Witness The

ARCTIC

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Arctic Climate Change: Where Reality Exceeds Expectations

By Mark C. Serreze

This article is adapted from the Nye Lecture I delivered in December 2007 during the American Geophysical Union (AGU) Annual Meeting; it outlines the evolution of my personal thinking on the issue of arctic climate change and in particular my confidence in attributing its cause to human activities. I am grateful to the entire arctic research community for their contributions to the development of these ideas and to the AGU Cryospheric Focus Group, which sponsors the Nye Lecture Series. The complete lecture can be viewed at www.agu.org/webcast/fm07/.

Recognition that the Arctic was in the midst of widespread change began to emerge in the mid and late 1990s. From work by Bill Chapman and John Walsh of the University of Illinois and Jim Hurrell at the National Center for Atmospheric Research (NCAR), it became clear that northern Eurasia and North America had experienced substantial warming since about 1970, largest during winter and spring and partly compensated by cooling over northeastern North America (see figure this page). Mark Dyurgerov and Mark Meier of the University of Colorado showed that the mass balance of arctic glaciers had become persistently negative, paralleling a global tendency. Other studies were finding increased plant growth in the Arctic, northward advance of the treeline, and an increased frequency of forest fires. Vladimir Romanovsky and Tom Osterkamp of the University of Alaska Fairbanks found that Alaskan permafrost was warming and locally thawing. Similar changes seemed to be emerging in Russia. While Seeyle Martin and Ignatius Rigor of the University of Washington (UW) and others documented the first hints of warming over the Arctic Ocean, growing evidence from satellite records indicated a decline in arctic sea ice extent. Members of the oceanographic community, including Jamie Morison and Mike Steele of UW, Eddy Carmack of the Department of Fisheries and Oceans Canada, Bert Rudels, then at the University of Hamburg, along with many others, established that increasing warm waters were entering the Arctic Ocean from the Atlantic.

In 1999, I started writing a review paper with nine co-authors spanning many disciplines that tried to collate this emerging evidence of arctic change and make some sense of it. The paper was published a year later in the journal *Climatic Change*. Our conclusions on the cause of the observed changes were a bit guarded: "Taken together, these results paint a reasonably coherent picture of change, but their interpretation as signals of enhanced greenhouse warming is open to debate". I was sitting on the fence.

Sitting on the Fence

The second assessment of the Intergovernmental Panel on Climate Change (IPCC) came out in 1995, giving strong support for a role of anthropogenic activities on observed global warming over the previous 50 years. Simulations from even the earliest global climate models had projected that the effects of loading the atmosphere with greenhouse gases would be seen first and be especially prominent in the Arctic, largely due to feedbacks involving the loss of sea ice and snow cover. The issue in my mind was not whether these projected changes

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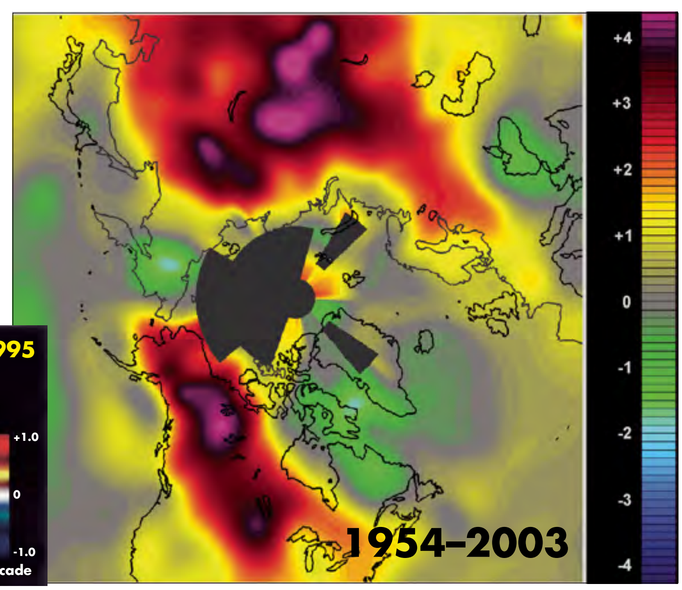

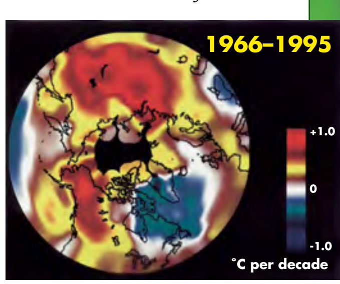

A comparison of the observed trends of arctic winter mean temperatures from 1954–2003 (main figure) and 1966–1995 (inset). The data available when we wrote our review in Climatic Change *(inset) showed temperature anomalies of 1–2 °C, while the more recent data show anomalies up to 4 °C in some areas. Figures by Bill Chapman and John Walsh.*

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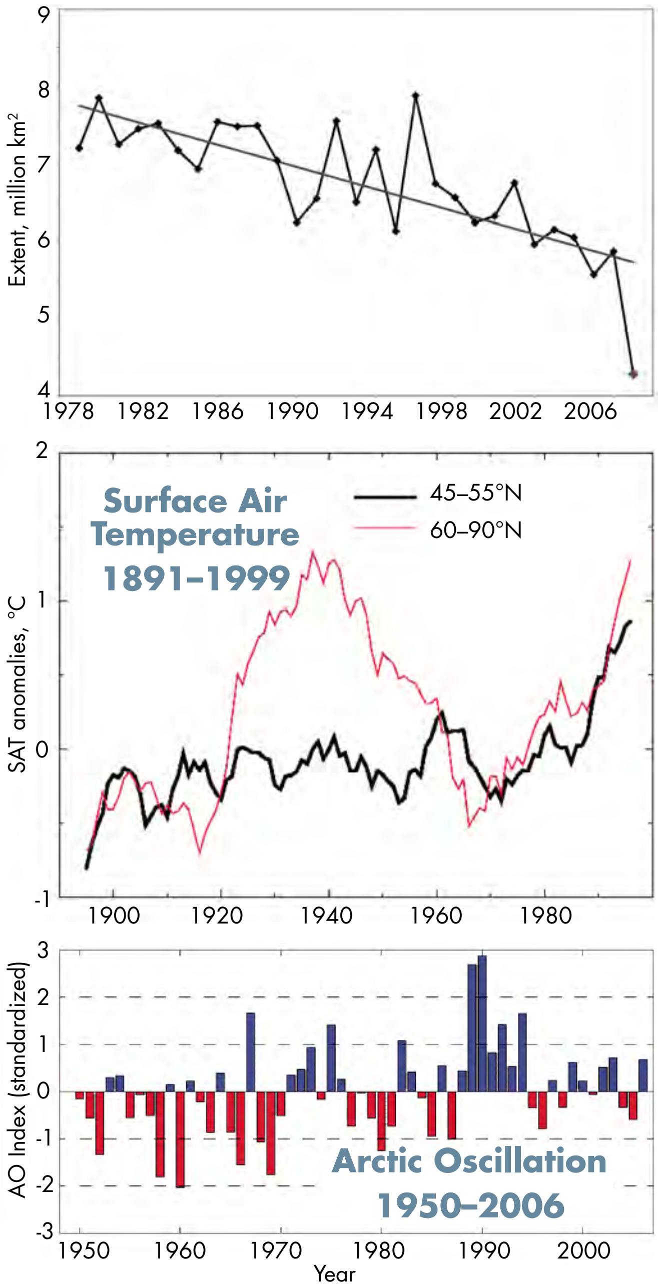
would eventually be seen in the Arctic, but rather whether they had emerged from the “noise” of natural climate variability. It was not clear to me that they had.

As noted in our *Climatic Change* paper, attribution of change had to acknowledge that many environmental records in the Arctic were rather short (e.g., satellite-derived sea ice extent, which starts in 1979 [see figure this page, top]), of uncertain quality (e.g., changes in forest fire frequency), or provided only limited spatial coverage (e.g., borehole measurements of permafrost temperature or oceanographic surveys). Over land, we had at least a rough idea of surface air temperature variability over the past 100 years or so. It was very clear from this record that natural variability is especially prominent in the Arctic. For example, the strong warming since about 1970 for high-latitude lands as a whole, while impressive, looked to be no larger than a period of warming that occurred between about 1920 and 1940 (see figure this page, center). The satellite-based record of sea ice extent showed downward trends in almost all months, but the time series, while short, also was very noisy.



Top: September ice extent from 1979 to 2007 shows an obvious decline, but the trend was less evident before 2000 (unshaded), when we published our review in Climatic Change. *The September rate of sea ice decline since 1979 is now approximately 10% per decade, or 72,000 km² per year. Figure from the National Snow and Ice Data Center.*

Center: Mean wintertime surface air temperature anomalies at 45–55°N (black line) compared to 60–90°N (red line) for the period 1891–1999. Figure by Ola Johannessen.

Bottom: Time series of the annually averaged Arctic Oscillation Index (AO) for the period 1950–2006, based on data from the National Weather Service Climate Prediction Center website (www.cpc.ncep.noaa.gov). Courtesy of Ignatius Rigor.

Furthermore, as first articulated in a brace of papers by Jim Hurrell, much of the terrestrial warming in recent decades could clearly be linked to a positive tendency in the winter phase of the North Atlantic Oscillation (NAO), a large-scale pattern of atmospheric variability linking the strengths of the semi-permanent cells of sea level pressure known as the Icelandic Low and Azores High. In 1998, a paper led by David Thompson, then a UW graduate student, argued that the NAO could be viewed as a regional manifestation of a more fundamental “mode” of atmospheric variability termed the Arctic Oscillation (AO). Thompson’s paper generated a new paradigm—that arctic environmental change and the behavior of the AO are intimately tied to each other. For example, while helping to explain recent warming, changes in atmospheric circulation related to the upward trend in the AO could also be linked to the decline in sea ice extent, changes in ocean circulation, as well as regional trends in precipitation.

Given clear links between emerging environmental changes and the behavior of the AO (or NAO, depending on one’s point of view), there was arguably no reason to invoke a prominent anthropogenic influence. On the other hand, paleoclimate reconstructions by Jon Overpeck, then at the National Oceanic and Atmospheric Administration Paleoclimate Program, and colleagues suggested that the late 20th century Arctic was the warmest of at least the past 400 years (see *Witness* Spring 1998). The upward trend in the AO also seemed suspiciously prominent in comparison to the available century-long record (the record of the NAO index extends back to about 1870). Could it be that the trend was not entirely of natural origin, but was forced by increasing carbon dioxide concentrations, or perhaps even decreases in stratospheric ozone? A flurry of modeling studies tried to test these hypotheses. Some simulations offered support, while others did not.

Evolving Thought

The 2001 IPCC Third Assessment Report featured updated analyses of global climate forcings, observed changes, and simulations based on improved global climate models. Evidence for a human role in global temperature rise over the instrumental record was now overwhelming. Meanwhile, in the arctic community, the AO paradigm was beginning to show some cracks. As was frequently pointed out, from peak positive values in the late 1980s to mid 1990s, the winter index of the AO had regressed and began bouncing between positive and negative states (see figure this page, bottom). Spatial patterns of surface air temperature anomalies changed, but the basic path continued to be one of warming. Sea ice extent continued to decline but seemingly at an accelerated rate. September

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of 2002 set a new record minimum. Ice extents in both September 2003 and 2004 were barely higher.

I remember telling myself that if the AO regressed and we still saw the Arctic stay on a basic warming trajectory, I would get off the fence and accept that the effects of greenhouse gas loading had emerged in the Arctic. It was probably by the end of 2002 that I climbed off for good. While natural variability in the system was obviously a very strong player, and always would be, the evidence of an emerging influence of external forcing was impossible to deny, at least to me.

There was nevertheless some room for lingering doubt. In 2004, Ignatius Rigor and Mike Wallace of UW provided convincing evidence that the sea ice cover was exhibiting a lagged response to the past positive phase of the AO. Their basic argument was that when the AO was in its strongly positive phase, altered wind patterns acted to flush some of the Arctic's store of thick, multi-year ice into the North Atlantic via Fram Strait. This left the Arctic with thinner ice, more prone to melting out during summer. These results reinforced the idea to me that the sea ice decline could be explained without attribution to external forcing. Through the mid and late 1990s, ice loss could be attributed to the positive trend in the AO. The sharp ice losses in more recent years, in turn, simply represent a lagged response to the AO. This, of course, assumed no influences of increasing greenhouse gas concentrations on the behavior of the AO, an issue that even today is unresolved.

