions in Seismology, the RIDGE and MARGINS steering committees, the Ocean Bottom Seismograph Instrumentation Pool oversight committee (as chair), and the Ocean Drilling Program Science Committee. He earned his Ph.D. in geological sciences from Northwestern University in 1985.

Warren Zapol, M.D. is the Reginald Jenny Professor of Anesthesia at Harvard Medical School and Anesthetist-in-Chief at Massachusetts General Hospital. Dr. Zapol has worked for many years in the Antarctic studying the adaptations of antarctic seals that allow them to breath-hold dive for over an hour at seawater depths over 600 meters. His seal research group was the first to use microprocessors (diving computers) for physiological monitoring and blood sampling of marine mammals free swimming under the antarctic fast ice. Our understanding of the strategy marine mammals use to avoid the bends and hypoxia (low blood oxygen levels) is based upon their blood nitrogen and oxygen measurements in free diving seals. Dr. Zapol is also interested in the safe and thoughtful study of various animal species, including marine mammals, to advance medical science and the therapy of critically ill humans. In 2003 he was awarded the Inventor of the Year Award for the treatment of hypoxic human newborns with inhaled nitric oxide, a lifesaving technique that he pioneered. Dr. Zapol is a member of the Institute of Medicine of the National Academy of Sciences.

NRC Staff

Sheldon Drobot has been a program officer at the Polar Research Board and the Board on Atmospheric Sciences and Climate since December 2002. He received his Ph.D. in geosciences (climatology specialty) from the University of Nebraska, Lincoln. Dr. Drobot has directed National Research Council studies that produced the reports *Elements of a Science Plan for the North Pacific Research Board* (2004), *Climate Data Records from Environmental Satellites* (2004), and *A Vision for the International Polar Year 2007-2008*. His research interests include sea ice-atmosphere interactions, microwave remote sensing, statistics, and long-range climate outlooks. Dr. Drobot will be joining the University of Colorado in December 2004, where he will continue researching interannual variability and trends in Arctic sea ice conditions and how low-frequency atmospheric circulation affects sea ice distribution, short-range forecasting of Great Lakes ice conditions, and biological implications of sea ice variability.

Chris Elfring is director of the Polar Research Board (PRB) and Board on Atmospheric Sciences and Climate (BASC). She is responsible for all aspects of strategic planning, project development and oversight, financial management, and personnel for both units. Since joining the PRB in 1996, Ms. Elfring has overseen or directed studies that produced the following reports: *Frontiers in Polar Biology in the Genomics Era* (2003), *Cumulative Environmental Impacts of Oil and Gas Activities on Alaska's North Slope* (2003), *A Century of Ecosystem Science: Planning Long-term Research in the Gulf of Alaska* (2002), and *Enhancing NASA's Contributions to Polar Science* (2001). In addition, she is responsible for the Board’s activities as the U.S. National Committee to the Scientific Committee on Antarctic Research.

Rachael Shiflett is a senior project assistant with the Polar Research Board. She received her M.Sc. in environmental law from Vermont Law School in 2001 and will complete her J.D. at Catholic University in May 2007. Her research interests include the Endangered Species Act, the Marine Mammal Protection Act, and the National Environmental Policy Act.

APPENDIX C

Workshop Agenda

International Polar Year 2007-2008: Implementation Workshop Report

July 8-9, 2004
The Lecture Room
National Academy of Sciences
2100 Constitution Avenue
Washington, DC

The objectives of this meeting were:
1. Review status of IPY planning
2. Discuss potential agency goals for the IPY
3. Discuss U.S. priorities and actions needed to move toward implementation

Thursday July 8

8:30	Welcome and Workshop Overview	*Robin Bell*, PRB Chair
8:40	Opening Remarks	*Bill Wulf*, NAE President, on behalf of the National Academies
8:55	The National Academies and IPY	*Chris Elfring*, PRB Director
9:00	A Vision for International Polar Year 2007– 2008	*Mary Albert*, Chair, USNC to IPY
9:30	Agency Remarks ❖ Each participating agency had 10-15 minutes to present possible goals for IPY	*Robin Bell*

11:45	Summary of possible goals and initial discussion of interagency coordination	*Phil Smith*
1:00	IPY Science Initiatives ❖ Assessing change (Rec'd 1) ❖ Coupled human-natural systems (Rec'd 2) ❖ New scientific frontiers (Rec'd 3)	*Moderators*: David Bromwich and Warren Zapol
3:00	IPY Technology Initiatives ❖ Observing networks (Rec'd 4) ❖ Critical human and physical infrastructure (Rec'd 5)	*Moderators*: Dave Karl and Richard Glenn
4:00	IPY Implementation Brainstorming: Identify what's needed to make IPY happen	*Moderators*: Peter Schlosser and Doug Wiens
5:15	Day 1 Wrap-up	*Robin Bell*

