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INTERNATIONAL POLAR YEAR: THE SCIENTIFIC AGENDA AND THE FEDERAL ROLE

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH

COMMITTEE ON SCIENCE

HOUSE OF REPRESENTATIVES

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

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INTERNATIONAL POLAR YEAR: THE SCIENTIFIC AGENDA AND THE FEDERAL ROLE

WEDNESDAY, SEPTEMBER 20, 2006

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH,
COMMITTEE ON SCIENCE,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Bob Inglis [Chairman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE
SUBCOMMITTEE ON RESEARCH
U.S. HOUSE OF REPRESENTATIVES

International Polar Year: The Scientific Agenda and the Federal Role

Wednesday, September 20, 2006
10:00 a.m. – 1:00 p.m.
2318 Rayburn House Office Building (WEBCAST)

Witness List

Dr. Arden Bement
Director
National Science Foundation

Dr. Robin Bell
Doherty Senior Research Scientist
Lamont-Doherty Earth Observatory
Columbia University

Dr. Donal T. Manahan
Professor of Biology
University of Southern California

Mr. Mark S. McCaffrey
Associate Scientist and Science Communications Expert
Cooperative Institute for Research in Environmental Sciences
University of Colorado, Boulder

Dr. Kelley K. Falkner
Professor of Chemical Oceanography
Oregon State University

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HEARING CHARTER

SUBCOMMITTEE ON RESEARCH
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

International Polar Year: The Scientific Agenda and the Federal Role

WEDNESDAY, SEPTEMBER 20, 2006
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Wednesday, September 20, 2006, the Research Subcommittee of the Committee on Science of the House of Representatives will hold a hearing to examine the research planned for the upcoming International Polar Year (IPY) and the U.S. role in the IPY.

2. Witnesses

Dr. Arden Bement is the Director of the National Science Foundation (NSF).

Dr. Robin Bell is a Doherty Senior Research Scientist at the Lamont-Doherty Earth Observatory of Columbia University. She chairs both the Polar Research Board of the National Academy of Sciences and the U.S. Committee to the IPY and serves as Vice-Chair of the International Council for Science (ICSU, based on the French acronym) Planning Group for the IPY.

Dr. Kelly K. Falkner is a Professor of Chemical Oceanography at Oregon State University and is a member of the Advisory Committee to the NSF Office of Polar Programs.

Dr. Donal T. Manahan is a Professor of Biology at the University of Southern California and runs an NSF-funded program to provide graduate students with research experience in Antarctica.

Mr. Mark S. McCaffrey is an associate scientist and science communications specialist at the Cooperative Institute for Research in Environmental Sciences (CIRES) at University of Colorado, Boulder. He is a member of the ICSU IPY Education, Outreach, and Communications Subcommittee.

3. Overarching Questions

- What are the most critical unanswered questions that we hope to resolve with the research conducted during this IPY? What are the societal benefits of this research? What has been learned from polar research and IPYs in the past?
- What role will each of the federal agencies play in the IPY? What is the U.S. role in the IPY, and how does the U.S. collaborate with international participants?

4. Brief Overview

- The IPY will consist of an intense, internationally coordinated effort of polar observations, research and analysis in many scientific fields, including study of how the Earth's remote polar regions influence global climate systems. The IPY also hopes to inspire the next generation of scientists and to educate the public about the polar regions.
- The IPY will begin in March 2007 and run through March 2009 so that scientists have the opportunity to work in both polar regions during the IPY or to study the poles during both summer and winter seasons. This is the fourth IPY, and it celebrates the 50th anniversary of the International Geophysical Year.

- To date, 38 nations have expressed interest in participating in the IPY. International coordination occurs through the ICSU and the World Meteorological Organization (WMO). In the U.S., the federal agencies actively involved in IPY are NSF, the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Department of Defense (DOD), the National Institutes of Health (NIH), the U.S. Geological Survey (USGS), the Department of the Interior (DOI) and the Smithsonian Institution.[1]
- The White House has designated NSF, which manages the U.S. Antarctic Program and chairs the Interagency Arctic Research Policy Committee, to be the lead federal agency for the IPY. NSF's fiscal year 2007 (FY07) budget request includes $62 million for research related to the IPY, including research on how the Arctic environment is changing, the history and dynamics of polar ice sheets, and how life forms adapt to harsh polar environments, and funding for associated logistics, infrastructure, and education and outreach activities. (NSF has funded research in these areas for many years, but is increasing its focus on, and funding for them in concert with the IPY.) Overall, the proposed NSF budget for FY07 is $6.0 billion, of which $438 million is for polar research programs and logistical support; both House and Senate appropriators have provided NSF with the requested overall level for FY07.

5. U.S. Agencies and the IPY

While the IPY is in an international effort, the approval of individual research projects is left up to each nation. ICSU, an international, non-governmental science organization, and the WMO are coordinating the IPY through a joint committee and a program office. That committee has enumerated themes for IPY research. Scientists wishing to undertake IPY research can submit their proposals to the committee, which then decides, based on the topic, whether the research can be considered an IPY activity. The application process is essentially over, and the committee has endorsed about 225 projects and is reviewing another 900 or so. Committee approval is not based on a review of the quality of the project, and few applications are rejected. (The committee also establishes guidelines for sharing of data and other aspects of research conduct.)

Federal research agencies in the U.S. have begun to solicit research proposals for the IPY (primarily through existing research programs), and it is not clear how the review process will take into account whether a project has already been designated as an IPY project through the ICSU–WMO process.

Of the federal agencies involved in the IPY—NSF, NOAA, NASA and DOE—only NSF's FY07 budget request specifically describes funds to be dedicated to IPY activities. These funds will go to expand support for ongoing research in areas related to the IPY. NSF has proposed spending $62 million on IPY activities in FY07, an increase of $8.3 million over FY06 levels for research in those areas.

NSF will distribute IPY funding both through ongoing programs and via IPY-specific solicitations seeking project proposals in high-priority research areas, such as Arctic climate monitoring, and IPY-related education and outreach activities. The first such solicitation was released in January 2006 (to distribute $12 million in FY06 funds), and NSF is expected to announce this fall which projects were selected for funding. Proposed projects must include a description of their relevance to the IPY, but they are not required to have been endorsed by the ICSU–WMO process.

6. Background

History of IPY

Over the past 125 years, there have been three occasions when scientists from all over the world gathered together to concentrate on research in the polar regions. Each occasion was marked by significant breakthroughs in scientific knowledge, provided benefits to society, sparked continued collaboration among participants, and set the stage for several political accords.

The first IPY took place in 1882–1883 when it was agreed that one nation alone could not adequately study the geophysical attributes of the polar regions. Twelve countries participated, with 13 expeditions to the Arctic and two expeditions to the Antarctic. The international legacy of this first IPY was that it set a precedent for

[1] Other U.S. agencies and organizations that have sponsored or participated in IPY planning workshops, are members of the Interagency Arctic Research Policy Committee (IARPC), and/or have interests in the polar regions include the Department of Agriculture, the Department of Education, the Department of Homeland Security, the Department of State and the Environmental Protection Agency.

international science cooperation. For the U.S., an immediate result was the creation of a permanent science station at Point Barrow, Alaska, the northernmost point of the U.S. To support this first IPY, Congress appropriated $33,000 to the Army Signal Corps of the War Department.

In 1932, a second IPY was proposed by the forerunner of the World Metrological Organization (WMO) in an effort to study the implications of the newly discovered jet stream. Forty nations participated in this IPY, which led to advances in meteorology, atmospheric sciences, and understanding of the Earth's magnetic field. Research findings on the nature and structure of the ionosphere surrounding the Earth also enabled significant improvements in radio communications. Part of the U.S. contribution to this IPY was the Byrd Antarctic expedition, which created the first inland research station (a winter-long meteorological station) in Antarctica. In addition, 40 permanent observation stations were established in the Arctic. The total U.S. investment for the 1932 IPY was approximately $100,000.[2]

Perhaps the most notable of the IPYs, and what the upcoming IPY hopes to build on, was the 1957–1958 International Geophysical Year (IGY). Originally referred to as the third IPY, organizers expanded the research opportunities beyond the polar regions and changed the named to the IGY in an effort to garner more international participation. Sixty-seven nations and over 80,000 scientists participated in the IGY. Part of the impetus for the IGY came from World War II physicists who wanted to redirect newer technologies from the war (radar and rockets) toward research applications, specifically the study of the upper atmosphere. Among the scientific successes of the IGY were the first informed estimates of the total size of Antarctica's ice mass, the confirmation of the phenomenon of continental drift, and the discovery of the Van Allen Radiation Belt surrounding Earth. Politically, the relationships developed during the IGY and the successes of the scientific collaborations helped lead to the ratification of the Antarctic Treaty in 1961. Much of today's polar research builds upon discoveries made during the IGY.

In the U.S., federal support for IGY primarily flowed through NSF, which was established in 1950. Between 1955 and 1961, NSF spent $59 million on IGY activities.[3] Additional funds were spent by other government agencies,[4] universities, and private laboratories.

Upcoming IPY (2007–2008)

In *A Vision for the International Polar Year 2007–2008,*[5] the U.S. National Committee for IPY, an arm of the National Academy of Sciences, identified five scientific challenges for the U.S. to address:

1. Assessing large-scale environmental change in the polar regions, with questions looking at both the physical and human dimensions of change and its impacts.
2. Conducting scientific exploration of new frontiers, whether these are once inaccessible places such as the sea floor, or areas of inquiry that are now open because of advances in technology, such as how the tools of genomics now allow exploration of previously unanswerable questions about biological adaptation.
3. Observing the polar regions in depth, with adequate coverage of the vast and challenging landscape, to provide a description of current conditions and allow for better future understanding of variability and change.
4. Understanding human-environmental dynamics in a region where the connections are intimate and where the impacts of change are clear.
5. Creating new connections between science and the public, using these regions that are inherently intriguing.

Education and outreach is a key focus of the upcoming IPY. IPY participants plan to share the research experiences with K–12 students, people who live in the polar regions, decision-makers, and the general public. Specific activities planned include

[2] Of the $100,000 U.S. investment in the second IPY, $30,000 was federal funds from the Department of State. Other funding came from university and private sources.

[3] In the early years, IGY was a significant piece of NSF's budget; in 1956 nearly half of NSF funding was dedicated to IGY.

[4] Other agencies providing support for IGY in some capacity included the Department of Defense, the State Department, the Commerce Department, the Atomic Energy Commission, and the Office of Defense Mobilization.

[5] *A Vision for the International Polar Year 2007–2008,* National Academy of Sciences, 2004; available online at *http://newton.nap.edu/html/ipr2007-2008/0309092124.pdf.*

web sites, workshops, newsletters, press kits, classroom remote participation and interactive programs, and polar theme contests and class lessons.

NSF Polar Research Programs

NSF is the lead federal agency supporting research at the North and South Poles. As an example, a recent survey of polar ice sheet's drainage basins provided a wealth of data for scientists studying the process of and reasons for the disappearance of glaciers. Ongoing research also includes studies on how the Antarctic mountain ranges formed and seismic and geochemical monitoring of Mt. Erebus, the world's southernmost active volcano.

In addition to projects that study the polar continents themselves, NSF also supports research in a variety of fields that can be conducted only at the poles. For example, the cold, dry climate and high altitude at the South Pole provide an excellent environment in which to make certain astrophysics measurements (such as looking at faint signals of radiation from when the universe was young). Finally, NSF also provides logistical and infrastructure support for polar research, including permanent and temporary research stations at the poles, research vessels, interagency leadership for research planning, and management of all U.S. activities in Antarctica. For FY07, the NSF budget request for polar research programs and logistical support is $438 million, $49 million over the FY06 level.

For the IPY, NSF will continue and expand ongoing polar research activities as well as provide logistical support. Specifically, research programs on how the Arctic environment is changing, the history and dynamics of polar ice sheets, and how life forms adapt to harsh polar environments have been identified as priorities for IPY and beyond. In FY06, the NSF budget for IPY planning activities was $12.4 million, and the FY07 NSF budget request includes $61.6 million to begin funding IPY research.

Projects to gather data on and model the Arctic climate will be part of the interagency Study of Environmental Arctic Change (SEARCH) program, a long-term program in which NSF, NOAA, and NASA are building a network of observing sites to monitor environmental change in the Arctic and supporting research on causes and impacts of the change. During the IPY, NSF will support the development of an international network to measure climate throughout the Arctic and to tap the knowledge of indigenous peoples about their environment.

Research on glaciers will occur under the Polar Ice Sheet Dynamics and Stability Program and is aimed at better understanding the ice sheets' impact on global climate change. A primary focus will be drilling projects to obtain samples from deep within the Antarctic ice sheets, mountain ranges, and ocean floors to improve our understanding of Antarctic climate over the past 40,000 years and gather data that can be compared to changes that occurred in the Arctic.

Studies on how life forms are able to adapt and survive the harsh temperatures and darkness of the polar regions are supported under NSF's program on Life in the Cold and Dark. Research projects will focus on studying how organisms have changed at the cellular and genomic levels and include investigations of human adaptation and how infectious diseases evolve due to climate change. During IPY, NSF will support research in this area at Toolik field station in Alaska, at Summit, Greenland; and in the McMurdo Dry Valleys of Antarctica.

In addition to these priority areas, other NSF initiatives planned for the IPY include efforts to improve climate modeling and upper atmosphere studies to better understand space weather. NSF's education and outreach plans include support for museum exhibits and film, television and radio documentaries; development and distribution of classroom materials for teaching about polar research; and polar research field experiences for undergraduate and graduate students and K–12 educators. One museum exhibit of photographs by the recipient of an NSF Antarctic Artists and Writers Program grant, Wondrous Cold: An Antarctic Journey, has already been displayed at the Smithsonian Museum of Natural History and is currently traveling around the country.[6]

Other Federal Agency Polar Programs and IPY Activities under Science Committee Jurisdiction

National Oceanic and Atmospheric Administration

NOAA's FY07 proposed budget does not include new funds specifically for the IPY, but it does include $9.27 million for ongoing NOAA activities in the polar regions. These activities are consistent with the international goals for the IPY, and

[6] For details about the exhibit and its travel schedule, see *http://www.sites.si.edu/exhibitions/exhibits/wondrous/main.htm.*

NOAA plans to coordinate their projects with other U.S. and international IPY activities. The planned NOAA projects include exploration of polar oceans, research on how to improve prediction and modeling of polar climates, polar atmospheric and stratospheric observations, studies on causes and impacts of Pacific Arctic change, and surveying of Antarctic marine life.

National Aeronautics and Space Administration

In addition to ongoing activities in support of the SEARCH program, NASA has a variety of education and outreach plans for during the IPY. For example, NASA is collaborating with NSF and NOAA on three IPY education and outreach symposia. These symposia are designed for educators and will focus on ways to teach about polar topics, such as the fragile ice, life in the cold and dark, and the effect of the water and energy cycle on polar regions and climate change. Existing NASA funds will be used for these activities.

Department of Energy

While no federal funds have been specifically requested for IPY activities at DOE, the DOE Office of Science has committed to deploy an Atmospheric Radiation Measurement mobile facility to the Arctic during the IPY to study the impact of clouds, aerosols and surface characteristics on the Arctic climate. The FY07 budget request for this activity is $3.5 million.

7. Witness Questions

The witnesses were asked to address the following questions in their testimony:

Questions for Dr. Arden Bement and Dr. Robin Bell:

- What has been learned from polar research and the IPYs in the past, and what do we hope to learn during this IPY?
- How will research conducted during this IPY relate to ongoing polar research programs at NSF?
- What is the U.S. role in the IPY, and how does the U.S. collaborate with international participants? What role will each of the federal agencies play in the IPY?
- What are the most critical unanswered questions that you hope to resolve with the research conducted during this IPY? What are the societal benefits of this research?

Questions for Dr. Kelly Falkner and Dr. Donal Manahan:

- What has been learned from polar research and the IPYs in the past, and what do we hope to learn during this IPY?
- What are the most critical unanswered questions that you hope to resolve with the research conducted during this IPY? What are the societal benefits of this research?

Questions for Mr. Mark McCaffrey:

- What has been the impact of polar research and the IPYs on students and the public in the past?
- What education and outreach activities are planned for this IPY? What are the goals and expected societal benefits of these activities?

Chairman INGLIS. Well, good morning, everyone. I would like to call this hearing to order. And we are very excited about hearing from our panelists, and I would recognize myself for the purpose of an opening statement.

I want to welcome everybody here and thank you for joining us for this hearing on the *International Polar Year: The Scientific Agenda and the Federal Role.*

The International Polar Year does not begin officially until March 2007, but the immense planning and coordination for it began more than three years ago. The purpose of this morning's hearing is fairly simple: to learn all we can about the International Polar Year, what role the United States will play in the upcoming one, and how this will be a benefit to the Nation.

Most of us in this room are familiar, at least somewhat familiar, with the International Polar Year and its immediate predecessor, the International Geophysical Year. But I wonder how much of the general public knows about all of the incredible scientific discoveries and advances that were made during the IGY. I am pleased to see that education and outreach is a major component of the upcoming International Polar Year. It is also important that we take this opportunity to instill excitement about science in our students and motivate future generations of scientists, much like the results of the IGY inspired those who we will be hearing from today to enter the fields that they did.

I have recently learned of one such educational program in my home State of South Carolina. As you could imagine, we are not necessarily known as the epicenter of polar studies. It is a little bit warm in South Carolina for that, but USC geologist, Dr. Doug Williams and his team at the EdVenture children's museum in Columbia, South Carolina, created a "Go Polar!" program that is quite impressive. While not IPY-specific, this program has made a variety of arctic research accessible and easily understandable to children under the age of 12 and their families. It has provided opportunities for children to meet and hear directly from scientists working in the arctic about their experiences. This kind of interaction inspires children and serves as a good model for how IPY research can be incorporated informally at our nation's museums, zoos, and aquariums.

I am looking forward to hearing what our witnesses have to say to us about the U.S. role in the IPY and some of the neat work that is being—that has been planned or will be enacted over the next two years and beyond in the polar region.

I am also reminded that in January, Ms. Hooley and I and others had the opportunity to travel to Antarctica, and what an experience it was. I went, knowing that we would see incredible scenery. I expected that, and that happened. I knew we would see impressive science, and that happened. The thing that was sort of surprising was the people. The people were absolutely fascinating. And with the help of the NSF, we met a lot of wonderful people down there.

One of them is before us today: Dr. Manahan. I must say—I have sent him a note afterwards saying this is a master teacher, somebody who held us all in rapt attention. I think that if I had had a teacher like that in seventh grade, Darlene, I might have stuck

with science. As it was, you know, political science sort of came easier than those formulas and things like that.

But it is wonderful to have you with us. It is also wonderful to have the rest of the panel with us. Dr. Bement, especially, it is wonderful to see you. We are excited about hearing from each of you. I will introduce you in a moment, but I just want to share with you my excitement and enthusiasm for the International Polar Year. And it comes, in large measure, from the opportunity to have been in Antarctica and to see that incredible science that is being done there and to see the very impressive people that are so committed to what they are doing. If we could—what I think I wrote to Kathie and Dr. Bement and others is if we could just bottle up that enthusiasm that I sensed in Antarctica among the scientists and bring it to Congress, who knows what we could accomplish in this place.

So one of those people that saw that is Ms. Hooley, the Ranking Member of this subcommittee, and I would yield to her for an opening statement.

[The prepared statement of Chairman Inglis follows:]

PREPARED STATEMENT OF CHAIRMAN BOB INGLIS

Good morning. I want to welcome everyone, and thank you for coming to this morning's hearing on *International Polar Year: The Scientific Agenda and the Federal Role.*

IPY does not begin officially until March 2007, but the immense planning and coordination for it began more than three years ago. The purpose for this morning's hearing is fairly simple. . .to learn all we can about International Polar Year (IPY), what role the U.S. will play in the upcoming one, and how this will be of benefit to the Nation.

Most of us in this room are familiar, or at least somewhat familiar, with IPY and its immediate predecessor, the International Geophysical Year (IGY), but I wonder how much of the *general public* knows about all of the incredible scientific discoveries and advances that were made during IGY? I am pleased to see that education and outreach is a major component of the upcoming IPY. It is so important that we take this opportunity to instill excitement about science in our children and motivate future generations of scientists, much like the results of IGY inspired those we will be hearing from today to enter the fields that they did.

I've recently learned of one such educational program in my home State of South Carolina. As you can imagine, we are not necessarily known as the epicenter of polar studies, but USC Geologist Dr. Doug Williams and his team at the EdVenture Children's Museum in Columbia, SC, created a *Go Polar!* program that was simply impressive. While not IPY-specific, this program has made a variety of Arctic research accessible and easily understandable to children under the age of 12 and their families. It has provided opportunities for children to meet and hear directly from the scientists working in the Arctic about their experiences. This kind of interaction inspires children and serves as a good model for how IPY research can be incorporated informally at our nation's museums, zoos and aquariums.

I'm looking forward to hearing from our witnesses about the U.S. role in IPY and some of the neat work that is being planned for the next two years and beyond in the polar regions.

With the encouragement of the Chairman, I had the opportunity to travel with the Science Committee to Antarctica in January. I knew the scenery would be awesome, and it was. I knew the science would be impressive, and it was. The thing I didn't anticipate was the people. They are impressive folks doing amazing work. Some of those impressive folks are before us today. We look forward to hearing from them.

I recognize the Ranking Democratic Member, Mrs. Hooley, for any opening statement she may have.

Ms. HOOLEY. Thank you, Mr. Chairman.

And I just want to echo what you said and talk about a wonderful teacher. I think all of us could have sat for at least ten hours and listen to you speak.

So it was an exciting trip. It was sort of an once-in-a-lifetime kind of experience for me, and it was—it is amazing the work you are doing there.

And I am excited also about the International Polar Year. And what I am looking forward to is how do we also spread that excitement to our children, our classrooms, the teachers that are there every single day with our young students. How do we get the public involved? And those are some of the things I would like to hear from you today as we are—as we go on with this.

But I welcome all of you to this hearing. I know this International Polar Year will be the fourth in a series of international cooperative scientific ventures focused on the polar regions that have occurred in the last 125 years. The last one was almost 50 years ago, and, I mean, there was a real legacy that was made with the International Polar Year 50 years ago, so I would want to know, what is our legacy going to be this time. What are we aiming for? What is going to—what is our legacy?

And then before that, you had—and that resulted—the last one resulted, as you know, in the Antarctic Treaty System, which has preserved that continent for peaceful purposes, for scientific research. I think that is a major accomplishment. The first ones were for exploration of those regions. As we learn more about the role of the polar regions in affecting such things as global scale, atmospheric, and oceanic processes, it has become clear that understanding the physical mechanisms at work at the poles is important to understanding the evolution of global warming. This lends urgency to accelerate the research needed to unlock the secrets that control climate on a global scale.

Research results from the IPY initiative and from other ongoing polar research is important to help guide public policy choices surrounding the global warming debate. And of course, increased knowledge and understanding of changes in northern high latitudes are of even greater interest and concern to the people that live there.

I am pleased the Subcommittee has the opportunity this morning to hear about the planning process that has been underway for IPY and about the research and education goals that will be pursued.

I would like to better understand what we may hope to achieve at this time from an intensified research effort in polar regions and what legacy we may expect from this IPY.

I would also like to take a moment to extend a special greeting to Dr. Kelley Falkner. She is a Professor at Oregon State University at the College of Oceanic and Atmospheric Sciences. An inorganic chemist by training, Dr. Falkner applies her expertise to problems such as tracking the fate of river water in the Arctic. She has participated in 24 major seagoing lake and river expeditions, seven times as chief scientist. Dr. Falkner is a graduate of Reed College, which is in Oregon, and received her Ph.D. from MIT-Woods Hole Joint Program in Oceanography while holding an NSF Graduate Fellowship. She was a recipient of an Office of Naval Research Young Investigator Award and the NSF Arctic Service

Award. She currently serves on the Advisory Committee for NSF's Office of Polar Programs.

Mr. Chairman, I want to thank you for calling this hearing, and I want to thank our witnesses for appearing before the Subcommittee today. And really, I am looking forward to what you have to say.

Thanks.

[The prepared statement of Ms. Hooley follows:]

PREPARED STATEMENT OF REPRESENTATIVE DARLENE HOOLEY

Mr. Chairman, I am pleased to join you in welcoming our witnesses today to this hearing to review the status of planning for the International Polar Year scheduled to begin next March.

This IPY will be the fourth in a series of international, cooperative scientific ventures focused on the polar regions that have occurred over the past 125 years. The last IPY was the International Geophysical Year of 1957–58. It was remarkable in its success in achieving international cooperation and good will at the height of the Cold War. It was also significant in laying the ground work for the development of the Antarctic Treaty system, which has successfully preserved that continent as a sanctuary for scientific research and other peaceful purposes.

The early IPYs were explorations to provide basic information about the most remote and forbidding regions of the globe. As we learned more about the role of the polar regions in affecting such things as global-scale atmospheric and oceanic processes, it has become clear that understanding the physical mechanisms at work at the poles is important to understanding the evolution of global warming. This lends urgency to accelerate the research needed to unlock the secrets that control climate on a global scale.

Research results from the IPY initiative, and from other ongoing polar research, is important to help guide public policy choices surrounding the global warming debate. And of course, increased knowledge and understanding of changes in northern high latitudes is of even greater interest and concern for the people living there.

I am pleased the Subcommittee has the opportunity this morning to hear about the planning process that has been underway for the IPY and about the research and education goals that will be pursued. I would like to better understand what we may hope to achieve at this time from an intensified research effort in polar regions and what legacy we may expect from this IPY.

In addition, I am interested in how the U.S. IPY activities will be integrated within the international program, and how the U.S. agencies that sponsor IPY-related research will coordinate their activities. Since NSF is the lead federal agency for U.S. participation in the IPY, is a major federal sponsor of research in polar regions, and fulfills a key role in providing research infrastructure and logistical support, I am happy to welcome Dr. Bement to this morning's hearing.

Also, I would like to take a moment to extend a special greeting to Dr. Kelly Falkner. She is a Professor in the College of Oceanic and Atmospheric Sciences at Oregon State University. An inorganic chemist by training, Dr. Falkner applies her expertise to aqueous geochemical problems, such as tracking the fate of river water in the Arctic. She has participated in 24 major seagoing, lake and river expeditions—seven times as chief scientist.

Dr. Falkner is a graduate of Reed College and received her Ph.D. from the MIT–Woods Hole Joint Program in Oceanography, while holding an NSF Graduate Fellowship. She was the recipient of an Office of Naval Research Young Investigator Award and the NSF Arctic Service Award. She currently serves on the Advisory Committee for NSF's Office of Polar Programs.

Mr. Chairman, I want to thank you for calling this hearing and thank our witnesses for appearing before the Subcommittee today. I look forward to our discussion.

Chairman INGLIS. Thank you, Ms. Hooley.

And I have only one correction to what you said, and that is let us hope it is not an once-in-a-lifetime opportunity about Antarctica.

Ms. HOOLEY. Oh, you are right. Okay. I agree. I am ready to go back.

Chairman INGLIS. Me, too. I was just saying, it might be fun to be down there in the winter. What do you think?

Ms. HOOLEY. I don't think so.

Chairman INGLIS. But——

Ms. HOOLEY. I would like to go in the summer again.

Chairman INGLIS. Kathie suggested that maybe I should go in a dark room and see if it is light, but——

Ms. HOOLEY. She is right.

Chairman INGLIS.—anyway, before I introduce the panelists, let me apologize in advance. There is a markup going on in the Judiciary Committee with some very contentious bills. They will be very close votes. And so if you see me leaving quickly, it won't be that I got offended by something you said. It is that I am literally going to have to run to that markup. If we don't have someone to take the Chair, we will have to recess the hearing. If that happens, I apologize in advance for having to do that. It is terribly inconvenient for everyone. Let us hope it doesn't happen, but just to put you on notice.

Now may I introduce the panelists?

First, we are going to hear from Dr. Arden Bement, the Director of the National Science Foundation and who needs no further introduction except to say we very much appreciate his fine work at the NSF.

We will also hear from Dr. Robin Bell. She is the Doherty Senior Research Scientist at the Lamont-Doherty Earth Observatory at Columbia University. She chairs both the Polar Research Board of the National Academy of Sciences and the U.S. Committee to the IPY and serves as Vice-Chair of the International Council for Science Planning Group for the IPY.

We will next hear from who I have already called a master teacher. By the way, I am sure the others are master teachers, too. We will find that out as you speak. And so we very much appreciate the opportunity to hear from Dr. Manahan. He is Professor of Biology at the University of Southern California and runs an NSF-funded program to provide graduate students with research experience in Antarctica.

Then we will hear from Mr. Mark McCaffrey, an Associate Scientist and Science Communications Specialist at the Cooperative Institute for Research in Environmental Sciences at the University of Colorado, Boulder. He is a member of the ICSU IPY Education, Outreach, and Communications Subcommittee.

And finally, we will hear from Dr. Kelly Falkner. She is a Professor of Chemical Oceanography at Oregon State University and a member of the Advisory Committee to the NSF for the Office of Polar Programs.

So we would be happy to recognize each of you in series here for five-minute statements. And so that you will be reminded, the green means you have got time, yellow means start summing up, and red means the guy—the person next to you really wants you to conclude. So we will look forward to hearing from you.

We recognize you first, Dr. Bement.

STATEMENT OF DR. ARDEN L. BEMENT, JR., DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. BEMENT. Thank you, Chairman Inglis and Ranking Member Hooley, for the opportunity to testify on the upcoming International

Polar Year and on how NSF and our sister agencies are addressing this important opportunity. Our job is to enable U.S. scientists and educators to realize these opportunities, opportunities that members of today's distinguished panel will be speaking to in more detail.

Fifty years ago, the Third International Polar Year and International Geophysical Year entranced America's youth and galvanized America's innovative powers in ways that created a legacy that lives on today. That legacy ranges from scientific Earth satellites to the development of a generation of world-class scientists and engineers whose interest in research was peaked by news coverage of polar research. We intend for the International Polar Year period to be a time to explore new frontiers in polar sciences, improve our understanding of the critical role of the Earth's polar regions and global processes, create a legacy of infrastructure and data for future generations of scientists, expand international cooperation, engage the public in polar discovery, and help attract and educate the next generation of scientists and engineers.

The impacts of climate change on northern peoples, and more generally on ecosystems and polar environments, strongly motivate a broader focus than that of the last IPY. Thus, NSF will focus particular attention on three scientific themes and will couple them to education and outreach: first, the extremes of polar environments combined with the new technology of genomics provide unique opportunities to study how organisms adapt to climate extremes, how they evolved at the genomic level, and how gene expression depends on a physical environment; a Circum-Arctic Observation Network is needed to provide the missing data essential to faithfully model arctic climate change and to predict it; and multi-national efforts to understand changes in the Earth's great ice sheets, changes that could have profound effects on global conditions, including global sea level.

This emphasis on the relationships between the physical environment and living systems, and especially on people, will be one of the distinguishing features of IPY. NSF's Office of Polar Programs and the Directorate for Education and Human Resources combined to jumpstart IPY preparations by committing $12 million from the fiscal year 2006 appropriations for a special IPY proposal solicitation. The solicitation attracted research, education, and public outreach proposals amounting to over $150 million. Approximately one-third focused on outreach and education. And of these, we were able to fund nine truly outstanding projects. We are releasing the details of those projects at today's hearing.

I truly share Chairman Boehlert's enthusiasm and your enthusiasm as well, both Mr. Chairman and Ms. Ranking Member, for these remarkable and creative projects. They will launch our IPY effort in great style.

Beginning in fiscal year 2007, NSF's IPY effort will be agency-wide, with significant participation by the disciplinary directorates as well as the Office of International Science and Engineering, the Directorate for Education and Human Resources, and the Office of Polar Programs. NSF is working with other federal agencies and countries to exercise the IPY leadership role assigned to it by OSTP. We are working with NASA to coordinate our ground-based

observations with those from space in order to provide a comprehensive body of benchmark data. NASA has initiated discussions with space agencies around the world to bring the worldwide satellite fleet to bear on this effort. We are working with NOAA to integrate their support with ours for the land and ocean-based Circum-Arctic Observing Network, or AON. Data from AON will enable scientists working in the U.S. multi-agency program search and study of environmental arctic change for years to come.

My written testimony contains more comprehensive information on how these and our other sister agencies are planning to help provide world leadership in IPY.

The Circum-Arctic system requires active contributions from countries around the Arctic rim. We have already developed strong links for coordination with the $30 million European program called DAMOCLES [Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies]. We have joined with Norway, Sweden, Germany, and Russia to establish an IPY office in St. Petersburg that will help link Russian activities to AON. And we are working actively with the European Polar Board and with Canadian officials to build IPY partnerships. Indeed, part of the IPY impact will be the enduring partnerships established among scientists in the 35 countries that have formed national committees for the IPY.

Countries around the world have seized on the 50-year anniversary of IPY–3 and IGY to create a new legacy of scientific understanding and a new generation of scientists and engineers.

Mr. Chairman, earlier I alluded to the education component of IPY. This effort has the potential to create a legacy for decades, one that will benefit the Nation as well as the science and engineering community more specifically.

Thank you, again, for providing an opportunity to highlight NSF's role in the coming International Polar Year, and I would be pleased to answer any of your questions.

[The prepared statement of Dr. Bement follows:]

PREPARED STATEMENT OF ARDEN L. BEMENT, JR.

Thank you, Mr. Chairman, for the opportunity to testify before the Committee concerning the upcoming International Polar Year (IPY) and on how NSF and our sister agencies are addressing this important opportunity. Our job is to enable U.S. scientists and educators to realize these opportunities, opportunities that members of today's distinguished panel will be speaking to in more detail.

We intend for the International Polar Year period—which has been declared by the International Council of Science (ICSU) and the U.S. National Academies (NAS) to be from March 2007 through March 2009—to explore new frontiers in polar sciences; improve our understanding of the critical role of the Earth's polar regions in global processes; create a legacy of infrastructure and data for future generations of scientists; expand international cooperation; engage the public in polar discovery; and help attract and educate the next generation of scientists and engineers.

Fifty years ago, the Third International Polar Year and International Geophysical Year entranced America's youth and galvanized America's innovative powers in ways that created a legacy that lives on today. That legacy ranges from scientific Earth satellites to the development of a generation of world-class scientists and engineers who drove our knowledge-based economy forward for the next half-century.

Advances in instrumentation and technology, the realization that polar regions are critical in the changing global climate system, and linkages among international research organizations offer opportunities for breakthrough developments both in fundamental disciplinary science and in science for policy during IPY. In addition, the impacts of climate change on northern communities, and more generally, on ecosystems in polar environments strongly motivate a broader focus than the last IPY

had. The NSF tradition of linking research and education offers the further opportunity to engage America's youth in this period of discovery and awaken them to the excitement of a career in science and engineering.

In his introduction to the "American Competitiveness Initiative, Leading the World in Innovation," President George Bush stated that a "well-educated and skilled workforce is the bedrock of America's competitiveness." U.S. institutions of higher learning remain the envy of the world, but the global economy has greatly increased the competition for the best and brightest students. America must ensure that its best and brightest young people give appropriate consideration to careers in science and engineering and that they take advantage of the fact that ours is the most open educational system in the world. NSF, its sister agencies and IPY have a key role to play in achieving this goal.