I recall being strangely relieved after reading a paper by Drew Rothrock and Jinlun Zhang of UW in 2005. On the basis of simulations with a coupled ice-ocean model, they argued that while this flushing mechanism was the dominant driver of declining ice thickness and volume from the late 1980s through the mid 1990s, the ice response to generally rising air temperatures was more steadily downward over the study period (1948–1999). In other words, even without the AO forcing, ice thickness still would have declined, just not as rapidly as observed. Subsequent studies reinforced this view.

The Future is Today

By the publication of the IPCC Fourth Assessment Report in 2007 (IPCC AR-4), a growing human imprint on global temperature change was inarguable (see figure this page). The Arctic Climate Impact Assessment (ACIA), published two years earlier in 2005, served to emphasize the outsized impacts of global warming expected in the Arctic. Current research is starting to move beyond just figuring out why the Arctic is changing to understanding why it is changing so darned fast.

September ice extent reached another new record low in 2005, an event which generated much attention in the media. In 2007, I had the honor of co-authoring an intriguing paper led by Julienne Stroeve, my colleague at the National Snow and Ice Data Center. Our key conclusion was that while essentially all of the IPCC AR-4 models simulate declining September ice extent over the period of observations (1979–2006), pointing convincingly to a role of greenhouse gas forcing on the observed trend, the observed trend is considerably larger. We seem to be at least 30 years "ahead of schedule"—could this apparent acceleration simply reflect an especially strong role of natural variability on the observed decline? Along with the known imprints of the AO, there are other effects to consider, such as changes in ocean heat transport into the Arctic from both the Atlantic and Pacific. As pointed out by Jennifer Francis of Rutgers University, changes in cloud cover seem to be important. While it is possible that aspects of natural variability have lined up in just the right way, the evidence points more strongly towards the models being too conservative regarding sensitivity of the sea ice to the enhanced greenhouse effect.

That paper was written before the remarkable events of summer 2007. By the end of July, it was clear that a new record low in sea ice extent was in the making. Monthly mean ice extent for September 2007 was 23% below the previous record of September of 2005, an area correspond-

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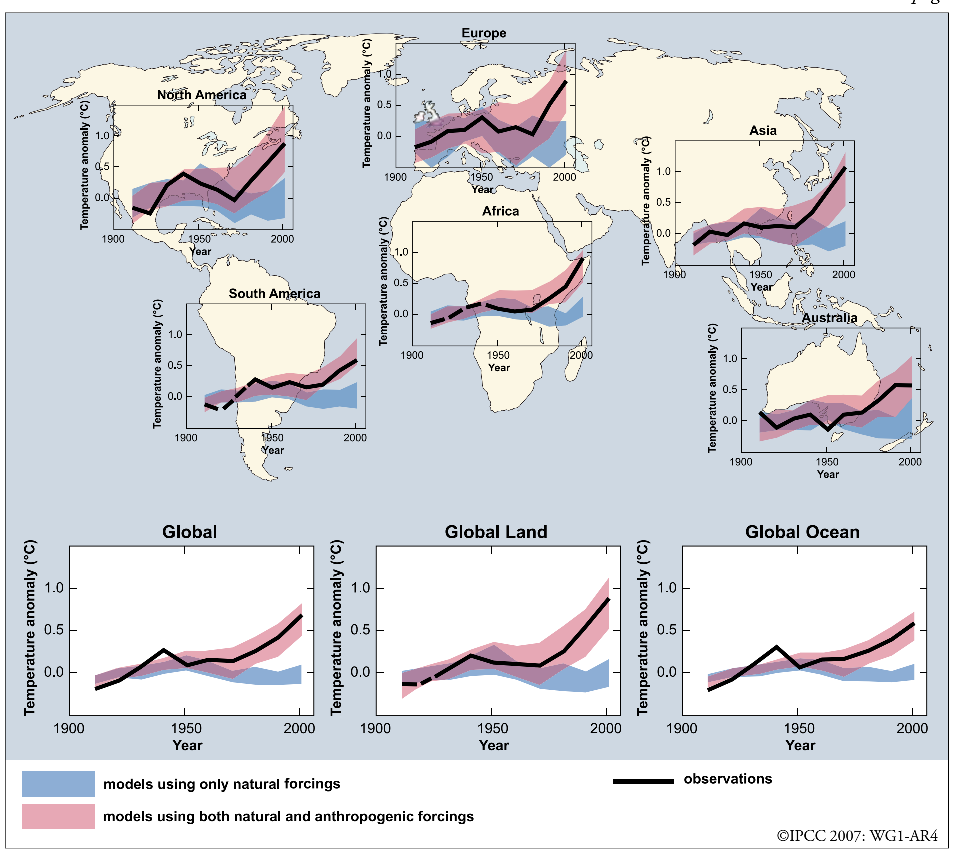


20th century observed temperature changes (black lines) in comparison to 90% of recent model simulations including both natural and human factors (red) or including only natural factors (blue) This figure increased my confidence both in the accuracy of our models and in the attribution of climate warming to anthropogenic causes. Figure © he Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR-4), 2007.

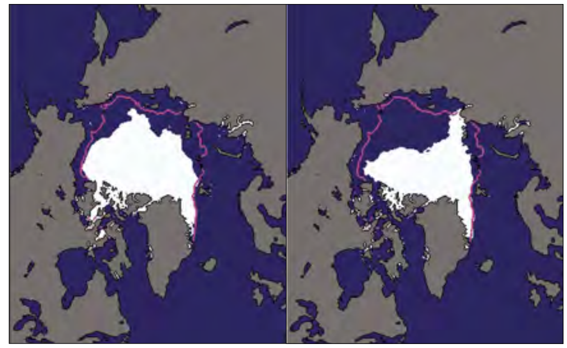
ing to the size of Texas and California combined (see figure this page, above). Based on an extended time series, ice extent in September 2007 was 50% lower than values in the 1950s and 1970s.

A seemingly ideal atmospheric circulation pattern accentuated the summer ice loss—a pattern that both pumped warm air into the Arctic and promoted sunny skies. Without this pattern, the ice loss would certainly not have been as severe as observed. It also is likely that had the same atmospheric pattern set up 25 years ago, it would not have had nearly the same impact, for the ice was considerably thicker back then. What seems to be emerging in recent years is that atmospheric patterns that formerly helped to preserve sea ice do not seem to be as effective as they used to be, and patterns that used to promote summer ice melt seem to be more effective in doing so. This is just what one would expect with a growing external forcing helping to thin the ice cover.

Rises in surface air temperatures through the 21^{st} century are projected to be especially pronounced over the Arctic Ocean during the cold season. This arctic amplification reflects the loss of sea ice cover, allowing for strong heat transfers from the ocean to the atmosphere. In October 2007, surface air temperatures showed very large positive anomalies (10–12 °C) over areas of the Arctic Ocean experiencing record sea ice loss. While particularly salient in 2007, this basic pattern of autumn warming has been emerging over the past seven years or so. Arctic amplification seems to be here, but like the sea ice loss that drives it, it is ahead of schedule.

Could we lose the summer sea ice cover as early as 2030? This no longer seems completely unreasonable, and some in the community think that 2030 may be overly optimistic. The growing recognition that the sea ice system may be close to a "tipping point" comes from modeling simulations led by Marika Holland of NCAR—if the ice thins to a more vulnerable state, a "kick" associated with natural variability can result in rapid loss of the remaining ice cover through the ice-albedo feedback. Might 2007 have been the kick that sets the rapid ice loss in motion? Might instead natural variability stabilize the ice cover for awhile? We will only know in hindsight. The simulations suggest that conditions are ripe for a "tipping point" once the spring ice thickness averaged across the Arctic Ocean thins to about 2.5 m, close to the value estimated for spring 2007 from IceSat, NASA's satellite altimeter system. In one of the model simulations, the tipping point occurred in 2024 when 1.8 million km^2 of ice was lost (see figure this page, below).

Over land, formerly treeless, windswept tundra continues to transition to shrub vegetation. Permafrost continues to warm and thaw. Extent and intensity of summer surface melt over the Greenland Ice Sheet, assessed since 1979 via satellite, has shown a general upward trend. According to work by Tom Mote of the University of Georgia and Marco Tedesco of City College of New York, the intensity of surface melt set a new record in summer 2007. This would perhaps be just another interesting indicator of a changing arctic if not for growing evidence that some of this water is finding its way to the base of large glaciers that drain the ice sheet, literally lubricating them and fostering increased iceberg discharge to the North Atlantic. This process, largely unanticipated a decade ago, raises concern that projections of sea level rise through the 21^{st} century are too conservative.



Minimum September sea ice extent in 2005, the previous record low (left), compared to the new record set in 2007. Pink line indicates median ice edge from 1979–2000; the long-term average minimum over this period is 6.74 million km^2, about 2.61 km^2 more than the 2007 minimum. Figures from the National Snow and Ice Data Center.

We have long known that the Arctic would be the first place to see the fingerprints of greenhouse warming. This was projected in even our earliest climate models. What has caught us by surprise is the pace of change. In many ways, the projected future of the Arctic is today. ■

Mark Serreze is a Senior Research Scientist at the National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder.

Further Reading

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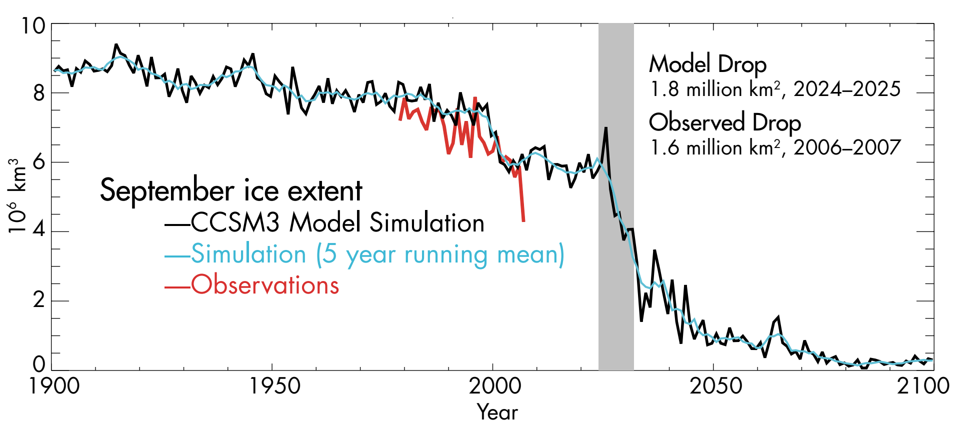


Observed September sea ice extent (red line) compared to a simulation by the Community Climate System Model version 3.0 (CCSM3; black and blue lines). The observed drop between 2006 and 2007 is eerily similar to the drop between 2024 and 2025 in this simulation, which was followed by rapid loss of most of the remaining ice cover (shaded). Figure by Marika Holland.

CH2M HILL Polar Services Supports IPY "Pulse of Activity"

As the primary logistics contractor to the NSF arctic research effort, CH2M HILL Polar Services (CPS, formerly VECO Polar Resources) has supported a multitude of scientists studying the North during the fourth International Polar Year (IPY). In 2007 alone, a total of 152 research projects, comprising 185 individual grants and 280 investigators, received CPS services at 153 different field locations.

These numbers reflect a 20% increase in the number of projects and a 33% increase in the number of sites supported by CPS over the totals for 2006, a clear indication that the "pulse of activity" promised by IPY organizers has produced a corresponding pulse for arctic support providers. The IPY shifted the characteristics of many of the experiments CPS supported as well: the projects were larger in scope and complexity and included many more sites and a larger number of collaborating investigators, many of whom were from institutions outside the U.S.

A Greenland-based geodetic network installation led by The Ohio State University's Michael Bevis exemplifies this trend. The NSF-funded network is part of the U.S. contribution to the international Polar Earth Observing Network consortium, an IPY-endorsed effort by more than 20 nations to improve geophysical observations of Earth's polar regions, largely using autonomous platforms.

Bevis joins colleagues from the Danish National Space Center and the University of Luxembourg to construct a network of up to 38 continuous Global Positioning System stations ringing Greenland's perimeter. This network, called G-Net, will measure the ice sheet's mass balance and the phenomenon of post-glacial rebound—how much Greenland's land mass rises in response to reduction in the ice sheet's weight as it loses mass due to melting.

In 2007, the researchers hopscotched along sections of Greenland's perimeter, waiting out foul weather and competition for helicopter resources to install 23 of their instruments along some of Greenland's most remote coastline. They returned to conduct maintenance on existing stations and to install more this summer. In 2009, they will complete the network, again with CPS logistics assistance.