Friday July 9

8:30	Day 2 Overview	*Robin Bell*
8:45	Preliminary discussion: ❖ Timeframe and process of decision making ❖ Funding mechanisms and strategies	*Phil Smith*
9:30	Other issues that require future consideration: ❖ Data accessibility and management ❖ Interagency coordination ❖ International coordination ❖ Education and public outreach ❖ Policy relevance	*Moderators*: Peter Schlosser and Doug Wiens
1:00	Summary recap discussion of: ❖ Scientific challenges ❖ Understanding change ❖ Exploring new frontiers ❖ Technology for observations	*Robin Bell and all PRB and USNC Members*

- ❖ Increasing public understanding

2:30	Next steps: Putting Tentative U.S. Initiatives and Budgets Together	*Phil Smith*
3:15	Closing Remarks	*Robin Bell*
3:30	Adjourn	

APPENDIX D

Workshop Participant List

for
INTERNATIONAL POLAR YEAR PLANNING MEETING
July 8th-9th Washington, DC

Andrews, James E. – Office of Naval Research
Arnaudo, Raymond - State Department
Bement, Arden – National Science Foundation
Berkson, Jonathan – U.S. Coast Guard
Bindschadler, Robert – National Aeronautics and Space Administration
Blaisdell, George – National Science Foundation
Borg, Scott – National Science Foundation
Boyd, Robert S. – Knight Ridder Washington Bureau
Bundy, Marie – National Science Foundation
Calder, John – National Oceanic and Atmospheric Administration
Cole, Eric – U.S. Navy
Crain, Reneé – National Science Foundation
Crane, Kathleen - National Oceanic and Atmospheric Administration
Erb, Karl – National Science Foundation
Fitzhugh, William - Smithsonian Institution
Foley, Gary J. – Environmental Protection Agency
Gaynor, John – National Oceanic and Atmospheric Administration
Gossett, Jeffrey – Arctic Submarine Laboratory
Grunsfeld, John - National Aeronautics and Space Administration
Halpern, David – Office of Science and Technology Policy
Hrynkow, Sharon – National Institutes of Health
Kaye, Jack - National Aeronautics and Space Administration
Koblinsky, Chester J. – National Oceanic and Atmospheric Administration
Krupnik, Igor – Smithsonian Institution
Mahoney, James R. - National Oceanic and Atmospheric Administration
Metcalf, Altie – National Science Foundation
Mullins, Jerry – U.S. Geological Survey
Myers, Charles E. – National Science Foundation
Olsen, Kathie - Office of Science and Technology Policy
Penhale, Polly – National Science Foundation
Rosen, Rick – National Oceanic and Atmospheric Administration

Sheppard, Christal – House Science Committee
Simarski, Lynn – National Science Foundation
Sirois, RADM Dennis – U.S. Coast Guard
Smith, Bradley - Office of the Secretary of Defense
Stevens, Alan – U.S. Geological Survey
Steele, Douglas – Environmental Protection Agency
Stone, Brian – National Science Foundation
Swanberg, Neil – National Science Foundation
Tuttle, Robin – National Oceanic and Atmospheric Administration
Underwood, Rear Admiral James W. – U.S. Coast Guard
Washburn, Edward – Environmental Protection Agency
Weedman, Susanne – U.S. Geological Survey
West, Peter – National Science Foundation
Wharton, Robert – National Science Foundation
Wiseman, Bill – National Science Foundation
Wojahn, Tom, CDR – U.S. Coast Guard

APPENDIX E

A Vision for the International Polar Year 2007-2008: Recommendations

Recommendation 1: The U.S. science community and agencies should use the International Polar Year to initiate a sustained effort aimed at assessing large-scale environmental change and variability in the polar regions.

- *Provide a comprehensive assessment of polar environmental changes through studies of the past environment and the creation of baseline datasets and long-term measurements for future investigations*.

  Environmental changes currently observed in the polar regions are unprecedented in times of modern observation. Studies investigating natural environmental variability and human influence on our planet will help in understanding mechanisms of rapid climate change and in developing models suitable for forecasting changes that will occur in the twenty-first century. This effort will need to be sustained after IPY 2007-2008.

- *Encourage interdisciplinary studies and the development of models that integrate geophysical, ecological, social science, and economic data, especially investigations of the prediction and consequences of rapid change.*

  Because of its broad interdisciplinary approach, research initiated in IPY 2007-2008 stands to make a significant contribution to our understanding of the causes and consequences of change in the polar regions.