NSF has been tasked by the White House Office of Science and Technology Policy to provide leadership for the U.S. in IPY. And, the agency is poised to do exactly that, both domestically and on the broad international stage. We have worked closely with our colleagues in other federal agencies and with the NAS to that end over the last two and a half years. Back in July 2004, I was pleased to be invited to deliver the keynote address at a meeting organized by the three Presidents of the NAS that was devoted to IPY planning. With your permission, I would like to enter my remarks for the record. As I said then, and I quote:

> Both the National Academy of Sciences and the International Council of Science have made a compelling case for why we should launch an international polar year in 2007. NSF is in full agreement. In the polar regions, we are discerning the outlines of environmental change, from sea ice extent, retreating glaciers, shifting patterns in flora and fauna, to environmental observations by Arctic natives.
>
> What is more, such change—whether environmental, biological or social—has 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 NAS subsequently conducted a year-long study to develop a Vision for the International Polar Year, one that would take advantage of the broad expertise of the U.S. scientific community; position the U.S. for world leadership in IPY; and most importantly, create a long-term legacy that would not otherwise exist. This Vision is providing a framework for IPY planning among the federal agencies. It was developed under the leadership of Dr. Mary Albert of the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire, and I believe my colleague on the panel, Dr. Robin Bell, will outline its recommendations in more detail. Robin chairs the NAS/National Research Council (NRC) Polar Research Board that oversaw the work of Mary's committee. They both have earned our continuing gratitude and congratulations.

In exercising NSF's leadership role, I also convened several meetings of the policy-level officials to discuss IPY planning. These activities resulted in a report we provided to the Congress last year and a number of agencies have taken the opportunity to update their sections of the report for this hearing. With your permission, Mr. Chairman, I would like to submit a copy for the record and mention a few highlights.

NASA is holding discussions with space agencies around the world to organize a coordinated program to map the polar regions using today's sophisticated satellites. NSF and NASA are working together to coordinate space- and ground-based observations in order to provide future generations of scientists and others with a comprehensive body of benchmarked data. These data will greatly increase our ability to discern change on a regional basis—a basis that relates directly to the different environments in which people work and live.

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and NSF are developing atmospheric, land and ocean-based environmental monitoring capabilities that will be key components of the planned circum-Arctic Observing Network (AON), which will significantly enhance our observing capability in the Arctic region beyond that currently available. Data from this AON will enable the U.S. multi-agency program SEARCH—the Study of Environmental Arctic Change—developed under the Interagency Arctic Research Policy Committee to get a handle on Arctic environmental change.

Here, too, the NAS have helped significantly with an NSF-funded study of how best to implement AON. A circum-Arctic system requires active contributions from countries around the Arctic rim. We have already developed strong links for coordination with the $30 million European program called DAMOCLES; have initiated discussions with our Canadian colleagues; and have joined with Norway, Sweden and Germany and Russia in establishing an office in St. Petersburg to assist with linking Russian activities to AON. NOAA has led an effort to build U.S.-Russian Federation collaboration in ocean and polar region studies, as highlighted by the Russian American Long-term Census of the Arctic RUSALCA program. This will be a key U.S.–Russian component of the IPY. NOAA in collaboration with NSF, also leads the U.S. participation in the IPY International Arctic System for Observing the Atmosphere.

Additional IPY efforts by NOAA, NASA and other sister agencies are described in the attached document entitled, *"The International Polar Years 2007–2009."*

NSF's Office of Polar Programs (OPP) and the Directorate for Education and Human Resources (EHR) combined to jump start IPY preparations by committing $12 million from their FY06 appropriations to a special IPY proposal solicitation. The solicitation drew a very strong response from U.S. scholars; taken together the proposals requested over $150 million in the four focus areas (three science areas and education).

We chose to focus on areas that for one reason or another needed extra lead time for preparation and that would represent a good start toward realizing the NAS/NRC Vision. The NSF merit review of the education proposals was completed just a few days ago, and the results exemplify the creativity and the enthusiasm of our educators and scientists. I expect to be able to announce the results from the three research areas by the end of October. Meanwhile, the program officers overseeing the merit review process tell me the quality of the proposals is outstanding.

Building on this excellent FY06 start, NSF Program Officers from the agency's disciplinary directorates are working with OPP to formulate how best to respond to IPY opportunities in FY07 and FY08. On the basis of their work, the Administration requested $62 million in FY07. And, I'm very happy that both Houses of Congress have signaled their agreement with our IPY agenda.

The strong partnership created with EHR in developing the FY06 solicitation is the very first legacy of IPY; it will ensure an effective outreach and education effort throughout the upcoming two years and well into the future. A strong partnership with the NSF's Office of International Science and Engineering (OISE) is enabling rapid development of new international links as well as a strengthening of existing ones. IPY planning by the Biological and Social, Behavioral, and Economic Sciences Directorates and studies by the NAS/NRC have identified an exciting group of leading-edge research subjects in biology and the social sciences, ones that with strong IPY support and focus could create 21st century legacies. The Geosciences Directorate and OPP have a long history of joint cooperation for proposals, and IPY provides a strong basis for developing new partnerships in key focus areas such as climate studies. The Mathematical and Physical Sciences Directorate and OPP have an outstanding partnership in astrophysics at the South Pole, another excellent IPY building block. Thus, there is great potential for creating legacies through research achievements, a new generation of American scientists and engineers, and new networks of international collaborations.

The aforementioned solicitation identified three science themes and a strong education focus as key investment areas for special emphasis during FY06. These themes will be developed further during FY07 and FY08. A cross-directorate working group is evaluating the extent to which the original focus areas will have been addressed by the FY06 solicitation and how they can be broadened to address more of the Vision developed by the NAS. NSF and the Office of Management and Budget will soon discuss how to address these focus areas in the FY08 budget request to Congress.

The first of these research themes addresses climate change in the Arctic by contributing to building the Circum-Arctic Observing Network (AON) that I mentioned earlier. This program was organized under the direction of the U.S. Interagency Arctic Research Policy Committee chaired by the NSF Director and involves partnership with NOAA, NASA, DOI, DOE, NIH, DOD, USDA and the Smithsonian Institution.

During the past few decades, the Arctic has experienced significant environmental changes that could have broad-reaching consequences for human and animal populations in the form of impacts on local ecosystems, as well as on global climate. The AON will provide a network of observations that will facilitate our understanding of the profound change that is occurring in the Arctic. To achieve this goal, Cyberinfrastructure (CI) will need to be developed to provide inter-operability be-

tween the various elements of the observing network, seamless broadband communications capabilities at the poles, data storage and archive capabilities, and timely access to data. This initiative will not only support the Foundation's broader CI interests, it also supports the broader administration goal of developing a Global Earth Observing System (GEOS). Any CI communications technology that is developed to support the AON could potentially be used to enhance communications capabilities at the South Pole.

A second broad theme addresses research on what we're calling Life in the Cold and Dark. Relatively recent developments in instrumentation and technology offer the opportunity to study the mechanisms by which organisms adapt to the climate extremes they face in polar environments, how they have evolved at the genomic level and how gene expression depends on the physical environment. A recent NAS report, "Frontiers in Polar Biology in the Genomics Era," outlines the opportunities and challenges, and describes the ecological relevance and research benefits of these tools of modern biology. The Life in the Cold and Dark theme also encompasses research on the interactions between living and physical systems at all levels and brings together researchers trained in the Biological and Social Sciences.

The last International Polar Year in 1957–58 focused almost entirely on physical science but IPY 2007–2009 will be different. Many northern languages are now spoken by only small numbers of elderly people and NSF will partner with the National Endowments for the Humanities in the U.S. and with Canada and other countries in sponsoring work to document those endangered languages in Alaska and throughout the Arctic.

NSF-supported research also will address issues associated with environmental change that are of critical importance to people living in the North. These studies, sponsored jointly by NSF and NIH, will seek to determine not only what causes change and predicting it more accurately, but also how change allows infectious diseases to move into new areas where vulnerability is high because the people and wildlife will not have developed resistance to the novel pathogens that will be moving into these regions.

The third broad theme addresses changes in the Earth's great ice sheets, changes that could have profound impacts on global conditions including global sea level. Recent data indicate that the Greenland ice sheet is thinning at the edges but thickening at the center. Some ice streams draining the West Antarctic Ice Sheet have slowed while at least one other is accelerating. Relatively small changes in the mass balance of these ice sheets can raise global sea level significantly while complete loss of the West Antarctic Ice Sheet would raise global sea level by over five meters. Furthermore, a combination of ground-based, airborne, and satellite observations shows that surface melt water can penetrate the ice sheet at thicknesses of a kilometer and accelerate flow beyond previously suspected rates. Research supported by NSF, NASA and other agencies under this theme will combine with work supported by many other countries to develop a much more complete understanding of the behavior of these ice sheets and how changes in this behavior might evolve. The theme will also address further studies of ice sheet changes that occurred over geological time and the causes and effects of those changes.

The overall scientific impact of IPY will only become apparent through synthesis activity that brings together results from disparate research groups addressing different aspects of these broad themes. NSF recognizes the critical importance of funding workshops and related activities to that end, and will do so well beyond the end of the two-year IPY period.

The education focus has the potential to create a legacy for the decades, one that will benefit the Nation as well as the science and engineering community more specifically. By linking the public's fascination with things polar to outreach that conveys the excitement of research and discovery, we hope to attract a new generation of Americans into S&E careers while contributing to a more informed public.

With the jump start provided by the EHR/OPP FY06 solicitation NSF will enter the IPY period well-placed to make major impacts during the ensuing two-year period. A multi-year outreach and education strategy will have substantially greater impact than one limited to a single year, while the international collaborations that can greatly enhance the reach and impact of NSF-supported research will also hinge on continued support.

While our outreach and education strategy will be focused on U.S. students, parents and families, we recognize that IPY also brings the opportunity to demonstrate to them how research and understanding can result when people from many nations work together on problems of global interest. The many international scientist-to-scientist collaborations now developing will help us carry that story to our public and to others around the world.

Indeed, part of the IPY impact will be the enduring partnerships established among scientists in the over 30 countries that have signaled their intention to provide funding for IPY activity. Countries around the world have seized on the 50 year anniversary of IPY–3/IGY to create a new legacy of scientific understanding and a new generation of scientists and engineers. We understand that Canada has committed $150 million over six years to its IPY effort, Korea—$150 million, Japan—$460 million for a new icebreaker, China—$60 million for infrastructure and research. Among the EU commitments one exceeds $30 million for a project closely linked to the U.S. IPY centerpiece addressing climate change in the Arctic.

The 1957–1958 International Polar Year culminated in an international meeting in Washington called by the State Department to frame what became the Antarctic Treaty. As President Reagan noted in 1970, ". . .the Antarctic is the only continent where science serves as the principal expression of national policy and interest." The State Department plans to host the annual meeting of the Antarctic Treaty Consultative Parties in 2009, which will spotlight the historic diplomatic achievement by the Treaty Parties 50 years ago. We expect this new IPY to create a further legacy of international partnerships in the interest of advancing scientific research and understanding.

The U.S. research community is poised to provide worldwide leadership throughout IPY, and NSF is committed to enabling that to the best of our ability.

The International Polar Years 2007–2009
Report on U.S. Federal Agencies' Planning

SEPTEMBER 18, 2006

The years 2007–2009 will mark the 50th anniversary of the International Geophysical Year (IGY) and of the third International Polar Year. This period has been designated the fourth International Polar Year (IPY) by the National Academies of Sciences (NAS), the International Council of Science (ICSU), the World Meteorological Organization (WMO), the Arctic Council and by many other international organizations. The National Science Foundation (NSF) was designated by the President's Office of Science and Technology to be the lead U.S. agency in organizing IPY activities.

Preparations are underway worldwide to make IPY a period of intense activity that promises, in the words of the NAS publication *A Vision for the International Polar Year,* to "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, (and). . .serve as a mechanism to attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues" (see *http://books.nap.edu/catalog/11013.html*).

The 1957–1958 IGY and IPY activities greatly increased our knowledge of the world around us and provided profound legacies that continue to benefit research and researchers today. These activities also resulted in the 1959 Antarctic Treaty, which "promotes international scientific cooperation including the exchange of research plans and personnel and requires that results of research be made freely available." The U.S. played a leading role in shaping and implementing the 1957–1958 IGY activities and plans to do so again in 2007–2009. IPY activities planned for this period are consistent with Agency missions and the NAS report of an implementation workshop (*Planning for the International Polar Year: Report of the Implementation Workshop, http://books.nap.edu/catalog/11110.html*). U.S. activities during IPY 2007–2009 will focus on research, education and public outreach efforts, and will be coordinated among the federal agencies and international partners that support research in polar regions.

NSF is creating a website as part of its work to coordinate IPY activities among the agencies: *http://www.us-ipy.gov/*. This site includes updates on the various agencies' programs, as well as information on IPY for a general audience and for scientists interested in obtaining IPY funding from the U.S. Government.

The following is an updated (since May 18, 2005) discussion of federal agency planning for the International Polar Year.

NATIONAL SCIENCE FOUNDATION

The upcoming International Polar Year is a unique opportunity to continue the legacy of international science years of the past, including IPY 1882–1883, IPY 1932–1933, and the International Geophysical Year of 1957–1958. Each of these bursts of internationally coordinated research and exploration opened the polar regions for exploration and science, led to significant discoveries about our planet, and

left a long-term legacy of data and observations for future generations. In particular, the IGY of 1957–58 brought a tremendous increase in our ability to predict weather worldwide, to measure the thickness of the antarctic ice sheets, and to understand the dynamics of the Earth's magnetosphere. However, there are still significant gaps in our understanding of the polar regions and the processes that structure polar environments. For example, the relationships between processes that drive long-term and short-term climate change in the Arctic are not well understood, nor do we have empirical observations sufficient to sort them out. In the Antarctic and in Greenland, the ice sheets that contain 70 percent of the fresh water on Earth are moving and thinning. In both polar regions, many organisms are adapted to withstand prolonged periods of darkness and extreme cold, yet we do not understand how these adaptations evolved or how these organisms may respond to increased variability in the polar environment.

The National Science Foundation has initiated support for the International Polar Year in a variety of ways, emphasizing three major research areas and also education and outreach in an Announcement of Opportunity that was released in January 2006. These areas of emphasis will help implement the goals developed by ICSU and the U.S. National Academies. They have evolved within the research community as high-priority topics derived from workshops and existing science programs. Education and outreach are also areas where NSF, with its partners in other agencies, can make a significant impact on the understanding of how polar regions influence society and the global environment. Thus, NSF has a particular interest in conducting activities in the polar regions that will leave a lasting legacy of data, observing capabilities, and educational resources for scientists and educators of the future.

Within NSF, the Office of Polar Programs will take the leadership role in implementing these activities. Partnerships for IPY will occur at many levels - within NSF, through interagency collaborations, and in the international arena. All the NSF directorates and the Office of International Science and Engineering have expressed interest in collaborating with OPP on IPY activities. Federal agencies such as NOAA, NASA, NIH, USGS, DOE, EPA, and the Smithsonian Institution, as well as the national science agencies of other countries, have closely related interests. Thus, maximizing the value from partnerships is a key overarching theme for NSF as we plan for IPY.

NSF and IPY in FY06

The Office of Polar Programs (OPP) and the Directorate for Education and Human Resources (EHR) committed over $12 million in FY06 to initiate activities in four major areas:

Establishment of a multi-national circum-Arctic observing system, with emphasis on the Study of Environmental Arctic Change (SEARCH) Program

SEARCH is a broad interdisciplinary, multi-scale interagency program with the core goal of achieving a predictive understanding of recent and ongoing changes in the arctic environment. In addition to understanding how changes in the Arctic are interrelated, SEARCH will investigate the links between arctic change and global processes and will assess the impacts that arctic change may have throughout the Northern Hemisphere. SEARCH will evaluate the possibility that observed changes in the Arctic can be used to anticipate changes elsewhere on the globe.

For the period of the IPY, NSF's principal interest related to SEARCH is the implementation of an Arctic Observing Network (AON). The purpose of AON will be to understand environmental change in the Arctic System and its interplay with global oceanic and atmospheric circulation. AON will employ an arctic-wide coverage of standard integrated measurements, long-term observations, and modeling and analysis.

Research related to the Bering Ecosystem Study (BEST) is underway under the IPY umbrella. The Bering Sea supports one of the most productive fisheries in the world, contributing about 40 percent of all finfish and shellfish landings in the United States, yet it is one of the least-studied areas of U.S. waters. In recent years, it has become evident that this seasonally ice-covered sea is subject to decadal changes in climate that have resulted in abrupt and unexpected changes in the ecosystem. Of particular concern is the possibility that the combined effects of climate change and fisheries removals may shift marine ecosystems into alternate stable states that may have a lower yield of species valuable to people. Identifying the mechanisms driving ecosystem change, including social and cultural factors, in the Bering Sea is a key research need.

Ice Sheet Stability, Dynamics and History

The global ice sheets are dynamic features that contain unprecedented records of climate over the past several hundred thousand years. Future changes in the ice sheets of both polar regions will affect sea level, and this is one of the major uncertainties in Intergovernmental Panel on Climate Change (IPCC) climate models. In Antarctica, we expect to emphasize studies of the stability and history of the major ice sheets. How do they work, how fast are they changing, and what will they be like in the future decadal to century time frame? Inquiry into these questions involves direct studies of ice sheet dynamics but also includes work to understand processes important for interaction of ice sheets with the lithosphere, oceans, and atmosphere. The combination of space-based and surface-based studies is critical to success in this area.

A detailed study of changes in the behavior of the Antarctic and Greenland ice sheets is also a topic of IPY research. One component of this comparative work includes obtaining a high-temporal resolution ice core in West Antarctica for comparison with the climate records obtained from the Greenland ice cores. There will likely be an opportunity to leverage logistics support to the ice core camp with support for other ground-based activity in West Antarctica and to couple detailed ground- and space-based observations. The work in West Antarctica might include traverse-based studies, or other types of work that will be possible from our logistical hubs, that could be linked to related work in East Antarctica as well as study of change in the Ross Sea region.

Because of the long lead time required for developing and implementing ice coring programs, NSF is also looking at the IPY as an avenue to create an international collaborative framework to facilitate international ice coring projects beyond the IPY. The Center for Remote Sensing of Ice Sheets (CReSIS), a Science and Technology Center led by the University of Kansas and supported jointly by NSF and NASA, will conduct and foster multi-disciplinary research that will result in technology and models necessary to achieve a better understanding of the mass balance of the polar ice sheets (e.g., Greenland and Antarctica) and their contributions to sea level rise. The focus areas for CReSIS relate closely to the goals of IPY.

The Antarctic drilling program (ANDRILL) is a multi-national ocean drilling program currently underway that is focused on extracting sediment cores from the Antarctic continental shelf. This activity will also contribute to the broader IPY goal of understanding ice sheet dynamics.

Frontiers In Polar Biology: Life in Extreme Cold and Prolonged Darkness

Ecologically important biogeochemical processes begin before the traditional operational season in polar regions and continue beyond the end of the traditional field season. Living organisms are known to continue functioning at temperatures well below freezing and during periods of prolonged darkness. New technologies (genomics, proteomics, etc.) offer the opportunity to gain a deep understanding of how organisms have adapted to these extreme environments. The Long Term Ecological Research (LTER) sites at Toolik Field Station in Alaska, at Palmer Station on the Antarctic Peninsula, and in the McMurdo Dry Valleys, as well as research platforms operating in the Arctic and Southern Oceans, offer the opportunity to bring these new technologies to bear in research on the polar regions. A recent NAS report, *Frontiers in Polar Biology in the Genomics Era* (*http://books.nap.edu/catalog/10623.html*) describes potential research benefits of these new tools. Within NSF, there is interest in OPP and in the Biological Sciences and Geosciences Directorates in this area of research. OPP has examined the technical feasibility of extending antarctic operations into the austral fall and early winter and may be able to implement this capability by 2007. Supporting winter work elsewhere in the polar regions will require evaluation of options on a case-by-case basis.

Education and Outreach

OPP has maintained strong support for linking research in the polar regions with formal education and outreach to the public. NSF has fostered U.S. scientists' interests in sharing their research with broad audiences. Many polar researchers have been successful in seeking support from education programs for more directed efforts, such as NSF's IGERT and GK–12 programs as well as Arctic Research and Education and Geosciences Education. Strong international partnerships in educational activities have developed in association with research programs in both polar regions. In the Arctic, such partnerships include U.S. collaboration with groups from Russia, Greenland, Iceland, Canada, Denmark, Norway, Sweden, and

Finland. In the Antarctic, partnerships include U.S. collaborations with many nations that participate in the Scientific Committee on Antarctic Research (SCAR).

OPP sponsored a workshop in June 2004 (*www.ldeo.columbia.edu/~mkt/PolarED_Web.htm*) to bring together educators, researchers, media and museum outreach experts, agency representatives, and others to discuss effective mechanisms to conduct education and outreach in support of the IPY. The workshop highlighted many of the education and outreach efforts that have already been supported by OPP, including Teachers Experiencing Antarctica and the Arctic (TEA), which was co-funded with NSF's Elementary, Secondary and Informal Education Division, Teachers and Researchers Exploring and Collaborating (TREC), Antarctic Artists and Writers Program, various journalists in the field, museum exhibits, and Research Experiences for Undergraduates (REU).

There is significant interest within NSF's Education and Human Resources (EHR) directorate in utilizing the inherently interesting features of the polar regions, including their remoteness and extreme conditions, to direct attention to scientific research and the importance of the polar regions to the global system. Other agencies such as NASA and NOAA have robust polar research and education programs interested in supporting IPY efforts. NSF is developing the foundation for international and interagency partnerships to bring together support and expertise from the community of researchers and educators. Another area where NSF can have a significant IPY impact is in research on distant education, both in terms of technology and in terms of the science of learning as it applies to different cultures. The aim of these efforts is to develop highly visible, long-lived education and outreach products for IPY research and to provide opportunities for educating the next generation of polar researchers, the public, and policy-makers.

As this document goes to print, OPP and EHR are set to make the education awards resulting from the FY06 IPY solicitation. The science awards from the FY06 solicitation are on track to be announced before the end of October.

NSF and IPY in FY07

The Directorates of Biological Sciences, Geosciences, Social, Behavioral and Economic Sciences, and the Office of International Science and Engineering have joined OPP and EHR in expanding the four foci established for FY06. The Agency has requested $61.57 million in its Budget Request for this purpose.

NSF is preparing a second solicitation that will support IPY science and education proposals in FY07. This solicitation will build on the momentum of the FY06 solicitation and broaden the science themes. For example, research on life in the cold and dark will expand to address human and biotic systems, providing opportunities for scientists to address fundamental questions about social, behavioural, and/or natural systems that will increase our understanding of how humans and other organisms function in the extreme environments of the polar regions. Studies on environmental change will specifically take advantage of the Arctic Observing Network developed during FY06 to support research that advances the understanding of the physical, geological, chemical, human, and biological drivers of environmental change at the poles, their relationship to the climate system, their impact on ecosystems, and their linkages to global processes.

In addition to large-scale projects such as those mentioned above, NSF plans to support IPY activities that address the ICSU and NAS guidelines in a broad spectrum of areas, particularly research that addresses opportunities in the social sciences, systematic and biotic diversity surveys (e.g., the ongoing Census of Marine Life), implementation of observing systems, and research in the Southern Ocean on the transport and fate of nutrients and carbon.

One example of research in the social sciences is the study of endangered languages in arctic cultures, where we have the opportunity to create a legacy of knowledge that will inform future generations of scholars while at the same time strengthening local cultures. The Documenting Endangered Languages (DEL) program is a multi-year funding partnership between NSF and the National Endowment for the Humanities (NEH) to support projects to develop and advance knowledge concerning endangered human languages. This program is made urgent by the imminent death of an estimated half of the 6000–7000 currently used human languages. Working with the SBE Linguistics Program, the OPP Arctic Social Sciences Program has identified DEL as a natural IPY project. The unfortunate situation of the estimated 52 arctic indigenous languages is no exception to the international prognosis. Following the first DEL Announcement of Opportunity, over 10 percent of the proposals were to research arctic languages and the DEL Management Group anticipates over 10 percent of the recommended proposals to be for research in the arctic region. NSF and NEH have agreed to funding for DEL for three years with an evaluation and possibility for renewal in 2008. Thus, IPY provides an oppor-

tunity to bring publicity and resources to the pressing issue of endangered languages in the Arctic.

With regard to the implementation of observing systems, the National Ocean Partnership Program, through the Ocean-U.S. office, is pursuing the establishment of an Integrated Ocean Observatory System (IOOS). The IOOS is planned to include three "Regional Associations" in Alaska, including the Chukchi Sea and North Slope, Bering Sea, and NE Pacific. NSF is working with the National Oceanic and Atmospheric Administration and local groups to identify and to support these regional associations. NSF is working with the research community in Barrow, Alaska, to develop a plan for a major observatory to be located in that community, with an emphasis on research that contributes to SEARCH and other high-priority arctic programs. Within NSF, participants in these activities include OPP, CISE, and ENG. To enable the IOOS and to provide for a new generation of polar research, NSF is committed to supporting work in developing and deploying novel instrumentation. New work is especially needed in chemical and biological sensors (for example, nutrients and plankton). In addition, a new set of platforms that must be developed for making and transmitting observations from under the ice pack, including both gliders and autonomous underwater vehicles. Finally, NSF's experience in deploying the first shore-based polar observatory off Palmer Station in January 2006 will be invaluable in planning other polar coastal observatories.

Strong emphasis is again placed on education and outreach, which will support stand-alone education proposals that specifically invigorate science, technology, engineering, and mathematics (STEM) education in the context of the IPY: formal science education projects at the K–12, undergraduate, or graduate level; informal science education projects for the broader public; and coordination and communication for IPY education projects. IPY provides a timely opportunity to advance the goals of the American Competitiveness Initiative (ACI).

Logistics Support

Arctic and Antarctic Research Support and Logistics are supported through contracts and other agreements. These arrangements provide flexible mechanisms that are capable of supporting a wide range of potential science and educational activities. NSF also works with the U.S. Coast Guard, NOAA, University-National Oceanographic Laboratory System (UNOLS), the Canadian Coast Guard and others to provide shipboard facilities for marine research in both polar regions. Other support is available in the Arctic through a cooperative agreement with the Barrow Arctic Science Consortium (BASC) in Barrow, Alaska, to provide research support and logistics for researchers working on the North Slope of Alaska and a cooperative agreement with the Institute of Arctic Biology at the University of Alaska Fairbanks to support operation of the Toolik Field Station, an NSF LTER site. Cooperation with other national polar research programs offers an avenue for supporting international projects.

One aspect of logistics support that is being explored is the feasibility of supporting year-round research or extending the research season at additional locations in the polar regions (currently only South Pole, McMurdo, and Palmer stations in the Antarctic and Summit, Greenland are staffed for year-round research activities). Year-round research and research in remote areas is complicated and expensive to execute, yet is necessary to provide adequate spatial and temporal coverage to address research questions. Evolving technology has made it possible to collect many measurements remotely through instrumentation or through the use of remotely operated vehicles. There are many improvements to be made to the technology to ensure consistency of data collection under extreme conditions and make use of renewable energy sources. Sensors could be integrated into a network that upload data via satellites in real-time. Upgrades and improvements of existing infrastructure include: improvements in the information technology infrastructure at research hubs such as Barrow, Alaska; development of unmanned sensor networks in the Arctic and Antarctic; development of remote power for sensors, particularly using renewable resources; and improvements in field research facilities (e.g., laboratory space and equipment, living quarters, communications and safety).

Data Management

The legacy of data created during IGY was instrumental in enabling many of the scientific advances in the decades following the IGY. Likewise, comprehensive management of the volumes of data to be generated during the IPY will be critical to ensuring that it is useful and available to future researchers and educators.

Archival and distribution functions for data required for support of arctic and antarctic IPY research are distributed among all the U.S. national data centers. These data are held in global archives at the National Climatic Data Center (climatology

and meteorology), at the National Oceanographic Data Center (oceanography), at the National Geophysical Data Center (seismology, geomagnetism, marine geology and geophysics, solar and ionospheric studies, ecosystems, topography, and paleoclimatology), and at the National Center for Atmospheric Research (upper atmosphere and ionospheric studies). Data sets for a vast array of cryosphere-specific variables in the Arctic (sea ice, snow cover, permafrost, etc.) are archived and distributed through the National Snow and Ice Data Center (NSIDC) and the World Data Center for Glaciology in Boulder, Colorado (*http://www.ngdc.noaa.gov/wdc/*). These also include satellite-derived measurements, in-situ observations, and ancillary information from the Antarctic and the Arctic that have been supported by NASA, NOAA, and NSF. NOAA/NESDIS/NCDC in Asheville, NC holds the global satellite data archives for polar-orbiting satellites.

For data management, a new focus on "Virtual Observatories" is being developed and promoted by the "Electronic Geophysical initiative Year" (*http://www.eGY.org*). As more researchers provide their data on individual or institutional Web or FTP sites, rather than submitting to data centers, the current "push data" approach (where the data must be submitted to the National and World Data Centers System) is now becoming more difficult to implement. Therefore, the worldwide data management community is focusing on providing more effective access to globally distributed data sets via the "pull data" concept. The eGY group and the ICSU World Data Centers Panel are working toward a convergence of data centers into "data clearinghouses," while the Virtual Observatories are developing a network of interconnected data holdings and retrieving/visualizing software that constitutes the worldwide "data fabric." NSF is supporting, under the broader umbrella of CyberInfrastructure, the concept of Virtual Observatories as a means of managing relevant data for IPY.

DEPARTMENT OF ENERGY (DOE)

DOE is planning to support the International Polar Year in a variety of important ways through the following programs:

- Atmospheric Radiation Measurement Program
- Climate Change Prediction Program

ATMOSPHERIC RADIATION MEASUREMENT PROGRAM (ARM)

The ARM Program will continue its year round operation at the North Slope of Alaska (NSA) site. This site is providing data about cloud and radiative processes at high latitudes. These data are being used to refine models and parameterizations as they relate to the Arctic. The NSA site is centered at Barrow and extends to the south to the vicinity of Atqasuk, and to the east to Oliktok Point. DOE will also support IPY-related proposals to conduct experiments using either the NSA site and/or the ARM Mobile Facility.

CLIMATE CHANGE PREDICTION PROGRAM (CCPP)

The CCPP will continue research to develop coupled climate models. The CCPP is developing ocean and sea ice models that are components of the *Community Climate System Model (CCSM).* In addition to coupled climate simulations, researchers apply the ocean and sea ice models to a variety of ocean and sea ice problems, including eddy-resolving ocean simulations, studies of the thermohaline circulation, and polar ice feedbacks. CCPP also supports analyses of the causes and consequences of biases in the mean climate and circulation of the Arctic.

ACTIVITIES OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) THAT SUPPORT THE OBJECTIVES OF THE INTERNATIONAL POLAR YEAR (IPY) MARCH 2007–MARCH 2009

NOAA began planning for IPY activities in the fall of 2004. Initial ideas were packaged into 11 broader themes and submitted to the IPY International Program Office in January 2005 as "expressions of intent." Over the next few months, the IPY International Program Office encouraged scientists to prepare more collaborative proposals, resulting in around 200 "integrated projects" that now define the international effort for the IPY. All of NOAA's original submissions are included in these integrated projects. This document summarizes the initial plans and provides an update to expected IPY activities during FY 2007 to FY 2009.

EXPLORATION

1. Ocean Exploration in Polar Regions

NOAA's Office of Ocean Exploration (OE) may support multiple projects in both the Arctic and Antarctic in conjunction with the International Polar Year (IPY). OE solicited specific projects for IPY via *Federal Register* announcements in calendar years 2005 and 2006. OE also expects to solicit IPY-related projects during the calendar year 2007 *Federal Register* notice. Ocean Exploration together with the NOAA Arctic Research Program and the Russian Academy of Sciences plan to facilitate an expedition to the Pacific Arctic in 2008, as part of the ongoing RUSALCA (Russian American Long-term Census of the Arctic) program.

OBSERVATIONS

2. Causes and Impacts of Recent Changes in the Pacific Arctic

Unprecedented minima of sea ice area have occurred in the Pacific Arctic during the four most recent summers. Summer 2003 and 2004 brought record forest fires and drought to eastern Siberia and Alaska after a decade of warm springtime temperature anomalies. In surrounding seas there has been a northward shift of ice-dependent marine animals, with pelagic species such as pollock favored over bottom-feeding flatfish. Many Pacific Arctic changes are continuing, despite the observation that climate indices such as the Arctic Oscillation were negative or neutral for six of the last nine years. The Pacific Arctic may be having a larger role in shaping the persistence of Arctic change than has been previously recognized. We will work with our partners to carry out observations in this area to measure movement of water through the Bering Strait, gather observations about physical change in the state of the ocean in the Bering and Chukchi Seas, and study impacts of physical change on marine ecosystems in this region. Bering Strait mooring programs will be conducted, as well as mooring and ship-board studies in the eastern Bering Sea. Limited ship-board studies will be made in ice-free areas in the vicinity of Bering Strait and Chukchi Sea in association with mooring cruises.

3. Polar Atmospheric Observatories and Field Campaigns

As part of the IPY project "International Arctic System for Observing the Atmosphere," a system of strategically located, long-term Atmospheric Observatories will be developed around the Arctic to carry out both routine measurements made at meteorological stations and intensive measurements at the surface and through the depth of the atmosphere. Measured quantities can include solar radiation, aerosols, air chemistry, trace gases, cloud properties, water vapour, ozone, temperatures, winds, precipitation, surface albedo and stratospheric properties. These measurements are essential to calibrate and validate satellite sensors and to improve the reliability of climate models. The Atmospheric Observatory partnership includes the United States, Canada, Russia, Norway, Finland, and China. NOAA's existing baseline observatories at Barrow Alaska and South Pole will continue to focus on measurements of trace gases and aerosols. The flask-sampling program has 15 polar stations that collect atmospheric samples for trace gas measurement. The Climate Research Program supports investigations of atmospheric processes that affect climate in polar regions. In the Arctic, a new observatory at Eureka Canada will operate during the IPY and the observatory at Barrow Alaska will continue. The observatory at Tiksi Russia will be partially operational. These three observatories will focus on measurements of clouds, radiation, and trace gases. Both Barrow and South Pole will offer logistic support to scientists for IPY projects if they can provide their own science support. The flask-sampling program will continue and research efforts will be supported on ozone, haze and aerosol/cloud/climate interactions in the Arctic.

NOAA/NCDC plans to install a Climate Reference Network (CRN) site configuration at the Russian Arctic observing site in Tiksi (dependent on final FY07 budget). Preliminary planning has already begun in concert with the IPY's International Arctic Systems for Observing the Atmosphere (IASOA), and installation is tentatively planned for the summer building season in the August/September 2007 timeframe. This installation is not only in support of the IPY, but is also in line with a longer term effort on the part of the U.S. GCOS Program Office to install reference surface observing sites in unique high elevation and high latitude location environments.

4. Polar stratospheric Ozone Depletion Observations

As a part of the International Geophysical Year in 1957, column ozone measurements were initiated at South Pole, Antarctica using Dobson spectrometers. In 1985, the annual stratospheric ozone depletion over Antarctica—the "Antarctic Ozone Hole"—was identified. In less than five years it was proven that the ozone hole was caused by human emitted fluorochlorocarbons (CFCs) and the ozone hole has become a globally recognized "poster child" for showing how humans can cause global

scale changes. The Arctic stratospheric ozone changes, though lesser in magnitude than the Antarctic ozone hole, are by no means of lesser importance. Key studies will be undertaken in the Arctic to monitor these changes. Routine observations of ozone will continue at Barrow and South Pole during the IPY.

5. Antarctic Living Marine Resource (AMLR) Survey

The principal objective of the NOAA AMLR research program is to collect the scientific information needed to detect, monitor, and predict the effects of harvesting and associated activities on target, dependent, and related species and populations of the Antarctic marine living resources and the ecosystem(s) of which they are a part. A 35-day ship-based research program is planned for FY07.

PREDICTION AND MODELING

6. Short-term Arctic Predictability (STAP)

This scientific study will explore the variability, and associated predictability of weather, sea ice, ocean wave, and land surface processes in the Arctic region in the 3–90 days time range, with special emphasis on improving forecast guidance for high impact events in the 3–14 day lead time range. NOAA will complete a study of northwest Alaskan coastal waves during the IPY. NOAA will also participate in sea ice studies at both poles aimed at improving measurement of ice thickness and forecasting. The NOAA THORPEX program is expected to make observations and introduce forecast products to improve weather and intraseasonal forecasts for the Arctic.