In addition to providing direct support to IPY science, CPS also experienced a significant pulse of activity around research infrastructure development. During 2007, CPS established the Temporary Atmospheric Watch Observatory at Summit Station, the NSF-managed science facility on the apex of the Greenland Ice Sheet. In spring 2008, CPS added facilities to support flux-type measurements of atmospheric constituents at Summit Station as well. Flux observations are extremely sensitive to turbulent disturbance and require that instruments be housed underground with an adjacent tower for mounting the sampling inlets. After working with stakeholders to identify immediate needs and long-range possibilities, CPS built the facilities to the specifications of the Summit research community.

The National Oceanic and Atmospheric Administration (NOAA) is an occupant of the new observatory. Having taken atmospheric measurements at Summit since the mid 1990s, NOAA added a gas chromatograph to its instruments at the station. The gas chromatograph complements similar instruments at NOAA baseline observatories in Barrow, Alaska, at the South Pole, and at several lower-latitude locations. Its hourly measurements provide information on concentrations and seasonality of trace greenhouse gases over the Arctic originating from Europe and North America.

To reduce Summit Station's reliance on fossil fuels, CPS worked with NSF and industry experts to launch several operational projects during the IPY. In 2007, the station's fuel use shrank by 20% due to conservation efforts, operational efficiencies, and power generated from a new wind turbine. A traverse launched from the coastal Thule Air Base in 2008 was successful in reaching Summit Station, signaling the potential for overland transportation to reduce the substantial costs associated with supplying the station by air.

While CPS support to arctic research projects continued, CPS staff also adjusted to the 2007 purchase of VECO Corporation by CH2M HILL, a large environmental and engineering consulting services firm based in Denver, Colorado. As part of the purchase, CH2M HILL assumed the NSF arctic logistics contract.

For more information, see the CPS website: www.polar.ch2m.com, or contact Kip Rithner (kip@polarfield.com). ■

Pat Haggerty Joins Arctic Section

In June 2007, Patrick Haggerty joined the Division of Arctic Sciences as program manager for the Arctic Research Support and Logistics (RSL) program (see pages 5–6). From 2004–2007, Haggerty provided program management support to the OPP Division of Antarctic Infrastructure and Logistics through a Systems Engineering and Technical Assistance (SETA) contractor. Haggerty worked for Holmes & Narver, Inc., for 26 years, much of it dedicated to the NSF Antarctic program. He took his first Antarctic assignment, as the Assistant Station Scientific Leader at Byrd Station, in 1970, and he has since been involved in most infrastructure projects undertaken by the U.S. in Antarctica. Haggerty earned a Masters in Project Management from George Washington University in 1998.

Haggerty co-manages the RSL Program with associate program manager Renee Crain. He oversees the contract with CH2M HILL (see this page), facilities management issues, the developing overland traverse for Greenland, and the multi-national Lake El'gygytgn core drilling project in eastern Russia. Renee works closely with project level support and manages the OPP cooperative agreements with ARCUS, Toolik Field Station, and the Barrow Arctic Science Consortium (see *Witness* Spring 2007).

In other OPP personnel news, glaciologist Jane Dionne retired as Arctic Natural Sciences (ANS) program manager effective January 2008; Dionne has served ANS since 1998. Janet Intrieri, associate program manager for Arctic System Science, left OPP in May 2007 to return to the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory. A search for their replacements is underway. ■

Federal Groups Identify Options for Aging Icebreaker Fleet

At a time of increasing international interest and activity in arctic waters, recent reports and testimony indicate concerns about the status of the U.S. Coast Guard (USCG) fleet of polar icebreakers. The fleet, whose missions include supporting polar research as well as defending U.S. strategic interests, consists of three ships:

- USCGC *Healy*, commissioned in 1999, primarily used for arctic research,
- USCGC *Polar Sea*, commissioned in 1978 and extensively repaired in 2006, and
- USCGC *Polar Star*, commissioned in 1976 and in caretaker status since 2006.

A 2007 National Research Council (NRC) report, *Polar Icebreakers in a Changing World* (see *Witness* Spring 2007) warned that the "U.S. icebreaking capability is now at risk of being unable to support national interests" and recommended that the U.S. build two new polar icebreakers to be operated by the Coast Guard.

A 2008 report from the Congressional Research Service (CRS), *Coast Guard Polar Icebreaker Modernization*, builds on the NRC report to outline cost estimates for four options for modernizing the fleet:

- Build one or two new icebreakers with a 30-year service life ($800–935 million each over 8–10 years);
- Extend the service lives of *Polar Sea* and *Polar Star* by 25 years ($400 million each);
- Reactivate *Polar Star* for 7–10 years ($57 million); or
- Reactivate *Polar Star* for one deployment ($8.2 million).

In a 2008 memorandum for the Joint Chiefs of Staff, the commanders of the Pentagon's Pacific, Northern, and Transportation commands describe icebreakers as "essential instruments of U.S. policy in the polar regions" and recommend building new polar icebreakers, keeping "existing icebreakers viable until the new ships enter service," and adequately funding USCG operations.

In his July 2008 testimony before the House Subcommittee on Coast Guard and Maritime Transportation, NSF Director Arden Bement emphasized that "polar research depends heavily on ships capable of operating in ice-covered regions, either as research platforms in the Arctic and Southern Oceans or as key components of the logistics chain supporting on-continent research in Antarctica." Bement's testimony is available at www.nsf.gov/about/congress/110/alb_transportation_071608.jsp.

In FY2006 Congress transferred budget authority for polar icebreaking from USCG to NSF as the primary U.S. user of these services. NSF provided USCG about $54 million for icebreaker operations and maintenance in 2007.

NSF Plans and Activities

Since the 1970s, *Polar Sea* and *Polar Star* have broken ice to ensure that logistics supplies can reach the main U.S. Antarctic Program hub at McMurdo station. Since 2004, however, NSF has chartered foreign icebreakers to lead or assist this mission; chartering costs have varied from $4.1–9 million. In 2007, NSF began a five-year cooperative arrangement with the Swedish Polar Research Secretariat and Swedish Research Council that allows the Swedish icebreaker *Oden* to break a channel into McMurdo and provide 20 dedicated science days for as many as 32 investigators.

Polar Sea stood by to support *Oden* in early 2008 but was not needed. In April 2008, *Polar Sea* supported law-enforcement activities in the Gulf of Alaska and science of opportunity for the National Oceanic and Atmospheric Administration (NOAA). *Polar Sea* returned to the Arctic in October 2008 for a six-week patrol and training cruise. While *Polar Sea* remains on indefinite standby to assist other vessels if needed, the FY 2009 NSF budget request no longer includes the $3 million needed to keep *Polar Star* in caretaker status.

Following four cruises for the Bering Ecosystem Study (BEST; see page 12) in 2007 and 2008, *Healy* will support two BEST cruises from March to May of 2009. After several busy seasons, *Healy* will have reached the USCG limit on days away from home port, so will spend part of summer 2009 in Seattle and return to the Arctic to support survey work on the Extended Continental Shelf for the Law of the Sea Treaty submission. The summer 2009 BEST cruise will be aboard the R/V *Knorr*. In October 2009, *Healy* will undergo extended dry dock maintenance, which is scheduled every three years, and a new multibeam system will be installed before she returns to service in May 2010.

Coast Guard Plans and Activities

Under the FY 2008 Appropriations Act (PL 110-161), Congress directed USCG to assess its ability to meet current and projected polar mission requirements and evaluate how to adapt or enhance current capabilities for future needs. According to the CRS report, the USCG has begun initial studies but is awaiting a revised U.S. national policy in the polar regions; released in January 2009, the updated U.S. arctic policy calls for the nation to "assert a more active and influential national presence to protect its arctic interests."

USCG Commandant Thad Allen and Department of Homeland Security (DHS) Secretary Michael Chertoff visited the Alaskan Arctic in August 2008; USCG announced increased operations in the region in September, including patrols by two high endurance cutters extended from the Bering into the Beaufort and Chukchi Seas and biweekly surveillance flights along the Chukchi coast by Hercules aircraft.

Congressional Actions

In April 2008, the House passed the Coast Guard Authorization Act, which calls for DHS to assess the need for additional USCG presence in high latitude regions. The Senate version of the bill authorizes acquisition or construction of two new icebreakers and bringing all vessels to full operational capability. The FY 2009 USCG budget requested $30 million to restore *Polar Star* to operational status, and the FY2009 DHS appropriations bill (S. 3181) includes $6.28 billion for the Coast Guard but not funding for new vessels. A 2008 House Appropriations Committee report (House Report 110-919) directs NSF and USCG to include operations and maintenance funding in the FY 2010 USCG budget request and develop a new joint plan for USCG support of scientific research.

For more information, contact Sue Lafratta (slafratt@nsf.gov) or Lisa Mack (Lisa.K.Mack@uscg.mil). ∎

President Bush Announces New USARC Commissioners

In July 2008, President Bush announced the appointment of three new members to the U.S. Arctic Research Commission (USARC)—Helvi K. Sandvik, Virgil (Buck) Sharpton, and Warren Zapol—and the reappointment of Michele Longo Eder and Charles Vörösmarty to second four-year terms.

Helvi K. Sandvik is president of NANA Development Corporation, which is part of NANA Regional Corporation, one of the 13 Alaska Native Regional Corporations created under the Alaska Native Claims Settlement Act of 1971. Sandvik was previously vice president of operations and of resources for NANA. Originally from Kiana, a village in northwest Alaska, she joined the corporation in 1995 after 12 years with the State of Alaska Department of Transportation and Public Facilities. Sandvik received a B.A. in Economics from Kalamazoo College in Michigan and a M.A. in Business Administration from the University of Alaska Fairbanks (UAF). She currently serves as chairman of the Seattle Branch of the Federal Reserve Bank of San Francisco.

Virgil L. (Buck) Sharpton, vice chancellor for research at UAF, joined the faculty in 1998 with a joint appointment at the Geophysical Institute (GI) and the Department of Geology and Geophysics. Responsible for setting the research agenda at UAF, he oversees the Center for Research Services, GI, International Arctic Research Center, Office of Electronic Miniaturization, Institute of Arctic Biology, and various other research programs. Prior to joining UAF, Sharpton was senior staff scientist at the Lunar Planetary Institute affiliated with the NASA Johnson Space Center, where he served for 14 years. He was a postdoctoral fellow at the Geological Survey of Canada from 1984 to 1986. Sharpton obtained a Ph.D. and M.S. in Geological Sciences from Brown University in 1984 and 1981 respectively and a B.S. with high honors in Geology from Grand Valley State University in 1979.

Warren M. Zapol, Emeritus Anesthetist-in-Chief at Massachusetts General Hospital (MGH) and the Reginald Jenney Professor of Anesthesia at Harvard Medical School, joined the MGH Department of Anesthesia in 1970 as a first year resident and served as chief from 1994 to 2008. He is a native of New York and a graduate of the Massachusetts Institute of Technology and the University of Rochester School of Medicine. He studies acute respiratory failure in animals and humans and has learned how free-diving seals avoid the bends and hypoxia (low levels of oxygen). In 2003, he was awarded the Intellectual Property Owners Association's Inventor of the Year Award for the treatment of hypoxic human newborns with inhaled nitric oxide, a life-saving technique that he pioneered. Zapol is a member of the Institute of Medicine of the National Academy of Sciences.

Michele Longo Eder is an attorney in Newport, OR, whose practice emphasizes marine and fisheries law and business law, representing commercial fishing businesses and their associations. A graduate of Johns Hopkins University in Baltimore, MD, Eder moved to Portland, OR, in 1976 to attend Lewis and Clark Law School, receiving her J.D. in 1979. In her tenure with USARC, Eder has focused on fishery management and marine ecosystem information needs, as well as on arctic human health matters. She serves as a member of the Groundfish Allocation Committee of the Pacific Fishery Management Council, the North Pacific Research Board, and the Public Policy Committee of the Consortium for Ocean Leadership.

Charles Vörösmarty recently joined the City University of New York (CUNY) as the NOAA-CREST Distinguished Scientist, director of the CUNY Global Environmental Sensing and Water Sciences Initiative, and as a full professor in the civil engineering department. Vörösmarty previously served as a professor at the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire, and Director of the Water Systems Analysis Group. He currently heads a team of scientists examining the application of scaling processes to arctic research.