Recommendation 2: The U.S. science community and agencies should pioneer new polar studies of coupled human-natural systems that are critical to U.S. societal, economic, and strategic interests.

- *Encourage research to understand the role of the polar regions in globally linked systems and the impacts of environmental change on society.*

  Daily life and economic and strategic activities are constantly affected by changing environmental conditions, including the frequency and degree of severe weather events such as storms or droughts in many regions, including the continental United States. Investigations of impacts of linked environmental-technological-social change and health effects in many communities, including northern communities, are needed.

- *Investigate physical-chemical-biological interactions in natural systems in a global system context.*

  Interdisciplinary approaches hold great promise for understanding the dynamics of anthropogenic activities, technologies, and environmental consequences. Investigations of linked atmospheric-oceanic-ice-land processes in the polar regions will enable understanding of global linkages and transformations due to natural and anthropogenic causes.

- *Examine the effects of polar environmental change on the human-built environment.*

  Because of the recent large-scale environmental changes, northern communities, infrastructure, and other forms of human-built environment are affected by a variety of factors, such as the thawing of permafrost, higher frequency of severe storms and weather conditions; increased shore- and beach erosion, vegetation die-off, and fire danger. New engineering and policy research should investigate economically feasible and culturally appropriate mitigation techniques for countering the effects of a changing environment on technology, local communities, and their infrastructure, including all-season ground and air transportation, the design of roads, harbors, foundations, and buildings.

Recommendation 3: The U.S. International Polar Year effort should explore new scientific frontiers from the molecular to the planetary scale.

- *Conduct a range of activities such as multidisciplinary studies of terrestrial and aquatic biological communities; oceanographic processes, including seafloor environments; subglacial environments and unexplored subglacial lakes; the Earth's deep interior; and Sun-Earth connections.*

  Opportunities for discoveries exist in many areas, and research could elucidate the structures of poorly understood biological communities, notably the microbial populations that contribute to most biogeochemical transformations; reveal oceanic processes that contribute importantly to biological productivity and climate; and discover new physical, chemical, and, potentially, biological characteristics of subglacial lakes long isolated from atmospheric contact. This research also could help understand major geological processes such as seafloor spreading, explore the subglacial topography and bedrock geology of regions important for Earth's climate history, map the structure of Earth's interior and explore the links between mantle structure and surface processes, and provide an integrative synthesis of the interactions of our planet with the Sun.

- *Apply new knowledge gained from exploration to questions of societal importance.*

  Polar biological studies, notably those that employ modern genomic methodologies, will advance biomedical and biotechnological research. For example, understanding how small mammals withstand temperatures near freezing during hibernation will contribute to improved protocols for cold storage of biological materials and for cryosurgery. Studies of oceanographic phenomena will facilitate more accurate understanding of the mechanisms driving climate change. Understanding how increased flow of fresh water into the polar oceans alters circulation patterns and transfer of heat from the tropics to the poles is one example of contributions from oceanography. Advances in the geosciences (e.g., through study of the extremely slow seafloor spreading rates in the Arctic) may shed light on tectonic processes that contribute to seismic events. Better understanding of solar influences on the atmosphere and Earth will improve understanding of the forces that drive weather systems and of solar activity on global communications and other technical systems.

- *Invest in new capabilities essential to support interdisciplinary exploration at the poles.*

  New scientific discoveries are based in part on the availability of enhanced logistics to provide access to unexplored regions as well as new technologies to provide new types of data. The IPY field component should aggressively seek to further develop innovative strategies for polar exploration.

Recommendation 4: The International Polar Year should be used as an opportunity to design and implement multidisciplinary polar observing networks that will provide a long-term perspective.

- *Design and establish integrated multidisciplinary observing networks that employ new sensing technologies and data assimilation techniques to quantify spatial and temporal change in the polar regions*.

  The IPY will provide the integrative basis for advancing system-scale long-term observational capabilities across disciplines. A goal of the IPY should be the design and establishment of a system of integrated multidisciplinary observing networks. New autonomous instrumentation requires development with the harsh polar environment in mind. Instruments required for different types of studies can be clustered together, minimizing the collective environmental risks of survival and encouraging integrated analysis. Common observational protocols, such as observation frequency and measurement precision, will increase the spatial range of the observations and simplify data assimilation. Once established in the IPY, such protocols will serve polar science in the longer term.

- *Conduct an internationally coordinated "snapshot" of the polar regions using all available satellite sensors.*

  Two hallmarks of the IGY were the dawn of the satellite era and the establishment of enduring benchmark datasets. Today's ever-growing suite of satellite sensors provides unique views of the polar regions with unprecedented detail. Marshaling the collective satellite resources of all space agencies around the world would supply generations of future scientists an unparalleled view of the state of the polar regions during the IPY 2007-2008.