7. Advances in Satellite Products and Their Use in Numerical Weather Prediction

Spatially comprehensive observations of the atmosphere in the data-sparse polar regions significantly and positively impact high latitude numerical weather predictions. In addition, errors in model forecasts for the high latitudes often propagate to the mid-latitudes, implying that improvements to high latitude forecasts will result in better mid-latitude forecasts. These findings provide the motivation to improve our ability to measure the state of the polar regions with satellites and to expand the use of these data in Numerical Weather Prediction systems. NOAA will participate in IPY projects to improve the application of satellite sensors to environmental problems in the polar regions.

8. Arctic Climate Modeling

The general goal of this project is to improve predictions of the Arctic environment on timescales ranging from seasonal to climate change. Thus, our research will focus on analyzing and modeling the physical processes and connections between the Arctic and the rest of the globe. NOAA's Geophysical Fluid Dynamics Laboratory will continue to improve global climate models that including polar processes.

9. Arctic System Re-analysis (ASR)

A concerted effort during the IPY (2007–2008) to construct pan-Arctic atmosphere-ocean-ice-land data sets, and to assimilate and enhance these with a high-resolution (coupled) reanalysis system optimized for the Arctic region, will provide researchers with an unprecedented description of the Arctic environment over the past several decades. The operational analysis system (post 2008) expected to be a legacy of this activity would provide constantly updated depictions of the Arctic environment, and foster improved short- and medium-range weather forecasts as well as seasonal climate outlooks. Improved understanding of Arctic climate processes resulting from development of the ASR will lead to better global climate models, in turn reducing uncertainty in projected future climate states of the Arctic. The ASR will also serve as a vehicle for diagnostic evaluation of ongoing changes in the Arctic system.

DATA, OUTREACH AND DECISION SUPPORT

10. NOAA's Data, Information, and Change Detection Strategy for the IPY

NOAA's fundamental data management responsibilities will be to securely archive IPY datasets and ensure that these and relevant polar data are easily accessible for current and future users. NOAA will utilize the existing World Data Center (WDC) System and NOAA's National Geophysical Data Centers in order to serve as a clearinghouse and facilitator for data-management issues and will work with IPY participants to ensure that International Council of Scientific Unions/World Meteorological Organization (ICSU/WMO) IPY Data Committee guidelines are followed. NOAA will

also ensure that international standards such as the Open Archival Information System Reference Model and the ISO19115 metadata standards are met.

NOAA intends to build and maintain a pan-Arctic view of climate variability and change that will serve decision-makers with information products. These range from baseline atlases against which future assessments can be carried out, to the Near Realtime Arctic Change Indicator Website, where information on the present state of Arctic ecosystems and climate is given in historical context. NOAA data centers will assist NOAA scientists to archive their IPY data. NOAA will continue to acquire historical data and present it on the Arctic Change Indicator Website to describe the state of the Arctic climate over the past 150 years, allowing a better context for new data collected during the IPY.

11. Decision support for increasing adaptive capacity to climate change and variability in Alaska and the Arctic.

The cornerstone of the National Oceanic & Atmospheric Administration's (NOAA) Regional Climate Decision Support program for Alaska and the Arctic is to establish an integrated program spanning stakeholder-influenced research and development of decision-support tools for the sustained delivery of customer services. This includes establishing in Alaska a Regional Integrated Sciences & Assessments (RISA) and a Regional Climate Center (RCC) with formal liaisons to NOAA's National Weather Service and the State Climatologist Office to foster growth of climate services.

NOAA is part of the U.S. presence in the Arctic Council (AC). The AC plans to conduct several assessments during the IPY period, including the Arctic Marine Shipping Assessment, an assessment of the Arctic carbon cycle, and others. NOAA will provide expertise and financial support within available resources. NOAA plans to initiate the Alaska RISA soon through the Univ. of Alaska, and as a five-year effort, it will operate during the IPY, but not at the full-performance level. Through the Regional Climate Centers program, an "Alaska desk" may be established in association with the Alaska RISA. NOAA expects to contribute staff time and limited financial support to the Arctic Council climate-related assessment tasks during the IPY.

The National Ice Center (NIC) is a U.S. Government agency that brings together elements from the Department of Commerce—NOAA , the Department of Defense—NAVY, and the Department of Homeland Security—U.S. Coast Guard (USCG) to support coastal and marine sea ice operations and research globally. The mission of the NIC is to provide the highest quality strategic and tactical ice services tailored to meet operational requirements of U.S. national interests. Over the Arctic, particularly, the NIC provides operational strategic basin-scale sea ice charting with the production of a hemispheric and over 30 individual regional charts, sea ice tactical ice navigation support, Chukchi Sea and Beaufort Sea ice seasonal forecasts, support for the development of a sea ice climatology for the Arctic, and management of the U.S. Interagency Arctic Buoy Program (USIABP). NIC is participating directly or indirectly in an increased number of research and application cooperative projects with other national and international groups as part of International Polar Year (IPY) activities throughout 2007 and 2008.

NOAA's National Data Centers handle a wide variety of Arctic data. An affiliated data center, the National Snow and Ice Data Center (NSIDC), CIRES, University of Colorado, has a NOAA NESDIS supported program (nsidc.org/noaa/) to produce and manage selected data sets. Significant data sets are the Online Glacier Photograph Collection of over 3000 photographs dating to the late 1800s; upward looking sonar data from submarines, providing estimates of sea ice thickness; and the Sea Ice Index, a site that shows, with graphical products, trends and anomalies in sea ice cover. Overall, the NOAA@NSIDC program emphasizes data rescue and in situ data. This emphasis helps collect and maintain the long time series with broad spatial coverage that is necessary to track and attribute arctic change. The program complements the activities of the Distributed Active Archive Center, a NASA funded center at NSIDC that supports the bulk of NSIDC's activities. In addition to data activities, NOAA supports approximately half of the operating cost of the World Data Center for Glaciology, Boulder, library. The archival activities of this library are becoming more visible as preparations for IPY gather momentum.

12. Formal and Informal Education

The Climate Program Office is leading a NOAA-wide effort with respect to the IPY. The Climate Literacy Working Group (CLWG), based at the Climate Program Office, is coordinating NOAA-wide IPY education and outreach activities with the NOAA Office of Education. The NOAA IPY effort is part of the NSF led interagency IPY education effort and will collaborate and coordinate their efforts with agencies

participating in the forth IPY. Several formal and informal education initiatives are focusing primarily on teacher professional and science center or museum exhibitions, however several formal lesson plans will be developed as part of our IPY efforts. Several current example IPY efforts are listed below:

IPY/NSTA Symposia: These are exciting Symposia designed for grade 5–8 educators in celebration of the International Polar Year (IPY), will delve into science content and educational activities developed by NASA, NOAA, and NSF. These symposia will happen at the NSTA national conference in March 2007.

http://institute.nsta.org/fall06/ipyice/symposium.asp

IGLO is a project of the Association of Science-Technology Centers, an international organization of science centers and museums dedicated to furthering the public understanding of science. IGLO's goals are to raise public awareness about the impact of global warming and the state of climate science, position science centers globally as recognized leaders in public engagement with science and support the aims and objectives of the IPY. NOAA, NASA and NSF are sponsors of the initiative.

http://www.astc.org/iglo/

Climate Change in the Arctic Ocean is a teacher professional development and mass media project aboard the NABOS 2006 Arctic Expedition aboard Icebreaker Kapitan Dranitsyn.

http://www.naturalsciences.org/education/arctic/

13. Public Outreach—

NOAA's Climate Program has expanded its Regional Integrated Sciences and Assessments (RISA) program to Alaska. The Alaska RISA is a five-year program designed to address regionally important climate issues to aid policy- and decision-making. The Alaska RISA program could contribute significant results to our understanding of key climate related challenges facing the state and would allow for innovative partnerships with neighboring countries.

DEPARTMENT OF STATE AND DEPARTMENT OF HEALTH AND HUMAN SERVICES (DHHS)

Arctic Human Health Initiative (AHHI)

The Arctic Human Health Initiative (AHHI) will advance the joint research agenda of the Arctic Council, an eight-nation inter-governmental forum for sustainable development and environmental protection, in the areas of infectious disease monitoring, prevention, and response; the effects of anthropogenic pollution, UV radiation, and climate variability on human health; and telehealth innovations. Specifically, the leaders of these research programs will build on their years of circumpolar collaboration to extend the International Circumpolar Surveillance network of hospitals and public health facilities into Russia and include additional infectious diseases of concern, to continue monitoring contaminants in human blood and tissues to reveal temporal and spatial trends and to combine experiences from the rapidly expanding disciplines of biomarker research and molecular epidemiology with these monitoring programs, and to extend circumpolar cooperation on telehealth, particularly to Arctic regions in the Russian Federation. In addition, the AHHI will draw on the outstanding leadership of the Arctic Council member states' national and international research programs in the areas of human genomics, hypothermia/hibernation, and health impacts of climate change (including spread of zoonotic and arboviral diseases in the Arctic).

Fogarty International Center (FIC) has been the designated focal point for Arctic issues at the National Institutes of Health (NIH). One of FIC's key roles is advancing bilateral and multilateral ties between and among governments, institutions, and scientists working on circumpolar issues. In this, FIC has been collaborating with other NIH Institutes and DHHS agencies in the development of symposiums and research programs, as well as actively exploring other opportunities for trans-NIH and interagency collaboration (e.g., with NSF, NASA, etc.), such as mental health. As an example, two major conferences on inhalant abuse and suicide were spearheaded by FIC with partnership from National Institute of Drug Abuse (NIDA) and National Institute on Mental Health (NIMH) in 2004 and 2005. With mental health being one of the most significant concerns for the AHHI, FIC has been working with the Polar Research Board at the National Academies of Science in the development of a study focused on mental health in the Arctic. In addition to these activities, in FY05, NIH spent 22 million on research programs in the Arctic. Some of the major areas of research included interactions of genetics and environment,

cancer, cardiovascular and mental health disease burdens. Overall, across DHHS, multiple agencies have been engaged in working on the improvement of health and health care in the Arctic. For example, SAMHSA spent 21.2 million in FY05, as it continues to provide services directed at the prevention and treatment of mental health and substance abuse problems in the Arctic. The U.S. Centers for Disease Control and Prevention (CDC), one of the leading agencies at DHHS has been developing partnerships and collaborations in the Arctic focused on improvement of public health and healthcare provision. In addition, CDC has been the leader of the AHHI steering group, which has been working with the International Union for Circumpolar Health (IUCH), FIC and other stakeholders in the development of outreach and public education programs focused on the promotion of good health for Arctic residents and better integration of the findings of Arctic health research.

U.S. GEOLOGICAL SURVEY (USGS)

The U.S. Geological Survey serves the United States by providing reliable scientific information to

- Describe and understand the Earth
- Minimize loss of life and property from natural disasters
- Manage water, biological, energy, and mineral resources; and
- Enhance and protect our quality of life.

The USGS will participate in the IPY through extension and enhancement of programmatic activities in research, assessment, and monitoring in the polar regions that support the scientific mission of the organization and address the themes and goals of the IPY. These activities span the biologic, geologic, hydrologic, geographic, and information sciences. While planning is still ongoing, we anticipate our major IPY activities will include:

Products to be released by the USGS during IPY:

- Satellite Image Atlas of Glaciers of Asia, Alaska, and Iceland (*http://www.glaciers.er.usgs.gov/html/chapters.html*)
- State of the Earth's Cryosphere at the Beginning of the 21st Century: Glaciers, Snow Cover, Floating Ice, and Permafrost
- Petroleum Resource Assessment of the Arctic

  USGS World Petroleum Assessment of 2000 estimated that approximately 25 percent of the remaining oil and gas resources of the world reside in the Arctic. This follow-on study will examine Arctic basins in more detail and report on oil and gas resource potential of unexplored basins, and the initial results should be completed during the IPY.
- Landsat 7 Image Map of Antarctica (LIMA)

  The LIMA will create three high-quality remotely-sensed mosaics of Antarctica from more than 1200+ Landsat scenes in cooperation with the British Antarctic Survey, funded by the National Science Foundation.

Analysis of long-term monitoring from the polar regions:

The USGS has been monitoring permafrost temperature in the Arctic, three Benchmark Glaciers for climate change, glacier geometry, glacier mass balance, glacier motion, and stream runoff, and marine mammals for many decades. The results of those monitoring efforts will be examined, analyzed and reported on during the IPY.

- Permafrost Temperature Monitoring
- Benchmark Glaciers
- Marine Mammals: polar bears and walruses
- Sea Ice

Initiation of new study:

Yukon River Basin—Rates and Effects of Permafrost Thawing in the Arctic.

The USGS is working with a consortium of U.S. and Canadian Federal, State, and Provincial agencies, university scientists, and tribal organizations to initiate a major project to understand and predict climate-induced changes to the air, water, land, and biota within the Yukon River Basin (YRB). This collaborative scientific effort, using the YRB and adjacent coastal ocean as a representative landscape unit, will

provide a benchmark for tracking and understanding changes occurring throughout the Arctic and Sub-arctic region.

USGS will be highlighting our Facilities and Resources for Arctic and Antarctic Research

- U.S. National Ice Core Laboratory, USGS, Denver, CO

  The U.S. National Ice Core Laboratory (NICL) stores, curates, and facilitates study of ice cores recovered from the polar regions of the world. It provides scientists with the capability to conduct examinations and measurements on ice cores, and it preserves the integrity of these ice cores in a long-term repository for current and future investigations. Ice cores contain an abundance of climate information—more so than any other natural recorder of climate such as tree rings or sediment layers. *http://nicl.usgs.gov/*

- U.S. Antarctic Resource Center, USGS, Reston, VA

  The U.S. Antarctic Resource Center (USARC) is the Nation's depository for Antarctic maps, charts, geodetic ground control, satellite images, aerial photographs, publications, slides, and video tapes. These resources are items produced by Antarctic Treaty nations in support of their activities in Antarctica and provided to the USARC in compliance with a standing resolution of the treaty providing for exchange of information. *usarc.usgs.gov*

- USGS Alaska Science Center, Anchorage, AK

  A Center of Excellence for the Department of the Interior to address important natural resources issues and natural hazards assessments in Alaska and circumpolar regions through long-term data collection and monitoring, research and development, and assessments and applications. Their mission is to provide scientific leadership and accurate, objective, and timely data, information, and research findings about the Earth and its flora and fauna to federal and State resource managers and policy-makers, local government, and the public to support sound decision-making regarding natural resources, natural hazards, and ecosystems in Alaska and circumpolar regions. *http://alaska.usgs.gov/index.php*

- McMurdo Long Term Research (LTER) Program

  The USGS provides cooperative support to the McMurdo Long-Term Research program for water resources data collection and related activities. The support provided is in the form of field assistance, guidance, and review of surface-water data collection by INSTAAR and University of Colorado researchers in the McMurdo Dry Valleys (Taylor Valley and Wright Valley) of Antarctica. Cooperation is also provided in the form of guidance and support for and access to USGS databases and streamflow-records processing applications.

- Antarctic Seismic Data Library System (SDLS)

  The SDLS is an Antarctic-Treaty-mandated effort under the auspices of the Scientific Committee on Antarctic Research (SCAR) to collate and make openly available for research purposes all marine multi-channel seismic reflection data (MCS) acquired in Antarctic regions (i.e., south of 60 degrees South). The SDLS was implemented in 1991 under USGS sponsorship, but since about 1996, the SDLS has been run jointly by USGS (with NSF–OPP and USGS funding) and Osservatorio Geofisico Sperimentale (OGS, Trieste, Italy). The seismic library has branches in 10 countries, with two branches in the U.S. MCS data are sent to the SDLS by data collectors, are put onto CD–ROM and distributed to SDLS branches where they can be viewed and used under the SDLS guidelines specified in SCAR Report #9 (and addendums). To date, 60 CD–Roms holding more than 120,000 km of stacked MCS data have been produced for SDLS branches.

- Web-enabling the US Antarctic Photography Collection from the USGS Earth Resources Observation Science (EROS) Center

  For more the 30 years, it has been USGS's privilege to archive and serve the U.S. Antarctic Program, the international Antarctic research community, and the public with access to the U.S. Antarctic aerial photography collection held at the USGS Center for Earth Resources Observation and Science (EROS) center at *http://eros.usgs.gov/*. This collection consists of an estimated 400,000 frames of historical aerial photography dating back to the 1940s. This collection is the best collection of Antarctic aerial photography held by

any country and that its value to the Antarctic research community will only increase with time as work and research continues in Antarctica.

However, neither online metadata, browse images, photographs nor film products are available via the Internet for the USAP Antarctic aerial photography collection. New technology and improved digitizing methods have made it possible to digitize the original aerial film rolls creating browse and medium resolution images of each frame. We propose to link the digitized USAP aerial photography browse and medium resolution image files to the USARC paper map-line plots and web-enable the digitized collection in such a way that users could download images over the Internet at no cost to the user. Implementation of the proposal will result in an integrated on-line query, browsing and delivery capability for all historical USARC photography in the USGS EROS Center.

- Antarctic Geographic Placenames

  The USGS operates the U.S. Board on Geographic Names in conjointly with other federal agencies. In accordance with recommendations of the Advisory Committee on Antarctic Names (ACAN), United States Board on Geographic Names (USBGN) approves all new names to be used in government use in Antarctica by the United States.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

NASA's contributions to IPY likely will involve ongoing activities (operating satellites, continuing ground networks, and scientific research), some episodic activities (satellite snapshots and field campaigns), new efforts related to the development and deployment of sub-orbital capabilities (aircraft and unmanned aerial vehicles), and coordination of remote sensing observations with in situ measurements supported both by NASA and other agencies—primarily the National Science Foundation.

Currently, NASA operates nearly 20 satellites that collect information about the polar regions. The Ice Cloud and Land Elevation Satellite (ICESat) was specifically designed to measure changes in the elevation of the Earth's great ice sheets and the ice sheet processes that are manifest in the surface topography in unprecedented detail. In addition, the mission has revealed new information about recent thickness characteristics of sea ice in the entire Arctic and Antarctic regions. Other recently-launched Cloudsat and Calipso missions are providing 3-dimensional information on the structure of the Earth's atmosphere, and as with all near-polar orbiting satellites, coverage will be maximum in the polar regions.

NASA has demonstrated success in the past in developing comprehensive polar observations through international collaborations with the Canadian Space Agency (CSA) to carry out the Antarctic Mapping Mission and the Arctic Snapshot of Arctic sea ice characteristics at very high spatial resolution. We expect to continue to develop these international efforts through a coordination of activities with our colleagues at space agencies in other countries.

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. 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, and activities in support of human exploration of space have been conducted in the Canadian Arctic. These polar environments continue to serve as important test-beds in support of activities related to NASA's Vision for Space Exploration.

NASA issued a solicitation for IPY research proposals in 2006. Specific research topics solicited were:

1. Integrated analysis of multiple satellite data sets, enhanced validation of NASA satellite data sets in polar regions needed for improving their interpretation by models, and/or the integrated analysis of satellite and related sub-orbital data addressing the scientific questions defined by NASA in its *Earth Science Enterprise Strategy* (at *http://earth.nasa.gov/visions/ESE_Strategy2003.pdf*) that can be addressed in the context of IPY;
2. Individual U.S. investigator participation in field activities carried out as part of IPY, especially U.S. participation in multi-national field campaigns to take place in the primary IPY timeframe from March 2007–March 2009.
3. Integrated regional modeling of the polar regions (including the terrestrial, oceanic, atmospheric, biospheric, and cryospheric components of these re-

gions and their interactions) that takes advantage of synergies between the enhanced international observational capabilities that will be available during the IPY time frame and NASA satellites;

4. Definition studies for potential U.S.-led, focused IPY activities that integrate field work (typically using NASA-provided sub-orbital platforms), satellite data analysis, and modeling to address IPY-related science questions and provide enhanced validation for NASA satellite data products in the unique geophysical and/or biogeochemical conditions found in the polar areas. At this point in time, proposals for conduct of and/or participation in significant multi-investigator, U.S.-led field-based activities beyond these definition studies are not solicited; and
5. Development of remote-sensing instruments suitable for implementation on uninhabited aerial vehicles (UAVs) such as are likely to be available for use during the IPY time frame (March 2007–March 2009). Such instruments would make contributions to IPY contributing to our knowledge of the unique geophysical and/or biogeochemical conditions found in polar regions in one or more areas, including: (a) providing early demonstration of instrumental approaches that may be suitable for use on future satellites, (b) providing enhanced calibration/validation information for NASA satellites (and/or those of our international partners), (c) providing more comprehensive information about polar regions that complements that available from satellite sensors to be operating in the IPY time frame, or (d) any combination of the above. Given the limited time and funding available, it is expected that such development would be based on currently available airborne instrumentation with significant heritage aboard onboard-piloted platforms, but for which modification to meet the requirements of potential UAVs would be required. Proposers should identify potential UAV platforms as part of their proposals, but need not make arrangements for their use. If proposals in this area are selected, NASA would provide and pay for any flight opportunities involving the use of the newly developed instrument during the IPY time frame.

The evaluation of proposals submitted in response to this solicitation is still underway, but proposals selected from responses to our IPY solicitation will form the basis of a significant portion of our IPY research portfolio. In the context of *The Vision for Space Exploration,* other areas of investment may include:

— Utilizing polar regions as a stepping stone to exploring other planetary environments
— Understanding poles of other planets and similarities and differences to those on Earth.

NASA continues to study the Earth as a system through the unique sampling capability afforded by remote sensing. During the IPY and beyond, we will continue to develop this capability to understand polar processes, the role of the polar regions in the Earth's environment, and the nature of poles on other planets in our solar system.

U.S. DEPARTMENT OF AGRICULTURE (USDA)

The U.S. Department of Agriculture plans to continue its mission related activities in the Alaska region through its various mission areas, in particular through the Research, Extension and Economics Mission Area and the Natural Resources and Environment Mission Area.

The Agricultural Research Service (ARS) will continue its work towards preserving Alaskan plant diversity through its preservation and archiving of high latitude plant germplasm through traditional seed collocation and modern molecular methods. The U.S. Forest Service through the Pacific Northwest Research Station is responsible for the management of the Alaskan boreal forest and will continue its commitment in support of the Bonanza Creek LTER, which takes place at the Bonanza Creek Experimental Forest. The Natural Resources Conservation Service (NRCS) will continue to provide assistance to state, Native Alaskan, and private landowners through the USDA Farm Bill. The Forest Service and NRCS will continue their joint activities in permafrost and wetland soil research. The Cooperative State Research, Education and Extension Service (CSREES) will continue its research support for the Agricultural Experimental Research Stations and educational support for the University of Alaska, the Alaska land-grant institution. Legislated funding for research, education and extension activities through the Hatch Act, Evans-Allen Act and the McIntire-Stennis Act will continue to be administered by CSREES. Competitive funding for research through the National Research Initiative and for education such as the Alaska-Native and Native-Hawaiian Educational

Grants Program will be offered by various CSREES programs. CSREES will also continue its extension activities through the Alaska Cooperative Extension Service. CSREES is currently contributing to the interagency Study of Environmental Arctic Change (SEARCH) by providing resources to a 2006–2007 joint solicitation with EPA and NASA for proposals on climate change, land use and invasive species. SEARCH is one of the primary activities of NSF for the IPY and the USDA will continue to work with the interagency working group of SEARCH to promote joint interests in Alaska.

SMITHSONIAN INSTITUTION (SI)

The Smithsonian is prepared to engage in a variety of research, education, and outreach programs in support of IPY–4. Some of the following plans—all of which have been developed with interagency collaboration—are already underway; others need further discussion and are offered here as ideas for consideration.

1. Of all U.S. Governmental agencies, the Smithsonian probably has the longest record of association with IPY activities, because of its critical role in the First U.S. IPY field expeditions of 1881–1884, in caring for its collections, and publishing its proceedings. Hence SI participation in IPY 2007–8 will include both historical and contemporary dimensions.
2. The SI contribution will be based upon the Institution's time-tested strengths: (1) the research of its scientific personnel; (2) special value of its museum collections as national treasures; and (3) its broad public outreach program, coupled with the unique position of Smithsonian museums on the National Mall and their special attraction to the general public and the Nation.
3. On the scientific side, the SI is already playing the leading role in framing the U.S. socio-cultural and Native studies programs based upon staff expertise through the NMNH Arctic Studies Center and the value of its ethnological collections (see below). An ASC Arctic ethnologist is playing a key role for planning the IPY 2007–2008 socio-cultural agenda as a member of both the U.S. National IPY Committee and the main ICSU–WMO Joint Committee for the International Polar Year. The ASC will continue its leading role in the socio-cultural planning through its meetings, symposia, publications, exhibits, coordination activities, and other means.
4. Smithsonian scholars are also active in other fields of Arctic and Antarctic research, particularly in biology, paleontology, ocean, and astrophysics studies that will be included in the Institution's IPY program. SI is also curates the U.S. National Antarctic Meteorite collection.
5. The Smithsonian offers to organize and host a national IPY symposium at the beginning of the IPY 2007–2008 activities, with the participation of the leading SI scientists and representatives of other agencies and research institutions.
6. SI is eager to offer its Arctic and Antarctic collections (ethnological, botanical, zoological, mineral, films and archival materials, etc.) and to facilitate all types of IPY collection research as its contribution to the interagency IPY 2007–2008 program. Of particular value are the ethnological and biological collections from Barrow, Alaska and Ellesmere Island (Greeley Expedition) Arctic Canada from the First IPY 1881–1884 expeditions, as well as scientific instrument collections and records of the early IPY stations; and the instrument collections from the IGY at the Air and Space Museum.
7. SI offers its space and personnel resources to serve as the key IPY interagency hub for Education, Outreach, and Public Communication during 2007–2008 (and even earlier), through its museum programs, outreach, and exhibit ventures.
8. Proposed IPY Events for the National Mall:
   a) The first event will be the opening of the new Smithsonian exhibit, The Arctic: A Friend Acting Strangely (June 2005), focused on the current impacts and science of arctic environmental change. This exhibit has been produced with financial support from NOAA and NSF will be a part of the NMNH "Global Links" Exhibition Program.
   b) As noted above, we propose organizing a national IPY symposium at the beginning of the IPY period (2007).
   c) As part of this symposium, SI will organize a small exhibit on the history of the early U.S. IPY efforts based upon its collections, instruments, and photographic and documentary records. We invite other agencies to

join us in exhibiting objects or graphic materials related to their own contributions to the U.S. IPY efforts.

d) In collaboration with the University of Colorado (INSTAAR) we propose mounting a special exhibit called Artifacts On Ice: The Emerging Archeology of Glaciers, featuring the 8000 year old evidence of humans, artifacts, animals, and climate science being recovered from melting high-altitude glaciers in the Pacific Northwest.

e) The fifth—and the major—Smithsonian public contribution could be a much larger exhibit, such as Science at the Poles: IPY 2007–2008, to publicize its preliminary results and major accomplishments. This might take place in early or mid-2010, and as a major public venture, would have to be supported by substantial agency contributions.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA plans to support other agencies' IPY efforts through its Environmental Monitoring and Assessment Program (EMAP), and its involvement in the Global Earth Observation System of Systems (GEOSS). For 15 years, EMAP has developed cost-effective and policy relevant probabilistic sampling approaches for freshwater and marine resources. EPA has supported monitoring of coastal resources in South Central and Southeastern Alaska, as well as freshwater monitoring in Central Alaska. The state of Alaska has submitted an IPY "Expression of Intent" for Arctic and Bering Sea Coastal Assessments. EPA will give non-budgetary support to this proposal. Other agencies also may wish to support this effort, and perhaps support a larger potential effort of developing a circumarctic or even circumpolar coastal monitoring program using EMAP approaches, to obtain baseline conditions. This larger effort could be done in the context of IPY 2007–2008.

EPA is involved in GEOSS as a data collector, integrator, and user. Also, EPA is co-chair of the GEO Secretariat's User Requirements and Outreach Subgroup. EPA is interested in how the oceans observing network is expected to be included under GEOSS, and how all the other Earth observations overlap with IPY. EPA looks forward to collaborating with other agencies in GEOSS activities related to the IPY.

REPORT IN BRIEF

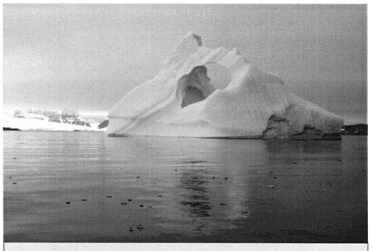
Photo courtesy Jan Curtis, University of Wyoming

Environmental change and variability are part of the natural pattern on Earth. But environmental changes currently witnessed in the polar regions are in many cases more pronounced than changes observed in the mid-latitudes or tropics. The Arctic sea ice cover is decreasing; some ice shelves in Antarctica are retreating and thinning; glaciers are shrinking; and ecosystems are changing, for instance, with plants flowering at earlier times. These changes are having human impacts: some Alaskan villages have been moved to higher ground in response to rising sea levels, and thawing of permafrost is undermining roads and buildings in northern communities around the world.

Why should the vast majority of us, who live in the warmer regions of the Earth, care? The polar regions, while physically distant, are critical links in the global climate system. The polar oceans play a critical role in maintaining ocean currents that keep coastal Europe much warmer than it would be otherwise, and the sea ice cover modifies Earth's surface temperature by reflecting solar energy. These are just a few of many global connections. The polar regions also hold unique information of Earth's past climate history, and they are growing in economic and geopolitical importance. They are a unique vantage point for studies that will help scientists understand environmental changes in the context of past changes, which in turn will help us make informed choices for our future. The exploration of new scientific frontiers in the polar regions also will lead to new discoveries, insights, and theories potentially important to all people. To better understand these and other questions, nations around the world are making plans to participate in International Polar Year (IPY) 2007-2008.

IPY 2007-2008: Scope and Objectives

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



This iceberg, 50 feet high, is located in the Ross Sea, Antarctica. The hole in the center is believed to have been formed by wave action as the iceberg rolls and breaks up in the sea. **Source:** Michael Van Woert, NOAA.

education and outreach activities designed to excite and engage the public, with a presence in classrooms around the world and in the media in varied and innovative formats.

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. It will run from March 1, 2007 until March 1, 2009, to allow two field seasons of research in both the Arctic and the Antarctic.

What Will Happen During IPY?

During the window of IPY 2007-2008, scientists from many nations will join together in expeditions and research projects designed to meet the IPY objectives, coordinated at both the national and international levels. They will work both in the Arctic and the Antarctic, and in universities, laboratories, and observatories around the world. The specific research projects have not yet been selected, but we envision teams of researchers collecting coordinated measurements to compile a snapshot of environmental conditions, which can serve as a baseline for understanding future environmental change. There might be an effort to coordinate satellites to gather consistent data on ice extent. Ecologists might mount a massive effort to conduct a census of marine life so that we better understand population trends for important fisheries. Other groups might drill into the ocean floor in search of sediment cores with evidence of past environments.

Scientific Challenges

IPY 2007-2008 is an opportunity to deepen our understanding of the physical, biological, and chemical processes in the polar regions and their global linkages and impacts, and to communicate these insights to the public. Five broad scientific challenges provide a framework for organizing IPY activities:

- Assessing large-scale environmental change in the polar regions, with questions looking at both the physical and human dimensions of change and its impacts.
- Conducting scientific exploration of "new" frontiers, whether these are once inaccessible places such as the seafloor, or areas of inquiry that are now open because of advances in technology, such as how the tools of genomics now allow exploration of previously unanswerable questions about biological adaptation.
- Observing the polar regions in depth, with adequate coverage of the vast and challenging landscape, to provide a description of current conditions and allow for better future understanding of variability and change.
- Understanding human-environmental dynamics in a region where the connections are intimate and where the impacts of change are clear.
- Creating new connections between science and the public, using these regions that are inherently intriguing.

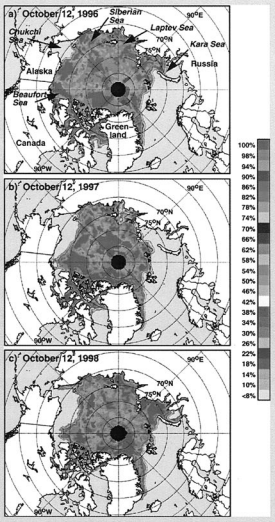
Multidisciplinary teams might document ecosystem changes in far northern communities where traditional subsistence foods are important to the local lifestyle and try to understand how changes are affecting the people of those communities. The next year is very important to IPY planning, because it is time to sort through the many ideas that have been suggested and see which are best to pursue.

Who's Involved in the IPY?

Enthusiasm for IPY 2007-2008 is strong and growing. In barely more than a year, the science community has progressed from its earliest discussions of possibilities for new international science endeavors to serious planning of what an IPY might accomplish and what resources are needed. More than 25 nations have formally declared the intent to participate and many more have discussions in progress. Here in the United States, scientists have been presenting talks and holding open forums at professional meetings and using an interactive website to brainstorm ideas where U.S. leadership might ensure significant contributions. A call to the science community for ideas about what science themes to pursue brought forward hundreds of ideas, and this input has been crucial in the IPY planning.

The U.S. Committee for the International Polar Year 2007-2008 was formed by the Polar Research Board of the National Academies to articulate a vision for U.S. participation in IPY 2007-2008 in coordination with and on behalf of our nation's scientific communities. The committee has worked closely with the U.S. science community using a variety of mechanisms. It has worked with our international colleagues, especially the International Council for Science's IPY 2007-2008 Planning Group, to identify the important science themes and develop the detailed information needed to implement its many contributing activities.

When IPY 2007-2008 gets underway, it will involve far more than scientists. The hope is that many people—scout leaders, teachers, museum directors, filmmakers, journalists, parents, and students of all ages—will be involved. Some of the participation will be hands-on; other involvement will take full advantage of the tremendous opportunities for instantaneous communication offered by modern technologies.



Reduction in sea ice extent in the Beaufort and Chukchi Seas over a three year period. The ice cover in 1998 was a then-record-minimum low north of Alaska for the satellite era (post-1979). Since 1998, a new record low was observed in the summer of 2002, and 2003 was a close second. **Source:** Comiso, 2002

What Should We Do To Make IPY a Success?

The committee recommends the following actions for ensuring a successful IPY 2007-2008:

- The U.S. scientific community and agencies should use the IPY to initiate a sustained effort aimed at assessing large-scale environmental change and variability in the polar regions.
- The U.S. scientific community and agencies should include studies of coupled human-natural systems critical to societal, economic, and strategic interests in the IPY.

- The U.S. IPY effort should explore new scientific frontiers from the molecular to the planetary scale.
- 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.
- The United States should invest in critical infrastructure (both physical and human) and technology to guarantee that IPY 2007-2008 leaves enduring benefits for the nation and for the residents of northern regions.
- The U.S. IPY program should excite and engage the public, with the goal of increasing understanding of the importance of polar regions in the global system and, at the same time, advance general science literacy in the nation.
- The U.S. scientific community and agencies should participate as leaders in International Polar Year 2007-2008.

Previous International Years

International Polar Year 2007-2008 is an ambitious program following in the footsteps of some past campaigns. There have been three similar programs over the last 125 years. During the first International Polar Year in 1882-1883, 12 countries launched 15 expeditions (13 in the Arctic and 2 in the Antarctic). As part of its contribution, the United States established our northernmost scientific station at Point Barrow, Alaska. 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 the "mapping" of ionospheric phenomena that advanced radioscience and technology. The United States established the first year-round research station inland from the Antarctic 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 scientific research. IGY brought many "firsts," such as the launch of the world's first satellites. IGY had a strong polar component, especially in the Antarctic: research stations were established and the experience in international collaboration, even in tense political times, led to ratification of the Antarctic Treaty in 1961. Each of these campaigns produced unprecedented exploration of Earth and space and led to discoveries in many fields of science. IPY 2007-2008 is expected to leave a similar legacy of accomplishments.