USARC was established by the Arctic Research and Policy Act of 1984. Its principal duties are to develop and recommend an integrated national arctic research policy and assist in establishing a national arctic research program plan to implement the policy. Commissioners also facilitate cooperation between the federal government, state and local governments, and other nations with respect to arctic research, both basic and applied.

The commission publishes a biennial *Report on Goals and Objectives for Arctic Research*. The upcoming report will be delivered to the President and Congress in early 2009.

For more information, go to www.arctic.gov or contact Kathy Farrow (k.farrow@arctic.gov; 703-525-0111).

USARC Testifies on Icebreakers

In testimony before both houses of Congress, Mead Treadwell, Chair of the U.S. Arctic Research Commission (USARC), encouraged the United States to prepare for significantly greater shipping in the Arctic Ocean, in part by investing in new U.S. polar class icebreakers. In hearings of the House Coast Guard and Maritime Transportation Committee on Transportation and Infrastructure in July 2008, and the Senate Committee on Commerce, Science, and Transportation in June 2008, Treadwell said:

"We foresee that U.S. Coast Guard arctic icebreakers will be used as they are now—as research platforms and as the visible U.S. maritime presence in both polar regions. But the advent of arctic transportation means we expect the other, more traditional missions of the Coast Guard will take center stage. These national assets, polar icebreakers operated by the Coast Guard, are needed in the future to provide the same protections the Coast Guard affords the rest of the nation: search and rescue, law enforcement, border protection, environmental protection, and oil spill response."

Treadwell's testimony for both hearings is available on the USARC website: www.arctic.gov/news.htm.

ARCSS Community Fosters Synthesis of Research Efforts

Recent NSF Arctic System Science (ARCSS) Program activities include synthesis workshops promoting coordination and integration of ARCSS-funded projects, an announcement of opportunity that will complement existing organized ARCSS research efforts, an online meeting focused on development of the "changing seasonality" effort, joint sponsorship of a meeting at the Arctic Observation Integration Workshops (see page 9), and launch of a Synthesis of Arctic System Science (SASS) website.

Synthesis Workshops

A series of ARCSS Synthesis Workshops were held in Alexandria, VA, in early October 2007. Over 75 representatives of SASS projects and other ARCSS efforts met to discuss project plans and results and to determine methods, approaches, and an organizational structure to advance cross-project integration and synthesis. The goal of the workshop was to advance development of complementary and interacting arctic system science synthesis projects.

Over 35 participants attended the Human Dimensions of the Arctic (HARC) Synthesis Workshop, which was held as part of the series to foster synthesis-focused communication and interaction among human dimensions researchers in ARCSS and the Arctic Observing Network. Participants discussed key issues, common challenges, and gaps in knowledge, and developed recommendations for moving towards formal synthesis.

Discussion and coordination at the workshop series also led to ARCSS Program involvement in the Lessons from the 2007 Arctic Sea Ice Minimum Workshop and organization of a symposium on terrestrial ecology at the 2008 Arctic Science Conference, the annual meeting of the Arctic Division of the American Association for the Advancement of Science.

"Changing Seasonality" Efforts

Over the past decade, results from the ARCSS research community and others have clearly demonstrated that pervasive changes in patterns of seasonality in the Arctic are underway. Recommendations from the ARCSS All-Hands Workshop in 2002 and subsequent community discussions, particularly those facilitated through ARCSS Communities of Practice and the Synthesis Workshops, identified changing seasonality as an interdisciplinary and cross-cutting science uncertainty that addresses a key unknown in our ability to predict arctic system behavior.

In June 2008, NSF issued an ARCSS program solicitation providing an opportunity for the research community to engage in coordinated studies of changing seasonality. The goal of the solicitation, Changing Seasonality in the Arctic System (CSAS), is to improve understanding of key linkages that are time sensitive and to begin to identify patterns in the kinds of processes that are vulnerable to changes in synchrony.

In August 2008, the ARCSS Committee held a forum for members of the research community to further discuss efforts focused on changing seasonality. Sixty people participated in the open, online meeting—presentations provided information on the ARCSS Program, development of changing seasonality as a science priority, the ARCSS announcement of opportunity, and examples of system-level seasonality science. Forum discussions centered on community vision for interdisciplinary seasonality science and ARCSS-relevant seasonality science questions that address system-level understanding.

The CSAS proposal deadline was in October 2008. NSF anticipates making between 10 and 20 awards totalling $5 to $10 million. When award decisions are announced, information will be available online at: www.nsf.gov/funding/pgm_summ.jsp?pims_id=503195.

Lessons from the 2007 Arctic Sea Ice Minimum Workshop

The ARCSS Program co-sponsored a workshop on Lessons from the 2007 Arctic Sea Ice Minimum. The meeting, which was part of the March 2008 Arctic Observation Integration Workshops in Palisades, NY, was organized in response to the drastic drop in the arctic minimum sea ice extent observed in September 2007 and also followed up on discussions at the October 2007 SASS workshop in Washington, DC. Over 40 participants attended the workshop, which served as an international forum to exchange information and develop cross-disciplinary integration activities to better understand the reduced sea ice cover in summer 2007 and to look ahead to summer 2008 and beyond.

One major recommendation of the meeting was the need to track and provide an integrated outlook and summary of the evolving Arctic Ocean ice pack over the 2008 summer season. This recommendation resulted in the Study of Environmental Arctic Change (SEARCH) Sea Ice Outlook (see page 9), which became available in June 2008 and provided an integrated, community-wide summary of the state of arctic sea ice through September 2008.

For more information on the workshops and to view the resulting report, go to: www.arcus.org/search/meetings/2008/aow/index.php.

Launch of SASS Website

A new SASS website was launched in April 2008 and is available at www.arcus.org/arcss/sass/.

The site contains information on the SASS effort, one of five ongoing research efforts supported by the ARCSS Program, which builds on and integrates existing data and knowledge to advance understanding of linkages, interactions, and feedbacks among components of the arctic system. The site also provides detailed information on the 17 currently funded projects, past and upcoming meetings, and the ARCSS Program listserve.

Upcoming Meetings

The ARCSS Committee plans to meet during summer 2009 to discuss science activities, priorities, and future directions.

For more information on the ARCSS Program, go to: www.arcus.org/ARCSS/index.html, or contact Neil Swanberg (nswanber@nsf.gov), Josh Schimel (Schimel@lifesci.ucsb.edu), or Helen Wiggins (helen@arcus.org).

SEARCH Activities Focus on High Latitude Observations

Recent activities of the interagency Study of Environmental Arctic Change (SEARCH) focus on advancing implementation of an arctic observing system in order to better understand and respond to environmental change being witnessed in this region.

Arctic Observing Network

The Arctic Observing Network (AON), an NSF initiative for the International Polar Year (IPY), is an integral part of the SEARCH program that will enhance environmental observing infrastructure required for the scientific investigation of arctic environmental change and its global connections. The AON is intended to gather the long-term observations needed to address SEARCH science questions.

The NSF IPY solicitations released in January and December 2006 both included an emphasis on advancement of an AON. In 2007 and 2008, NSF grants to support the development of the AON were made to 24 projects (45 awards), for a total of approximately $24 million to be spent between 2007 and 2010 (see box on pages 10–11). The AON projects fall into categories outlined in the *SEARCH Implementation Plan*: atmosphere, ocean and sea ice, hydrology/cryosphere, terrestrial ecosystems, and human dimensions. AON data management is provided by the Cooperative Arctic Data and Information Service (CADIS).

In July 2008, NSF issued a third solicitation inviting proposals for projects that contribute to the further development of AON and enable SEARCH. The solicitation invites proposals for the following activities:

- continuation of existing NSF-supported AON projects;
- the initiation of new AON projects; and
- projects that address environmental observing system coverage, design, and optimization.

NSF anticipates funding between 15 and 20 projects for a total of $18 to $24 million. The deadline for proposal submission was 30 September 2008, and NSF anticipates that the first awards will be announced in spring 2009.

The solicitation is available at: www.nsf.gov/pubs/2008/nsf08579/nsf08579.htm. For more information, contact Martin Jeffries at NSF (mjeffrie@nsf.gov).

Arctic Observation Integration Workshops

In March 2008, a series of NSF-sponsored workshops was held in Palisades, NY, to advance planning and implementation of an integrated AON that is responsive to the critical scientific issues of environmental arctic change. Over 70 representatives from the U.S. and international arctic observational and modeling communities attended, including investigators affiliated with AON, SEARCH, the NSF Arctic System Science Program (ARCSS; see page 8), the European Union Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES) program, Nansen and Amundsen Basins Observational System, Canada's ArcticNet, Japan Agency for Marine-Earth Science and Technology, the International Study of Arctic Change, and U.S. agency representatives.

The workshop series included three interrelated meetings:

- a meeting for NSF AON principal investigators to review progress, coordinate activities, and develop cross-disciplinary efforts and integration,
- a workshop, jointly sponsored by the AON and SEARCH for DAMOCLES (S4D) programs, on optimizing deployment of Lagrangian platforms for observations of the ocean-ice-atmosphere system, and
- a workshop, jointly sponsored by AON, ARCSS, and S4D, to improve observing and modeling activities for understanding recent arctic sea ice change and its impacts throughout the arctic system.

The resulting report, *Arctic Observation Integration Workshops Report*, summarizes short- and long-term activities to address key challenges:

- integrating different observation efforts into a system that serves science as well as broader society and key stakeholder groups,
- understanding the extraordinary seasonal retreat of sea ice observed in 2007, and
- identifying scientific and programmatic gaps and next steps for observing, understanding, and responding to arctic environmental change with emphasis on high-amplitude, unexpected changes.

The report is available at www.arcus.org/search/meetings/2008/aow/report.php. For more information, contact Helen Wiggins at ARCUS (helen@arcus.org; 907-474-1600).

SEARCH Sea Ice Outlook

The SEARCH Sea Ice Outlook, which also emerged from discussions at the Arctic Observation Integration Workshops and is supported by NSF and the National Oceanic and Atmospheric Administration, is an international effort to provide an integrated, community-wide summary of the state of arctic sea ice over the summer season.

The Sea Ice Outlook produces monthly reports based on an open and inclusive process that synthesizes input from a broad range of scientific perspectives. This process, which provides a coordinated summary based on observations, models, and expert opinions, not only advances scientific understanding of arctic sea ice loss and variability but also improves integration of scientific activities and serves as a model for data integration.

The Outlook website does not issue predictions, but rather provides the scientific community, stakeholders, and the public with a summary of the best available information on the evolution of the arctic sea ice cover.

Monthly reports were published from May through September 2008 and a summary report provides an initial retrospective review of the 2008 Outlook. The summary report discusses preliminary analyses of the causes of the 2008 minimum, the accuracy of the Outlook values, and implications for future Outlook efforts.

continued on next page

SEARCH Activities *(continued from page 9)*

Two meetings concerning the Sea Ice Outlook—a presentation describing the effort and a community forum—took place during the 2008 Fall Meeting of the American Geophysical Union in San Francisco, CA. Plans for a workshop in early 2009 are also being discussed, which would provide an opportunity for organizers to meet in person for effort evaluation purposes.

The SEARCH Sea Ice Outlook is implemented through close cooperation with the DAMOCLES program and other relevant national and international efforts.

For more information, go to www.arcus.org/search/seaiceoutlook/index.php, or contact James Overland at NOAA (james.e.overland@noaa.gov), or Hajo Eicken at the University of Alaska Fairbanks (hajo.eicken@gi.alaska.edu).

IARPC Report

In May 2008, the Interagency Arctic Research Policy Committee (IARPC) released a report, *Arctic Observing Network (AON): Toward a U.S. Contribution to Pan-Arctic Observing* (see page 19). Led by NSF, IARPC is composed of representatives from more than 15 Federal agencies, departments, and offices that support or conduct research in the Arctic or are otherwise concerned with the region. The report, a fist step in interagency collaboration in the development of AON, summarizes the arctic environmental observing activities of each agency, both ongoing and future, and includes a strategy for enhanced coordination and integration of these activities. The report is available at www.nsf.gov/pubs/2008/nsf0842/.

For more information on AON, contact Martin Jeffries at NSF (mjeffrie@nsf.gov). For more information on IARPC, contact Mike Van Woert at NSF (mvanwoer@nsf.gov).

SEARCH SSC Meeting

Members of the SEARCH Science Steering Committee meet in late October 2008 in Arlington, VA, to discuss agency plans, implementation of SEARCH activities, and continued involvement in international activities.