Recommendation 5: The United States should invest in critical infrastructure (both physical and human) and technology to guarantee that the International Polar Year 2007-2008 leaves enduring benefits for the nation and for the residents of northern regions.

- *Ensure the long-term availability of assets necessary to support science in the polar regions, such as ice-capable ships, icebreakers, submarines, and manned and unmanned long-range aircraft.*

  Although IPY 2007-2008 is planned as a focused burst of activity with demonstrable results, it should also provide long-term value and leave a legacy of infrastructure and technology that serves a wide range of scientific studies for decades to come.

- *Encourage development of innovative technologies to expand the suite of polar instruments and equipment, such as unmanned aerial vehicles (UAVs), autonomous underwater vehicles (AUVs), and rovers.*

  Observational systems for the polar regions can be improved enormously by applying innovative technologies. Recent technological advances in UAVs, AUVs, and robotic rovers can be marshaled and adapted for the IPY to ensure that these platforms enhance IPY research capabilities.

- *Develop advanced communications systems with increased bandwidth and accessibility capable of operating in polar field conditions.*

  The innovative technologies and large-scale field operations during IPY 2007-2008 will require advanced communications systems with high-speed, real-time access to communicate and distribute data from both polar regions to the rest of the world.

- *Develop international standards, policies, and procedures that ensure data are easily accessible for the current generation and permanently preserved for future generations.*

  The data management systems should provide free and open access to data in standard formats. In addition, extensive metadata should be included to facilitate long-term reanalysis and so that datasets can be used by a variety of users. This effort should include data rescue efforts to expand the data record back in time and ensure that historical data are not lost.

- *Develop the next generation of scientists, engineers, and leaders and include underrepresented groups and minorities.*

  Tomorrow's leaders are in today's classrooms, and the IPY effort should focus on cultivating an interest in the next generation of scientists, engineers, and leaders to create a lasting legacy.

Recommendation 6: The U.S. International Polar Year effort should excite and engage the public, with the goals of increasing understanding of the importance of polar regions in the global system and, at the same time, advancing general science literacy in the nation.

- *Develop programs in education and outreach that build on the inherent public interest of the polar regions and provide a broad lay audience with a deeper understanding of the polar regions.*

  The polar regions have important direct and indirect effects on the rest of the world, and the IPY can help explain the importance of the polar regions to the public.

- *Create opportunities for education, training, and outreach for all age groups and build on successful existing models. Education and outreach during the IPY should include innovative new approaches that are interactive, make use of diverse media, and provide opportunities for hands-on participation by the public.*

  The polar regions are inherently exotic to many people—the terrain, the plants, the animals, the weather, the remoteness—and they capture our imagination. This is key to engaging the public. There will be opportunities for formal classroom programs for people of a variety of ages and media coverage that will provide both entertainment and enjoyable science education.

Recommendation 7: The U.S. science community and agencies should participate as leaders in International Polar Year 2007-2008.

- *Guide and contribute to IPY 2007-2008 activities and help to evolve the international framework, using the IPY as an opportunity to build long-lasting partnerships and cooperation across national borders.*

  IPY 2007-2008 is an international effort, with more than 25 nations already committed to participate. Because of the strength of U.S. polar programs, our nation stands to play a leadership role in organizing and carrying out this ambitious program. Planning at the international level is under the auspices of two major organizations, the International Council for Science (ICSU) and the World Meteorological Organization (WMO), and the United States should lead the coordination with other countries through the ICSU and WMO to ensure the success of the IPY.

- *Continue to plan IPY 2007-2008 using an open, inclusive process.*

  The initial impetus for organizing IPY 2007-2008 came from the science community, which has come together and worked diligently to identify activities of merit. This open process leverages the intellectual assets of the U.S. science community and should be continued.

- *Coordinate federal efforts to ensure a successful IPY effort, capitalizing on and supporting existing agency missions and creating new opportunities.*

  International polar science efforts that have already been planned by the U.S. science community provide models for interagency collaboration, and additional future interagency efforts are encouraged, including coordination with the Arctic Council.

- *Continue planning for IPY 2007-2008, moving toward the creation of a more detailed science implementation plan.*

  The next phase of IPY planning will need to provide concrete guidance that defines the science goals and addresses logistics and other key aspects of implementation. This phase of planning should include active participation by the U.S. science community and U.S. funding agencies and also continued efforts to coordinate with international planning activities so that resources are leveraged.

- *Provide mechanisms for individuals, early-career researchers, and small teams to contribute to the IPY.*

  The overarching science goals of the IPY are broad and focused on international cooperation, but mechanisms for early-career researchers and small teams must be included in the larger IPY framework.