U.S. National Committee for the International Polar Year: Mary Albert, (Chair) ERDC Cold Regions Research and Engineering Laboratory; **Robert Bindschadler**, National Aeronautics and Space Administration - Goddard Space Flight Center; **Cecilia Bitz**, University of Washington; **Jerry Bowen**, CBS News; **David Bromwich**, The Ohio State University; **Richard Glenn**, Arctic Slope Regional Corporation; **Jacqueline Grebmeier**, University of Tennessee; **John Kelley**, University of Alaska, Fairbanks; **Igor Krupnik**, Smithsonian Institution; **Louis Lanzerotti**, Bell Laboratories-Lucent Technologies; **Peter Schlosser**, Lamont-Doherty Earth Observatory of Columbia University; **Philip Smith**, McGeary & Smith; **George Somero**, Stanford University; **Cristina Takacs-Vesbach**, University of New Mexico; **Gunter Weller**, University of Alaska, Fairbanks; **Douglas Wiens**, Washington University; **Mahlon Kennicutt,** (Ex-officio) Texas A&M University; **Patrick Webber**, (Ex-officio) Michigan State University; **Terry Wilson**, (Ex-officio) The Ohio State University; **Robin Bell** (Ex-officio), Lamont-Doherty Earth Observatory of Columbia University; **Sheldon Drobot**, (Study Director) Polar Research Board; **Chris Elfring**, (Board Director) Polar Research Board; **Kristen Averyt**, (Christine Mirzayan Intern) Polar Research Board; and **Rachael Shiflett**, (Program Assistant), Polar Research Board.

This brief was prepared by the National Research Council based on the committee's report. For more information, contact the Polar Research Board at 202-334-3479. *A Vision for International Polar Year 2007-2008* is available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242 or 202-334-3313 (in the Washington area); www.nap.edu.

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BIOGRAPHY FOR ARDEN L. BEMENT, JR.

Arden L. Bement, Jr., became Director of the National Science Foundation on November 24, 2004. He had been Acting Director since February 22, 2004.

He joined NSF from the National Institute of Standards and Technology, where he had been Director since Dec. 7, 2001. As head of NIST, he oversaw an agency with an annual budget of about $773 million and an on-site research and administrative staff of about 3,000, complemented by a NIST-sponsored network of 2,000 locally managed manufacturing and business specialists serving smaller manufacturers across the United States. Prior to his appointment as NIST director, Bement served as the David A. Ross Distinguished Professor of Nuclear Engineering and head of the School of Nuclear Engineering at Purdue University. He has held appointments at Purdue University in the schools of Nuclear Engineering, Materials Engineering, and Electrical and Computer Engineering, as well as a courtesy appointment in the Krannert School of Management. He was director of the Midwest Superconductivity Consortium and the Consortium for the Intelligent Management of the Electrical Power Grid.

Bement came to the position as NIST director having previously served as head of that agency's Visiting Committee on Advanced Technology, the agency's primary private-sector policy adviser; as head of the advisory committee for NIST's Advanced Technology Program; and on the Board of Overseers for the Malcolm Baldrige National Quality Award.

Along with his NIST advisory roles, Bement served as a member of the U.S. National Science Board from 1989 to 1995. The board guides NSF activities and also serves as a policy advisory body to the President and Congress. As NSF director, Bement now serves as an *ex officio* member of the NSB.

He also chaired the Commission for Engineering and Technical Studies and the National Materials Advisory Board of the National Research Council; was a member of the Space Station Utilization Advisory Subcommittee and the Commercialization and Technology Advisory Committee for NASA; and consulted for the Department of Energy's Argonne National Laboratory and the Idaho National Engineering and Environmental Laboratory.

He currently serves as a member of the U.S. National Commission for UNESCO and serves as the Vice-Chair of the Commission's Natural Sciences and Engineering Committee.

Bement joined the Purdue faculty in 1992 after a 39-year career in industry, government, and academia. These positions included: Vice President of technical resources and of science and technology for TRW Inc. (1980–1992); Deputy Under Secretary of Defense for Research and Engineering (1979–1980); Director, Office of Materials Science, DARPA (1976–1979); Professor of nuclear materials, MIT (1970–1976); Manager, Fuels and Materials Department and the Metallurgy Research Department, Battelle Northwest Laboratories (1965–1970); and senior research associate, General Electric Co. (1954–1965).

He has been a director of Keithley Instruments Inc. and the Lord Corp. and was a member of the Science and Technology Advisory Committee for the Howmet Corp. (a division of ALCOA).

Bement holds an engineer of metallurgy degree from the Colorado School of Mines, a Master's degree in metallurgical engineering from the University of Idaho, a doctorate degree in metallurgical engineering from the University of Michigan, an honorary doctorate degree in engineering from Cleveland State University, an honorary doctorate degree in science from Case Western Reserve University, an honorary doctorate degree in engineering from the Colorado School of Mines, and a Chinese Academy of Sciences Graduate School Honorary Professorship. He is a member of the U.S. National Academy of Engineering and a fellow of the American Academy of Arts and Sciences.

Chairman INGLIS. Thank you, Dr. Bement.

Dr. Bell.

STATEMENT OF DR. ROBIN ELIZABETH BELL, DOHERTY SENIOR RESEARCH SCIENTIST, LAMONT-DOHERTY EARTH OBSERVATORY, COLUMBIA UNIVERSITY

Dr. BELL. Good morning. Thank you very much for inviting me to speak on International Polar Year. I consider it the scientific opportunity of a generation for our nation, our society, and our planet.

I am Robin Bell, and I am from Columbia University's Lamont-Doherty Earth Observatory where I run programs looking at the stability of the ice sheets and sub-glacial links using geophysical techniques, so I am a geophysicist. I also chair the Polar Research Board of the National Research Council, which acts as the national coordinating committee for IPY, and I have been active internationally in the planning process pretty much since the beginning.

[Slide.]

You might wonder why, in this day of connectivity, scientists are so excited about this concept, a concept that was developed when this is what the map of the world looked like. And at that point, the big white spot in the middle, we didn't know whether that was a continent or the ocean—or an ocean. There were still truly unknown frontiers. And the cutting-edge communication was the telegraph.

So today, our maps are much richer. We actually know that one pole is a continent and one is an ocean, but there is still a fundamental need to push our limits of knowledge, particularly because environmental change and variability are part of the natural pattern of the Earth, but environmental change at the poles is much more pronounced than what is going on at the tropics. We know that arctic sea ice is decreasing. Some of the ice shelves, as you see on the left, in Antarctica are retreating and thinning. The glaciers are shrinking, and the ecosystems are changing. In some places, the plants are flowering significantly early.

These changes do have human impacts, both locally and globally. Alaskan villages have been moved to higher ground. Buildings in northern communities have had to be moved. And rising sea level continues to be a global concern. Understanding the poles is important for understanding the inclinations of environmental change.

So one motivation is environmental change.

But although we have made tremendous progress in science, and although the maps I showed you are much richer than they were 100 years ago, the maps aren't blank, and the—but the frontiers and the unknowns have actually gotten broader. We now know that there are frontiers from the molecular scale, like Donal's studies, to the continental scale, like I study. Questions like how can certain nematodes survive at -2 degrees Fahrenheit? How is it that polar fish evolve antifreeze proteins in their cells? And what will happen to the under-ice ecological communities as we see the environment change? And what happens to the water beneath these large lakes in Antarctica? There are still fundamental limits to our knowledge. These are the frontier questions that the science community is planning to address during the International Polar Year.

The planning process identified five major challenges.

First is the one I have alluded to, the large-scale environmental change. What is happening at the ends of our planet, and how does it affect the rest of our planet?

The second is looking at conducting scientific exploration of these new frontiers, molecular to continental.

Third is observing the polar regions in depth.

Fourth is looking at the human dimensions of the environment, recognizing that now, we, as humans, are a discreet part of this environment.

And finally, looking for those new connections, looking at how we can reach out to the public to build new connections between the science and the public.

So one of the distinct differences of this polar year is the inclusion of the human face. We will, in fact, as a science community, be looking more at how human beings are part of the global community and how the communities in the north are part of the global system.

So what is going to be the outcome?

I think, in essence, we should be thinking about what the societal benefits of the International Polar Year are. As it is emerging, the science programs are multi-faceted and multi-disciplinary, and so the results and the benefits will be both multi-faceted and multi-disciplinary. So it is going to advance our fundamental understanding of the planet. It is going to—whether it is the polar ecosystems or sub-glacial terrains. It will improve our understanding of the processes of change that are—and how they are influencing society, especially the inhabitants of the north. It will inspire the spirit of discovery across all ages and help us develop the next generation of our leaders in science, engineering, industry, commerce, and government. It will also demonstrate that, even in the most difficult times, science can be a very powerful arena for international cooperation.

So why should the vast majority of us who live in warmer parts of the Earth, whether it is New York or South Carolina, care about IPY? The poles are physically distinctive, but they are critical links. So I would like you to think about this. I am going to do this experiment, but I would like you to think about what happens. If you hold an ice cube in your hand, you know, just imagine holding it. What you start to feel is you start to feel the melting at the ends. While your fingers are melting at the ends, you can actually feel the water dripping down across the ice cube and down your arm. The changes from the warmth of your fingers are actually being conducted to the ice cube.

The relationship between the poles and the rest of the planet is very similar to that ice cube. The relation—the polar oceans play a critical role in maintaining ocean currents that keep coastal Europe warm and the ice cover that covers both continents reflects much of the solar energy and is a critical part of the equation of how our planet remains habitable. Melting ice sheets will raise sea levels and threaten the global communities around the world. Polar regions are the integral component of the Earth system that respond to and drive changes elsewhere.

So, in conclusion, from assessing long-scale environmental change in the polar regions, to pushing the frontiers of science, the International Polar Year really is a scientific opportunity for everyone.

Thank you very much, and I am more than welcome to address questions.

[The prepared statement of Dr. Bell follows:]

PREPARED STATEMENT OF ROBIN ELIZABETH BELL

INTERNATIONAL POLAR YEAR 2007–2008: THE OPPORTUNITY OF A GENERATION

Good Morning. Thank you very much for inviting me to speak about International Polar Year 2007–2008. The International Polar Year (IPY) is the scientific opportunity of a generation for our nation, for our society, and for our planet.

My name is Robin E. Bell, Ph.D. from Columbia University's Lamont-Doherty Earth Observatory, where I am a Doherty Senior Research Scientist. I am a geophysicist by training and at Columbia I lead major geophysical programs on the stability of ice sheets including subglacial lakes. I also direct Columbia's NSF sponsored ADVANCE program, aimed at recruiting and retaining women in science. I was the first women to lead a major aerogeophysical program from the Antarctic continent, and this has been the focus of much of my research for the past two decades.

In addition to my research, I chair the National Research Council's Polar Research Board, which acts as the national coordinating committee for IPY. The Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, chartered by Congress in 1863 to advise the government on matters of science and technology. I served as the Co-Chair of the International Council for Science's (ICSU) initial IPY Planning Group, which developed the first major international IPY planning document, *"A Framework for International Polar Year."* I currently serve on the ICSU–WMO Joint Committee for IPY, the main international planning group.

Today I will provide an overview of why IPY is happening and why it's important to us here in the United States. What has motivated more than 5000 scientists from some 63 nations to decide to participate in a year devoted to polar studies and education? I'll highlight the major science questions that will be addressed, outline the role that U.S. scientists and science managers have been playing developing IPY, and conclude with thoughts on the many societal benefits that can result from the IPY.

In this era of instant communications and global connectivity, it might seem surprising that the global scientific community is so excited by a scientific strategy that was developed more than 100 years ago. Because it was indeed back in 1882–1883 that the idea of holding a focused, internationally-coordinated year of polar research—an International Polar Year—was first developed. At that point in history, the poles were blank white spaces on maps and the cutting edge communications technology was the telegraph. The decision to coordinate with other nations rather than compete, and to focus on research to understand polar phenomena rather than acquisition of territory, was something new and exciting. That first IPY in 1882–83 and subsequent ones in 1932–33 and the International Geophysical Year (IGY) in 1957–58, drew great minds and generated great leaders; these "international years" set a precedent of cooperation in science that, while innovative at the time, is considered the norm today.

Today's scientists are similarly motivated by society's need for integrated global knowledge. There is still a fundamental human need to push the limits of our understanding about polar phenomena. The polar regions are integral components of the Earth system. As the heat sinks of the climate system they both respond to and drive changes elsewhere on the planet. While environmental change and variability are part of the natural pattern on Earth, the environmental changes currently witnessed in the polar regions are in many cases more pronounced than changes observed in the mid-latitudes or tropics. The Arctic sea ice cover is decreasing; some ice shelves in Antarctica are retreating and thinning; glaciers are shrinking; and ecosystems are changing, for instance, with plants flowering at earlier times. These changes are having human impacts: some Alaskan villages have been moved to higher ground in response to rising sea levels, and thawing of permafrost is undermining roads and buildings in northern communities around the world. We must understand the implications of environmental change for the future of our global society.

Although we've made tremendous progress in all science over the past 100 years, the polar regions are still at the frontiers of human knowledge. The maps aren't quite as blank, but the frontiers and unknowns have actually increased, and range from the molecular, to the ecological, to the continental. How is it that certain microbes can survive at minus two degrees Fahrenheit, that certain nematodes live even when ice forms in their cells, that polar fish species have evolved with an anti-

freeze protein in their blood? What will happen to the unique under-ice ecological communities of the Arctic, which are the base of the Arctic food web, as ice conditions change and new species arrive from southern waters? In just the last 10 years we discovered more than 150 subglacial lakes that exist under the ice in Antarctica. These range in size from something similar to the reflecting pool on the Mall to a lake the size of Lake Ontario. Why are these lakes important? They are thought to contain exotic ecosystems; the water in these lakes is part of the subglacial plumbing system that can be thought of as the lubricant that makes the ice sheet flow faster.

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 multi-disciplinary in scope and international in participation. IPY will provide a framework 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 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 a 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 in 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 multi-disciplinary and interdisciplinary studies, including biological, ecological, and social science elements.

IPY 2007–2008 is an opportunity to deepen our understanding of the polar regions and their global linkages and impacts, and to communicate these insights to the public. IPY planners have identified five broad scientific challenges to be addressed:

- Assessing large-scale environmental change in the polar regions, with questions looking at both the physical and human dimensions of change and its impacts.
- Conducting scientific exploration of "new" frontiers, whether these are once inaccessible places beneath the ice sheet, or areas of inquiry that are now open because of advances in technology, such as how the tools of genomics now allow exploration of previously unanswerable questions about biological adaptation.
- Observing the polar regions in depth, with adequate coverage of the vast and challenging landscape, to provide a description of current conditions and allow for better future understanding of variability and change.
- Understanding human-environmental dynamics in a region where the connections are intimate and where the impacts of change are clear.
- Creating new connections between science and the public, using these regions that are inherently intriguing.

One of the major differences between the first two IPYs and IGY and our upcoming IPY 2007–2008 is the recognition that the physical world and the biological world and human society are intimately interrelated. This upcoming IPY is inherently about not just science, but science in support of human interests. It includes work in engineering, medicine, sociology, and human-environment interactions. The present map of 225 IPY projects highlights the geographic and discipline breadth of the IPY 2007–2008. Each cell represents a major program with an international team of scientists working together to advance our knowledge of our planet—producing a tremendous multiplicative effect. The net result will be a huge leap forward in our understanding of polar processes—physical, biological and social—and their global connections.

Previous IPY efforts were characterized by very top down planning and generally driven by the military. For example, under the oversight of Abraham Lincoln's son, Robert Todd Lincoln, then head of the Department of War, the U.S. participation in the first IPY in 1882–83 was led by the Army. The science priorities for our upcoming IPY, on the other hand, emerged from grass roots planning, international

scientific groups, U.S. agency input, and help from the U.S. National Academy of Sciences and National Academy of Engineering.

Beginning in 2002, with the support of more than two dozen members, the National Academies invested some of its own endowment funds to launch the IPY planning process within the U.S. The chair of that first effort was Dr. Mary Albert of the Army's Cold Regions Research and Engineering Laboratory. She led a committee that sought wide input on whether the U.S. should participate in IPY and, if so, what we should hope to accomplish. The committee led a series of web discussions, gave talks at numerous professional meetings, met with agency leaders, hosted a multi-day workshop, and compiled contributions from 13 federal agencies into an initial planning document. The report, *"A Vision for International Polar Year 2007–2008,"* was released early in 2004 and came to be the foundation for much of the international planning as well. (A summary of this report is attached to my testimony.) This early investment of financial and intellectual capital put the U.S. in a position to play a leadership role in planning the IPY internationally.

Today, four years after the planning for IPY began, over 225 projects have been proposed as part of IPY around the globe. Of these, the U.S. plays a leadership role in 52 projects (20 percent) and is participating in 80 percent. This "honeycomb diagram" provides an illustration of the breadth of activities, with projects at both poles, across disciplines, and across nations. Right now, everything is still conceptual—what will actually happen on the ground is still being determined, both here and in other nations. There is an international IPY Programme Office, staffed by Dr. David Carlson and hosted in Cambridge, England, by the British Antarctic Survey. There is also an international planning committee, called the Joint Committee, of which I am a member, and various subcommittees devoted to data management, observation systems, and education and outreach. It's a very lean administrative organization for such a complex undertaking.

While planning for IPY started with the scientific community, all the federal agencies with cold regions responsibilities are having roles in implementation. When the National Academies hosted a workshop to encourage agency coordination in 2004, 13 agencies participated. At the request of the White House, the National Science Foundation is serving as the lead federal agency. (In Alaska, the University of Alaska Fairbanks has stepped forward as the state-wide leader.) NSF has shown real leadership in its role, holding interagency planning meetings, initiating a multi-agency web site, and establishing mechanisms so that science and education/outreach proposals are in the process of being funded. The National Academies continues to provide coordination through the Polar Research Board, which acts as the U.S. National Committee for IPY. The Polar Research Board hosts an IPY web site, distributes an IPY e-newsletter, communicates information to and from the international Joint Committee, and holds meetings as needed to accomplish IPY planning and coordination. Continuing to serve in this coordinating role, in early October, the Polar Research Board will be hosting a meeting of the IPY secretariats so the staff working on IPY behind-the-scenes have an opportunity to coordinate.

In conclusion, I want to think ahead about the societal benefits of the International Polar Year. Just as the IPY and the emerging science programs are multifaceted and multi-disciplinary, the benefits of the IPY will be multifaceted and multi-disciplinary. The IPY will advance our fundamental understanding of our planet—from the polar ecosystems to the subglacial terrains. The IPY will improve our understanding of the processes of change and that complex double-edged sword of how society is influencing change and how change is influencing society—especially the inhabitants of the north. The IPY will inspire a spirit of discovery across all ages and help us develop the next generation of our nation's leaders in science, engineering, education, industry, commerce, and government. At the international level, IPY will again show that even in the most difficult times, science can be an arena of international cooperation. IPY will foster the continued peaceful use of the polar regions, engage new partners in the global science community, and leverage precious scientific and logistical resources so that, in essence, we get more from our investments.

Why should the vast majority of us, who live in the warmer regions of the Earth, care about IPY? The polar regions, while physically distant, are critical links in the global climate system. Does this matter for the rest of the planet? Imagine holding an ice cube between your thumb and your forefinger. Beneath your fingers a pool of water forms quickly. The water will drip down your arms and down the ice cube. The changes at the end driven by the warmth of your fingers are transferred across the entire ice cube. The relationship between the poles to the rest of the globe are the same. The polar oceans play a critical role in maintaining ocean currents that keep coastal Europe much warmer than it would be otherwise, and the sea ice cover modifies Earth's surface temperature by reflecting solar energy. Melting ice sheets

will raise sea levels, threatening coastal communities around the world. The polar regions are integral components of the Earth system that both respond to and drive changes elsewhere on the planet.

The polar regions also hold unique information of Earth's past climate history, and they are growing in economic and geopolitical importance. They are a unique vantage point for studies that will help scientists understand environmental changes in the context of past changes, which in turn will help us make informed choices for our future. The exploration of new scientific frontiers in the polar regions also will lead to new discoveries, insights, and theories potentially important to all people.

In summary, International Polar Year 2007–2008 will leave us important legacies:

— an improved understanding of environmental status and change,
— more comprehensive data and the ability to understand trends in the future,
— improved observation systems to capture future environmental change,
— a continued spirit of exploration into new frontiers of science,
— a new and inspired generation of scientifically literate citizens and leaders,
— an enhanced level of international cooperation to address global scale issues.

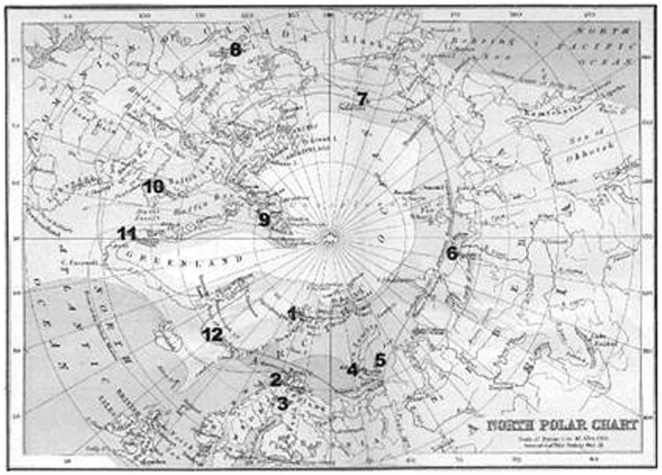
Thank you for your time. I'd be happy to answer any questions.

INTERNATIONAL 2007 2008
POLAR YEAR

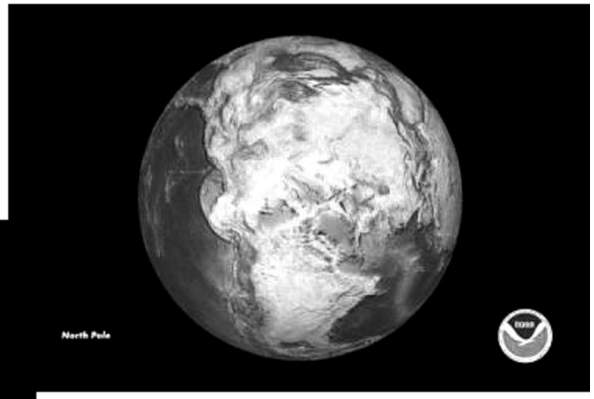
INTERNATIONAL POLAR YEAR 2007-2008: THE OPPORTUNITY OF A GENERATION

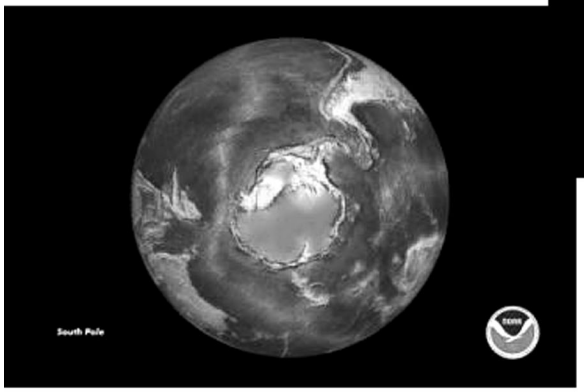
Dr. Robin Elizabeth Bell

Lamont-Doherty Earth Observatory of Columbia University
Chair, Polar Research Board, National Research Council

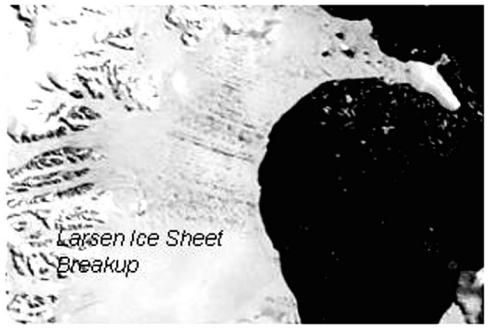


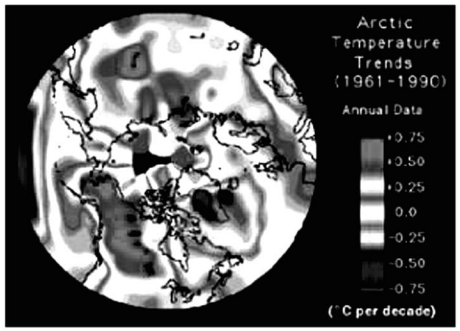
Map of the Poles 1884 - First International Polar Year
"Sketch Map of South Polar Regions" from the Scottish Geographical Magazine Volume X, No. 2, 1894.


North Pole

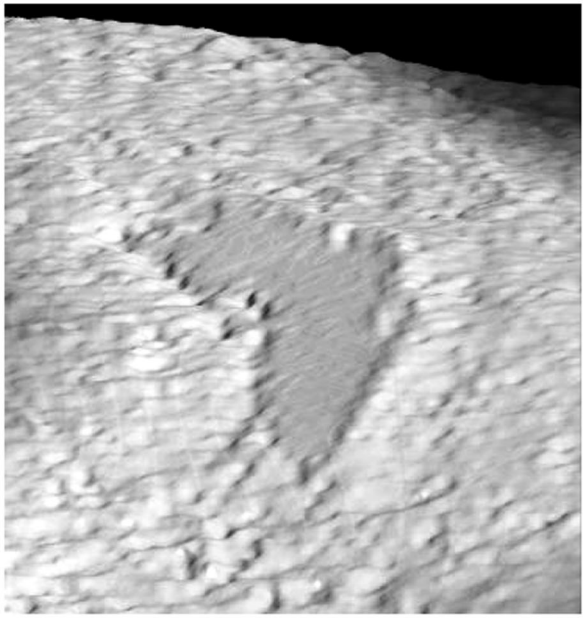

South Pole

Changing Polar Environments



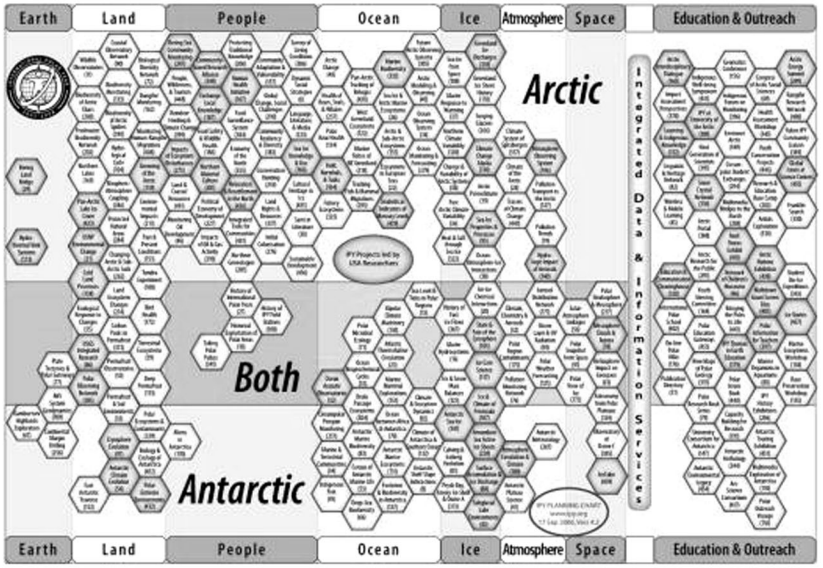


Arctic Temperature Change:
1961 to 1990



- Ice Surface Over Lake Vostok, M. Studinger, LDEO, Columbia University

International
Polar Year
2007 - 2008

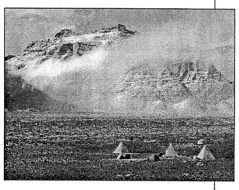

Earth
Land
People
Ocean
Ice
Atmosphere
Space
Education & Outreach
Arctic
Both
Antarctic
Integrated Data & Information Services

EDITORIAL

The International Polar Year

Change is ubiquitous in Earth's history, and evidence is clear that Earth's climate is changing rapidly now. The harbingers of change can be seen vividly in the polar regions. The Arctic ice cover is melting, ice shelves in Antarctica are crumbling, glaciers in temperate regions are disappearing, some ecosystems are changing, and permafrost thawing is causing the collapse of roads, buildings, and pipelines. Are we witnesses to an extreme in natural variability, the threshold of an abrupt change, or something more subtle? How will changes first seen in the polar regions affect us all?

Plans are under way for the International Polar Year (IPY) 2007–2008. Previous IPYs (1882–1883 and 1932–1933) and the International Geophysical Year (1957–1958) (which began as an IPY) produced unprecedented exploration and discoveries in many fields of research and fundamentally changed how science was conducted in the polar regions. IPY 2007–2008 will benefit society by exploring new frontiers and increasing our understanding of the key roles of the polar regions in globally linked systems. Recent technological developments give us a new ability to investigate previously unexplored areas, using new tools and new ways of looking to understand once-unanswerable questions. Autonomous vehicles, genomics, and remote sensing instruments and networks are just a few of the technologies providing new tools for investigating previously inaccessible realms. The polar regions also continue to loom large in facilitating our understanding of the processes by which solar activity may seriously disturb Earth's space environment, affecting the performance of modern technologies deployed in space and on Earth. We believe that research is needed now, so that future generations may mitigate vulnerabilities and adapt to potential change.



Many important broad and interlinked research challenges exist today. To name just one example, how and why are the changes in polar regions occurring, and how can we predict and mitigate the outcome? Changes in ice mass are linked with regional and global environments and atmospheric and oceanic processes; implementing polar observation systems would help document these changes. Clues for understanding how and why similar changes occurred in the past remain stored in polar earth and ice; sediment and ice coring would help us understand past changes. Polar changes are interlinked with the behavior and survival of ecosystems, from microbial life to large organisms, including humans; studies in polar biology are needed. Keys to fundamental discoveries for understanding change may spring from new modes of exploration that range from using autonomous underwater vehicles under the ice to the use of genomics for investigating adaptation; exploration reveals surprises. Communications technologies such as television and the Internet, combined with changes in the environment, are challenging traditional human lifestyles in our cold regions and elsewhere. Yet these same technologies hold the potential for sharing ideas and experiences in both polar regions and for promoting global understanding; Internet-based efforts in global data collection, sharing, and education are needed.

Various international organizations and individual nations are actively planning for the IPY. The International Council for Science (ICSU) formed an international planning group to catalyze IPY development across national boundaries. The World Meteorological Organization also has identified IPY as a major new initiative. Other endorsements to date include the Scientific Committee on Antarctic Research, the International Arctic Science Committee, and the Arctic Council. Interested countries have begun to form national committees and develop a consensus regarding scientific themes that will form the backbone of the activities. In the United States, the Polar Research Board of the National Academies has formed a committee* to facilitate IPY planning.

In a world of much uncertainty and change, citizens turn to science for answers. The polar regions play an important role in providing these answers. A framework such as the IPY can provide the impetus to undertake projects that normally could not be achieved by any single nation, reaching beyond our traditional borders toward a new level of cooperative international science. Our vision for IPY 2007–2008 is that it will be the dawn of a new era in polar science, kicked off by an intense internationally coordinated campaign of activities. IPY 2007–2008 will address research in both polar regions, which have strong linkages to the rest of the globe. It will be multi- and interdisciplinary in scope and truly international in participation. It will educate and excite the public and help produce the next generation of engineers, scientists, and leaders.

Mary R. Albert

Mary R. Albert is chair of the U.S. Planning Committee for IPY 2007–2008.

*The U.S. National Committee to the IPY actively welcomes input from the science community (www.us-ipy.org).

CREDIT: JOSH LANDGRAF

A Year to Remember at the Ends of the Earth

Researchers charting a course for an International Polar Year in 2007–08 are hoping to recapture the glory of a similarly ambitious venture a half-century ago

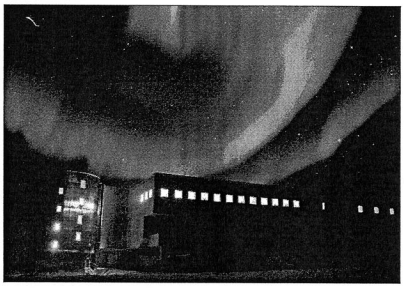
CAMBRIDGE, U.K., AND BERLIN—When Les Barclay and 20 intrepid fellow voyagers set out for Antarctica in November 1956, they knew they were embarking on the scientific adventure of a lifetime. After 5 weeks at sea, the radiophysicist and his colleagues on the International Geophysical Year (IGY) Antarctic Expedition put in at Halley Bay, then Britain's new toehold on the Antarctic Peninsula. They had lugged all the equipment they could possibly need there until the next ship called a year later. "We went down without recourse to any facilities back home," says Barclay.

For the next 2 years, he and counterparts across Antarctica and at the other end of Earth, in the High Arctic, made some of the first high-latitude measurements of the ionosphere and its most spectacular phenomenon, the aurora. Barclay also teamed with W. Roy Piggott to pioneer the use of radio waves for measuring the thickness of ice shelves, a technique that led to ground-penetrating radar. Other major finds of the $1 billion IGY of 1957–58 include the discovery of the Van Allen radiation belts and radical new estimates of ice volume on Earth's surface. "We learned a tremendous amount about the world," says Barclay, who now runs a consulting firm in Chelmsford, U.K.

Nearly a half-century later, researchers are marshalling forces for another major assault on the poles. Under the auspices of the International Council of Scientific Unions (ICSU), the World Meteorological Organization (WMO), and more than a dozen other scientific groups, an ambitious plan is taking shape for an International Polar Year (IPY) to kick off during the Arctic spring of early 2007 and extend through the Antarctic fall of early 2008. "We want a real quantum jump in our understanding of how the poles work," says Chris Rapley, director of the British Antarctic Survey and chair of ICSU's IPY planning board.

Rapley and other organizers now face the daunting task of convincing countries to pitch in funding and logistical support beyond that already committed to ongoing polar programs. The overall investment could easily top $1 billion, organizers say, as dozens of countries sign up to multilateral agreements that will govern IPY projects.

The will be no shortage of ideas in search of funding, for unanswered questions of polar research are legion. IPY's planning board will try to winnow the field to a few major themes that promise to have deep scientific impact and broad public resonance. "One of the goals is to get people to realize that … the cold ends of the sphere we live on really do influence us," says ICSU IPY planning vice chair Robin Bell of Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York. And, like their predecessors, they intend to leave a lasting legacy. "We want to design a way to take the pulse of the poles in 2007 and 2008," Bell says, "but we also want to leave a heart monitor in place so we can continue to see what's going on."



Lighting the way. The U.S.'s Amundsen-Scott South Pole Station, under a brilliant aurora, will host a broad palette of research during the upcoming International Polar Year.

CREDIT: JONATHAN BERR/NATIONAL SCIENCE FOUNDATION

From Cape Horn to Sputnik

The polar year of 2007–08 will follow in the footsteps of illustrious predecessors, each of which overhauled our understanding of global processes. The first IPY, in 1882–83, was largely the brainchild of Karl Weyprecht, an Austrian naval lieutenant who commanded a ship during the Austro-Hungarian Arctic Expedition of 1872–74. He argued that polar exploration required more than geographic discovery and called for the establishment of a network of research stations in the polar regions. The idea caught fire, and during the first polar year, 11 nations established 14 stations—two at Cape Horn and South Georgia Island in the South Atlantic and a dozen in the Arctic—to record data on everything from meteorology to terrestrial magnetism and the aurora, findings that shaped later theories of the ionosphere. "It was the first big meteorological experiment," says Cornelia Lüdecke, a science historian at the University of Hamburg, Germany.

The second IPY took place 50 years later, in 1932–33. Despite a global economic depression, 44 countries teamed up on nearly two dozen dedicated expeditions to the Arctic and the Southern Hemisphere, although like the previous IPY the effort did not reach as far south as Antarctica. Technology had come a long way: Telephone, aircraft, and radio sounding all were at the disposal of researchers. A major achievement was obtaining detailed measurements of the upper atmosphere, including the first maps of the jet stream.