For more information, contact Helen Wiggins at ARCUS (helen@arcus.org; 907-474-1600).

2007 and 2008 Arctic Observing Network Awards

The NSF International Polar Year (IPY) solicitations released in January and December 2006 both included an emphasis on advancement of an Arctic Observing Network (AON). The following AON award decisions were made in 2007 and 2008 and fall into categories outlined in the *SEARCH Implementation Plan*: atmosphere, ocean and sea ice, hydrology/cryosphere, terrestrial ecosystems, and human dimensions. Awards marked with asterisks (**) were originally funded under the Long-Term Observing (LTO) effort, which NSF supported prior to IPY. These projects are now an integral part of AON.

Atmosphere

Cloud Properties Across the Arctic Basin from Surface and Satellite Measurements.

- Von Walden (University of Idaho). *$131,589.*
- Matthew Shupe (University of Colorado at Boulder [CU]). *$119,616.*

** **Core Measurements at Summit Greenland Environmental Observatory.** Roger Bales (University of California Merced). *$943,382.*

Development of Data Products for the University of Wisconsin High Spectral Resolution Lidar. Edwin Eloranta (University of Wisconsin Madison). *$309,852.*

Halogen Chemistry and Ocean-Atmosphere-Sea Ice-Snowpack (OASIS) Chemical Exchange During IPY. Paul Shepson (Purdue University). *$469,513.*

Pan-Arctic Studies of the Coupled Tropospheric, Stratospheric and Mesospheric Circulation. Richard Collins, David Atkinson (University of Alaska Fairbanks [UAF]). *$528,557.*

The Collaborative O-Buoy Project: Deployment of a Network of Arctic Ocean Chemical Sensors for the IPY and Beyond. Patricia Matrai (Bigelow Laboratory for Ocean Sciences). *$295,104.*

Ocean and Sea Ice

Aerial Hydrographic Surveys for IPY and Beyond: Tracking Change and Understanding Seasonal Variability.

- James Morison, Andreas Heiberg, Michael Steele (University of Washington [UW]). *$458,567.*
- Robert Collier (Oregon State University [OSU]). *$211,853.*
- Miles McPhee (McPhee Research Company). *$80,950.*
- Christopher Guay (Pacific Marine Sciences and Technology, LLC). *$51,990.*
- Andrey Proshutinsky (Woods Hole Oceanographic Institution [WHOI]) *$49,839.*

A Modular Approach to Building an Arctic Observing System for the IPY and Beyond in the Switchyard Region of the Arctic Ocean.

- Michael Steele, Craig Lee, Jason Gobat (UW). *$1,023,856.*
- Peter Schlosser, William Smethie, Dale Chayes (Columbia University). *$483,129.*
- Ronald Kwok (National Aeronautics and Space Administration). *$47,000.*

An Array of Ice-Tethered Profilers to Sample the Upper Ocean Water Properties During the IPY. John Toole, Carin Ashjian, Andrey Proshutinsky, Richard Krishfield (WHOI). *$1,537,544.*

continued on page 11

Arctic Observing Network Awards 2007 and 2008

(continued from page 10)

An Array of Surface Buoys to Sample Turbulent Ocean Heat and Salt Fluxes During the IPY. Timothy Stanton, William Shaw (Naval Postgraduate School). *$961,983.*

An Innovative Observational Network for Critical Arctic Gateways—Understanding Exchanges through Davis and Fram Straits. Craig Lee, Richard Moritz, Jason Gobat, Kathleen Stafford (UW). *$1,481,197.*

Bering Sea Sub-Network: International Community-Based Observation Alliance for Arctic Observing Network (BSSN). Victoria Gofman, Patricia Cochran, Lilian Alessa, Joan Eamer (Aleut International Association). *$677,816.*

** **Comparison of Water Properties and Flows in the U.S. and Russian Channels of the Bering Strait—2005 to 2006.** Rebecca Woodgate (UW). *$99,596.*

** **Coordination, Data Management, and Enhancement of the IABP.** Ignatius Rigor (UW). *$600,000.*

Ice Mass Balance Buoy Network: Coordination with DAMOCLES. Jacqueline Richter-Menge, Donald Perovich (U.S. Army Cold Regions Research and Engineering Laboratory [CRREL]). *$629,246.*

** **North Pole Station: A Distributed Long-Term Environmental Observatory.**
- James Morison, Knut Aagaard, Richard Moritz, Andreas Heiberg, Michael Steele (UW). *$5,934,139.*
- Miles McPhee (McPhee Research Company). *$44,975.*
- Robert Collier (OSU). *$310,407.*

Observing the Dynamics of the Deepest Waters in the Arctic Ocean. Mary-Louise Timmermans, Luc Rainville (WHOI). *$204,406.*

State of the Arctic Sea Ice Cover: An Integrated Seasonal Ice Zone Observing Network (SIZONET).
- Hajo Eicken, Mark Johnson, Rolf Gradinger, Amy Lovecraft, Thomas Heinrichs (UAF). *$574,160.*
- Donald Perovich, Matthew Sturm (CRREL). *$174,935.*

** **The Beaufort Gyre System: Flywheel of the Arctic Climate?** Andrey Proshutinsky (WHOI). *$3,476,873.*

The Pacific Gateway to the Arctic—Quantifying and Understanding Bering Strait Oceanic Fluxes.
- Rebecca Woodgate, Ronald Lindsay (UW). *$838,613.*
- Thomas Weingartner, Terry Whitledge (UAF). *$357,943.*

Hydrology/Cryosphere

A Prototype Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net).
- Matthew Sturm (CRREL). *$420,507.*
- Douglas Kane, Daqing Yang, Svetlana Berezovskaya (UAF). *$314,363.*
- Glen Liston, Christopher Hiemstra (Colorado State University [CSU]). *$163,000.*

Arctic Great Rivers Observatory (Arctic-GRO).
- Bruce Peterson (Marine Biological Laboratory [MBL]), *$231,535.*
- Robert Holmes (Woods Hole Research Center). *$141,957.*
- Peter Raymond (Yale University). *$114,713.*
- James McClelland (University of Texas at Austin). *$60,986.*

Development of a Network of Permafrost Observatories in North America and Russia. Vladimir Romanovsky UAF). *$632,160.*

Dynamic Controls on Tidewater Glacier Retreat.
- W. Tad Pfeffer, Ian Howat, Shad O'Neel (CU). $201,179.
- Howard Conway (UW). $64,438.

** **Long-term Measurements and Observations for the International Arctic Research Community on the Kuparuk River Basin, Alaska.** Douglas Kane (UAF). *$1,040,363.*

** **Thermal State of Permafrost (TSP): The U.S. Contribution to the International Permafrost Observatory Network.** Vladimir Romanovsky (UAF). *$274,850.*

Terrestrial Ecosystems

Carbon, Water, and Energy Balance of the Arctic Landscape at Flagship Observatories and in a PanArctic Network.
- Marion Bret-Harte, Brian Barnes, Sergei Zimov (UAF). *$1,108,225.*
- Gaius Shaver, John Hobbie, Edward Rastetter (MBL). *$719,429.*

** **Development and Implementation of the Terrestrial Circumarctic Environmental Observatories Network (CEON).** Craig Tweedie (University of Texas at El Paso). *$750,126.*

Study of Arctic Ecosystem Changes in the IPY Using the International Tundra Experiment.
- Steven Oberbauer, William Gould, Caroline Lewis (Florida International University). *$534,584.*
- Jeffrey Welker, Bjartmar Sveinbjornsson, Patrick Sullivan, Keith Boggs (University of Alaska Anchorage [UAA]). *$172,359.*
- Robert Hollister (Grand Valley State University). *$134,463.*
- Julia Klein (CSU). *$52,707.*

Human Dimensions

Is the Arctic Human Environment Moving to a New State?
- Jack Kruse (UAA). *$894,556.*
- Lawrence Hamilton, Cynthia Duncan, Richard Lammers (University of New Hampshire). *$200,708.*

Data Management & Coordination

A Cooperative Arctic Data and Information Service (CADIS).
- James Moore, Mohan Ramamurthy, Don Middleton (University Corporation for Atmospheric Research). *$909,195.*
- Roger Barry (CU). *$434,992.*

Exchange for Local Observations and Knowledge of the Arctic (ELOKA).
- Shari Gearheard, Roger Barry, Mark Parsons, Henry Huntington (CU). *$428,165.*

NSF and NPRB Partner to Fund Bering Sea Research

From 2007 to 2012, a special research partnership between the NSF Bering Ecosystem Study (BEST) program and the North Pacific Research Board (NPRB) Bering Sea Integrated Ecosystem Research Program (BSIERP) is supporting a comprehensive, vertically integrated investigation of the Bering's eastern continental shelf ecosystem to improve understanding of how climate variability influences this productive ecosystem.

In July 2006 (see *Witness* Spring 2007) and September 2007 (see box), NSF announced BEST awards, which total $15 million. The NSF component of the partnership focuses on physical and chemical oceanography, as well as plankton studies. The NPRB component supports a range of studies with an emphasis on forage fish, commercial species such as pollock, Pacific cod, and arrowtooth flounder, as well as fur seals, walrus, whales, and several species of seabirds. Both organizations support ecosystem modeling, social and economic studies, and local and traditional knowledge (LTK) research.

The combined program involves more than 90 investigators from over 25 institutions; the organizations include universities, several National Oceanic and Atmospheric Administration research units, other state and federal agencies, and local communities. The group met at a joint principal investigators' meeting in Seattle, WA, in September 2007, and a subset of investigators also met in Seattle in November 2007 and Anchorage, AK, in January 2008, to plan for the 2008 field season. In October 2008, principal investigators met in Girdwood, AK, to discuss program integration.

A series of collaborative research cruises began in 2008 and will continue through 2010. In 2008, NSF-funded investigators participated in three cruises in the region aboard the U.S. Coast Guard Cutter *Healy*:

- a short early spring cruise concentrating on the benthic environment south of St. Lawrence Island, 13–26 March,
- a longer spring cruise on the eastern Bering Sea shelf, 29 March–6 May, and
- a summer cruise on the eastern Bering Sea shelf, 20 June–18 July.

The program includes community-based efforts with the goal of incorporating results of LTK research into ecosystem models and syntheses. In each of six Bering Sea communities—Savoonga, Emmonak, Togiak, St. Paul, Nelson Island, and Akutan—local research coordinators assist in studies on recent changes in subsistence and knowledge of residents about the local environment and species. Each community's local advisory board works closely with the program's regional advisory board to help guide the research.

The BEST projects also represent an NSF contribution to related efforts:

- the interagency Study of Environmental Arctic Change, and
- the international Ecosystem Studies of Sub-Arctic Seas (ESSAS; http://web.pml.ac.uk/globec/structure/regional/essas/essas.htm).

For more information, see the program's website: http://bsierp.nprb.org, or contact William Wiseman (wwiseman@nsf.gov; 703-292-8029).

2007 BEST Awards

In addition to the five BEST projects that NSF funded in 2006 (see *Witness* Spring 2007), in 2007 NSF awarded 12 projects a total of $11.3 million over three years:

Assessment of Mesozooplankton Population and Biomass in the Eastern Bering Sea for Spring and Summer of 2008, 2009, and 2010. K. Coyle (University of Alaska Fairbanks [UAF]). *$220,154.*

Benthic Ecosystem Response to Changing Ice Cover in the Bering Sea. J. Grebmeier, L. Cooper (University of Tennessee Knoxville). *$628,214.*

Bering Ecosystem Study Data Management. J. Moore, G. Stossmeister (University Corporation for Atmospheric Research). *$833,599.*

Downscaling Global Climate Projections to the Ecosystems of the Bering Sea with Nested Biophysical Models. N. Bond, A. Hermann (University of Washington [UW]), E. Curchitser (Rutgers University), K. Hedstrom, G. Gibson (UAF). *$1,176,125.*

The Impact of Changes in Sea Ice Extent on Primary Production, Phytoplankton Community Structure, and Export in the Eastern Bering Sea. S.B. Moran (University of Rhode Island [URI]), M. Lomas (Bermuda Biological Station for Research). *$800,129.*

Impacts of Sea Ice on the Hydrographic Structure, Nutrients, and Mesozooplankton over the Eastern Bering Sea Shelf. G. Hunt (UW). *$164,697.*

Mesozooplankton-microbial Food Web Interactions in a Climatically Changing Sea Ice Environment. E. Sherr, B. Sherr (Oregon State University), R. Campbell (URI), C. Ashjian (Woods Hole Oceanographic Institution). *$1,798,465.*

Sea Ice Algae, A Major Food Source for Herbivorous Plankton and Benthos in the Eastern Bering Sea. R. Gradinger, K. Iken, B. Bluhm (UAF). *$1,061,747.*

A Service Proposal to Examine Hydrographic Structure and Nutrients over the Eastern Bering Sea Shelf During Summer. T. Whitledge (UAF), R. Sonnerup, C. Mordy (UW). *$660,182.*

A Service Proposal to Examine Impacts of Sea Ice on the Distribution of Chlorophyll-a Over the Eastern Bering Sea Shelf. R. Sonnerup (UW), T. Whitledge, D. Stockwell (UAF). *$246,478.*

A Service Proposal to Examine Impacts of Sea Ice on Hydrographic Structure and Nutrients over the Eastern Bering Sea Shelf. T. Whitledge (UAF), R. Sonnerup, C. Mordy (UW). *$995,804.*

Stratification on the Bering Shelf and its Consequences for Nutrients and the Ecosystem: The Effects of Ice and Coastal Water Advection. T. Weingartner (UAF), K. Aagaard (UW). *$1,538,798.*

The Trophic Role of Euphausiids in the Eastern Bering Sea: Ecosystem Responses to Changing Sea Ice Conditions. R. Harvey (University of Maryland Center for Environmental Sciences), E. Lessard (UW). *$1,182,629.*

Widespread Spring Streams Present Distinctive Ecology

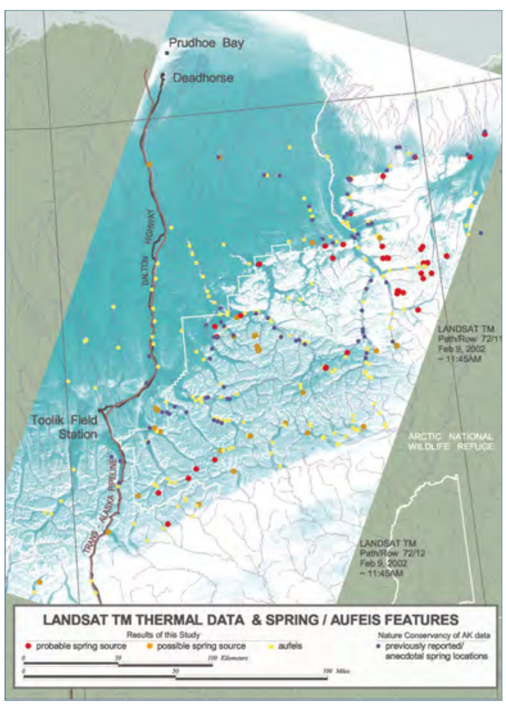
It is often assumed that headwater streams in the Arctic freeze solid during winter, limiting the biological communities that can inhabit them. In arctic Alaska, however, streams with continuous flow and above-freezing water temperatures year-round are relatively widespread. Andrew Balser of the University of Alaska Fairbanks and Alex Huryn of the University of Alabama Tuscaloosa used thermal images from the Landsat Enhanced Thematic Mapper (ETM) to reveal more than 200 spring-like features in a relatively small area (~62,872 km^2) of the eastern North Slope (see Figure). These features, which included *aufeis* (water flowing over surface ice) as well as likely perennial spring sources, had temperatures of 3–7 °C, even though the ambient air temperature was -34 °C when the imagery was acquired in February 2002.

In the study area, spring streams tend to occur on lower mountain slopes, where the lisburne limestone group contacts sandstone strata. These streams show year-round flow because much of their discharge is groundwater from sources below the permafrost layer. The spring sources are connected to the groundwater reservoirs by unfrozen zones called *talik*. Unlike most other arctic streams, which are usually frozen solid for seven to eight months each year, the channels of these spring streams remain ice-free all winter, when air temperatures may be much lower than -40 °C for extended periods.

Although perennial springs contribute only 1% to headwater stream length on Alaska's North Slope, these regular landscape features have disproportionate importance for biodiversity and food-web dynamics in the region. Perennial springs offer essential winter refuge for both aquatic and riparian taxa unable to tolerate freezing, including insects (e.g., the stonefly *Isoperla sobria*), northern Dolly Varden char, the American dipper (a semi-aquatic passerine bird), the American river otter, and a number of plant species (e.g., balsam poplar, sparrow's egg orchid, common mountain juniper, butterwort). The use of these winter refugia by large, mobile predators—specifically Dolly Varden char—may be particularly significant to arctic food webs because when these predators move during summer from their winter habitat they can take advantage of feeding opportunities in freshwater and coastal habitats across the landscape, including stream reaches from which they would otherwise be excluded by winter freezing.

These springs may also be "hot spots" of regional freshwater productivity. Compared with other types of arctic streams, the invertebrate biomass in some spring streams can be extremely high (>10 g dry mass m^{-2}), and their projected annual secondary production may exceed 50 g dry mass m^{-2}—productivity that would be considered high even for temperate or tropical headwater streams. This potentially enormous rate of productivity, as well as the ultimate fate of production and the mechanisms that potentially explain these factors (e.g., hydrologic stability, geologically derived nutrients, and consumer-driven nutrient recycling from migratory fish species), cannot be completely understood without a year-round research program.

The Arctic Natural Sciences Program has funded Huryn and Jonathan Benstead, also of the University of Alabama, to investigate seasonal patterns of productivity in the food webs of perennial springs. For two years beginning in March 2007, Huryn and Benstead are collecting monthly measurements on a representative stream, Ivishak Hot Spring, a headwater tributary of the Ivishak River in the Arctic National Wildlife Refuge, which they access by helicopter from Toolik Field Station.



Landsat Enhanced Thematic Mapper image of the Toolik Lake region and northwestern Arctic National Wildlife Reserve showing the distribution of springs and spring-associated features. Figure by Andrew Balser.

A shallow stream habitat with relatively constant physical conditions in the intensely seasonal arctic environment provides a unique context for ecological research. Because the spring's water temperature is essentially fixed, rates of heterotrophic activity (e.g., secondary production, ecosystem respiration) should differ little from summer to winter, assuming no resource limitation. Rates of photosynthesis, however, should differ dramatically between seasons due to extreme annual cycles in available light, potentially forcing cycles in related ecological processes (e.g., herbivory). Additionally, the migratory movements of overwintering Dolly Varden char in and out of spring streams presumably affect predation rates and nutrient supply—processes that may further amplify seasonal patterns of community and ecosystem dynamics.

Huryn and Benstead are completing their first deep-winter field season, collecting data on seasonal changes in ecosystem metabolism, decomposition rates, macroinvertebrate community structure and production, char population structure and production, and rates of predation and nutrient excretion. The logistical challenges of working in an open stream channel while air temperatures hover as low as -47 °C have been largely solved. Early data indicate dynamic seasonality in variables such as nutrient uptake and metabolism, with evidence of severe carbon limitation of system productivity during the polar night. With 18 monthly trips to the Ivishak site remaining, the team anticipates being able to answer many fundamental questions about the winter ecology and landscape role of these fascinating stream ecosystems.

For more information, contact Alex Huryn (huryn@bama.ua.edu).

Studies Indicate Soot's Effect on Arctic Climate

People have known for centuries, and perhaps for millennia, that dark impurities in snow can hasten melting; they have sometimes dumped coal dust or other forms of black carbon (BC) onto snow to uncover ground for grazing animals or to enhance the melting of glaciers for irrigation. Remarkably little BC is needed to have a significant effect.

In fact, most snow in the Northern Hemisphere is affected by BC without direct human action. BC in the form of soot is produced by incomplete combustion by industrial sources (e.g., diesel engines) and from biomass burning (e.g., forest fires). Much of the soot is in the form of small particles that can linger in the atmosphere for several days, enabling them to travel thousands of kilometers from their source.

Several groups of investigators have taken a variety of research approaches to this issue. In 1980, Stephen Warren, now at the University of Washington (UW), and Warren Wiscombe, now at the National Aeronautics and Space Administration Goddard Space Flight Center, quantified the theoretical effect of soot on snow reflectance (albedo) with radiative transfer modeling; Thomas Grenfell and coworkers at UW verified their results with field measurements in the Cascade Mountains in 1981. Antony Clarke, now at the University of Hawaii, and Kevin Noone, now at Stockholm University, surveyed the amount of soot in snow samples from the North American and European Arctic in 1985; values ranged from 5 to 50 parts per billion (ppb), implying albedo reductions of 1–3%.

Steve Warren filters meltwater from snow samples in the Sverdrup laboratory in Ny-Ålesund, Svalbard, in 2007. Photo by Antony Clarke.

More recent modeling results indicated that this albedo reduction in arctic snow may have a large effect on the climate of the Northern Hemisphere, and the Arctic Natural Sciences Program has funded two current projects on the topic:

- Warren, Grenfell, and Clarke have support to update and expand their earlier work on BC and albedo, and
- Joe McConnell and Ross Edwards of the Desert Research Institute and colleagues have analyzed a record of BC from Greenland ice cores.

BC Effects on Surface Albedo

Because snow albedo is affected by many variables, most importantly snow grain size, the effect of small amounts of soot cannot be quantified accurately by albedo measurements at the surface, and even less so from satellite (for example, sooty snow has the same spectral signature as thin snow). Estimating the effect of BC on albedo is thus a two-step process: measuring the BC content of snow and then calculating the albedo reduction using radiative transfer modeling.

This indirect approach requires a series of experiments to test the accuracy of these approaches, and several laboratories are cooperating on this work. The UW investigators are comparing three methods for directly measuring soot content on identical snow samples; in collaboration with the Norwegian Polar Institute, they intercompared both soot analyses and albedo measurements in fieldwork at Barrow, AK, in April 2008. Three research groups are directly measuring albedo in artificial, vertically homogeneous snowpacks that vary in soot content, and two groups are studying how soot is redistributed in the snowpack as it melts—since soot is somewhat hydrophobic, it may remain on the surface, resulting in a greater effect on albedo.

With initial funding from private foundations via the Clean Air Task Force, an extensive survey of snow is underway in all parts of the Arctic. In addition to sampling by UW project personnel, many investigators carrying out their own International Polar Year projects are contributing snow samples from their study sites. Dean Hegg of UW is analyzing the samples to identify sources of the soot aerosols. The soot content of snow is quite variable across the Arctic, depending on airmass trajectories from source regions as well as snowfall rates. The Greenland Ice Sheet has the cleanest snow in the Arctic, perhaps because of its high elevation. Preliminary survey results suggest that arctic snow is now cleaner than in 1985, most likely because some major soot sources in eastern Europe and Russia have shut down since the demise of the Soviet Union. These findings are consistent with the results of continuous air sampling at Alert in Canada, showing a decline in atmospheric BC from 1990 to 2000. Data since 2000 show a hint of an increase, possibly the result of increased emissions from China.

BC Record from Ice Cores

Ice core data indicate that arctic soot has changed significantly over time and may have had important effects on climate in the past. McConnell and Edwards obtained a 215-year BC record with well-resolved seasonal cycles from two Greenland ice cores; new automated melting and analysis methods were used to differentiate sources of the soot. In particular, vanillic acid is a characteristic organic molecule emitted from burning spruce forests, while non-sea-salt sulfur indicates industrial pollution.

The record shows North American forest fires as the major BC source until 1850; then industrial emissions became dominant. The concentration of BC in snow peaked between 1900 and 1910, due to coal burning in North America. McConnell and colleagues estimated that the surface climate forcing in early summer from BC during this peak was about eight times the preindustrial value. Although industrial activity in North America has since increased, the switch from coal to cleaner-burning oil resulted in a decline in the soot content of snow after 1951.

For more information, see www.atmos.washington.edu/sootinsnow and www.dri.edu/People/jmcconn/.

Local Experts Provide Valuable Landscape Perspective

The dominant landscape process on the Arctic Coastal Plain (ACP) of northern Alaska is the continual formation and drainage of thaw lakes. Thaw lakes form where water pools atop permafrost. About 20% of the surface of the ACP west of the Colville River is covered with thaw lakes and ponds, and another 26% can be identified as drained thaw lake basins. Much of the remaining surface has been affected by the repeated filling, thawing, draining, and erosion processes associated with the thaw lake cycle. Long-term landscape and vegetation changes in drained thaw-lake basins are significant in arctic environmental change issues, including estimates of soil carbon reservoirs, permafrost dynamics, surface hydrology, and coastal and river-bank erosion.