Grand as those efforts were, they paled in comparison to the massive undertaking of 1957–58. Lloyd Berkner of the Carnegie Institution of Washington aired the IGY idea at a dinner party at the home of space physicist James Van Allen in the spring of 1950. The suggestion snowballed into one of the biggest global scientific undertakings ever. Still, it was the depths of the Cold War, and politics was never far from the surface: The Soviet Union in 1956 announced that it would put the first satellite in orbit during the IGY (Sputnik duly went up the next year), and China withdrew from the effort after Taiwan was brought aboard. Antarctica was seen as a potential Cold War battleground, with countries laying claim to slices of the continent. An international research effort, some hoped, would ease tensions—and indeed, the IGY is credited with fostering the political climate for the Antarctic Treaty, in which signatories agreed to share the continent in the name of "peace and science." In all, roughly 80,000 scientists

An Otherworldly Place to Hunt for Other Worlds

High on Antarctica's frozen desert, astronomers have found some of the best conditions on Earth for peering into space. The calm, cloudless skies above Dome C, 3233 meters above sea level in the middle of the main Antarctic ice sheet, make the isolated spot a stargazer's dream. The site is the location of the newest permanent year-round station in Antarctica, a joint French-Italian project called Concordia.

The main buildings, which will host 16 people over the 9-month winter and twice as many in summer, are expected to be finished by the Antarctic winter of 2005–06, in ample time for the station to participate fully in the International Polar Year (IPY) to begin in 2007 (see main text).

New kid on the ice. Concordia is expected to become a hotbed for studies in astronomy, paleoclimatology, and the psychological stress of isolation.

Concordia, perched on an ice dome, should entice scientists from a range of disciplines. For example, researchers who use ice cores to decipher clues to past climates expect to look deep into the last Ice Age thanks to nearly 500,000 years of snow accumulation at Dome C. And as the third permanent station on the continent's interior, located more than 1000 kilometers from its nearest neighbor, the United States' Amundsen-Scott South Pole Station, Concordia will help fill gaps in measurements of Earth's magnetic and gravitational fields and the continent's seismic activity.

Concordia is also set to rival the South Pole as a premier astronomical outpost. Although there are not yet any full-size telescopes at the site, measurements suggest it is an outstanding place for optical and near-infrared astronomy. The air can be so still, says Eric Fossat, an astronomer at the University of Nice in France, that smoke rings from tractors at the construction site often linger for tens of seconds before dissipating. The lack of wind and heat currents makes the atmosphere extremely clear, cutting down on the shimmer that disrupts Earth-based views of stars. Thus astronomers can look forward to some of the best "seeing" anywhere on Earth. "The indications are that the seeing may be absolutely extraordinarily good," says astronomer Tony Stark of the Harvard-Smithsonian Center for Astrophysics, who has worked extensively at the South Pole.

That quality, combined with the site's aridity and average ambient temperature of −50°C, makes it a great spot for infrared astronomy—perhaps the best on Earth for searching for planets similar to our own, Fossat says. In the infrared, planets show up brighter and stars dimmer, allowing astronomers to discern planets more easily. And, he notes, there is half as much cloud cover as at the already impressively clear South Pole Station. Astronomers are still securing funding, but they hope to have the first telescope in place for the IPY in 2007. An array of telescopes could come further down the road.

Concordia may even help humans reach for the stars. To simulate the effects of long-duration space flight, researchers plan to study how staff members cope with the Antarctic winter (*Science*, 15 August 2003, p. 906). Fossat himself says he won't winter there. "I'm too old for that kind of sacrifice," he says. But with Concordia's astronomical attributes, don't expect any shortage of volunteers.

–G.V.

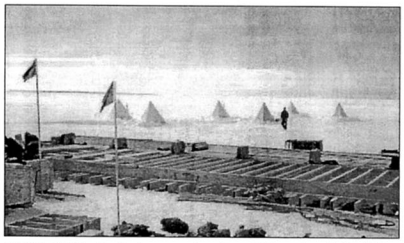
and support staff from 67 countries took part in the IGY.

"It was a thrilling time," recalls David Limbert, who confesses that as a 29-year-old meteorologist he left several girlfriends in England to join the Royal Society's IGY advance team, dispatched in late 1955 to build the Halley Bay camp. "We were there as pump primers," he says. For the first several weeks he and the other expedition members slept in tents as they built Halley beam by beam. Halley and many of the other few dozen Antarctic bases established during the IGY continue to produce world-class science. The IGY, says Rapley, "set the standard for what can be achieved."

The next frontier

The IGY will be a hard act to follow. But the half-century of polar science it ushered in has only deepened scientists' appreciation of the complexity and importance of polar processes. What happens at the poles is inextricably tied to patterns of cold and warmth, rainfall and drought. To have any hope of understanding what is happening to global climate today, and what might happen in the future, scientists need a better picture of conditions at the poles and how they interact with and influence ocean and air currents.

So far scientists have only the vaguest clues to how those interactions work. "We know the climate models don't get the polar regions right, and there is a lot of work going on to understand why that is," Rapley says. One puzzle, he notes, is that the models have largely failed to predict the dramatic melting of the Antarctic ice shelf. And even state-of-the-art models vary widely in their predictions for the severity of the warming that might occur in the Arctic.



Roughing it. "The sleeping bags came in only one thickness," recalls David Limbert, part of the advance team that slept in tents while assembling the Halley Bay base in early 1956.

One challenge is that the polar regions seem to be reacting more dramatically than other latitudes to global climate changes. The three fastest-warming regions in the last 2 decades have been Alaska, Siberia, and parts of the Antarctic ice sheet, notes Rapley. But whether that is the start of a long-term trend or a normal fluctuation is unclear. Figuring this out "is directly related to our ability to collect data," Rapley says.

One likely project for the upcoming IPY will be updating an array of monitoring stations strung across the Russian

CREDITS: (TOP TO BOTTOM) A. MANDJOVIE/IPEV; DAVID LIMBERT

Arctic during the IGY. In the last decade alone, many of those stations have fallen silent, depriving meteorologists of key data on temperature and rainfall, for example. According to the Russian Academy of Sciences, only 45 polar hydrometeorological stations were functioning in 2002, a two-thirds reduction over the past decade. Refurbishing the stations is a top priority, says Eduard Sarukhanian, WMO's IPY coordinator. However, adds Rapley, "what we're keen to do is make sure that doesn't just focus on meteorology and hydrology but opens up new vistas on other research—from any field that people can convince us is worthwhile."

Opening new vistas may well be the driving theme of the IPY. "There are subglacial lakes and the spreading ridges under the Arctic that have never been explored," Bell says. And while biologists have barely begun to catalog life in polar oceans, there are hints that here, too, the frozen ends of Earth have a global influence.

One theory suggests that the Southern Ocean might have been a source of much of the biodiversity in the deep oceans worldwide. When the Antarctic continent broke away on its own, a girdle of swift-moving ocean currents formed around it, trapping species in the chilly waters of the Southern Ocean and forcing them to adapt to extreme conditions, Rapley explains. Those creatures, then, may have hitched a ride to other oceans. Brigitte Hilbig of Ruhr University in Bochum, Germany, recently identified several worms in 5000-meter-deep waters off Angola that are nearly identical to one first identified in the Southern Ocean, 5000 kilometers away, suggesting that there may be important connections between the life forms of polar oceans and seabed habitats worldwide. To probe this further, Hilbig and colleagues have proposed taking a zoological and genetic census of the Southern Ocean as part of the IPY.

The Arctic waters, too, likely hold new surprises. An expedition in 2001 to the Gakkel Ridge, where the continental plates bearing Europe and North America are spreading apart, turned up much more hydrothermal activity than scientists expected, says Jörn Thiede of the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. As part of the IPY, he and his colleagues hope to send a remote-controlled sub to survey the region.

IPY organizers also hope to attract interest from astronomers who can use polar summers for uninterrupted views of the sun; medical researchers who study human responses to extreme conditions; and social and political scientists who could study the impact of Arctic warming on northern Russia, Canada, and other Arctic Rim nations.

In an initial call, organizers received nearly 150 proposals. "It's taking off like gangbusters," Rapley says. The ICSU committee and its partners will settle on a handful of flagship projects by autumn, he says. (Contributions are still welcome; see Editorial, p. 1437.) Rapley says that ICSU might try to coordinate three to five large-scale efforts, such as major transects across the poles or large-scale atmospheric or ocean surveys. He hopes the effort will inspire a wellspring of multinational projects around the globe organized by other scientists.

It's not yet clear whether such efforts will add up to the $1 billion infusion the last IGY enjoyed. Karl Erb, director of the U.S. National Science Foundation's Office of Polar Programs, estimates that NSF might contribute up to $50 million in research funding and logistical support for IPY-specific activities, from its nearly $400 million annual budget. Given the formidable base that the field is building on, a smaller investment than that plowed into IGY could have just as profound an impact, argues Chad Dick of the Norwegian Polar Institute in Tromsø, Norway. The onus will be on organizers to choose projects with far-reaching payoffs. "If all we do is have a blast for 2 years and nothing changes in our ability to monitor the poles for the long term, we will have failed," he says. Considering the track record of the first two IPYs and the IGY, failure would appear to be only a remote possibility.

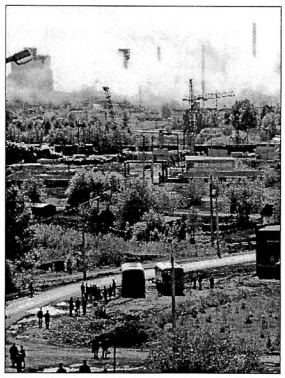
–RICHARD STONE AND GRETCHEN VOGEL

Climate Change

A Eurasian Tiger Threatens To Maul Kyoto

A new U.N. report is likely to strengthen the case of hard-liners intent on ditching Russia's commitment to ratifying the climate treaty

Two years after the United Nations began putting the heat on Russia to ratify the Kyoto Protocol, enthusiasm in Moscow for the global plan to tackle climate change has cooled rapidly. In recent months, senior Russian government officials have repeatedly challenged U.N. greenhouse gas forecasts suggesting that Russia would benefit from a key treaty sweetener, the sale of billions of dollars' worth of emissions credits. Now Moscow's Kyoto doubters are about to get a boost from a surprising source: the U.N. itself. According to a draft report for the secretariat of the U.N. Framework Convention on Climate Change in Bonn, Germany, the data underlying the U.N.'s emissions forecasts for Russia are full of holes and out-of-date. "It's a problem in general with the U.N. estimates," says Kremlin economist Peter Kaznacheev. "They tend to base their estimates on old data."



Back to the future? Coal mines and steel mills belch greenhouse gases in the southern Siberian city of Novokuznetsk.

CREDIT: PETER TURNLEY/CORBIS

The future of the Kyoto Protocol is in Russia's hands. For the treaty to come into force, it must be ratified by countries whose greenhouse gas emissions total more than 55% of global output in 1990. With the world's biggest greenhouse gas emitter, the United States, having renounced the treaty, Russia is crucial to slipping over the 55% bar.

For a while, things were looking up for Kyoto backers: Russia had long signaled its intention to ratify the treaty. Its carbon emissions plummeted in the 1990s as decrepit Soviet-era plants and factories

BIOGRAPHY FOR ROBIN ELIZABETH BELL

Born: May 29, 1958, Keene, New Hampshire, U.S. Citizen

(A) PROFESSIONAL PREPARATION:

1977–1980 Middlebury College, B.A. (magna cum laude), Geology, 1980

1982–1989 Columbia University, M.S., M. Phil, Ph.D., May 1989

2006 Honorary Doctor of Science Degree Middlebury College

(B) APPOINTMENTS:

1999–present *Doherty Senior Research Scientist,* Lamont-Doherty Earth Observatory of Columbia University (LDEO); *Director,* Columbia University Earth Institute's Center for River and Estuaries (2003–present); *Director,* Earth Institute ADVANCE Initiative (2004–present)

1994–2000 *Co-Director,* Support Office for Aerogeophysical Research, (SOAR), Institute for Geophysics, University of Texas at Austin

1996–1999 *Research Scientist,* LDEO

1991–1996 *Associate Research Scientist,* LDEO

1989–1991 *Post-Doctoral Research Associate,* LDEO

1982–1989 *Graduate Research Assistant,* LDEO

1980–1982 *Geophysicist,* U.S.G.S., Marine Office, Woods Hole, MA.

(C) PUBLICATIONS:

Related Publications:

2006 Bell, R.E., M. Studinger, M.A. Fahnestock, and C.A. Shuman, Tectonically controlled subglacial lakes on the flanks of the Gamburtsev Subglacial Mountains, East Antarctica, *Geophys. Res. Lett.* 33 (2) L02504 10.1029/2005GL025207.

2005 R.E. Bell, M. Studinger, A. Tikku, J.D. Castello, Ancient Ice and Subglacial Lake Environments: Lake Vostok as an Example. In: *Life in Ancient Ice Proc.,* edited by J.D. Castello, and S.O. Rogers Princeton University Press, ISBN: 0–691–07475–5, pp. 251–267.

2004 Studinger, R.E. Bell, A.A. Tikku, Estimating the depth and shape of subglacial Lake Vostok's water cavity from aerogravity data, *Geophys. Res. Lett.* 31, doi:10.1029/2004GL019801.

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2004 M. Studinger., Bell, R.E., Buck, W.R., Karner,G.D., and Blankenship, D.D., Sub-ice geology inland of the Transantarctic Mountains in light of new aerogeophysical data, *Earth Planet.* 220, pp. 391–408.

Other Significant Publications

2005 Bell, R.E., Studinger, M., Karner, G.D., Finn, C.A., and Blankenship, D.D., Identifying Major Sedimentary Basins Beneath the West Antarctic Ice Sheet from Aeromagnetic Data Analysis, in Antarctica, Contributions to Global Earth Science, *Proceedings of the 9th ISAES,* Springer Verlag, pp. 117–121.

2002 R.E. Bell, M. Studinger, A. Tikku, G.K.C. Clarke, M.M. Gutner, C. Meertens, Origin and fate of Lake Vostok water frozen to the base of the East Antarctic ice sheet, *Nature* 417, pp. 307–310, 2002.

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1998 R.E. Bell, D.D. Blankenship, C.A. Finn, D. Morse, T. Scambos, J.M. Brozena, and S.M. Hodge, Influence of Subglacial Geology on the Onset of a West Antarctic Ice Stream from Aerogeophysical Observations, *Nature* 394, pp. 58–62.

1993 D.D. Blankenship, R.E. Bell, S.M. Hodge, J.M. Brozena, J.C. Behrendt, C.A. Finn, Active volcanism beneath the West Antarctic ice sheet and implications for ice-sheet stability, *Nature* 361, pp. 526–529.

(D) SYNERGISTIC ACTIVITIES

(i) Committees:

2004–present Member, ICSU WMO IPY Joint Committee

2003–2004 Co-Chair for the ICSU International Polar Year 2007/8 Planning Group

2002–present Chair, Polar Research Board, National Academy of Sciences Polar Research Board (member 2001–present)

1999–present Steering Committee, SCAR Committee on Subglacial Lake Exploration

1998–present U.S. representative to the Scientific Committee on Antarctic Research Geophysics Section.

(ii) Recent Invited Talks:

Antarctic Treaty Meeting in South Africa—IPY, IPY Keynote Speakers for XXVIII SCAR Meeting Bremen, Germany, Interagency Working Group for IPY—Guest Lecturer, American Museum of Natural History-Biodiversity, New York State Department of Dredging and Disposal, SCAR Lake Vostok Meeting, AAAS—Frontiers in Polar Science, New York State Department of Conservation, Institute for Ecosystem Studies, National Maritime Historical Society, NY League of Conservation Voters Hudson Forum.

(iii) Instructor:

Barnard College, "Exploring the Poles," Columbia, "Geophysics."

(iv) Other Activities:

Reviewer—Geophysics, NSF, NASA and JGR.

(E) COLLABORATORS

(i) Collaborators: M. Bain (Cornell), D. Blankenship (UTIG), J. Brozena (NRL), S. Cande (SIO), R. Cerrato (SUNY), G. Clarke (UBC), S. Findlay (IES), C. Finn (USGS), R. Flood (SUNY), C.A. Raymond (JPL), M. Siegert (Bristol), D. Strayer (IES), U. ten Brink (USGS).

(ii) Advisors: A.B. Watts (Oxford).

(iii) Advisees: Vicki Childers (NRL).

Columbia University
IN THE CITY OF NEW YORK

LAMONT-DOHERTY EARTH OBSERVATORY

September 11, 2006

Bob Inglis , Chairman, Research Subcommittee
U. S. House of Representatives
Committee on Science
B-374 Rayburn HOB
Washington DC 20515

Dear Chairman Inglis:

I will be testifying to the Subcommittee on Research in the U. S. House of Representatives Committee on Science on Wednesday September 20th, 2006 as part of the hearing on the "International Polar Year: The Scientific Agenda and Federal Role". The information provided here summarizes the federal funding that I have received for this fiscal year and the two preceding years.

AGENCY	PROGRAM	GRANT TITLE	DURATION
NATIONAL SCIENCE FOUNDATION	ANTARCTIC POLAR PROGRAMS	Fire and Ice: Examining the Potential for Sampling a West Antarctic Sub-Ice Volcano	9/15/05-8/31/06
NATIONAL SCIENCE FOUNDATION	SOCIAL/ BEHAVIORAL/ ECONOMIC	ADVANCE Institutional Transformation Award: Earth Institute of Columbia University	6/1/04-5/31/09
NATIONAL SCIENCE FOUNDATION	ANTARCTIC POLAR PROGRAMS	Development of a Polar Multidisciplinary Airborne Imaging System for the International Polar Year 2007-2009	8/15/06-8/14/09
NATIONAL SCIENCE FOUNDATION	BIOENGINEERING AND ENVIRONMENTAL SYSTEMS	CLEANER: Collaborative Project - Riverscope: Large-Scale Engineering Analysis Network for Environmental Research on the Hudson River	7/31/04-8/1/05
NATIONAL SCIENCE FOUNDATION	OFFICE OF POLAR PROGRAMS	Bridging the Poles: Education Linked with Research	5/31/04-4/30/06
NATIONAL SCIENCE FOUNDATION	ANTARCTIC POLAR PROGRAMS	Collaborative Research: Calculation of Antarctic Gravity Field from GRACE satellite data and comparison with independent measurements	7/1/04-6/30/07

I look forward to addressing the committee on this exciting upcoming scientific event.
Sincerely

Robin Bell
Dougherty Senior Research Scientist

P.O. Box 1000 61 Route 9W Palisades, NY 10964-8000 USA 845-359-2900 http://www.ldeo.columbia.edu

Chairman INGLIS. Thank you, Dr. Bell.

Dr. Manahan.

STATEMENT OF DR. DONAL T. MANAHAN, PROFESSOR OF BIOLOGY, UNIVERSITY OF SOUTHERN CALIFORNIA

Dr. MANAHAN. Good morning, Mr. Chairman, Ranking Member Hooley. Thank you so much for the opportunity to speak to you today. And thank you, too, for your fine comments about my efforts as a teacher. I hope I won't let you down here this morning in a couple of moments.

Chairman INGLIS. The pressure is on, isn't it?

Dr. MANAHAN. Indeed, yes.

My name is Donal Manahan. I am a professor of biological sciences at the University of Southern California. I have conduced research as a chief scientist and field-team project leader in Antarctica for over 20 years. What I am going to talk about today is the upcoming IPY, the International Polar Year. And I am going to do that under the context of four questions: what are the most critical unanswered questions that we need to resolve during this IPY, why educational and research activities during IPY are important to us here in the United States, and the general societal benefits from IPY. I will focus most of my comments on Antarctica, as other colleagues on the panel here today will discuss other aspects and regions of polar research.

Think of this. Even after centuries of geographic exploration of the human spirit, it was really only about 50 years ago that we came to grapple with the seventh continent, as illustrated here by this National Geographic front page of this magazine published in the 1960s where it says, "We are filling in the blank spaces in Antarctica. The map we are showing is a revolution in understanding this seventh continent." And that, frankly, 40 to 50 years ago was in—within my lifetime. That is a remarkable issue that Antarctica has taken us this long to really get a handle on. And this is just describing its geography.

Shoot forward 40 years later, and what we are learning from this continent and for polar regions in general, is illustrated on this front page of Science Magazine published a few years ago, and it discusses polar science in general and its importance. and the lessons we have learned from the studies of the pole is two-fold: first, it has really surprised scientists at how quickly things have changed down there, the "ozone hole" 20 years ago really dumbfounded and surprised many scientists it occurred so fast; secondly, issues of rising temperatures collapsing ice sheets. All of these issues, which have really come to the forefront in the last few years in a consensus among the scientific community, are of enormous societal benefit, no matter where you live on this planet.

As it is picked up in terms of explaining this to the public in general, I draw to your attention this interesting issue of *Time Magazine,* which discussed the whole concept and put it very bluntly on the front page: "Be Worried. Be Very Worried", to use their words. This threatens your health. It affects you, your kids, and your kids' kids. And they introduced the concept of a tipping point.

Now when I was in graduate school 20 years ago, I was informed that these kinds of changes took thousands to perhaps millions of

years to occur. Now we know they can occur on timescales of perhaps 10 to 100 years, the lifetimes—life spans of single human beings. This is the concept of the tipping point. We need to know more about these tipping points to have any hope of being able to predict the massive changes that may occur on our planet.

What have we learned in the last 50 years?

Well, if we go back 50 years to the International Geophysical Year, this illustrates, I think, two points in a nutshell. Firstly, it was mainly focused on the geosciences, trying to understand Earth as a system. And it introduced, also, a very important concept. Look at this beautiful, lonely planet sitting out in dark space. These things had a huge impact on me as a kid, actually as a kid growing up in Ireland, with the Apollo programs, seeing America as the dominant player in science at the time and to this day, watching to see how this whole concept of understanding planet Earth was being so pioneered by the scientists here in the United States when I was a young kid.

When I look at this now where we are going in the future, what I see IPY doing is building upon that but expanding it in some very important ways: introducing the concept of cross-disciplinary research; looking at the life sciences, the chemical sciences, the physical sciences, and also, most importantly, the social sciences; and looking at all of these in the context of complex systems, spanning all of the way from bio-systems, whether it be a human or organisms where we would look at, perhaps, issues of adaptation at the cellular and the molecular level, all of the way up through ecosystems of the geosystems. They are all interconnected.

It is very important to emphasize the educational issues here. And here, if you may allow me to put in a personal note, I am a father of two young boys in school. I am a scientist. I am a professor. And I am also highly aware of the fact, especially as an immigrant to this country, that I have been treated very well. I have received taxpayers' money for a long time to conduct research in these isolated environments. I feel very passionately about needing to communicate this back into the general community and the public at large. And here we have a great opportunity. Of the thousands of lectures that I have probably given in a quarter of a century of my time in America, few have the impact on little kids all of the way up to retired citizens as when I talk about my polar research. I do genomics, molecular biology, biochemistry. "Yes, yes, yes, Professor Manahan, but what about your polar research?" This really grabs people, as I think it did when you visited the ice yourself. And that is a big opportunity we have with IPY to educate the U.S. population in the issues of excitement in science, technology, and literacy.

But we also have a very large challenge, and that challenge is how do we train the next generation? It is very easy for me to sit here and say, "Think across disciplines: physics, chemistry, biology, social sciences, and off you go and do your stuff, next generation." Our challenge is to find new, innovative ways to keep Americans ahead of the international competitive race in science and learning and education. And one way we are going to do this during International Polar Year is we are going to bring some of the best and the brightest students in the United States to Antarctica to have

the experience that you had, to be there, not just for four days, but for a month or so, to live and work and understand this environment, to actually do on-the-ice training. And we think this is a very important component.

[Slide.]

The pictures you see here are some programs we have done in the past. NSF has taken a remarkable lead in this over previous years. The first country in the world to offer a graduate-level course on the seventh continent was sponsored by the leadership of the National Science Foundation. All of the students you see here were part of previous courses, with the obvious exception of the penguins, of course, who were less cooperative.

If I may conclude with a couple of comments.

Firstly, I want to say that, in my opinion, the timing of launching a new International Polar Year is perfect. The reasons for this go far beyond that it is just merely the 50th anniversary of IGY, although that, in itself, is a very valued reason. The general public is certainly highly aware that the study of polar regions is critical to understanding our Earth. Scientific interest is very high in wanting to have accurate information about polar regions and their role in climate stability and global processes. That is the key issue with respect to societal impact. In addition, of course, we have unique educational opportunities that are both vast and exciting.

Again, thank you for the opportunity to speak today. I would be pleased to address any questions that you may have.

Thank you.

[The prepared statement of Dr. Manahan follows:]

PREPARED STATEMENT OF DONAL T. MANAHAN

Good morning, Mr. Chairman and Members of the Committee. Thank you for the opportunity to speak to you today as you consider the scientific agenda and the federal role for the International Polar Year.

My name is Donal Manahan. I am a Professor of Biological Sciences at the University of Southern California (USC). I have conduced research as a chief scientist and field-team project leader in Antarctica for over 20 years. I have previously served as the Chair of the National Research Council's Polar Research Board for three years (1999 to 2002). The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. In addition to my teaching and research experiences at my university, I have served as Director of environmental science programs for both undergraduate education and graduate research; have been the Chair of the USC Department of Biological Sciences; and Dean of Research for the USC College of Letters, Arts, and sciences.

My comments today will address the upcoming International Polar Year (IPY, March 2007 through March 2009) in the context of (i) what has been learned from polar research and IPYs in the past; (ii) what are the most critical unanswered questions that we hope to resolve during this IPY; (iii) why educational and research activities during IPY are important to us here in the U.S.; and (iv) the societal benefits of IPY. I will focus most of my comments on Antarctica. I believe my colleagues on this panel will address other aspects and regions of polar research.

Regarding current impact from past IPYs, accurate scientific knowledge and current public awareness of the importance of polar regions to our planet as a whole is still a fairly recent occurrence. For instance, in 1963 National Geographic released a map of Antarctica that [quote] "revolutionizes our conception of its geography." Taken in the context of the many centuries of geographic exploration of our Earth, it is quite remarkable that it was only about 40 years ago that more accurate maps of Antarctica emerged. Such maps still continue to be refined to this day. Antarctica has long been considered to be the "last and loneliest of the seven continents" (National Geographic, 1963). Following the "Heroic Age" of early explo-

ration of polar regions in the late 19th and early 20th Centuries, the modern understanding of Antarctica began in earnest with the great international effort of IPY3—The International Geophysical Year of 1957–58. Yet the growth of awareness of the importance of polar regions by many educators, scientists, and the public in general (i.e., by those not already living in polar regions) is a fairly recent occurrence. I will expand further on this point, as I believe it is important in the context and timing of the next IPY.

Both polar regions of our planet are now known to be capable of undergoing very rapid change. In the mid-1980s, the rapid opening of the "Ozone Hole" over Antarctica was certainly one of the great surprises in environmental science during the latter part of the 20th Century. Rapid rates of change for important processes in polar regions, such as ice sheet stability, ozone chemistry and biological rates, have surprised many scientists. Announcements of these rapid changes have also surprised the public at large. Today phrases and concepts such as "Abrupt Climate Change" and "Surprises" regarding our environment are now in common use in scientific publications, in media presentations, and in educational settings. The recent National Academy Press publication on *"Abrupt Climate Change: Inevitable Surprises"* provides an excellent report on this subject of rapid change. There is no doubt in my mind that further research in polar regions is absolutely essential for understanding our planet and for being better able to predict environmental change and its impact on life on Earth.

The specific research questions that will be addressed during this next IPY are still under review through our own national agencies and through collaborations with international partners. As I believe will be highlighted by others during this hearing, the current list of potential educational and research projects is extensive. Here I would like to compliment NSF, the National Academies' Polar Research Board and other polar scientific groups and agencies for doing an excellent job of coordinating these complex national and international activities and for helping raise awareness of the importance of polar research.

Regarding the approach to undertaking future research, one important point that I do want to emphasize is that the next IPY will differ from previous ones in enhancing our understanding of polar regions through novel, cross-disciplinary research. For instance, during the International Geophysical Year in the 1950s, the focus then was more on the physical sciences. For the next IPY, the scientific focus will be more cross-disciplinary—involving biological, chemical, physical, and social sciences to better understand polar regions. In my own area of expertise, the biological sciences, I foresee an exciting interplay between the physical and the life sciences. An example of such collaboration is that as physical scientists provide a better understanding and predictability of temperature change, biologists will be better able to undertake more realistic experiments to define biological responses of organisms to such changes (e.g., temperature adaptation, timing of life cycles, and other ecological changes). Research during IPY will certainly span from the scale of individual molecules and genes to the larger scale of whole oceans and continents.

A point that is not often widely appreciated is that most of the potential habitats where life might exist on our planet are cold. By volume, the "Cold Biosphere" represents approximately 90 percent of the living biosphere on Earth, with temperatures less that four degrees C ("home refrigerator" temperatures). Most of this cold biosphere is in the deep sea (79 percent by volume of the biosphere: Broad, 1998) and in polar regions. Further biological research in polar regions will substantially increase our understanding of the "Cold Biosphere" and its role in the sustainability of life on Earth. New research themes under consideration for IPY, such as NSF's "Life in the Cold and Dark," will be key to understanding critical questions regarding life in polar regions and in the cold biosphere in general.

A major success of past IPYs, and in particular IGY, was the important legacy that continued into the future from training the next generation of scientific leaders in the U.S. This legacy of excellent science and training from IGY, started about 50 years ago, is still active today. For the next IPY, we must strongly encourage the active involvement and advanced training of the next generation of polar scientists. This, of course, must include outreach and educational activities to students of all ages, and to the general public, to encourage interest and careers in science and engineering. Additionally, during IPY we need to develop innovative educational and training programs designed to bring young scientists at the Ph.D. level to polar regions. We need to actively engage these young scientists in polar research by having them actually work "on the ice" during IPY. To this end, an international training program in Antarctic science (NSF-funded: "Integrative Biology and Adaptation of Antarctic Organisms") is planned for January 2008 at the U.S. Antarctic Program's McMurdo Station in Antarctica. This program (that I have directed in the past and will continue to direct in IPY 2008) will involve bringing highly-qualified

young investigators, selected from universities all over the U.S. and some from international institutions, to Antarctica for the first time in their scientific careers. This next generation of potential leaders in polar science will be provided with intense training programs during which they will be exposed to the unique research opportunities in Antarctica. Training these individuals to conduct science in Antarctica "on the ice" will be a very different experience from learning about polar science from traditional classroom settings in the U.S.

I believe the societal benefits from undertaking further polar research will be immense. First, Antarctica holds a fascination for the general public. Second, there has been a dramatic recent increase in the public's awareness of the importance of polar regions in impacting events on a global scale (e.g., strong media coverage of ice sheet stability, with obvious implications for potential sea-level rise globally). Third, further research in polar regions will yield important insights into the connectivity of polar regions to the rest of Earth. In fact, the polar regions often drive fundamental processes in other parts of the world (e.g., major ocean currents and oceanic circulation patterns, with global implications for climate stability).

As a Principal Investigator and polar scientist myself, I will add a few comments here from my own experiences. In my more than 20 years of working in Antarctica, I have never before personally experienced such a widespread and intense interest by the general public in research in polar regions. In addition to increased interest in polar biology at scientific conferences and professional meetings, I receive numerous requests to speak about polar science at career days of elementary, middle, and high schools; to speak in a wide range of university settings, including discipline groups outside of the natural sciences; to address communities of retired citizens; and to present at natural history and community science museums. I attribute much of this recent surge in public interest about the state of our environment to be the result of highly publicized scientific discoveries in physics, chemistry and biology of polar regions.

I will conclude my comments here today by saying that, in my opinion, the timing is now most appropriate to launch a new IPY. The reasons for this go far beyond the timing of the 50th anniversary of IGY, although that is a valued reason too. The general public is certainly highly aware that the study of polar regions is critical to understanding our Earth. Scientific interest is high in wanting to have accurate information about polar regions and their role in climate stability and global processes.

Again, thank you for the opportunity to speak with you today. I would be pleased to address any questions that the members of the Subcommittee may have.

References:

Broad, W.J., 1998. *The Universe Below: Discovering the Secrets of the Deep Sea,* 432 pp.

National Geographic, 1963. *Filling in Antarctica's Blank Spaces,* Volume 123: 297–298.

National Research Council, 2002. *Abrupt Climate Change: Inevitable Surprises,* National Academy Press, Washington D.C. 230 pp.

BIOGRAPHY FOR DONAL T. MANAHAN

Education and Professional Preparation:

Undergraduate Institution: BA, from Trinity College, Univ. of Dublin, Ireland; Area of Focus: Zoology; Years: 1972–1976.

Graduate Institution: Ph.D., from University of Wales, Bangor, UK; Area of Focus: Marine Physiology; Years: 1976–1980. Advisor: Prof. D.J. Crisp, F.R.S.

Postdoctoral Institution: University of California, Irvine; Area of Focus: Cellular Physiology; Years: 1980–1983. Advisor: Dr. Grover C. Stephens.

Academic Appointments:

1983 to present: Assistant, to Associate, to Full Professor. Department of Biological Sciences, University of Southern California, Los Angeles, California 90089–0371.

Sept. 1992 to Sept. 1993: Visiting Faculty, Division of Biology, California Institute of Technology, Pasadena, California (sabbatical year in the laboratory of Dr. Eric Davidson).

Some Senior Administrative and Service Positions Held:

- NSF, Internal Advisory Committee, Director of NSF's Office of Polar Programs (appointed February 2006).
- Chair, U.S. National Academies' National Research Council's Polar Research Board (1999–2002) (member of Board, 1995–2002).
- NSF, Decadal Group—Planning Committee for Ocean Sciences 2000 (1998–2001).
- Dean of Research, USC College of Letters, Arts and Sciences (July 2000–June 2005).
- Chair/Vice Chair, USC Department of Biological Sciences (Sept 1999–July 2000).
- Director, USC Research Division of Marine Environmental Biology (1995–2000).
- Science Director, USC's Environmental Studies Program (1995–2000).

Recent Awards:

For Service (2000 to present):

2000—a 6000-foot mountain in Antarctica named *"Manahan Peak"* for contributions to Antarctic research, education, and service to the science community.

2001—appointed a lifetime *"National Associate"* of the United States' National Academies in recognition of [quote] "extraordinary service to the National Academies in their role as advisors to the Nation in matters of science, engineering, and health."

2005—University of Southern California, College of Letters, Arts and Sciences Award for "Outstanding Leadership and Service."

Recent Awards for Research Papers (2000 to present):

Pace, D. and Manahan, D.T., 2000. Genetic variance and feeding rates in bivalve larvae. National Shellfisheries Association Annual Meeting, Seattle, Washington. Best Paper Award.

Green, A.J. and D.T. Manahan, 2004. Metabolic efficiency in fast-growing bivalve larvae. Society of Integrative and Comparative Biology. Best Paper Award in Comparative Physiology and Biochemistry.

Green, A.J. and D.T. Manahan, D.T., 2004. High growth efficiencies in Antarctic larvae. Ocean Science Research Conference, American Society of Limnology and Oceanography. Outstanding Poster Award.

Yu, P.C., A.L. Moran and D.T. Manahan, 2004. Genetic variation in survival and growth recovery following prolonged starvation of invertebrate larvae. Ocean Science Research Conference, American Society of Limnology and Oceanography. Outstanding Poster Award.

Meyer, E., D. Hedgecock, and D.T. Manahan, 2006. Genomic analysis of growth in larvae of the Crassostrea gigas. Annual Meeting of National Shellfisheries Association, Monterey, California. Best Paper Award.