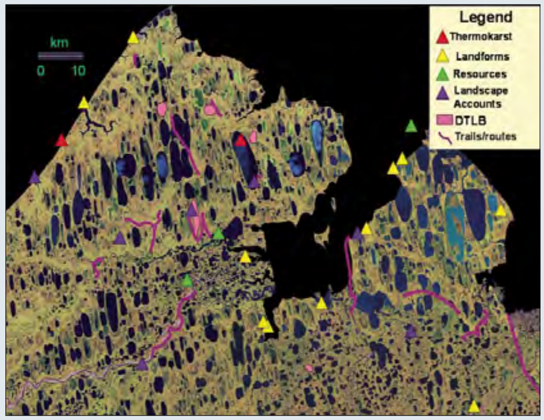
For more than a decade, Wendy Eisner and Kenneth Hinkel of the University of Cincinnati have been working with their collaborators to improve understanding of the basic processes responsible for these important elements of the northern Alaskan landscape. With support from several programs at NSF, including Arctic System Sciences and Arctic Natural Sciences, they have combined remote sensing, GIS, field data collection, and use of traditional native ecological knowledge.

As Iñupiaq elders have expressed concern about the changing landscape, interest in scientific findings about those changes, and a desire to share their knowledge of local ecosystems with scientists and others with similar concerns, community members of all ages have indicated that they want the ecological and historical knowledge of their elders to be documented. An NSF project jointly funded by the Geography and Regional Science and Arctic Social Sciences Programs enabled Eisner, Hinkel, and University of Georgia collaborator Chris Cuomo to explore the intersection of native knowledge and landscape process research in the Arctic in greater detail. One product is a GIS database that shows environmental changes based on information from Iñupiaq elders and other local experts (see figure). The knowledge and expertise of elders, hunters, and berry pickers has been especially valuable in developing GIS layers that address community concerns and interests, as well as identifying geomorphic changes that are occurring at a rapid rate. Elders have identified thaw lakes that have drained over their lifetime, areas where permafrost thawing has been extreme, and locations where sea and river bluffs are eroding. During the course of this research, a number of their observations have been corroborated by site visits, aerial photography, and satellite imagery.

Local knowledge was critical in investigating thaw lake drainage over the past 50 years on the ACP. Interviews with elders validated timing of landscape changes and provided insight into landscape processes. In particular, their knowledge of the human use of the landscape indicated that 37% of the lakes on the Barrow peninsula that drained between 1949 and 2002 were affected by human activities that triggered thermokarst and erosion processes. The activities included deliberate drainage in support of natural gas development and inadvertent damage due to repeated use of tracked vehicles in some areas.

The research team has integrated interview methods to include unstructured talks as well as semi-directive interviews—a format which encourages informants to speak freely about their observations and knowledge of environmental changes. This approach arises out of respect to the informants, recognizing the richness of their body of knowledge. The material obtained greatly exceeds the original scope of the project and has expanded into wider realms including life stories, cultural history, human impacts on the land, and environmental ethics. The information is returned to local communities for use as an educational and resource management tool. The research team received invaluable support from the Barrow Arctic Science Consortium and translators Lollie Hopson, Ethel Burke, and Ida Panik.

For more information contact Wendy Eisner (wendy.eisner@uc.edu).



A generalization of layers from the Iñupiaq Indigenous Knowledge ArcGIS database. The layers are superimposed on a 2002 Landsat 7+ satellite image and refer to sites and/or events recounted by informants. "Thermokarst" indicates evidence of noticeable permafrost degradation. "Resources" may identify fresh-water springs or hunting or fishing areas. "Landforms" indicate areas where landscape changes have occurred (for example, distinctive rocks or boulders that served as navigation aids and have disappeared due to shoreline erosion). "DTLB" indicates drained thaw lake basins. These categories and site locations are somewhat general, pending permission of the community to release more specific information to the public. Figure courtesy of Wendy Eisner.

In this excerpt from one of the interviews, Mr. Thomas Brower, Jr., of Atqasuk describes the rapid draining of a thaw lake immediately adjacent to the Usuktuk River in 1989, which he witnessed while setting his fishing nets. His report pinpointed the drainage date more precisely than was possible from the satellite or photographic record.

Brower: That lake is empty (pointing to a DTLB on the satellite image).
Interviewer: Do you know when that happened?
Brower: 1980s. . .1989. I was boating right there. I see a little water come out, I watch it. I was setting my net down here (points downstream from the lake). About this high (raises his arm above his head) little bit [water] was coming out.
Interviewer: What caused that?
Brower: I don't know; a lot of ice in there.
Interviewer: How long did it take to empty?
Brower: Faster than anything. It's not really deep; it's shallow.

interviews are available at www.geography.uc.edu/~kenhinke/DTLB/

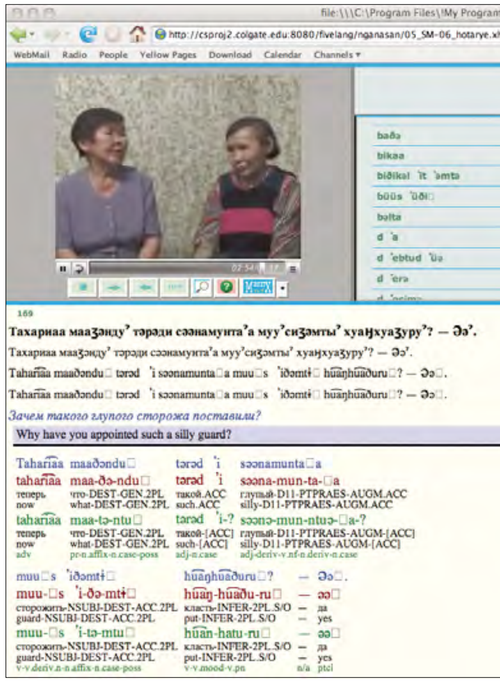
Innovative Digital System Archives Siberian Languages

At least 30 languages in Siberia can be considered endangered. Three of these are Samoyedic languages; Samoyed territory is in northcentral Siberia and includes the Taimyr peninsula. Traditionally the Samoyedic peoples were nomadic hunters, fishers, and herders of reindeer who largely escaped outside influence until fairly recently. Beginning in the 1960s, the majority were settled, sometimes forcibly, in a few villages. Four of the eight known Samoyedic languages are already extinct. Nenets is the only Samoyedic language currently spoken by more than 1,000 people.

Two Samoyedic languages, Nganasan and Enets, are included in a project documenting and archiving six endangered Eurasian languages. Alexander Nakhimovsky of Colgate University leads the project, which is funded by the NSF Documenting Endangered Languages program (see box), the Arctic Social Sciences program, and the Russian Fund for Basic Research. Nakhimovsky is collaborating with linguists from Moscow State University, the Russian Academy of Sciences, Russian State University for the Humanities, and St. Petersburg State University.

A 2002 census identified 834 total Nganasans, about 250 of whom still speak the language, and 237 Enets, 119 of whom speak at least one of two dialects. While his colleagues from Russia do intensive linguistic field work with the remaining Nganasan and Enets speakers, Nakhimovsky is working with Tom Myers of N-Topus Software to develop a browser-based software system for annotating, searching, and sharing the resulting multimedia archive (see figure).

The system makes it possible to search through a media archive for segments that include specific information of interest to a researcher or student, such as a particular grammatical category. Nakhimovsky's approach to media annotation is based on the operation of time alignment; each unit of time-based media is associated with a text (usually the transcript), which can then be annotated and searched. The open source system uses a pair of programs: an annotator for time alignment and annotations and a player for navigation, playback, and search. It complements the Language



A window from the Endangered Languages of Eurasia project website. In the upper left is a video clip of Nganasan speakers Kuptchik (Serafina Mudimeevna) and Chundanchar (Nina Dentumeevna) telling a story about the shaman Hotarye. The upper right provides a search window and glossary. The lower window contains a transcript in Nganasan, Russian, and English. The clip was recorded in Ust'-Avam in 2006 by Valentin Gousev of the Moscow Institute of Linguistics.

Archiving Technology software package developed at the Max Planck Institute for Psycholinguistics in the Netherlands; the resulting repository will be archived at Moscow State University and at Colgate.

Media repositories that can be easily annotated and searched will be useful beyond linguistics. For example, the National Endowment for the Humanities is supporting Nakhimovsky to adapt his system for use in developing a repository of materials about the history and ethnography of the Pashtun tribes of central Asia. The technology of multimedia annotation and search provides a structure for a new type of online publication with potential that is only beginning to be explored.

For more information, see the project websites: http://csproj2.colgate.edu:8080/fivelang/ and www.philol.msu.ru/~languedoc/eng/index.php, or contact Alexander Nakhimovsky (adnakhimovsky@mail.colgate.edu; 315-228-7586). ■

NSF Makes DEL Program Permanent

About half of the 6,000–7,000 languages currently spoken can be considered endangered; approximately 300 have fewer than 100 native speakers. The death in January 2008 of Marie Smith Jones, the last native speaker of Eyak, an Athabaskan language, focused attention on the urgency of this issue.

Over the past decade, funding agencies around the world have increased support or initiated new programs to focus on endangered languages. In the U.S., NSF and the National Endowment for the Humanities developed a joint Documenting Endangered Languages (DEL) initiative, with the Smithsonian Institution as a non-funding partner. The DEL initiative has awarded $13.8 million for projects on more than 70 endangered languages since 2005 (see *Witness* Spring 2006).

In October 2007, at an NSF-supported international workshop on the topic, the agencies announced that the DEL initiative is now a permanent program. Proposals are due 15 September annually. DEL gives the highest priority to projects that involve recording endangered languages in digital audio and video format before they become extinct.

For more information, including presentations and a summary from the workshop, see the DEL website: www.nsf.gov/funding/pgm_summ.jsp?pims_id=12816&org=BCS, or contact Anna Kerttula (akerttul@nsf.gov; 703-292-7432). ■

NSF Addresses Expanding Cyberinfrastructure Needs

Established in 2005 with a budget of $127 million, the NSF Office of Cyberinfrastructure (OCI) coordinates and supports the acquisition, development, and provision of cyberinfrastructure resources, tools, and services for science and engineering research and education; these include computing systems, data, information resources, networking, digitally enabled-sensors, instruments, virtual organizations, and observatories, as well as software services and tools.

NSF investment in cyberinfrastructure (CI) is guided by a March 2007 report, *Cyberinfrastructure Vision for 21st Century Discovery* (www.nsf.gov/dir/index.jsp?org=OCI). About two-thirds of NSF funding for CI comes from the foundation's directorates and offices, with the remainder from OCI funds. The OCI budget request for FY 2009 is $220 million, which is expected to support more than 70 competitive awards. Recent program solicitations include:

- **Cyber-Enabled Discovery and Innovation** (NSF 08-604, www.nsf.gov/funding/pgm_summ.jsp?pims_id=503163). This five-year NSF-wide initiative intends to create revolutionary science and engineering research outcomes through innovations and advances in computational concepts, methods, models, algorithms, and tools. The preliminary proposal window was 8 November–9 December 2008; the program will continue for an additional three years after this call for proposals.
- **Sustainable Digital Data Preservation and Access Network Partners** (NSF 07-601, www.nsf.gov/funding/pgm_summ.jsp?pims_id=503141). This program supports digital data preservation research and long-term access by integrating library and archival sciences, cyberinfrastructure, computer and information sciences, and domain science expertise. Preliminary proposals were due 13 November 2008, and the full proposal target date is 15 May 2009.
- **Strategic Technologies for Cyberinfrastructure** (NSF PD 06-7231, www.nsf.gov/funding/pgm_summ.jsp?pims_id=500066&org=OCI&from=home). This program's intent is to support work leading to the development and/or demonstration of innovative cyberinfrastructure services for science and engineering research that does not fit exactly within other targeted solicitations. The full proposal target dates are 12 February and 13 August 2009.

Further information on these and other OCI solicitations can be found by regularly checking the OCI website.

New OCI Director

NSF selected astrophysicist Edward Seidel as the new director of OCI. Before assuming his new role in September 2008, Seidel was a professor at Louisiana State University (LSU) and directed the LSU Center for Computation and Technology, which he was instrumental in creating. He also helped initiate, and was chief scientist for, the Louisiana Optical Network Initiative.