Recent Grants and Funded Research Projects (active during 2000 to present):

1. NSF. Larval Dispersal at Hydrothermal Vents. Co-investigators: L. Mullineaux (Woods Hole, MA), C. Young (Harbor Branch Oce. Inst.). Duration: April 1997 to Mar 2002.
2. U.S. Dept. of Agriculture. Improving Pacific Oyster Broodstocks for Aquaculture. Co-investigators: D. Hedgecock (USC), C. Langdon (Oregon State Univ.). Duration: April 1997 to March 2002.
3. NSF. Integrative Biology and Adaptation of Antarctic Marine Organisms. Duration: March 1998 to February 2006.
4. W.M. Keck Foundation. Experimental Research in Evolutionary Biology. Co-investigators: M. Waterman, N. Arnheim, M. Nordborg (all at USC). Duration: January 2002 to February 2006.
5. NSF. Energetics of Protein Metabolism during Development of Antarctic Echinoderms. Duration: April 2002 to March 2007.

6. NSF. Genomic Approaches to Understanding Variation in Marine Larval Recruitment. Co-investigators: D. Hedgecock (USC), E. Hofmann (Old Dominion), E. Powell (Rutgers). Duration: July 2004 to June 2008.
7. U.S. Dept. of Agriculture. Crossbreeding Pacific oysters for high yield. Co-investigators: D. Hedgecock (USC), C. Langdon (Oregon State Univ.). Duration: July 2004 to June 2008.
8. NSF. Integrative Biology and Adaptation of Antarctic Marine Organisms. Graduate training grant with co-investigators. Duration: August 2005 to September 2010.

Five Selected Publications (past five years—2001 to 2006):

Pace, D.A., A.G. Marsh, P.K. Leong, A.J. Green, D. Hedgecock, and D.T. Manahan, 2006. Physiological bases of genetically determined variation in growth of marine invertebrate larvae: A study of growth heterosis in the bivalve *Crassostrea gigas. Journal of Experimental Marine Biology and Ecology* 335: 188–209.

Pace, D.A. and D.T. Manahan, 2006. Fixed metabolic costs for highly variable rates of protein synthesis in sea urchin embryos and larvae. *Journal of Experimental Biology* 209: 158–170.

Moran, A.L. and D.T. Manahan, 2004. Physiological recovery from prolonged starvation in larvae of Pacific oyster *Crassostrea gigas. Journal of Experimental Marine Biology and Ecology* 306: 17–36.

Marsh, A.G., L.S. Mullineaux, C.M. Young and D.T. Manahan, 2001. Larval dispersal potential of the tubeworm *Riftia pachyptila* at deep-sea hydrothermal vents. *Nature* 411: 77–80.

Marsh, A.G., R. Maxson and D.T. Manahan, 2001. High macromolecular synthesis with low metabolic cost in Antarctic sea urchin embryos. *Science* 291: 1950–1952.

Five other selected publications (2000 and before):

Marsh, A.G., P.K.K. Leong, and D.T. Manahan, 2000. Gene expression and enzyme activities of the sodium pump during sea urchin development: Implications for indices of physiological state. *Biological Bulletin* 199: 100–107.

Vavra, J.S. and D.T. Manahan, 1999. Protein metabolism in lecithotrophic larvae (Gastropoda: Haliotis rufescens). *Biological Bulletin* 196: 177–186.

Hoegh-Guldberg, O. and D.T. Manahan, 1995. Coulometric measurement of oxygen consumption during development of marine invertebrate embryos and larvae. *Journal of Experimental Biology* 198: 19–30.

Manahan, D.T., 1990. Adaptations by invertebrate larvae for nutrient acquisition from seawater. *American Zoologist* 30: 147–160.

Manahan, D.T., J.P. Davis, and G.C. Stephens, 1983. Bacteria-free sea urchin larvae: Selective uptake of neutral amino acids from seawater. *Science* 220: 204–206.

Teaching and Service Activities:

Research Statement: My work bridges the fields of animal physiology, developmental biology, and molecular biology—all studied in an environmental context. Most animals have complex life history strategies and early developmental stages (embryos, larvae) that are, in general, less well understood in comparison to adult phases of life cycles. I study developmental biology from the perspective of environmental biochemistry and physiology, in particular how developmental stages "work" in contrasting and 'extreme' environments. Some of the implications of such research for basic science, include—understanding the molecular biology and physiology of growth and development of cells and animals, and defining the biological mechanisms that set differences in metabolism. There are also 'applied' aspects to this research—e.g., the search for ways to improve the production of food from the ocean for human consumption, through the application of "hybrid vigor" to enhance growth rates of marine animals (cf. "Green Revolution" in agriculture) and the search for novel biochemical processes in 'extreme' environments (Antarctica).

Teaching Statement: I have taught at the university level for over 25 years. The *undergraduate courses* for which I specifically developed new curricular materials include: Animal Biochemistry and Physiology; Biological Diversity and Adaptation; Cellular Physiology; Humans and their Environment; and Introductory Biology (latter are large courses with several hundred students). *Graduate (Ph.D.-level) courses*

include: Developmental Biology; Integrative Biology and Evolutionary Adaptation; Physiology and Metabolic Plasticity; Oceanography and Biology; and History of Science. For over a decade, I have also directed international biology training programs for Ph.D.-level students and postdoctoral-level scientists in Antarctica. These NSF-funded educational programs have focused on themes of major and current interest in environmental science (e.g., global warming and the "ozone hole") and biological adaptations to environmental change, studied from different biological levels of analyses (from whole-organism to single genes). The individuals who have participated in these training programs were from ~120 different research institutions, representing over 20 different countries.

USC
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CALIFORNIA

College of Letters, Arts and Sciences

Biological Sciences

December 4, 2006

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before The Committee on Science of the U.S. House of Representatives, Research Subcommittee, on September 20th, 2006 for the hearing *"International Polar Year: The Scientific Agenda and the Federal Role"*.

In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding I currently receive related to the hearing topic.

1. Federal Agency: National Science Foundation, Office of Polar Programs.
Grant Number: ANT-0504072
Grant Start Date: August 2005 (to present).
Project Title: *A Graduate Training Program in Antarctica: Integrative Biology and Adaptation of Antarctic Marine Organisms.*
Total award: $942,711

2. Federal Agency: National Science Foundation, Office of Polar Programs.
Grant Number: ANT-0130398
Grant Start Date: April 2002 (to present).
Project Title: *Energetics of Protein Metabolism during Development of Antarctic Echinoderms.*
Total award: $496,659

Sincerely,

DT Manahan

University of Southern California
Allan Hancock Foundation Building
Los Angeles, California
Tel: 213-740-5793
Fax: 213-740-8123
manahan@usc.edu
http://www.usc.edu/dept/LAS/bio/

Donal T. Manahan, Ph.D.
Professor of Biological Sciences
Phone: 213-740-5793
E-mail: manahan@usc.edu

Chairman INGLIS. Thank you, Dr. Manahan.

Mr. McCaffrey.

STATEMENT OF MR. MARK S. McCAFFREY, ASSOCIATE SCIENTIST AND SCIENCE COMMUNICATIONS EXPERT, COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES, UNIVERSITY OF COLORADO, BOULDER

Mr. MCCAFFREY. Thank you, Mr. Chairman, and Members of the Committee. It is a huge honor to be here.

And my name is Mark McCaffrey. I am an Associate Scientist at the University of Colorado at Boulder and a member of the IPY Education, Outreach, and Communication Subcommittee, or IPY EOC, as we call it for short. And over the next few minutes, I would like to give you a whirlwind tour of some of the things that are planned for Education, Outreach, and Communication efforts with the International Polar Year. I feel like I am a little bit of an anomaly here, because I have never actually been to a polar place. I grew up in Colorado, and the closest I have been to the polar experience, I think, is up on the Continental Divide in the middle of winter, which gives you a little taste, I think, of the polar experience.

But over the next couple minutes, I just want to give you a little taste of what is in store with our plans for the Education, Outreach, and Communication efforts, particularly at the international level.

You could write a book about the impact of past IPY and polar science on society, and actually, Michael Robinson from the University of Hartford has written a book called "The Coldest Crucible" that just came out that I think some of you—some of us in this room might be interested in checking out.

But I recently did a Google search on "International Year", and I got 1.6 billion responses. And I had to scroll all of the way down to number 55 to get to International Polar Year, IPY.org. And of course, from the IPY.org website, we linked to all of the national websites, including the U.S. site. But it is good to remember that the very first international year was the International Polar Year. We have thousands of international years out there these days, but IPY was the original, and it was the vision of Karl Weyprecht, who in the 1870s was frustrated by the fact that international collaborations were not very successful because nations were going off on their own and maybe doing a little bit of science but it was much more in the exploratory and territory acquisition mode, if you will. So Weyprecht had the vision of international cooperation in collecting data, and the first IPY in the United States was actually led by Abraham Lincoln's son, Robert Todd Lincoln. And there were a lot of incredible adventures in research and some mishaps along the way. But in my mind, I think of IPYs, starting with the very first one, and then, of course, the second one in the 1930s, and then IGY in the 1950s as benchmarks that we can look back and see the evolution of science and technology, particularly in the polar regions, of course. But the world has changed at each IPY. And I would like to thank—and I think there is some evidence that the IPYs have changed the world in small ways and maybe even, looking back, in some profound ways.

The second IPY actually focused a lot on communication, wireless communication issues, because in polar regions, the ionosphere and the magnetosphere don't behave the way they do in other parts of the planet. And of course, we talk a lot about IGY and the fact that Sputnik and Explorer programs were a part of that effort, but I think of it also as the launch of the modern science education movement, certainly in the United States, efforts led by the National Academies and the films that they produced and the curriculum materials that they helped develop and the magnificent posters that I think some of you have seen around. These are all fantastic artifacts that we can actually take—make use of today. In fact, on the National Academy's website, they—you can download one of the curriculum materials from IGY. And these are terrific resources for teachers and students today.

There are so many education outreach activities planned. How many of them actually will be funded and deployed is a question at this point, but there has been a lot of work through a series of workshops that—the first one, "Bridging the Poles," that Robin and Stephanie Ferman organized that was held here in 2004 in Washington. Then the "Poles Together" workshop that we held in Boulder last summer. There have been, also, workshops in Europe that were inspirited by the workshops here to try to come up with an integrated approach internationally for some of these education efforts. The International Polar Foundation has been very involved. And of course, their—they have designed the Belgian station in Antarctica that is zero emissions, and it will be built during the IPY. We had an online workshop funded through NSF and NOAA back in March. And one of the outcomes of the ice workshop was a series of polar literacy themes that evolved. And I have got more details on this in the written testimony. But peoples and stories were something that came up over and over again. There is so much passion and the whole narrative approach of being able to share information through stories is an extremely powerful way to communicate.

I have touched on just a few of the recommendations that have come out of these workshops in the written comments, but blending art and science is a very powerful way to communicate to broad audiences. And the use of narrative, as I mentioned before, is extremely powerful. There is—the four themes of research—of education that NSF is funding, we have the honeycomb chart that I think you all are familiar with, or I hope you will be. And the United States is involved as leaders on about—over 50 of these 250 projects on here. And then the United States is also a partner on another 125. So the honeycomb is a powerful outreach tool in itself that can help teachers find information, learn more about particular projects.

And to sum up here, we have a lot of plans for launch events during the IPY, the ice hotel up in Sweden has offered to help in some of the launch events, polar art exhibits. And of course, in terms of the societal benefits, the polar science is really the tip of the iceberg. We can foster a scientifically-savvy society, I think, through IPY efforts and support these international partnerships, because there is so much power in the polar, if you will, both in terms of the survival, when you see "March of the Penguins" and

"Eight Below" and movies like that. There is the emotional resonance that people inherently feel towards polar places. And of course, the polar perspective challenges us intellectually. These spectacular images from NASA, the blue marble with a polar perspective, I think, are—they should be on posters in every classroom in the country with the question: "What is wrong with this picture?" Because as spectacular as these images are, they make it look like the sun is shining directly down on the poles, which, of course, is not the case. So I think these can be powerful learning tools in classrooms.

And with that, I thank you for your time.

[The prepared statement of Mr. McCaffrey follows:]

PREPARED STATEMENT OF MARK S. MCCAFFREY

POLAR POWER: EDUCATION, OUTREACH AND COMMUNICATION AND THE INTERNATIONAL POLAR YEAR

Good morning Mr. Chairman and Members of the Committee. Thank you for the opportunity to speak to you today regarding IPY EOC, education, outreach and communication relating to the International Polar Year. My name is Mark McCaffrey. I am an Associate Scientist at the University of Colorado at Boulder and a member of the IPY EOC Subcommittee, which is currently made up of representatives from eleven of the 66 nations currently participating in IPY. I also have been involved with organizing several recent IPY EOC-related workshops and will share some of the findings of these workshops with you in a few minutes. What I'm really here to talk to you about today is polar power: the potential for IPY and polar people, places and science, to change the world, as it has in the past.

I am deeply honored to be here today with this esteemed group of polar scientists and distinguished individuals whose lives were in some way changed by the third IPY, the International Geophysical Year of half a century ago. But I confess I feel like an anomaly here. I am not really part of the polar research community. I've never been above the Arctic or Antarctic circles. My background is in environmental science education, and over the years I have worked with a variety to research scientists to develop strategies and programs to help translate their research for non-specialists and, hopefully, make it more accessible and meaningful to students, teachers, and the general public. But I've long been fascinated by the power of the polar realm to challenge us at deep emotional, intellectual, even, spiritual levels.

I am also a child of the IGY, and I remember watching some of the IGY films that the National Academies produced, and reading about scientists in Antarctica in my *Weekly Reader* newsletter in the early 1960s. I also recall it was a somewhat terrifying time, with "duck and cover" air-raid drills at school, and neighbors up the street building bomb shelters in preparation for possible Soviet missile attacks. And in the midst of it all, scientists around the world embarked to the ends of the world, measuring change, sharing data, developing networks and relationships that led to massive jumps in our understanding of the Earth as a system, and fostered a robust international scientific community that, while still dependent on national support, transcends national agendas and benefits our global society.

In my opinion, the upcoming International Polar Year, if sufficiently funded and well coordinated at grassroots, national and international levels, will be a revolutionary catalyst for informing, engaging and inspiring a more scientifically savvy and literate society, forging new and strengthening existing national and international collaborations and partnerships, leveraging the 125 legacy of IPY—the first, the original international year—and building on the tremendous preparation and energy that has gone into planning the education, outreach and communication efforts for IPY.

But with less than six months before the launch of this International Polar Year, there is no guarantee that the rich potential will be realized. Without appropriate funding and coordination, the International Polar Year risks becoming yet another well-intentioned program insufficiently supported, yet another international year in a sea of other international years that will fail to live up to its potential. For IPY to make the splash that is could, that it should, for it to trigger a ripple effect lasting for generations to come, it is urgent that the United States, which has played

a crucial, integral role in planning IPY research and EOC, steps up and enables this important endeavor to achieve its vision and goals.

IPY EOC is certainly about explaining what scientists know—and don't know—about the accelerated surge of melting snow and ice and its global significance. It is also all about learning from the experiences and insights of the over four million people living in the Arctic. And it is about examining the carbon cycle and how it relates to seasonal cycles, the hydrosphere, the biosphere, the atmosphere, and its intrinsic role in the global climate system, which is amplified in the polar regions due to their seasonal extremes.

Fundamentally, IPY EOC is about exploring how polar regions and polar research is vitally important to all people on Earth. But IPY is also about exploring the role of technology in our society, and demystifying and articulating how science itself is conducted, how data are collected, analyzed, modeled, reviewed and communicated. It is about showcasing the state of the art research and phenomenal technology of modern scientific research into the planet's complexities via high-definition television programs, 3D Imax movies, video logs and web casts from teachers at the poles, radio programs, science center and children's museum exhibits, and good, old fashioned lectures from scientists and stories from polar people with their compelling, tales of adventure and insights into what they have learned about our changing planet.

Running from March 2007 to March 2009, the International Polar Year 2007–2008 will involve hundreds of projects and thousands of scientists and will leverage billions of dollars of infrastructure and prior research. Organizers of this IPY recognized from the start that ultimate success of the upcoming IPY would depend as much on effectively communicating the project's activities and findings to broad audiences as it would on the quantity or quality of the science. Just as IGY is remembered, at least in the United States, for helping to inspire a new generation of scientists through the films, media and posters as much as it is for launching the first Earth observing satellites and breakthroughs in science and politics, the legacy and success of the upcoming IPY may be measured in the public realm by its societal impacts from EOC efforts more than it will its data archives or scientific publications.

I have been specifically asked to address three questions. The first is "what has been the impact of polar research and IPYs on students ad the public in the past?" Obviously, this is an enormous question which one could write a book about. And in fact, Michael Robinson, a history professor at the University of Hartford, has recently written a book entitled *"The Coldest Crucible: Arctic Exploration and American Culture,"* which explores the phenomenon of "Arctic Fever" that was part of 19th century American culture. I am not a historian, but I do have a few thoughts about the legacy of the first IPYs. Most significantly, IPY is the original international year, dating back to the first IPY in 1882–83. Today, there are literally thousands of international years. A recent Google search on the phrase "international years" netted over 1.5 billion results, and down at number fifty-five was IPY.org, the homepage from the IPY Programme Office in Cambridge, UK, which links to the U.S. and other national IPY Web sites.

The concept of an international polar year, which has become the model for the proliferation of international years, was originally the vision of Lt. Karl Weyprecht, an Arctic explorer and scientist in the Austro-Hungarian navy. The idea was born out of the frustration that Weyprecht experienced on several Arctic expeditions when he realized that nationally led efforts to explore and acquire territory were not the ideal way to collect observational data of polar processes that would help scientists understand global climate dynamics. In Weyprecht's view, the only way to really understand polar regions and their global connections would be through a coordinated, international effort of at least one full year of seasonal fluctuations that would include the extremes of winter, when solar radiation was minimal, and life in the cold and dark the most challenging.

Weyprecht called on nations to put aside their national agendas for the sake of scientific progress and an improved understanding of the natural world. While international scientific collaboration was not unheard of at the time, the concept of an intensive, coordinated, year-long research effort was. Participants agreed to share their data and use compatible formats. They built a network of Arctic stations with the aim of better understanding of global climate processes, polar geography and seasonal processes, and phenomenon such as auroras.

Weyprecht died in 1881 before he was able to see his vision of international year fulfilled, but others, especially Georg von Neumayer, kept the vision alive. In the United States, Abraham Lincoln's son, Robert Todd Lincoln, then Secretary of War, headed the U.S. activities during the first IPY, which included establishing several stations, one at Point Barrow, Alaska.

I mention the history of IPY and its 125 year legacy and lineage not only because it has become the model for the plethora of international years that have spun-off from Weyprecht's vision, but also because we can use the history of IPY science and technology to support the aims articulated in National Science Standards and other benchmarks and frameworks that emphasize the importance of inquiry and the history of science. The three past and upcoming IPYs themselves can serve as a conceptual scaffold and timeline to examine at how science and technology, and the world itself, has changed in a few short generations.

Incidentally, a complete analysis of the meteorological data collected during the first IPY in the Arctic has not been fully completed until recently when two NOAA Scientists, Kevin Wood and Jim Overland, completed a thorough analysis which will be published soon in the Bulletin of the American Meteorological Society. Their article, which will be an excellent outreach tool for the upcoming IPY, provides an superb overview of the first IPY and, for the first time, presents a detailed analysis of the combined Arctic data sets, offering a baseline of Arctic climate at the time. This analysis will make an excellent "data story" using the data from the first IPY as a baseline to compare subsequent data. (See Wood & Overland, in press. Also see Luedecke 2004, The First International Polar Year (1882–83): A big science experiment with small science equipment.)

In the fifty years between the first IPY and the second in 1932-33, the world transformed in dramatic ways. Alternating current had begun to electrify the world and radio was an increasingly important communication medium. Internal combustion engines were revolutionizing transportation, including air-travel. The North and South poles had been reached in races that again drew widespread interest to the polar regions among young and old alike. The world, with a global population of two billion, had been through a Great War and devastating influenza pandemic. And during the second IPY, the United States and other nations were experiencing severe economic depression. Nevertheless, forty nations managed to participate in the second IPY and the development of an international network of stations and community of scientists monitoring weather, auroras and other processes was furthered.

A significant focus of the Second IPY was the Earth's ionosphere and magnetosphere and their relationship to communication and electrical technologies, an issue that is extremely relevant today with our increased reliance on such technologies. We are currently working with the Stanford Solar Center on a potential collaboration between IPY and the International Heliophysical Year, IHY (one of several international years overlapping with the upcoming IPY) to deploy hundreds, potentially thousands, of "sudden ionospheric disturbance" (SID) monitors to schools and science clubs around the world. Developed by the Stanford Solar Center, the SID monitors allow students and amateur scientists to measure the diurnal, seasonal and solar cycle variability of the ionosphere. Such a collaboration would link IPY history with one of the centerpieces of the upcoming IHY education and outreach efforts.

Twenty-five years after the third IPY, Weyprecht's IPY model was used in organizing the IGY, which focused on the polar and equatorial regions. Occurring in the middle of the Cold War, after a second World War and advent of the Atomic age, IGY not only served as the medium for the scientific and political breakthroughs previously mentioned, but also marked the beginning of the modern era of science education. The public read updates of IGY expeditions in newspapers and magazines, while students read about IGY in their Weekly Reader newsletters. During and after IGY, the National Academies, funded by NSF and the Ford Foundation, led the development of curriculum and outreach materials about IGY science, including a set of thematic posters, many which are proudly displayed in science institutions around the world, and a series of thirteen educational films shown in classrooms and on educational television throughout the Nation. While behind the scenes these pioneering efforts were beset with challenges (Korsmo 2004, Korsmo & Sfraga 2003), they left an enduring impression on a generation of citizens and scientists around the world.

I have also been asked to address what education and outreach activities are planned for this IPY. Before getting into specifics, I would like to take a moment to reflect on how the world has evolved significantly in the fifty years since IGY: the planet's population and energy usage has more than doubled; new tools, particularly the Internet and wireless technologies, offer revolutionary means of communication that will be harnessed for IPY, although, due to the sheer proliferation of media, such efforts will be competing for people's limited attention. Nevertheless, polar power has the ability to grab people's attention and hold it.

In recent years, in part due to NSF's emphasis on integrating research and education and the broader social impacts of science, there has been increased collabora-

tion between research scientists, educators and various other media and communication experts. But numerous reports and commissions, including the 2001 U.S. Commission on National Security, warn of the long-term implications of neglecting our science education programs, and funding for such integrating efforts, including for the upcoming IPY, remain insufficient to meet the needs of the EOC community and the citizens they serve. Science educators, vying against each other for limited funds, face daunting odds in an ultra-competitive environment.

Planning to make EOC an integral part of IPY began at the outset, both at the national and international levels. Over the past two years, a series of workshops has helped to build the IPY EOC community inside and beyond the U.S., exploring the ways and means to maximize EOC impact. The first workshop, entitled "Bridging the Poles: Linking Education with Research," was funded by NSF OPP and organized by Robin Bell and Stephanie Pfirman of Columbia University's Lamont-Doherty Earth Observatory . Held in Washington, D.C., in June 2004, Bridging the Poles brought together polar researchers, science educators, and other polar enthusiasts to brainstorm potential strategies and resources. Participants recommended that EOC efforts build on the strength of polar research by focusing on three elements: "a 'sense of place' for researchers, educators, students, and the general public; 'pride of place' for Arctic residents, especially indigenous Alaskans; and a sense of connectedness [and] relevance." A full report on the workshop, which describes the vast potential of IPY EOC, is available online at *http://www.ldeo.columbia.edu/res/pi/polar_*workshop/.

One of the recommendations from the Bridging the Poles workshop was for the IPY community to tap the expertise and resources of the International Polar Foundation (IPF). Based in Brussels, Belgium, IPY has been actively involved with polar science and related education efforts, participating in all the IPY EOC workshops and assisting the IPY Programme Office in the development and translation of the IPY brochure and designing the IPY.org web site. In addition to offering a wealth of education materials available online and available on CD in multiple-language formats, IPF also been instrumental in the design the new Belgian zero-emission Antarctic station that will be constructed during IPY. (In the spirit of full disclosure, through a collaboration between IPF and CU–Boulder, 20 percent of my salary is covered by IPF, which allows me to continue to be involved in IPY activities.)

To build on the momentum of Bridging the Poles and re-access the potential for IPY EOC, a second workshop, "Poles Together: Coordinating IPY Outreach and Education," was held in Boulder, Colorado, in July 2005. Organized by the University of Colorado's Cooperative Institute for Research in Environmental Science (CIRES), with in-kind support from NOAA and numerous volunteers, the workshop drew more than 100 participants including researchers, teachers, representatives from U.S. federal agencies (NOAA, NSF, USGS and NASA), and representatives from the International Antarctic Institute in Hobart, Australia, the International Polar Foundation, and members of the Canadian, Swedish, Dutch, and German national IPY committees. David Carlson, who had recently become Director of the International Polar Year Programme Office (IPO) based in Cambridge, U.K., gave the keynote address and discussed plans for IPY in general and EOC in particular.

The core of the workshop was a series of breakout discussions, focusing initially on IPY science themes and key audiences. One idea for EOC communication that emerged was identifying and addressing common misconceptions about the Polar Regions, such as the differences between Arctic and Antarctic geography, the real effect of Earth's axial tilt on seasonal change, and the reason why polar bears don't eat penguins.

Other recommendations included the call for a coordination office for U.S. EOC efforts, and the development of a framework for polar literacy, with key concepts and messages that could help in correlating IPY activities and polar science to education standards and benchmarks.

One of the participants, Stan Ruttenberg, who had worked as a science writer for many of the IGY films, commented that he was impressed by the degree of excitement and enthusiasm of the participants. Where IGY education efforts had been very much top-down, it was clear to Stan that IPY EOC was, above all, tapping a tremendous energy at the grass-roots level.

Some participants of the Poles Together workshop expressed concern that, without sufficient funding for IPY, all the enthusiasm would lead not only to failure of IPY EOC goals, but to disappointment and disillusionment among the IPY science education community. A representative of the NSF attending the workshop indicated that NSF, the lead U.S. agency for IPY, would be able to fund only one to two million dollars of education and outreach projects for fiscal year 2006. (As it turns out, nearly $6 million was made available, meaning that the over 80 percent rate of proposals not funded could have been far higher.) In order to seek a solution

to the funding conundrum, a group of interested individuals was formed to explore funding options from corporations and foundations to augment IPY EOC projects that NSF would not be able to fund. Several meetings were held in the fall of 2005 to explore funding options through corporate or foundations, but after Hurricane Katrina, donor fatigue in the foundation community made it necessary to put plans to seek alternative funding for IPY EOC activities on the back burner. A full report of the workshop, funded through support from the National Science Foundation Office of Polar Programs (OPP) and NOAA Office of Education (OED), is available at *http://cires.colorado.edu/education/k12/ipyoe/*.

To further the preparation for IPY EOC and prepare for the NSF IPY solicitation, with it's strong focus on formal and informal education and related coordination, the Integrated Collaborative Education (ICE) workshop, (funded by NSF OPP and NOAA OED) was held in virtual space in an asynchronous environment, allowing participants from around the world and with varied work-schedules, to participate at their convenience. More than 200 individuals from around the world participated between March 17 and 31, using tools developed and facilitated by the Virginia-based College of Exploration, which has worked with NOAA and National Geographic in developing ocean literacy priorities.

Like all the prior workshops, ICE served as an incubator for collaboration and networking, helping to inspire and inform the broad community of participants. Organized on a few weeks notice, ICE's ambitious goals included the development of an initial framework for polar literacy that could be linked with related ocean and environmental literacy programs.

Participants focused on ten themes they considered integral to such a framework: the uniqueness of the Polar Regions; the complex interconnections of Earth systems; global climate change; the importance of the Polar Regions to science; their history and culture; places of extremes; new models of land ownership/stewardship, international collaboration, and cooperation; the need and opportunity to study holistically; "what we don't know" (i.e., the spaces between disciplines and the gaps in our knowledge); and people and stories. While these themes in many cases overlap with "official" IPY themes and other science education frameworks, the community-based process itself was valuable. A final report of the ICE workshop is available at *http://coexploration.net/ipy*.

Inspired by the Poles Together workshop, the European Polar Board of the European Science Foundation hosted a workshop in Brussels in mid-March of 2006 to engage the European polar research and education community. The workshop sparked later discussions of the EOC subcommittee on how education, outreach and communication can be more fully integrated since, all too often, they are considered separate, unrelated domains.

The IPY Framework document called for the IPY Programme Office to establish an Education, Outreach and Communication Subcommittee of the ICSU–WMO Joint Committee, which would review EOC-related proposals, help coordinate and integrate activities, and assist in establishing the IPY Web site. The Subcommittee, made up of representatives from eleven nations that will be expanded as IPY gets underway, began meeting in early 2006 through monthly teleconferences and is focused on coordinating launch events, developing the IPY.org web site, and supporting international EOC collaborations.

The discussions at the Brussels European Polar Board workshop in March, 2006 on linking education, outreach and communication helped to inform the development of the IPY EOC Action Plan (still in development), which explores how information from a particular IPY research project—say, a study of seasonal and longer-term sea ice fluctuations or of caribou migrations—might be customized and repurposed for different audiences. Over the years, the terms "education," "outreach," and "communications" have become separate, specialized domains, rarely overlapping or collaborating. The concept of using IPY as an opportunity to begin to integrate these different, sometimes competing realms while recognizing the unique needs and expertise required to be effective in each area, has been an emerging goal of the IPY EOC subcommittee. For example, we envision that:

- A short media summary of the research goal and its methods used by public affairs or media specialists could also be used to help a classroom teacher see at a glance whether a specific project is relevant and of interest to her students.
- A "who, what, where, when, why, and how" narrative description or "data story" in non-technical language could help a teacher, exhibit designer or curriculum developer develop strategies for contextualizing the data.
- A database of high-definition video clips could be used by journalists, students, teachers, and exhibit developers alike.

- A blog from graduate students in the field could assist students in the classroom virtually participate in the project by providing a human context to how the research is conducted and data are collected.
- Mapping the science of the project to science standards and frameworks, taking into account related misconceptions, could help scientists calibrate their own communication with non-technical audiences.
- Reviewing and annotating existing background materials and learning activities and linking them with standards and curriculum could have benefits far beyond the formal education realm.

To facilitate the integration of information that public affairs and media relations officers, researchers, educators and students and other polar enthusiasts can access, the IPY Programme Office is developing a database that will include short summaries of IPY projects, longer descriptions of the "who, what, where, when, why, and how" involved, and, once funded and deployed, can be augmented with audio and video clips, blogs and journals, relevant curriculum and education standards, and so forth. Ideally, this database will be integrated into the IPY Data Information Service, or IPYDIS, which is a U.S. led proposal headed by Mark Parsons of the National Snow and Ice Data Center.

Dr. Bell has talked about the famous "honeycomb chart," and I'd like to share it with you again. It is in itself an invaluable outreach tool and is included as an attachment to my written statement. Of the 233 proposals, many of them made up of numerous smaller projects, the U.S. is involved in 183 of them, or 82 percent of the total, roughly 20 percent as the lead, in red on the chart (51), and 60 percent as a key partner, in yellow (122). Again, I'd like to point out the IPY Data Information Service as an integral part of the big plan, which the U.S. is the lead on.

All of these cells of the honeycomb, which combine in some cases multiple nationally funded projects, are subject to funding through their national agencies. But there is no guarantee that they will be funded at all, especially when budgets are tight and review criteria between national and international programs differ. We now know that some of the proposals approved at the international level will not be funded by NSF, at least at this time, and we can anticipate that the honeycomb chart will look significantly different a year from now.

The main point I'd like to make here is that those who did go through the international process and were endorsed by the IPY Joint Committee had to address the basic IPY EOC criteria, meaning they needed to have a plan of how they would address EOC goals identified in the IPY Framework document. They also needed to be international to some degree, including the education proposals, of which there are 54, the majority of which involve U.S. partners or leads. All have international linkages and partners.

Which brings us to a question: Should EOC for IPY be only addressed at the national level? The conventional wisdom seems to be, "yes," that every nation has their own education systems and unique communities with needs. But the decade-old GLOBE program, which has just funded an IPY-related project looking at seasonal changes, suggests otherwise. Indeed, learning from the experience of GLOBE, and perhaps leveraging its network and those of the space science education community of IHY, IPY EOC has the potential to forge a new, robust international education network that will live on long after IPY is completed. Rather than have every nation approach IPY EOC exclusively internally, this is an opportunity for "soft diplomacy" that could, in the spirit of Weyprecht's vision, truly transcend national agendas and make a robust contribution to global awareness and cooperation.

Some nations, such as Canada and Norway, require that proposals seeking funding for IPY first go through the international process, which mandates international partnerships. The U.S. and most other nations did not require IPY international endorsement. Funded projects that did not go through the international process will still have an opportunity to become part of the honeycomb, but they will be required to go through the review process and either be linked with an existing program in the honeycomb, or be endorsed as a new cell.

The final question I have been asked to address is: what are the goals and expected societal benefits of these activities? At the level of the Joint Committee, the U.S. National Committee, and NSF, the goals have been primarily polar science-specific: "to attract and develop the next generation of polar scientists, engineers and to leaders and to capture the interest of the public and decision-makers," (ICSU 2004a) , to increase "public understanding and participation in polar science" (NRC 2004) and "educate the public about the polar regions" (NSF 2006).

But to many involved at the grassroots level of IPY EOC, including many participants in workshops and on the IPY EOC Subcommittee, polar science is merely the tip of the iceberg in terms of the potential for this international endeavor to go be-

yond simply showcasing polar science and its global relevance. As the recent draft IPY EOC Action Plan suggests, IPY can also "demonstrate the scientific process in real-time by engaging the public with an exciting, enormous, and diverse, interdisciplinary scientific investigation. It is an opportunity for an open dialogue between scientists and society that will demystify and increase accessibility of science. This will strengthen the public's perception, understanding, and appreciation of science and therefore empower them in making valid assessments of scientific information." (IPY EOC 2006)

The goals of promoting polar science and recruiting new polar scientists is, frankly, the easy part. The far broader goals of fostering a more scientifically savvy society and forging new science education partnerships at every level is much more daunting, and will require robust funding and support to achieve the inherent potential of IPY as a catalyst for positive change. There is a very small window—right now—to seize this opportunity, devote the necessary, leadership, resources and people power to meet the challenge, and set the wheels in motion to allow IPY live up to its vast potential.

There is tremendous power in the polar realm to inspire, inform and engage people of all ages and walks of life. At a gut level, the extremes of the polar environment challenge us in terms of basic survival; ask any child who has seen "The March of the Penguins" or "Eight Below." It has been suggested that in the first two IPYs, survival required 90 percent of the time and energy with science requiring the remaining 10 percent. Polar regions will always remain dangerous, forbidding places, no matter how sophisticated the technologies. Now, with increased concern about human impacts on the Earth's climatic and environmental systems, people look to the poles to gain information about and insights into the survival of the planet itself.

Polar power also has tremendous emotional resonance, appealing to our sense of beauty and wonder. The stories and experience of people from polar communities, including the millions of Arctic residents and the scientists, explorers and teachers who have spent time in Antarctica, are a powerful way of bringing a human dimension and personal touch to IPY activities.

And, finally, the polar perspectives offer a unique way to engage and challenge our intellects, whether at the cutting edge of the scientific frontier, or addressing common misconceptions that students have about the reason for seasonal change. I would love to see posters of the spectacular polar "night" and "day" images from NASA Goddard, part of the Blue Marble series, in every grade schools everywhere with the title: "What's Wrong With This Picture?" These wonderful photo-mosaics can leave the impression that the sun is shining directly down on, or is directly behind, the north or south pole, when in fact, that never occurs. There is never a time of day, or time of year, when there is so much sunshine. . .or darkness. . .in the north or south hemispheres. Realizing this, students can then consider how the axial tilt impacts polar seasons.

There are countless international years but only one IPY. For IPY to be more than just another international year in a crowded field and live up to its huge potential, the support and leadership of the U.S., working in close collaboration with our international partners, is imperative. The time for IPY is now.

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BIOGRAPHY FOR MARK S. MCCAFFREY

Professional Preparation

M.A.—Educational Leadership—University of Northern Colorado, Greeley, CO, 1994

B.A.—Southwest Studies, Spanish Emphasis—Fort Lewis College, Durango, CO, 1980

Relevant Appointments

Cooperative Institute for Research in Environmental Sciences

Associate Scientist, Professional Research Assistant, January 2001–present

CIRES Outreach Program, August 2004–present

Co-Chair, Poles Together IPY Outreach and Education Workshop, July, 2005

Member, International Polar Year Education, Outreach, Communications Subcommittee

Principal Investigator, Integrated Collaborative Education (ICE) Strategic Planning Online Workshop

Principal Investigator, DLESE Climate Change Collection

Principal Investigator, NOAA Coral Reef Information System Data Outreach Project

Managing Director, International Polar Foundation USA

NOAA Paleoclimatology Program, National Climatic Data Center

Science Communications Specialist, January 2001–July 2004

Principal Investigator, Climate TimeLine Information Tool

Lead Author, Paleo Perspective on Abrupt Climate Change

Project Manager, Spanish translations of Paleo Perspectives

Boulder Creek Watershed Initiative, 1996–2003

President, 2000–2003

Co-founder and Board Member, 1996–2003

Boulder Area Sustainability Information Network, 1998–2001

Co-PI and Communications Coordinator

University of Northern Colorado, ChemQuest Curriculum Project, 1996–1999

Education Consultant and Curriculum Developer

The Naropa Institute, Environmental Leadership Masters Program, 1996–1999

Adjunct Faculty and Developer—Boulder Creek Atlas Project

Front Range Community College, Environmental Sciences Department, 1995–1996

Adjunct Faculty, Introduction to Environmental Science

Recent Publications, Presentations and Products

McCaffrey, M.S., Bishop, T., Lynds, S., Tuddenham, P. (2006). ICE: The Integrated Collaborative Education Online Strategic Planning Workshop Summary Report. Available: *http://www.coexploration.net/ipy/ice*

McCaffrey, M.S., Lynds, S. (2006). Poles Together: Coordinating International Polar Year (IPY) Outreach and Education Summary Report. Available: *http://cires.colorado.edu/education/k12/ipyoe*

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McCaffrey, M.S. (2000). "BASIN.org, a case study on the use of information technology in developing local watershed networks." Stockholm International Water Symposium, Stockholm, Sweden, August 2000.

McCaffrey, M.S., Murphy, S., (2000). "Boulder Area Sustainability Information Network (BASIN): One Community's Approach to Gathering and Providing Environmental Data." U.S. EPA Community Involvement Conference: The New Millennium: Community Involvement and Effective Environmental Protection." San Francisco, CA, August, 2000.

Synergistic Activities

Member, International Polar Year Education, Outreach and Communications (EOC) Subcommittee and IPY.org Web Design Team—Contribute to reviewing EOC-related proposals for the IPY Programme Office, reporting to Director David Carlson, offering input and recommendations on coordination efforts and design of the IPY.org portal site.

Member, American Geophysical Union and European Geoscience Union—Co-convener of upcoming IPY Education and Data Literacy sessions at the AGU, December 2006. Have previously convened Education sessions at past AGUs and assisted in organizing the GIFT Workshop at Fall 2003 AGU on polar science and at the Spring 2005 in New Orleans on hurricanes and other natural hazards.

DLESE Working Group—Earth System Framework—Participant in working group tasked with examining approaches to organizing resources within DLESE using an Earth System framework and recommending strategies and options to the Steering Committee.

Coral Reef Information System and Coral Reef Task Force Outreach—Through involvement with the NOAA Coral Reef Information System (CoRIS), serve as principal investigator of the CoRIS Data Outreach project, facilitating stakeholder meetings with coral reef communities. Participant in the Coral Reef Task Force's Outreach and Education Committee.

Collaborators and Affiliations

Susan Buhr, CIRES, University of Colorado at Boulder

Linda Capper, British Antarctic Survey

David Carlson, International Polar Year Programme Office

Michelle Hall-Wallace, Science Education Solutions

Louise Huffman, Golden Apple Foundation

Martin Jeffries, University of Alaska, Fairbanks

Roberta Johnson, UCAR Education

Carol Knight, NOAA

Tamara Ledley, TERC

Susan Lynds, CIRES, University of Colorado at Boulder

Russanne Low, UCAR–DLESE

Cathy Manduca, Science Education Resource Center

Frank Niepold, NOAA Climate Program Office

Mark Parsons, National Snow and Ice Data Center

Stephanie Pfirman, Columbia University

Lesley Smith, CIRES, University of Colorado at Boulder

Peter Tuddenham, The College of Exploration

Daniel Zalles, SRI International

Graduate Advisor: Richard King, University of Northern Colorado.

CIRES
COOPERATIVE INSTITUTE FOR RESEARCH
IN ENVIRONMENTAL SCIENCES

September 15, 2006

Congressman Bob Ingliss
Chairman
Research Subcommittee
U.S. House of Representatives
Committee on Science
Suite 2320 Rayburn House Office Building
Washington, DC 20515-6301

Dear Chairman Inglis:

In accordance with the Rules of the House of Representatives, this letter is to state my sources and amount of federal funding relating to the International Polar Year which is the subject of your hearing on September 20th. In the current fiscal year and past two fiscal years, I have received a total of two and a half months of salary support relating to IPY, half from the NSF Office of Polar Programs, half from the NOAA Office of Education, specifically to write a final report for the Poles Together workshop held in Boulder in July, 2005, and to organize and write a final report for the Integrated Collaborative Education (ICE) online workshop held in March, 2006.

I have received no federal funding for my involvement in the International Polar Year Education, Outreach and Communication (EOC) Subcommittee. This work has been done on a volunteer basis and through a small grant from the International Polar Foundation.

Don't hesitate to let me know if you have any questions or concerns.

Sincerely,

mm

Mark S. McCaffrey
Associate Scientist &
Science Communication Specialist
The Cooperative Institue for Research in Environmental Sciences
The University of Colorado at Boulder
UCB 449
Boulder, CO 80309

Chairman INGLIS. Thank you, sir.

Dr. Falkner.

STATEMENT OF DR. KELLY KENISON FALKNER, PROFESSOR OF CHEMICAL OCEANOGRAPHY, OREGON STATE UNIVERSITY

Dr. FALKNER. Thank you for the opportunity to testify this morning.

My testimony draws from published reports from input from the arctic community and 14 years of experience in arctic field work.

The research projects to be sponsored during IPY have yet to be finalized, as you heard earlier, but based on ideas voiced during the IPY planning process, I suspect there will be many more excellent research projects proposed and can be supported by available U.S. funds.

Well, I was asked to address what did we learn from polar science in past IPYs, and in the interest of time, I refer you to my written testimony and the comments of my colleagues here, but I also highly recommend that you consult the four weekly issues of November 1960 Life Magazine, which reported to the public the remarkable findings of the International Geophysical Year.

So what do we hope to learn from this IPY?

As has been well publicized, the arctic has been undergoing dramatic changes. Air temperatures are increasing and are now higher than they have been in at least four centuries. Last year, large portions of the arctic were four to seven degrees Fahrenheit warmer than they had been in the previous 26 years. Sea ice area and thickness are diminishing. Satellite records show that summer sea ice area has decreased 20 percent, or roughly twice the area of Texas, since 1979, with a record minimum in 2005, and this year being very close to it.

Loss of sea ice cover will change the global heat balance and will affect our global weather patterns. Sea ice retreat is already posing severe habitat challenges to animals dependent upon it, such as the polar bear. A changing ice cover also has implications for shipping routes and access to resources, such as offshore oil and gas.

Permafrost is thawing, posing serious challenges to infrastructure, altering ecosystems, and increasing greenhouse gas emissions. An article published two weeks ago in the *Journal of Nature* reported far more of the potent greenhouse gas methane being emitted from Siberian Fall Lakes than previously estimated. Methane output from this vast terrain has increased by 58 percent from 1974 to 2000. The Greenland ice sheet is undergoing a net melting trend that shows signs of accelerating due to processes we are only beginning to understand. Realize that Greenland holds about 20 feet of potential sea level rise. The arctic hydrologic system has been altered such that large amounts of freshwater have made their way into sensitive areas of circulation in the North Atlantic.

Now global system models that include greenhouse gases predict amplified warming in the arctic. Detailed records of climate change from ice cores show that change in the past has, at times, been very abrupt. Several degrees of temperature change and atmospheric circulation and precipitation rearrangements have occurred during less than 10-year timescales. Intensified research efforts during the IPY will come none too soon.

In addition, there remain a number of basic science questions that are under-explored in the arctic because of its remoteness and harshness. We now have the ability to observe in places and during seasons where we haven't before and at scales ranging from the molecular to the global.

It is an exciting time to be embarking on an IPY. The international science community has developed new approaches and tools that are ripe for application, so intensified research can be expected to foster new discoveries in realms, such as sea floor dynamics, the Earth's magnetic field, biology, and contaminant transport.

So it is also asked what are the most critical unanswered questions that we hope to resolve with the research conducted during the IPY.

The magnitude of the changes in the arctic raises the possibility that the arctic system may be approaching a tipping point, especially if amplification or irreversibility of changes introduced through reinforcing feedback processes. Such considerations led to the overarching question that is a main driver of the Study of Environmental Arctic Change Program (SEARCH): is the arctic transitioning toward a new state.

It is also important to ask: what new discoveries lie ahead? What are the societal benefits of this research? If the IPY is fully implemented, as envisioned, the arctic, as well as Antarctic plans, address the future climate of our planet with the intention of establishing observation networks that take us into the future.

Concentrated efforts during the IPY will help to train the next generation. As a mother, I am excited by the education efforts centered on the IPY that are aiming to bring fun into math and science so we can get our kids on track and capable of competing in the global economy.

IPY findings will help to prepare the people of the north for adapting to what appears to be inevitable further change there. The findings should also help provide guidance for further resource development possibilities.

Finally, a firm commitment by the United States to the 2007–2008 IPY will demonstrate to the world that the United States is capable and willing to play a leading role in assuring the quality of our collective environmental future.

Thank you.

[The prepared statement of Dr. Falkner follows:]

PREPARED STATEMENT OF KELLY KENISON FALKNER

I would like to begin by thanking the Committee for giving me this opportunity to testify regarding the 2007–2008 International Polar Year. I was specifically asked to address the following questions from an Arctic research perspective:

- What has been learned from polar research and IPYs in the past and what do we hope to learn from this IPY?
- What are the most critical unanswered questions that you hope to resolve with the research conducted during the IPY? What are the societal benefits of this research?

Before I address those questions, let me outline for you my qualifications. In 1983, I was awarded a Bachelor's degree in Chemistry from Reed College, followed by a Ph.D. in Chemical Oceanography in 1989 from the MIT-Woods Hole Oceanographic Institution Joint Program. Following this, I undertook postdoctoral work at MIT under an NSF Women's Initiation Award and then continued my studies at the Centre National D'Etudes Spatiales, Toulouse, France, under a NATO Postdoctoral Fel-

lowship. In 1992, I took a faculty position at the College of Oceanic & Atmospheric Science at Oregon State University, where I currently carry out research and teach as a Professor of Chemical Oceanography. Shortly after arriving at OSU, I embarked on studies in the Arctic with support of an ONR Young Investigator Fellowship. My initial objective was to devise methods to track river waters and other water types within the Arctic Ocean using naturally occurring chemical signals. Since then my research group has been applying these methods in numerous collaborative studies to document the remarkable changes in Arctic Ocean circulation over the past decade, including at the North Pole Environmental Observatory. Hence, I have been traveling to the Arctic to conduct field-based research from a variety of platforms for the past 14 years. I have served on numerous Arctic related national and international science steering and review committees. In addition, I am the mother of two children, ages six and 11.

In preparation for my testimony, I informed the Arctic research community via the ArcticInfo listserv of this pending hearing and requested their input via e-mail regarding the questions I was tasked to address. The timing allowed five working days for the community to respond during what is typically an active field season period for the group. Nonetheless, I received 35 responses from a broad sampling of the community. Without exception, all of the respondents endorse the importance and timing of the IPY. They brought to my attention significant issues I might have otherwise missed and so I am indebted to them for their input.

Development of the overall vision for the 2007–2008 IPY was strongly driven by community input. I personally took part in several town hall discussions early in the process that took place at various national and international science meetings. The 2004 National Research Council Report, *"A Vision of the International Polar Year 2007–2008,"* nicely captured the input and presented a path by which to proceed. I have drawn on aspects of that report for part of my testimony this morning.

In addition, I am a signatory of an open letter that was circulated in the science community beginning in 1995, proposing a program to study Arctic change. As the scientific vision developed to a broad initiative involving several federal agencies, it was galvanized under the acronym SEARCH, standing for Study of ARctic Environmental CHange. Under U.S. leadership, the international community was invited to an open science meeting in Seattle, Washington in 2003, since it was clear that SEARCH activities transcend the intellectual, infrastructural and fiscal resources of any single nation. In response to our request to foster an international effort on Arctic change, the International Arctic Science Committee and Arctic Ocean Sciences Board initiated the International Study of Arctic Change in 2004. This is the international umbrella under which SEARCH is a national component. An Interagency Program Management Committee consisting of eight U.S. federal agencies have agreed to work together on implementing SEARCH. These are the National Science Foundation (current chair), National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, U.S. Department of Defense, U.S. Department of Energy, U.S. Department of the Interior, Smithsonian Institution and the U.S. Department of Agriculture.

In May, 2005, over 80 members of the U.S. Arctic community met to align research priorities for SEARCH with the evolving thinking in the Arctic community at large. The criteria used to prioritize activities included: importance to meeting SEARCH science objectives, fit with international activities and readiness for implementation. The report that resulted is entitled *"Study of Environmental Arctic Change: Plans for Implementation During the International Polar Year and Beyond"* (2005, Arctic Research Consortium of the United States, Fairbanks Alaska, 104 pp.). My testimony also draws from that report and I refer you to it for further detail and original references. I would like to note that the upcoming IPY marks the first time that northern residents are being included directly in planning and implementation. The IPY vision also includes integration of social and physical sciences in the north in order to identify socioeconomic impacts of change and adaptation and mitigation strategies.

One final point I would like to make before addressing the questions is that decisions regarding the exact research programs to be sponsored during IPY have yet to finalized by several participating nations including the U.S. For example, science proposals submitted to the U.S. National Science Foundation are currently under review and decisions about the initial round of submissions are expected late this fall. Once the initially funded projects have been identified, it is intended that another call for proposals will ensue permitting gaps in a coherent research portfolio to be addressed. The peer review process should help to assure that the best possible ideas go forward. I am aware of attempts to coordinate funding of projects that pass our merit review system with efforts funded by other countries. This is not easy to accomplish given diverse deadlines and funding cultures but IPY will forge

new ground in that direction. My answers to your questions are what the community hoped to accomplish. Based on ideas voiced during the international IPY planning process, I suspect there will be many more excellent research programs proposed than can be supported by available funds in the U.S. and our funding agencies will have some difficult decisions to make.

What has been learned from polar research and IPYs in the past?

As already pointed out, the first IPY took place in 1882–1883 and was primarily Arctic in focus. Coordinated observations were carried out at widely spaced locations. The international community demonstrated that it could collaborate in the name of science and that collective efforts can pay handsome dividends. One of the more notable findings was the first description of the large-scale motion of the sea-ice with important implications for exploration that followed. Priceless baseline data for anthropology and natural history were also obtained during this era, preserving what we now know was in the process of being lost to interactions with the lower latitude world.

The second IPY in 1932–33 heralded the beginnings of modern weather related observations around the globe and including the Arctic. Systematic Arctic Ocean observations began to be undertaken by the Russians at this time, which they continued through to the 1980's. While the Russian data collection efforts were aimed at informing their cold-war activities, that data provide us today with an essential basis for assessing the magnitude of recent changes in ice-ocean and atmosphere conditions.

Fifty years later in 1957–58, the IGY expanded its focus to include geophysical observations of the entire planet and outer space. Scientists took advantages of technology that sprung from World War II, such as rockets, satellites, radar, sonar, radio-communications, diverse telescopes and seismic sounding, to make extraordinary advances in our understanding of Earth and space science. Many of the accomplishments around the globe involved a close collaboration between the military and science communities. Although polar efforts were focused more on the Antarctic, in the Arctic the first large-scale determination of the sea floor relief was accomplished. The work on the interaction of solar and cosmic particles and the Earth's magnetosphere in a year of peak solar activity generated an appreciation of the cause of radio communication disruptions at the poles. The first globally synoptic weather observations were undertaken. The first submarine based surveys of sea-ice thickness were undertaken in the Arctic. Global carbon dioxide monitoring was initiated at the South Pole. The first World Data Centers were established during IGY. This is but a short list of the myriad IGY science accomplishments. The cooperative spirit of generating new knowledge overrode international tensions of the time and fostered enduring treaties regarding Antarctica and space. The public was broadly engaged by numerous media reports on the science and educational materials that evolved from it. Clearly IGY left many positive and enduring legacies.

What do we hope to learn from this IPY?

One would have to be avoiding the popular media not to realize that the Arctic has been subject to some remarkable changes over the last few decades and that many of the changes appear to be linked and are accelerating. Some of these changes are large and in certain cases, unprecedented in the period of instrumental and satellite observations. It is not an exaggeration to say that the magnitude and rapidity of recent changes caught many scientists by surprise. Quasi-cyclical atmospheric pressure patterns were initially thought to be driving many of the changes but now departures from those relationships have many of us wondering whether the Arctic is in transition to a new state altogether. What are these changes?

Arctic air temperatures are increasing. Average air temperatures have risen strongly in recent decades and are now higher than they have been in at least four centuries. In 2005, large portions of the Arctic were four to seven degrees Fahrenheit warmer than they have been over the previous 26 years. Sea-ice area and thickness is diminishing. Over the period of the satellite record, summer sea-ice extent has decreased 20 percent (twice the area of Texas) with a record minimum in 2005, and 2006 being very close to it. Snow-covered ice reflects most incoming sunlight or as scientists like to say, has a high albedo, and water absorbs light or has a low albedo. Thus the loss of sea will change the global heat budget and so affect our global weather patterns. The ice retreat is already posing severe habitat challenges to animals dependent upon it such as the polar bear. The changing ice cover has implications for shipping routes and access to resources such as offshore oil and gas. Permafrost is warming and thawing, posing serious challenges to infrastructure, altering ecosystems and greenhouse gas emissions. Just two weeks ago, K. Walter from the University of Alaska Fairbanks and colleagues reported (*Nature,*

Sept. 7, Vol. 443, p. 71–75) that lakes resulting from thawing in Siberian tundra probably emit 10–60 percent more of the potent greenhouse gas methane than previously estimated. Moreover their area has increased with the warming increasing their methane output from 1974 to 2000 by 58 percent. Woody shrubs are becoming larger and more abundant throughout the Arctic tundra as they out compete other plants, interfering with caribou migration and in some instances with oil exploration. Other plant and animal species are beginning to appear in the Arctic that have been previously unknown there. The Greenland Ice Sheet is undergoing a net melting trend that shows signs of accelerating. There are signs of concurrent ice-sheet losses in Antarctica. Recent observations highlight more dynamic response factors in ice sheet behaviors than we had previously appreciated. Realize that the Greenland Ice holds about 21 feet of potential sea-level rise; we need further observations and model improvements that incorporate these dynamic factors to anticipate the rate of future sea level changes. Freshwater cycling in the Arctic hydrologic system has been altered such that large pulses of freshwater have made their way into potentially sensitive areas of circulation in the North Atlantic that can impact our regional and global climate.

Global climate system models that take into account greenhouse gas forcing predict amplified change in the Arctic. Detailed records of climate from ice cores have taught us that change in the past has at times been very abrupt with multiple degrees of temperature change and atmospheric circulation and precipitation rearrangements occurring on less than 10 year time scales. Intensified research efforts during the IPY will come none too soon.

The IPY affords us the opportunity to accelerate the implementation of SEARCH, to provide leadership and to collaborate internationally to understand and document the nature of these changes and their linkages to each other within the Arctic and to our global climate system. It appears that some amount of further change and challenges to ecosystems and human systems in the North are inevitable. We need to understand the changes to better chart their future course. What are the foreseeable benefits and difficulties of Arctic and global warming? The people of the north need answers to help them anticipate and cope with change. The effects of changes in the Arctic on global climate may well be disproportionate to its area. We need to push our understanding of Arctic-global linkages so that people outside of the Arctic can know what to expect under possible future greenhouse levels.

In addition to the very visible issue of Arctic change, there remain a number of aspects of the Arctic that are under-explored because remoteness and harsh conditions make for challenging logistics. The science community has developed new approaches and tools that are ripe for application during the IPY and so intensified research can be expected to foster new discoveries in several realms. For example, the Gakkel Ridge is the slowest spreading ridge in the world's oceans. Preliminary evidence has shown that the nature of hydrothermal activity associated with that feature spans the full range of that observed elsewhere in the world's oceans. By current thinking, this is not supposed to be the case. Further exploration offers the possibility of entirely new insights in marine geology. Another example is that the geomagnetic North Pole is currently on the rapid move. Recent studies of marine and lake sediments have revealed similar shifts of the pole's position and repeating patterns in the past that may lead to a better understanding of the behavior of the Earth's core. IPY activities could help unveil tantalizing links between the Earth's magnetic field position, solar and cosmic particle flux and climate.

Another example is that much of what we know about past climate on Earth comes from what we call proxies or signals preserved in ice cores, sediments and organisms. There are plans to conduct scientific drilling for the first time in ocean sediments in the Bering Sea region to determine the climate and ecological impacts of the Bering Sea Bridge that emerges during low sea-level stands as well as volcanic eruptions in the region. The ice-coring community is hoping to obtain the first complete ice record from Greenland that extends back through the interglacial period at the Eem site. Advances in trace element and isotope geochemistry offer the possibility of developing and applying new proxies for teasing out the past conditions. The international community has embraced a program called GEOTRACES to track the behavior of such trace elements and isotopes in the world's oceans and has targeted their initial observations in polar regions as part of the IPY. GEOTRACES also aims to provide accurate baseline information for micro-nutrients such as iron and problematic contaminants such as mercury in the polar oceans.

The integration of biological sciences during this IPY offers many new knowledge frontiers. For example, advances in molecular techniques can be applied to characterizing the diversity of organisms both north and south and potentially important functional genes such as anti-freeze proteins and UV protection of DNA. Our Euro-

pean and Canadian colleagues are planning to focus on migratory bird health, which has important links to avian flu and global health.

It is an exciting time to be embarking on an IPY. We have the ability to observe in seasons and places where we haven't before and at scales ranging from the molecular to the global. We are bound to make many new discoveries.

What are the most critical unanswered questions that you hope to resolve with the research conducted during the IPY?

The magnitude of the changes in the Arctic raises the possibility that the arctic system may be crossing a threshold or approaching a tipping point, especially if amplification or irreversibility of change is introduced through processes such as the ice-albedo-temperature feedback. Such considerations lead to the overarching question that is a main driver of the SEARCH program:

Is the arctic system moving to a new state?

Key questions that must be addressed in order to understand whether the Arctic is moving into a new state include the following:

- To what extent is the Arctic system predictable, i.e., what are the potential accuracies and/or uncertainties in predications of relevant arctic variables over different timescales?
- To what extent can recent and ongoing climate changes in the Arctic be attributed to anthropogenic forcing, rather than to natural modes of variability?
- What is the direction and relative importance of system feedbacks?
- How are the terrestrial and marine ecosystems services affected by environmental change and its interaction with human activities?
- How do cultural and socioeconomic systems interact with Arctic environmental change?
- What are the most consequential links between the Arctic and the Earth systems?

In keeping with the spirit of previous IPY's, it is also important to ask:

What new discoveries lie ahead?

What are the societal benefits of this research?

The Arctic is harbinger of global change and research community is poised to make unprecedented advances in understanding of our climate system at the present juncture. We will apply interdisciplinary approaches to these complex issues in a manner that wasn't conceivable during the IGY. Our observational tools have progressed dramatically. Satellites can now provide us the larger scale view of numerous essential system parameters. A wide array of in-situ sensor and autonomous platforms have been developed which can be applied to unmanned observations of the ocean, atmosphere, ice, biosphere, land, the interior of the Earth and space. Modern computational, as well as data storage and dissemination, capabilities will allow us to move and share information in new ways. In fact, it is the hope of many of us that the IPY might provide a very visible opportunity to develop and showcase advances in cyberinfrastructure in a way the benefits the larger science enterprise.

If the IPY is fully implemented as envisioned, the Arctic as well as Antarctic plans address the future climate of our planet with the intention of establishing observation networks that take us into the future. Concentrated efforts during the IPY will help to entrain the next generation into polar science and transfer unique operational and logistics know-how to that new generation. As a mother, I am excited by the education efforts centered on the IPY that are aiming to bring fun into math and science so that we can get our kids on track and capable of competing in the global economy. The findings from IPY and the observation networks that result will help to prepare the people of the north for adapting to what appears to be inevitable change. The findings should help provide guidance for further resource development possibilities in the north under a changing climate. IPY research will provide data with which to assess environmental base line conditions and future change. The IPY data set should also advance our knowledge of past conditions on earth and improve the basis for predicting future perturbations. Finally, a firm commitment by the U.S. to the 2007–2008 IPY will demonstrate to the world that the U.S. is capable and willing to play a leading role in assuring the quality of our collective future.

BIOGRAPHY FOR KELLY KENISON FALKNER

Date & Place of Birth, Family: March 1, 1960; Lancaster, NH, USA; Married, two children born 13 Sep 95 & 9 Nov 99.

EDUCATION

B.A., Chemistry with Russian minor, Reed College, 1983

Ph.D., Chemical Oceanography, M.I.T./W.H.O.I. Joint Program in Oceanography, 1989

Languages: French & Russian

ACADEMIC POSITIONS

Postdoctoral Researcher, M.I.T., 1989–1990

NATO Postdoctoral Research Fellow, Groupe de Recherche Géodésie Spatiale, Centre National D'Etudes Spatiales, Toulouse, France, 1990–1992

Assistant Professor, College of Oceanic & Atmospheric Sciences, OSU, 1992–1997

Associate Professor, College of Oceanic & Atmospheric Sciences, OSU, 1997–2005

Full Professor, College of Oceanic & Atmospheric Sciences, OSU, 2005–present.

RECENT COMMITTEES, EDITORSHIPS, etc...

NSF office of Polar Programs, Office Advisory Committee, 2005–present

Arctic-Subarctic Ocean Fluxes Science Steering Committee, 2003–present

Associate Editor, Geochimica et Cosmochimica Acta, 2002–2006

UNOLS Arctic Icebreaker Coordinating Committee, 1996–2002

NSF Office of Polar Programs, Strategic Plan for Marine Science in the Arctic, 1998–1999

NSF Office of Polar Programs, Ocean-Atm-Ice Interactions Steering Committee, 1997–2001

RESEARCH INTERESTS

Application of inorganic elemental and isotopic measurements to aqueous geochemical issues

This entails sampling of waters and associated solids of diverse media including snow, ice, rivers, lakes, and the oceans and analysis by state-of-the-art laboratory instrumentation, including ICPMS, TIMS & IRMS. Current projects include tracing origins and pathways of river waters and other water types to characterize the nature and causes of variability in Arctic Ocean circulation and characterizing tributary and main stem Salmon River (OR) chemistry as part of a collaborative study of salmon life history as recorded in their otoliths.

HONORS

National Science Foundation Arctic Service Award, 2000

COAS Student Mentoring Award, 2000

Office of Naval Research Young Investigator Award, 1993

NATO Postdoctoral Fellowship, 1990

Association for Women in Science Predoctoral Award, 1987

National Science Foundation Graduate Research Fellowship, 1984–87

Phi Beta Kappa, 1983

FIELDWORK

Participated in 25 major seagoing, lake and river expeditions, 1981–2006

Served as Chief Scientist on seven of these missions.

REVIEW PANELS

NSERC Site Review Panel for acquisition of ICPMS at UVic, Victoria, BC, January 1994

NSF Chemical Oceanography Panel, July 1993, May 1997 & November 1997

NSERC Earth and Environmental Sciences Grant Selection Committee, 1996–1997

Committee of Visitors to evaluate NSF Office of Polar Programs, July, 2000

RECENT PUBLICATIONS

Taylor, John Ryan, K. Kenison Falkner, U. Schauer, M. Meredith (2003). Quantitative considerations of dissolved barium as a tracer in the Arctic Ocean, *J. Geophys. Res.* Vol. 108, No. C12, 3374, 10.1029/2002JC001635.

Falkner, K. Kenison, M. Steele, R.A. Woodgate, J.H. Swift, K. Aagaard and J. Morison (2005). Dissolved oxygen extrema in the Arctic Ocean halocline from the North Pole to the Lincoln Sea, *Deep-Sea Res. I* 52, 1138–1154.

Woodgate, R.A., K. Aagaard, J.H. Swift, K. Falkner and W.M. Smethie, Jr. (2005). Pacific ventilation of the Arctic's lower halocline by upwelling and diapycnal mixing over the continental margin, *Geophys. Res. Lett.* 32(18), DOI 10.1029/2005GL023999.

Münchow, A., H. Melling and K.K. Falkner (2006) Volume and freshwater fluxes in Nares Strait from observed salinity and velocity fields, *J. Phys. Oceanogr.,* in press.

Falkner, K.K., L. Bandstra, I. Royer, N. Ryckelynck, M. Wetz, D. Zima, R. Collier, B. Hales, F. Prahl, C. Reimers, M. Torres, S.M. Meyers and E. Volk (2005). A chemical study of the Oregon Salmon River Estuary and tributaries, Estuary, in revision.

Woodgate, R.A., K. Aagaard, J.H. Swift, W.M. Smethie Jr. and K.K. Falkner (2006). Atlantic water circulation over the Mendeleev Ridge and Chukchi Borderland from thermohaline intrusions and water mass properties, *J. Geophys. Res.,* in press. *(http://psc.apl.washington.edu/HLD/CBL/Atlanticwaterzigzag paper.html)*

Morison, J., M. Steele, T. Kikuchi, K. Falkner and W. Smethie (2006). Relaxation of the central Arctic Ocean hydrography to pre-1990s climatology, *Geophys. Res. Lett.* 33, L17604, doi:10.1029/2006GL026826.

K. Kenison Falkner, E. Carmack, P. Jones, F. McLaughlin, H. Melling, A. Muenchow, M. O'Brien and P. Strain (2006). Implications of nutrient variability in passages of the Canadian Archipelago and Baffin Bay for freshwater through flow and local productivity, Arctic Freshwater Cycle Special Issue of *J. Geophys. Res. Biogeocsi.,* in prep.

28 additional peer reviewed publications.

COLLEGE OF OCEANIC & ATMOSPHERIC SCIENCES

OREGON STATE UNIVERSITY
Ocean Admin Bldg 104 • Corvallis, Oregon • 97331-5503
Telephone 541-737-3625 • Fax 541-737-2064
Internet: kfalkner@coas.oregonstate.edu

3 October 2006

The Honorable Sherwood Boehlert
Chairman, Science Committee
2320 Rayburn Office Building
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 12th for the hearing entitled "***The Future of Computer Science Research in the U.S.***." In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding I currently receive related to the hearing topic.

- $174,824, #0352984, NSF-OPP Collaborative Research: North Pole Station: A Distributed Long-Term Observatory, Sep 2004-Aug 2007
- $1,333,009, #0230354, NSF-OPP Collaborative Research: Variability and Fluxes through Nares Strait and Jones Sound: A freshwater Emphasis, Jan 2003-Dec 2007

Sincerely,

Kelly K Falkner

Professor Kelly Kenison Falkner

DISCUSSION

Chairman INGLIS. Thank you, Dr. Falkner.

We are expecting a vote on the House Floor soon, but we have got a plan for how we will continue the hearing so that we will keep you all on schedule. And now Ms. Hooley and I can tell everybody in the audience that those pictures really are for real. Those—if I hadn't been there, I am not sure I would have believed the incredible beauty of those pictures, but having been there, I can testify those are really actual shots. You know, they look like they might be staged, sort of like the moonwalk, you know, all that was staged, as you know, as many people in my hometown believed for a long time. Maybe they still do.

But it is—while we were on the ice, I actually had an opportunity to—with Dr. Olsen's help and Tony Gibson's help, to hook up some students in high school science classes with a slideshow of—speaking of pictures, slideshow of shots that I had taken. And we were actually able to interact. They were watching. They were looking at them from a website that we had loaded them up on, and then I was able to go through the shots, rather than telling them what we were doing. It is fascinating to see how interested the students became in that. And they spoke to me afterwards about it. You know. I mean, that—my kids would tell about a friend of theirs who was in one of those science classes who really was very excited about the whole thing. And it is—as you said, Dr. Manahan, there is something about the poles that captivates the imagination.

And so what can we do to—here, in Congress—I will ask Dr. Bement first and then anybody else. What can we do, here, in Congress, to facilitate that, to make sure that that kind of interaction takes place? I know you have plans in place to do that kind of thing, and far better than the shots that I took, I imagine. But—Dr. Bement.

Dr. BEMENT. Well, thank you, Congressman.

Let me say, first and foremost, it is part of our appropriations for 2007——

Chairman INGLIS. Yeah.

Dr. BEMENT.—because even though we have detailed plans in what the other agencies plan to do, what they could actually do will depend on that. But apart from that, I think promoting visibility of IPY within your districts, and especially within the schools is critically important. You know, visits. You have been to the Antarctic, but have you been to the arctic?

Chairman INGLIS. I have not.

Dr. BEMENT. There is a whole range of exciting things that are going on in the arctic and the trans-arctic. Greenland, for example, would be a very interesting place to visit. So getting firsthand experience in what is happening in IPY and then bringing that back, I think, would be critically important.

Chairman INGLIS. Right.

Dr. Manahan, any thoughts on that?

Dr. MANAHAN. Absolutely. I couldn't agree more about that comment that Director Bement made about promoting visibility even within your own districts.

I think this message is just starting to get out that the poles affect, potentially, everybody's lives. Even my mother asks me these questions, and she rarely had asked me questions for 26 years since I have been in America. She called me from Ireland after news broke about possible melting of issues in the north and pushing back the currents and cooling down northern Europe and possibly northern America. It is a speculative model, but it is remarkable how few people seem to be aware of these issues. So—and promoting visibility as much as you can, talking about it in your speeches when you talk with your—anybody in your communities to get the word out, because as you said, people in the Carolinas may say, "Well, is this really affecting me?"

Chairman INGLIS. Right.

Dr. MANAHAN. Yes.

Chairman INGLIS. Other suggestions about ways we can help here, in Congress, to accomplish that? Mr. McCaffrey had the good idea of making sure those posters are in every classroom kind of thing. And maybe make "March of the Penguins" as required viewing or something.

Mr. MCCAFFREY. You know, from my perspective, in kind of the trenches of education, the science education world, a lot of the incredibly talented folks are scrambling for funding. And so I don't mean to come across like we are, you know, desperate for funds, but I do feel , from the research I have done and the people I have talked to, that we have a science education crisis, particularly, I think, at the K–12 level in this country. And some of it has to do with the preparations for teachers. We actually have some exciting plans, for instance, for the National Science Teacher Association meeting this coming March 2007, which is perfect timing for the launch of the IPY to have a number of symposia that NSF and other agencies are organizing in St. Louis that, I think, will actually make a big splash with a lot of the science teachers out there. so if we can continue to leverage those types of events and provide the training and the networking, not just nationally here, but I—to my mind, one of the huge opportunities of this is to have teachers network internationally, along the lines of the Globe Program, which you may be familiar with, that has a network of teachers around the world where the students collect data and then share data among themselves through the Internet. And——

Chairman INGLIS. One suggestion to pass along to you—I was excited to hear you mention the mission list module that—research module. I speak—I presume to speak for Roscoe Bartlett, who was also on the trip. He is a Member of Congress from Maryland. He was asking in Antarctica about the use of more windmills and the use of solar to produce some of the power rather than diesel generators. It would be a neat way, if that is possible, to hook the poles with alternative energy so that it makes it much more interesting that here, in this environment, we are keeping it pristine as much as we can by producing energy from renewable sources. That would be pretty exciting. You have got a lot of wind there and an awful lot of sunshine, at least—well, not now. But I hope that happens.

I see my time is up, but let us see, Ms. Matsui.

Ms. MATSUI. Thank you, Mr. Chairman.

And I want to thank all of the distinguished witnesses today for testifying before us.

And I realize in your testimony that I was probably, as a young person, a beneficiary of the last polar year in the education arena, the emphasis on science and excitement of it. And I would like to see more of that happening, obviously, with this IPY. Young people are very, very interested, and to get them interested in this way is, I think, absolutely fascinating.

To get to a very practical place, I represent Sacramento, California. And after New Orleans, we are now the most at-risk river city, as far as flooding. And so I am doing everything I can, obviously, to protect my constituents. And an essential component of that effort is to understand how global climate change can be affecting the snow melts in the Sierra Nevada Mountains and the weather patterns coming off the Pacific Ocean. And from your testimony, it is clear that IPY has the potential to yield valuable insight for my constituents and for people all over the world. And I do look forward to working with you, because, on a very practical level, I can see now where this particular effort now is going to be really meaningful for people in the community, in essence. I am certainly making an effort. I live at the confluence of two rivers. And we see every day that the weather patterns coming off the Pacific are more intense now. We have more rain now and not as much snow. And as the snow melt comes much faster, we are going to be impacted. So for us, it is certainly something of very much interest.

I would like to ask any of you if past research has actually revealed what happens that polar regions drive, actually, the fundamental processes of the globe and—such as ocean circulation and the early signs of global climate change in high latitudes. How will research, under the IPY, advance understanding of these processes associated with climate change? And are there any particular projects that you have in mind or types of projects that would be enabled by this? I am looking at very practical efforts here, because that is a way to get our constituents and the people of this Nation really, really involved.

Dr. BELL. Maybe I will answer, and then I think Kelly looks like she has something to follow up on.

And one of the things that came out of the planning process of the Academy was this similar sense of concern about environmental change and our ability to monitor it. One of the real goals is to come out of the IPY with two things: one, a better understanding of how the polar environments are changing; and two, the better capability of how to watch them change so that we can both contribute to the models of change and also understand how fast it is happening. So those are sort of the two messages back to you that—both trying to understand the basic physics and the rates and the processes and then putting in place a system so we can see how the poles are changing. We, as scientists, actually have been surprised at how fast the poles and the planet is changing. I mean, my little story is 20 years ago, when I entered graduate school, the debate was whether or not we were going to enter an ice age. It has taken, you know, five to seven years for the community to swing. So we now, as a—fairly uniformly believe that the planet is

changing, and every year, we chock up more information on how the poles are changing, and we realize we haven't been looking at them carefully enough. And that is one of the very fundamental tenets of what we hope will come out of the IPY.

And I think Kelly looked like she wanted to follow this up.

Dr. FALKNER. Yeah. There is an effort within the community to try and assess what the impact of the loss of the ice cover in the north would be, for example. The reason we need to be concerned about that, with respect to the heat balance, is that snow-covered ice reflects the majority of incoming light, and water is a very efficient absorber of that. So you are going to change things fairly dramatically. The work that has been done to date suggests that it will have strong effects on regional climate. I am aware of a study actually conducted in your district by people who pointed out the possibility that the loss of sea ice cover in the Barents Sea, all of the way around the globe, is going to shift storm track patterns in the Pacific north so that Alaska regions would receive more rain and Oregon would become more like Sacramento. And again, there are studies that are focused primarily on regional climate that show, as you say, that the snow pack is diminishing. The timing of our rain will change. These are the things that are in models, and these models will be informed by the activities of the IPY. The physical processes that we are using in these models need to be improved for our confidence levels to go up, and that is a major objective of IPY.

Ms. MATSUI. Okay. Thank you very much.

I have to just say that, for my constituents, and I think people in California, in particular, anyway, is that we are greatly affected by this. And I think, for most of us in California, we understand this, so we are aggressively trying to figure this out. Obviously, in many cases, government works very slowly, but what we are trying to do is incorporate some of the scientific information into policy arenas as much as possible. And as much as you could tailor your projects to look at practical aspects, I think the better it is for all of us as we move forward.

So I really thank you very much. I—would you also like to comment? I am sorry. Do I have enough time or am I——

Mr. SODREL. [Presiding.] Your time has——

Dr. MANAHAN. Mr. Chairman, can I comment?

Mr. SODREL.—expired, but a very short comment.

Dr. MANAHAN. Sorry. Sorry. Sorry.

Dr. BEMENT. Yes. High visibility is a very important issue to understand. We know that the ice sheet in the western Antarctica is beginning to break up. Those ice sheets tend to hold back the movement of land-based glaciers. As those ice sheets break up, the glacier movement accelerates. We know the surface water will penetrate as much as a kilometer down into the ice and will lubricate the movement of glaciers. And we know, as a matter of fact, that glaciers in Greenland, as a result of this effect, are beginning to accelerate. Those are the kinds of mechanisms we need to understand. We need to know what the inter-relationship is near the oceans and lithosphere as well as the ice sheet.

Mr. SODREL. We are trying to keep on schedule while we are also trying to vote, so I am going to yield to myself since we are a little

out of order here, but I will ask a question, because I will have to have leave as soon as the Chairman comes back.

You know, I attended a lot of trade associations when I was in the private sector, and people would say, "Boy, this is a great meeting." Well, you don't know it is a great meeting until you go home and see what develops as a result of the meeting. And my question for you, if I might, is how will you know the International Polar Year has been a success? What would you like to see accomplished? And what is the desired result that you would like to see at the end? And we will start with Dr. Bement.

Dr. BEMENT. Well, first of all, we will understand considerably more about the impact of climate change on the ecology in the arctic and the Antarctic. We will understand more about ocean flow patterns in the Arctic Sea and to the Bering Sea and on into the North Pacific and how that affects fish production, seafood production, in those regions. We will understand more about the impact of global change on the native populations in Alaska and on coastal erosion and also on the thawing of the tundra, which is causing considerable damage not only to housing but also infrastructure. In the Antarctic region, we will understand more about paleoclimate change over two million years. And we will also understand more about the climate patterns that existed over the entire continent. In some parts of Antarctic, the temperature is rising. In other parts, it is cooling. In some parts of Greenland, at least on the margins, we are seeing considerable melting, but in the center of Greenland, we are seeing ice buildup. Those are patterns that we need to be able to model in order to predict better what the volume change of ice melting is likely to be over time. And the work of NASA in helping us understand from space what is happening on the surface of the ice sheet areas compared to what we could measure on the ground will also be critically important.

Mr. SODREL. Dr. Bell.

Dr. BELL. In addition to the important inputs towards understanding the planet and the change and looking at those new frontiers, the other success will be if we stimulate both the scientifically-literate public and the next generation. That is really one of the long-lasting legacies of the previous IPYs and people who went into science because of it and people who were educated at an earlier age. So I think that is the other clear benchmark that we have set for ourselves is the scientifically-literate public and engaging the next generation of leaders.

Dr. MANAHAN. And I think another matrix of success, in addition, I would agree completely with what I have just heard, would be a move towards a more interdisciplinary kind of systems thinking that links life sciences and physical sciences. As you know, for 50 years, those are often in universities in separate buildings. They are separate graduate program, separate undergraduate education. We have to start linking the life and the physical sciences and in between, the chemical sciences, et cetera, and that is going to be, I think, at the graduate level, a very obvious matrix of success if we start to see the emergence of new ways of training the next generation of scientists and engineers.

Mr. SODREL. Yes.

Mr. MCCAFFREY. I would just like to add that, in addition to what Robin was saying about a science-literate society, I think that this is an opportunity for people to gain skills in understanding how science is conducted in terms of how scientists go out and collect data and analyze the evidence and so forth, because I think increasingly people are going to have to become—they are going to have to start making decisions and—along the lines of what Ms. Matsui was saying in terms of her community and her constituents needing more scientific information as they make decisions in their lives. I think IPY is an incredible opportunity for us to kind of demystify how science is conducted. And we know a lot about people's misconceptions in terms of polar regions. People are disappointed to learn that polar bears don't live in Antarctica, for instance. And these types of misconceptions are also an opportunity for us to sort of get them engaged and excited about the science involved.

Dr. FALKNER. I guess I have the last comment here.

I think we will be successful if, when you ask the general public, the majority of them know, by the end of IPY, where Antarctica is, where the arctic is, they don't mix them up, and they know they are very important to the whole global system.

Mr. SODREL. Thank you. The Chairman hasn't made it back. I want—I have only got about five minutes or maybe a little less to get to the Floor, so I would like to call a 10-minute recess, because I am confident that the Chairman will be back in 10 minutes.

Thank you.

[Recess.]

Chairman INGLIS. Let us see. We will resume the hearing now. I am aware that we don't have Ms. Hooley back yet, and she hasn't had an opportunity to ask questions. But while we are waiting for her, maybe I will go ahead and ask a question.

But Dr. Bement, you had something to add.

Dr. BEMENT. Yes. I was looking for an opportunity to tell you about our alterative energy source that is——

Chairman INGLIS. Oh, good.

Dr. BEMENT.—in our plans, and this——

Chairman INGLIS. Yeah.

Dr. BEMENT.—might be a good time.

Chairman INGLIS. Yeah, I—that would be a great time to do it. Please.

Dr. BEMENT. We currently are using wind turbines to power our satellite communications, and we plan to increase that. Now we have, as part of our request for 2007, a planning exercise to extend that type of alternative energy supply to include photovoltaics and also biodiesel. So it is a very active part of our program, and we appreciate your support on that.

Chairman INGLIS. Yeah, what—and what do we need to do make that happen in Congress?

Dr. BEMENT. Well, I think a little bit of hand-holding would help, but we already have a good momentum to make this happen. And of course, it will offset the use of diesel fuel. So this will take place over time, but we are pursuing it.

Chairman INGLIS. Right. Well, I am speaking in for Roscoe Bartlett, who was very interested in whether there are also some ways

to handle waste differently than we are handling it now at the—and perhaps advance systems for dealing with that. Is that—any work being done on that?

Dr. BEMENT. On waste disposal or retrograde, as we like to call it?

Chairman INGLIS. Particularly sewage systems that might be adapted for that environment. He had some thoughts that——

Dr. BEMENT. If I may, I would like to call on Dr. Erb to answer that question.

Chairman INGLIS. Sure.

Dr. ERB. Mr. Chairman, we—as I think you know, we have a very—you probably remember all of the different waste baskets you had to sort trash into.

Chairman INGLIS. Right.

Dr. ERB. And as a result of that, we actually make money on trash. It is so well sorted, that when we bring it back to the States, we can actually sell it. Sewage treatment at McMurdo is done through a—I think it is a three-stage biochemical waste treatment plant. So we are in good shape there. We are well ahead of most other countries and way in advance of what the Antarctic Treaty requires. At the South Pole, we are interested in seeing if we could develop a closed system. Closed systems work in the space station, for example. And what we are looking at is whether we can scale that kind of system up to a system where you have 200 people creating waste.

Chairman INGLIS. Right.

Dr. ERB. So we don't know if we can do that yet. It is something that is on the agenda to continue to look at. Here in the room today, one of the young people in our office, Maggie Kanopp, has been discussing and attended a meeting in Australia last year where she presented what we are doing in McMurdo and talked to other countries, particularly the French, who are also experimenting with this closed circuit system.

Chairman INGLIS. Yeah. And I think Roscoe mentioned—Roscoe Bartlett mentioned composting as a possibility. Is that the kind of system—particularly in the field operations.

Dr. ERB. Yes, in the field operations, that is possible. We have done that in some areas, and that is just a matter of straightforward scale-up.

Chairman INGLIS. Right. For the record, we have been hearing from Dr. Karl Erb, who is Director of the NSF Office of Polar Programs. We thank you——

Dr. ERB. Thank you, sir.

Chairman INGLIS.—for answering that question.

And we are mostly waiting for Darlene Hooley, if she has an opportunity to come back.

But I wonder if, while I was out handling that vote, I wonder if there are other comments that you might want to add that you feel deserve a little amplification.

Dr. Bell, you look like you have something to——

Dr. BELL. Well, I think the—you know, the interesting question is, you know, are there any hurdles out there to keep the International Polar Year from being a success.

Chairman INGLIS. Right.

Dr. BELL. I mean, it has come a tremendous way in the four years since the planning really started in earnest, mostly in the United States and internationally. And when I stand back, I think there seem to be sort of four potential hurdles or things that could be improved, and I thought maybe I would share the——

Chairman INGLIS. Yes.

Dr. BELL.—these with you. First is, NSF is doing a tremendous job in their leadership in putting forward and planning the International Polar Year. But I think it would be—the polar year will be more likely to succeed if the support from the agencies is deeper and broader. I think there could be stronger engagement from more of the agencies.

I think the second one is, clearly, funding. Again, funding at a greater level across the board, beyond NSF. I think it is very clear that those two come together: the engagement of the agencies and the funding specifically for projects within other agencies.

Chairman INGLIS. When you are speaking of "other agencies", you mean, for example, EPA or somebody like that or——

Dr. BELL. The ones that come to mind that I think would—could strengthen their engagement would be NOAA and NASA. Those are the big players that I think would—a stronger engagement, because of the tools they bring to the table, or the potential tools they bring to the table, a deeper engagement would strengthen the outcome.

The third would be I think a little bit more coordination nationally and internationally. It is something that much of this has been done on a shoestring, on both levels, and I think, again, science is very different now than it was in 1950s, or in 1882, when much of it was run by admirals, captains. It was run by the military and it was very top-down. The nature of science today is much—as you know, is much more grass roots. And we are running the balance between how do you have tremendous grass roots efforts and how do make sure you coordinate it to maximize the output. So I think a little bit more coordination.

And the fourth one is one that Dr. Manahan mentioned was the need to continue to foster interdisciplinary research, that that is really what is different about this IPY, and it is something that our society will benefit from when we break down these disciplinary boundaries, and so continuing to look for ways to foster that process, because it is hard. It really is hard for scientists and agencies to talk across those disciplinary boundaries.

So those would be the four things that I think need a little attention or thought.

Chairman INGLIS. Do others want to add something to that?

Mr. MCCAFFREY. I would like to just make a follow-up to Dr. Bell's comments. Within the international EOC Subcommittee, we have been looking at how to try to integrate education, outreach, and communication in new ways, because over the years, those realms have become very specialized and often the public affairs folks at agencies don't necessarily know what the education people are doing. And then the informal education folks working with museums and science centers don't necessarily know what is happening with—in classrooms, for instance. So this, I think, is also an opportunity to be integrating at that level as well.

What Robin just mentioned about the grass roots aspect I think is particularly true in education. And we—at the Poles Together Workshop we held in Boulder last year, there were a number of folks that had been students during IGY who, you know, were retired or were still excited to be involved with planning for the upcoming IPY, and they commented on how different it is now than it was then in terms of just this incredible enthusiasm at the grass roots level. And so whatever we can do to continue to build that community and support that community of, for instance, teachers who—that had been to Antarctica through NSF programs and so forth, we need to really do whatever we can to keep that enthusiasm alive, because people get discouraged. And you know, I think NSF has done an incredible job of providing leadership, and at the same time, there is the reality that 80 percent of the proposals that were submitted did not get funded. So there is more we could do to support these efforts.

Chairman INGLIS. And Dr. Manahan, what do you think about the possibility of using the International Polar Year to somehow reduce the political overtones in the climate change debate? I mean, is this an opportunity to maybe sort of stick to science and sort of turn down the heat on the political side of things and turn up the emphasis and the heat on the science? Could that be an outcome of the International Polar Year?

Dr. MANAHAN. That is a very, very insightful question.

I think you are absolutely right. I think it has to be made clear that the scientific process always involves disagreements and debates. And sometimes it is picked up as being that there is not a consensus. And I think it is fair to say that there is an enormous consensus that the globe is warming. And without getting into the debates about causality, just that it is warmer. And we have to deal with this. And just that step alone, as a sort of a national or an international recognition, I think would be extremely important. The debate about the cause and all of those issues are secondary, but right now, it is warmer, and we have to deal with this. And it is going to require a different level of training of people to see its impact. It is going to be a different kind of science. America has led the world in graduate education for decades and decades and decades, and it will continue to do so if we are very forceful in coming up with new ways to educate at that graduate level, so we will still be this great magnet to attract the best and the brightest, you know, from around the world. I would like to think that I am one of those who was attracted to America for that very reason. And I—and we have a real opportunity to hit two things here: one, to educate people about the scientific consensus; and two, to excite graduate students and younger students to come into the sciences in a very interdisciplinary way.

Chairman INGLIS. Does anybody else want to comment on that?

If not, we are very happy to have been joined by Ms. Hooley.

Mr. MCCAFFREY. Actually, could I just make another brief comment to follow up?

The *Time Magazine* article that Dr. Manahan showed, I think the notion of being very, very worried is not necessarily very effective for young people. Young people want to have the tools. They want to have the insight, and they need the scientific savvy to be

able to understand these very complex issues. You know, when we talk about climate change without understanding climate, I think we are sometimes getting ahead of ourselves. And there are some very, very fundamental issues in terms of just understanding seasonality, you know, what happens over the course of the year in terms of the water cycle and the carbon cycle and how we use energy and so forth that could be outcomes from IPY. You know, we are focusing on the poles where the seasons are very extreme, but we can also use that as an opportunity to just look at the basics of how we live our lives and how we can use simple scientific observations and data to become more sustainable and so forth.

Chairman INGLIS. Yeah. And I would point out that—I am really taking all kinds of license here with the time. I think I have had more time to talk here than anybody else today.

But I point out that one of the strengths of the trip that we took to Antarctica was being able to hear from people, very knowledgeable people, who presented the facts, as they understood them, or the observations that they have taken in a non-hysterical way. Sometimes—well, I won't be—I don't want to be too critical of *Time Magazine*'s cover, but it sort of begins to tend toward hysteria, which causes a reaction among, particularly conservatives, who say, "Wait a minute. Wait a minute. Let us not get hysterical here." But to hear presentations like we heard from Dr. Manahan, very thoughtful presentations with observations that were clear, and I am sure that there are some people that would doubt some of those observations, and there are all kinds of debates about the observations, but the weight seems to be there that the observations are valid and they are worth considering, and therefore, we should be taking some action. And it helps to have it presented in that way. And so to have had that opportunity was a real eye-opener for me and very helpful to my understanding of the issue.

Dr. Bement, do you want to add something to that?

Dr. BEMENT. Yes, I just wanted to comment briefly that there has been a revolutionary change that we have an opportunity now to use very effectively since the last geophysical year in 1957 and 1958. In those days, we could inform the public, but we didn't have the capability to involve the public. Now we can involve the public. We have the Internet. We have I-pods. We have broadband communications. We can bring, in real time, polar exploration into the classroom, and we can involve the children directly in the activities going on, either in Alaska or in Antarctica. That is a dramatic shift in the way we can communicate and communicate broadly across a whole nation.

Chairman INGLIS. Yeah. And you know, it is interesting. I want to get to yield to Ms. Hooley, but since coming back from the trip, a number of times I would be passing through our kitchen, and I would say to my kids, "Let us see what is happening on the webcam." You know. And it is just—I mean, it is fascinating just to turn it on, and they would say, "Oh, that is so cool." You know. And I have kids that are somewhat interested in science, not from their dad, from their mom, but, you know—so, but my interest in the—in being there and showing them the webcam caused them to get excited about Antarctica. So school kids across the country being able to, as you say, Dr. Bement, access the webcam and see

what the weather is looking like right now in Antarctica. Of course, they wouldn't be very interesting pictures right now, but once the sun comes up, there are some great shots.

So now, Ms. Hooley.

Ms. HOOLEY. Thank you, Mr. Chair.

For all of you, I just would like to ask, if we didn't have the International Polar Year, what are some of the research projects or type of projects that wouldn't get done, or would they all get done whether we have it or not?

Anyone want to answer? Go ahead, Dr. Bement.

Dr. BEMENT. The one thing that has happened as a result of IPY is international collaboration and the ability to work on a much larger and higher level of complexity than what would normally be possible. For example, we have an International Trans-Antarctic Scientific Expedition [ITASE], which I believe is involving 19 other nations working collaboratively to understand, at least within the near surface of the ice, what has happened over the last 200 years since the beginning of the industrial revolution in climate change across all of Antarctic, not just in one specific region. We could not have done that before. We have developed new facilities in preparation for IPY that will provide further outreach into regions of Antarctic that would ordinarily not be accessible for ice drilling and for other activities. We will be improving our communications systems on a scale that would not have happened otherwise, not only in the Antarctic, but also in Alaska at their new global change laboratory.

So there are a number of things like this that I don't believe would have happened otherwise.

Ms. HOOLEY. Okay.

Yes.

Dr. MANAHAN. I have a comment that struck me, as you were saying, Mr. Chairman, about it would be—it would not be interesting to look at Antarctica right now, because it is dark. But just remember how many things are going on on planet Earth in the dark. And I think this new initiative of NSF, Life in the Cold and Dark, is an example of some very new thinking about—in stimulating the life sciences to look into this cold, dark biosphere. A number that is in my written testimony that I didn't mention in my oral testimony is that if you look at anywhere where anything can live on planet Earth, some 90-plus percent of it has to live in the refrigerator. And so this is—the most of this planet Earth is cold biosphere. Most of it is cold.

Ms. HOOLEY. Ninety percent?

Dr. MANAHAN. Eighty percent alone is in the deep sea, which is at about two to four Centigrade. Oceanographers have known this for a while. And the link between the poles through the deep sea, it is a huge biosphere. And looking into this dark, cold biosphere in the poles is a great type of program that will understand the cold biosphere, which ultimately, in a cold, dark way that we don't even think about, many that are microbiological processes, they are sustaining life on this planet. And we need to know what they are doing in the dark.

Ms. HOOLEY. Dr. Bell.

Dr. BELL. When you ask, "What would not have occurred without the International Polar Year?", Dr. Bement pointed to a number of

very international programs that wouldn't have happened. But to—what has surprised me, and I think will be a lasting legacy, is how putting this process on the table has opened the doors for meaningful collaboration with places that we wouldn't have been able to collaborate before, so that we would have been going out, very similar to what was happening in the 1880s with territory. We would have been going out and doing our individual science, trying to go places, trying to accomplish our goals, but in fact what this honeycomb that you have seen has produced is a willingness across the world for doors to be opened and conversations to be happening so that we have a greater number of minds working on these problems. And we are actually building a stronger international science community. It is—I hadn't actually anticipated this as an outcome, but I have found, through my own research, I found the doors in China, for example, thrown open where I had not been able to make in roads before.

So to me, that is one of the—it is difficult to point to all of the individual projects, but I think it is the—what we are going to see is the multiplicative effect. We are going to get more off our investment. We are going to learn more, because of the greater number of brains that are being applied, and a variety of approaches.

So I think that is one of the precious nuggets that is going to come out is sort of the enhancement of the science at a level that we wouldn't have seen otherwise.

Ms. HOOLEY. Have you seen other countries willing to put in additional money for this project where, I mean, they may have allocated X amount of dollars but because an International Polar Year they are putting in additional dollars for this?

Dr. BELL. Well, I think that—I mean, certainly, there are the nations that have put in specific allocations for International Polar Year: China, Canada, and the European Union have put in significant new funds for the large scale. I don't have any good examples off the top of my head of, you know, places where individual projects have gotten significant increments, but in terms of the whole umbrella, the—there has been additional investment in the polar sciences.

Ms. HOOLEY. Dr. Bement.

Dr. BEMENT. Well, close to home, Canada has already made a commitment for $150 million for International Polar Year, and they are going to be one of our important partners in the Arctic Exploratory Network, which we are putting together with other arctic nations, such as Sweden, Finland, Denmark, Greenland, Iceland, and Russia, to look at global climate change as part of the search network. And so that will be a collaborative activity that would not, again, have happened otherwise.

Ms. HOOLEY. Yes, Mr. McCaffrey.

Mr. MCCAFFREY. In terms of the education, outreach, and communication aspects of IPY, and referring, once again, to the honeycomb, every single one of these cells on the honeycomb, and some of these are made up of multiple projects, a dozen projects in some cases, they all have their own education, outreach, communications plans and strategies. And then there are 54 programs over here on the side that are specifically education outreach oriented. And none of this would have happened if it weren't for IPY and the collabo-

rative, sort of, incubator that this whole process has provided. The process has not been easy, and certainly not all nations have required people to be involved at the national—at the international level, but for those of us who have participated and had the patience to stay involved, it has led to some unbelievable partnerships that otherwise would never have happened.

Ms. HOOLEY. Yes.

Dr. FALKNER. If I may speak, please. First off, I just want to say it is really obvious to me we have got to get you to the arctic. There is a cam up there that I am part of a party putting out, so if you want to see the weather at the North Pole, you can tune in there, too.

The comment I want to make regarding what we might not have done without an IPY effort is that back in 1995, the arctic science community wrote an open letter that I circulated, I was a signatory of this, saying we are seeing remarkable changes. They look well outside the scope of a highly variable environment, so we are very concerned and we know we need to address this. Now this has evolved to this broad interagency initiative we are calling SEARCH, but the attempt to get SEARCH really going has been more than 10 years in the making. What IPY offers us is the chance to jumpstart what we know we need to do in order to observe the changes in the arctic, which are very dramatic and perhaps, you know, in some sense, more dramatic than what you witnessed in Antarctica.

Ms. HOOLEY. Dr. Falkner, a question. You talked about if you—if IPY is fully implemented as envisioned, that you would see permanent observation networks. Do you see any sign that IPY will not be implemented as envisioned? I mean, is there the money to do it? That is always an issue.

Dr. FALKNER. Certainly, that is true. The level that was informally discussed is—among a board of people looking at this, is a lot larger than what we have on the table. I personally am concerned that, particularly the other agencies, which do have as Robin pointed out, some important components to contribute, are pointing to what they are doing in science and don't necessarily have the means or the commitment to do intensified research at the poles. So I think Robin summarized nicely the concerns about the issues.

Ms. HOOLEY. Okay. Dr. Bement, let me ask you just a quick question.

You are the lead agency. What does that entail? What does that mean?

Dr. BEMENT. Well, we started planning in cooperation with the National Academy of Sciences and Dr. Bell's research board three years ago. In the course of coordinating with the National Academy of Sciences and also with the International Council for Scientific Union, we also had interagency workshops and meetings. I hosted one of those at NSF in order to put all our plans on the table. And we gathered those plans, and we have been working on them since, and you now have an update of what is currently being planned and roughly what the funding is. So that is sort of a snapshot of where we are today, but our planning will continue over the next year.

Also, in the terms of education and public outreach, we have had workshops putting together the information officers of all of the participating agencies to coordinate how best we can communicate the results of IPY to the public and what kind of educational initiatives we should be supporting. That has been very helpful in our planning, and it has also led to a common website on the Internet, which is available to anyone, which will have all of the current outreach and educational activities being planned by all of the participating agencies.

So those are some of the coordination mechanisms we have responsibility for.

Ms. HOOLEY. I have one last question for all of you.

We have got your written testimony. We have asked questions. Is there something that you think we need to hear or know that you just can't wait to get out and we haven't asked you the question?

Yes.

Dr. BEMENT. Just to put the hearing in a longer-term perspective, the International Geophysical Year and the International Polar Year III occurred 50 years ago, and that led to a wealth of data and also a wealth of archived photographs that is still being mined today. So there has been a long-term legacy based on what happened 50 years ago. Our outlet in IPY 2007 is to develop the legacy for the next 50 years, and there will be much more data generated. They will be analyzed in terms of modeling and simulation, trying to get a deeper understanding and be able to develop predictive tools of where our planet is going over the next 50 years. And I think that long-range perspective shouldn't be lost sight of.

Ms. HOOLEY. Dr. Bell.

Dr. BELL. I would like to second that in that I have a paper in review that is using some data that grew out of an IPY project that was never published, so you know—and somewhere this is now new different data that no one has ever had a chance to look at, but it shows you what a legacy this data has, particularly when it is in these places that are so difficult to get to. So I feel very strongly that the legacy of the data is—scientists love data. It is their gems. It is their truth. You know, we may not wear beautiful jewelry, but that is what is our tenet. You know, that is on which we build our results, so the data and the legacy of the data, besides the other important legacy of the people. You know, people like Dr. Bement, who—I believe one of the reasons he went into science and engineering had to do with the lure of International Geophysical Year. So those are the legacies that we look at so preciously.

Dr. BEMENT. I hate to say I was getting my masters degree at the time.

Dr. MANAHAN. I, too, would like to comment on this legacy thing.

It is very important that we don't do this quick-burst, one or two years and then say, you know, "We are done now. Let us move on."

Ms. HOOLEY. Right.

Dr. MANAHAN. I work in a building that I am told there were samples collected on big expeditions in the 1930s that aren't still finally worked up. It is fairly easy, in environmental science, to collect data and samples. It is the workup, as you have heard. And so it might be worth even, you know, calling us to order, if I may

use that phrase, in years to come and say, "Well, where are we five years, 10 years?" There is going to be a huge legacy of data that we have to keep an eye on and not just, you know, cut off the funding support and say, "Good. You went there. You collected it. It is over." Decades and decades of information is going to come out of this.

Ms. HOOLEY. Okay. Thank you.

Mr. MCCAFFREY. Excuse me. I—the legacy, to me, is a huge opportunity, and recently, I read an article that Kevin Wood and Jim Oberland from NOAA put together about the data from the first IPY, and the focus on the arctic that—it is a fascinating, sort of data story, if you will, a narrative description of what went on during the first IPY in terms of the number of stations and how the data were collected. And then they actually do a reanalysis of the data, and, in effect, they create a baseline data set, which was actually never accomplished back in the first IPY, but looking back over 125 years at this reanalysis not only makes a fascinating historical story that I think can help us understand the history of science and technology certainly in the United States and even internationally, but it also is a showcase for how data from many, many years ago that was essentially forgotten about can be resurrected and be very relevant to today's studies.

So I think there are many, many opportunities like that that we can begin to mine.

Ms. HOOLEY. Thank you.

Dr. FALKNER. And I am very much hoping that the IPY serves as a showcase for how we communicate science to the public and how we engage the public. I think there are a lot of creative ideas I am aware of. We don't know specifically which directions we are going in yet, but I think there is a tremendous potential there.

Ms. HOOLEY. Good. Thank you.

Chairman INGLIS. Well, thank you very much to all of you for testifying here today.

Dr. Falkner, I have got to get that webcam address from you so that I can look at it. And Dr. Grossman has just pointed out that the sun will be rising at the other one here soon, I suppose, so I need to go look again at that—at the Antarctica cam.

And I think, Ms. Hooley, that this was an engraved invitation that we got from Dr. Bement to go to the North Pole, don't you think?

Ms. HOOLEY. I absolutely believe that.

Chairman INGLIS. I think that it is one that we should accept as soon as we can.

So I thank you all for testifying. Thank you for the work you are doing.

Ms. HOOLEY. Thank you.

Chairman INGLIS. We are excited about it and we want to help you make it a great success.

Ms. HOOLEY. It is really important.

Chairman INGLIS. Hearing adjourned.

[Whereupon, at 12:00 p.m., the Subcommittee was adjourned.]

Appendix:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Arden L. Bement, Jr., Director, National Science Foundation

Questions submitted by Representative Darlene Hooley

Q1. Has joint planning by the agencies participating in the International Polar Year (IPY) produced a coordinated research agenda with a corresponding budget? What is the total planned federal budget for fiscal year (FY) 2007 in support of IPY activities, by agency?

A1. The National Academies of Science developed broad goals and objectives for U.S. IPY activities. NSF and its sister agencies participate in meetings devoted to discussing their plans for IPY research, education and outreach. For example, several Interagency Arctic Research Policy Committee (IARPC) meetings were devoted to discussing the IPY plans of the federal agencies, as was a workshop at the National Academies of Science.

One major coordinated program is SEARCH, the Study of Environmental ARctic CHange. The IPY focus for this program will be on implementing an Arctic Observing Network (AON). In FY 2006, NSF provided $4 million toward AON. Subject to Congressional approval, NSF will provide up to an additional $6 million toward AON in FY 2007. In this activity, NSF is working primarily with NOAA and NASA, but opportunities are also being explored with DOE and DOI. Network sites are being established, with the U.S. playing a leading role in Alaska, Canada, Russia, and the Arctic Ocean.

NSF will direct $31 million from ongoing programs to IPY, and its FY 2007 budget requests an additional $30 million for IPY.

In recent data calls to other agencies, many indicated that they would contribute on-going Arctic and Antarctic programs to IPY. See, *The International Polar Years 2007–2009—Report on U.S. Federal Agencies' Planning,* submitted with Dr. Bement's testimony at the September 21, 2006 hearing on IPY, and the web site created by NSF as part of its work to coordinate IPY activities among the agencies: *http://www.us-ipy.gov/*. This site includes updates on the various agencies' programs, as well as information on IPY for a general audience, and for scientists and educators interested in obtaining IPY funding from the U.S. Government.

Q2. Did the Administration give any direction through the Office of Science and Technology Policy or the Office of Management and Budget for agencies' funding targets for IPY activities for FY 2007?

A2. While the Administration is supportive of NSF's IPY activities, NSF does not comment on OMB guidance or other predecisional discussions with OMB.

Q3. How will individual research projects be selected and supported? Does each agency do its own proposal reviews or are there joint reviews? Are there any international projects planned with joint reviews?

A3. Merit review is a critical component of NSF's decision-making process for funding research and education projects. Through use of rigorous, competitive merit review, NSF maintains high standards of excellence and accountability. Merit review enables investments in projects that couple the best ideas from the most capable researchers and educators.

NSF and NASA referenced each other's solicitations in their own solicitations. In addition, all participating agencies are communicating about their prospective portfolios, and information about proposals is exchanged so that related projects are properly coordinated.

Countries around the world are actively planning their IPY activities, and the International Council for Science and the World Meteorological Organization are working to provide project integration where appropriate. NSF expects that many proposals will be submitted to NSF by U.S. scientists and to agencies in other countries by scientific collaborators. U.S. program officers will coordinate international programs with their foreign colleagues to determine the proposals that best satisfy merit and IPY criteria. This coordination activity is already beginning to take place between the United States, Canada, and the European Union.

Q4. Dr. McCaffrey raised the concern that, since the National Science Foundation (NSF) declined to fund a U.S. IPY coordinating center for education, outreach and communications activities, teachers are without a point of contact for information on IPY and researchers are without a point of contact for sharing their research outcomes with educators and the public. Why did NSF not support a coordination center for this purpose?

A4. Scientists and educators proposing education and outreach activities to NSF need to convince a panel of their peers that they have effective outreach plans. NSF is committed to supporting the most meritorious proposals, whether for scientific research or for education and outreach. Where possible, NSF program officers work to build ties between grantees where these would enhance the overall outreach effort for the program, and NSF has initiated a series of meetings among federal agency outreach officials to coordinate our various outreach efforts.

NSF is highly committed to its mandate to educate the Nation's future scientists, engineers, and mathematicians. NSF is planning a new IPY solicitation in FY07, and we remain open to the possibility of funding a high quality and well-reviewed proposal for an IPY coordinating center for education.

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