Seidel's career has focused on numerical relativity, pioneering techniques and algorithms for simulating black hole collisions and gravitational waves on supercomputers. Seidel and collaborators also developed software approaches to solve the general relativity equations, which led to new tools for advanced computing environments that can serve other disciplines. Seidel earned his Ph.D. from Yale University in relativistic astrophysics and has served on the faculty of the Max-Planck-Institute for Gravitational Physics in Potsdam, Germany, and the University of Illinois, Urbana-Champaign.

For more information, see the OCI website: www.nsf.gov/dir/index.jsp?org=OCI. ■

Google and IBM Partner with NSF

The private sector recently launched a number of Internet-wide applications powered by massively scaled and distributed computing resources. Although academic researchers have expressed interest in this emerging model of computing, these prohibitively expensive resources have been largely unavailable to the research community.

In February 2008, NSF announced the formation of a strategic partnership between the NSF Directorate for Computer and Information Science and Engineering (CISE), IBM, and Google Incorporated to explore a new method of computational analysis, known as the Cluster Exploratory (CluE). The new partnership will enable the research community to use a massive distributed computing resource, or "cluster," composed of approximately 1,600 processors owned and operated by IBM and Google that work in parallel and have the ability to catalogue and analyze very large amounts of data. Cluster computing, an ensemble of hundreds or thousands of standard commodity PCs, supports terabytes of data and allows for very high-level computations.

The CluE endeavor builds upon Google and IBM's Academic Cluster Computing Initiative, which began in October 2007, involves six pilot universities, and is aimed at improving student knowledge of parallel computing practices to better address the emerging paradigm of large-scale distributed computing. By involving NSF, the CluE partnership will provide the scientific community with the computational capacity needed to run data intensive studies, accelerate the pace of research into complex data analysis, and enhance collaboration between scientists by increasing access to information and data.

In April 2008, NSF released a CluE program solicitation providing the opportunity for researchers to access the large-scale computing resources and services supported by Google and IBM. Awards were announced in early 2009 and funded proposals will cover a range of activities that lead to advances in computing research, but that also explore the potential of this computing paradigm to contribute to science and engineering research and to applications that benefit society as a whole.

For more information, see www.nsf.gov/cise/clue/index.jsp or contact Jim French at NSF (jfrench@nsf.gov). ■

Community Envisions Arctic Synthesis Collaboratory

In seeking to understand the myriad of changes underway in the Arctic, the scientific community is encouraging a new approach to research involving synthesis of linkages between system components and threshold behaviors. The approach requires improvements to methods commonly used today, with an eye toward better integrating complex and disparate data from observations and outputs from models. Innovative data discovery, standardization, interdisciplinary data integration, distribution, and advanced data assimilation need to be the new order of the day.

The NSF Arctic System Science (ARCSS; see page 8) Program supported a series of community planning activities in 2006 and 2007 to foster such synthetic modes of inquiry, including an April 2007 workshop on New Perspectives through Data Discovery and Modeling. A summary of the workshop's recommendations are available online (www.arcus.org/ARCSS/2007_data) and were published in *EOS* in July 2007.

The workshop's central recommendation was the creation of a new framework—the Arctic Synthesis Collaboratory. A collaboratory is a network-based entity that supports human interaction oriented to a common research area and provides access to data sources and tools required to accomplish research tasks. Such a collaboratory offers a means to promote system synthesis, improve scientific understanding and prediction, and increase the utility of scientific results. The Arctic Synthesis Collaboratory is envisioned as an "umbrella" concept that would:

- foster interactions among arctic scientists and other stakeholders;
- integrate data analysis and modeling activities;
- provide outreach, education, and policy-relevant resources; and
- offer training and development opportunities for the arctic science community.

Each of these four functions could be established virtually or take advantage of existing facilities. The collaboratory would fundamentally serve as a partnership-building mechanism, providing opportunities for individuals and groups to interact and execute synthesis studies, education, and outreach.

Implementation Planning

The next steps in the development of the collaboratory focus on implementation, including working with cyberinfrastructure experts and industry to outline the appropriate supporting structure, tools, phasing, funding, and management. In early December 2007, members of the research community were invited to contribute to this planning during an online eTown meeting, as well as a town hall meeting during the American Geophysical Union meetings. Discussions centered on community needs and organizational and implementation issues. A workshop focused on refining the collaboratory activities and implementation strategy is tentatively planned for winter 2009.

For more information, see the ARCUS website: www.arcus.org/ARCSS/2007_data, or contact Charlie Vörösmarty at the City University of New York (c/o pwildes@ccny.cuny.edu). ■

Lubin Leads OPP Cyberinfrastructure Efforts

In late 2007, Dan Lubin joined the Office of Polar Programs (OPP) as the program manager for cyberinfrastructure.

Before coming to NSF, Lubin was a research physicist and senior lecturer at the Center for Atmospheric Sciences at Scripps Institution of Oceanography, which he joined in 1990. He later became associate director of the California Space Institute, also at Scripps. His research interests are atmospheric science and climate change in the polar regions; he is the coauthor of a two volume textbook entitled *Polar Remote Sensing*, published by Springer in 2006.

Lubin earned a B.A. in physics at Northwestern University in 1986; at the University of Chicago, Lubin earned an M.S. in geophysical sciences in 1987, an M.S. in astronomy and astrophysics in 1988, and a Ph.D. in geophysical sciences in 1989.

For more information, see the OPP website: www.nsf.gov/dir/index.jsp?org=OPP or contact Dan Lubin (dlubin@nsf.gov). ■

Workshops Focus on Virtual Organizations

The NSF Office of Cyberinfrastructure identified virtual organizations (VOs) as a fundamental element of its infrastructure plans and sponsored a series of workshops in Washington, DC, on the design, construction, evaluation, and operation of VOs.

The first meeting in the series was held in September 2007. Forty-two participants from academia and industry gathered to:

- share systematic knowledge about the components, characteristics, practices, and transformative impact of effective VOs;
- identify topics for future research that will inform the ongoing design, development, and analysis of VOs for science and engineering research and education; and
- create a new cross-disciplinary VO research community to conduct research across a range of important topics.

To explore these topics further, the subsequent workshop in January 2008 brought together more than 200 practitioners and researchers to discuss building effective VOs.

The resulting workshop report, *Beyond Being There: A Blueprint for Advancing the Design, Development, and Evaluation of Virtual Organizations*, was published in May 2008 and is available at: www.ci.uchicago.edu/events/VirtOrg2008/VO_report.pdf.

For more information, see the workshops' website: www.ci.uchicago.edu/events/VirtOrg2008/index.php?pg=main or contact Carl Kesselman at the University of Southern California (carl@isi.edu). ■

Federal Stimulus Bill Adds $3 Billion to NSF Budget

The $789 billion stimulus bill signed by President Obama on 17 February 2009 provides $3 billion for NSF:

- $2 billion for research awards;
- $300 million for the Major Research Instrumentation program;
- $200 million for Academic Research Instrumentation, unfunded since 1996;
- $100 million to the Education and Human Resources Directorate; and
- $400 million for Major Research Equipment and Facilities Construction.

Most of these funds, which are in addition to the agency's regular annual appropriation, are designated as FY 2009 money, and the agency will be expected to make its spending decisions quickly.

Like many federal agencies, NSF has been operating since October 2008 under a continuing resolution (CR), valid through 6 March 2009, that maintained its FY 2009 budget at the FY 2008 level ($6.0 billion). In December 2008, Congress began preparing an omnibus FY 2009 spending bill to fund most federal agencies; the bill (H.R. 1105), which passed the House on 25 February, reccommends $6.49 billion for NSF, a 5.9% increase over FY 2008. Assuming final FY 2009 appropriations are at least at FY 2008 levels, the additional funding from the stimulus puts NSF well ahead of the $7.3 billion authorized for the agency in the 2007 America COMPETES Act and back on track to double over a decade.

FY 2010

President Obama released his FY 2010 budget proposal on 26 February 2009. The request includes $7 billion for NSF, a 16% increase over FY 2008. The budget proposes new funding for climate change research and education; details of these programs will be available in April.

FY 2008

Increases of 8–10% proposed by the administration and Congress for the FY 2008 NSF budget were eliminated in the omnibus appropriations bill signed by President Bush in December 2007. The appropriated NSF budget totaled $6.0 billion, an increase of $116 million (2%) over FY 2007. A supplemental funding bill signed in June 2008 included an additional $63 million for NSF, bringing the total FY 2008 increase to 3.6% over FY 2007. These appropriations continued a trend of stagnant or declining budgets in real terms for most NSF directorates since FY 2004.

For more information, see the NSF Budget Division website: www.nsf.gov/about/budget/, the American Association for the Advancement of Science website: www.aaas.org/spp/rd/, or the Library of Congress Legislative Information website: http://thomas.loc.gov/.

New Report Summarizes U.S. Arctic Observing Activities

In May 2008, the Interagency Arctic Research Policy Committee (IARPC) released a report titled *Arctic Observing Network (AON): Toward a U.S. Contribution to Pan-Arctic Observing*.

In April 2007, IARPC staff were charged with the development of an arctic observing network as part of the implementation of the Study of Environmental Arctic Change (SEARCH; see pages 9–12) and as a lasting legacy of the International Polar Year. NSF and the National Oceanic and Atmospheric Administration assumed joint leadership in responding to this charge. The resulting report is the first step in interagency collaboration in AON development and achieving the goals of SEARCH. The report also constitutes the biennial update of the U.S. Arctic Research Plan, one of IARPC's major responsibilities. The report describes:

- Some of the changes that are occurring in the Arctic, which illustrate the need for improved arctic observing.
- The development of consensus that the need for AON is urgent.
- A conceptual framework to guide the development of AON by broadly defining participants, activities, and outcomes.
- The scope of current U.S. federal observing activities in the Arctic, including a general description of each agency's activities, maps of observing sites, and links to a multitude of data and information sources. This information is organized according to the categories presented in the *SEARCH Implementation Plan*: atmosphere, ocean and sea ice, hydrology and cryosphere, terrestrial ecosystems, human dimensions, paleoenvironment, and data and information management.
- Federal agencies' plans for future arctic observing activities, a conceptual framework for integration and coordination of existing and new observing activities, and data and information management to enable open and timely access to all federal arctic observing data.
- Description of the international cooperation necessary to realize the development of a multinational, pan-arctic network.
- Ten action items for federal observing activities in the Arctic, particularly as they relate to the need for enhanced, coordinated, and sustained observing to advance the goals of SEARCH.

This comprehensive resource will enable the agencies to further coordinate their efforts, make the data readily available in usable form, and work together to serve arctic residents.

The report is available at www.nsf.gov/pubs/2008/nsf0842/. For more information on AON, contact Martin Jeffries at NSF (mjeffrie@nsf.gov). For more information on IARPC, see the IARPC website: www.nsf.gov/od/opp/arctic/iarpc/start.jsp, or contact Mike Van Woert at NSF (mvanwoer@nsf.gov).

Award Builds on 63 Years of Research in Bristol Bay

Commercial catches of Pacific salmon in Bristol Bay and the Alaska Peninsula began in the late 1800s and, by the early 1900s, were the largest salmon fisheries in the world. By the mid 1900s, the fundamental biology of salmon was still poorly understood, and management of the fishery was based on the simple premise that salmon should not be over-fished.

With the goal of improving management decisions, the University of Washington (UW) established the Alaska Salmon Program in 1947 to determine physical and biological factors influencing sockeye salmon production. Studies conducted at permanent field sites in Bristol Bay, which are still in use today, monitored the interdependent relationship between salmon and their ecosystems. Many basic techniques for counting salmon and understanding their life history patterns were developed by the UW program and adopted as routine operations by the Alaska Department of Fish and Game, which now manages the fisheries.

The Alaska Salmon Program's current research draws on its long history of involvement in fisheries management. Biological sampling activities, conducted at five research stations in southwestern Alaska, continue to provide basic information on life history patterns and population dynamics, which is used to guide conservation of salmon populations in Bristol Bay and elsewhere. Other sampling programs, with no direct connection to fisheries management, document the seasonal and annual patterns of the physical environment and biotic communities.

One major focus area of the program is the linkage between biocomplexity and fisheries sustainability. Humans have exploited animal populations by hunting and fishing for thousands of years, but extensive commercial harvest is now largely limited to aquatic ecosystems. Evidence in Bristol Bay suggests that maintaining the diversity of stock structure and life history characteristics is critical to the ability of salmon populations to respond to climatic changes. In addition to this biotic dimension, there are equally important human dimensions, including regulations, investments in vessels and gear, locations of communities, property rights, licenses, and traditional and cultural aspects of fishing.

With support from the NSF Biocomplexity in the Environment program (Dynamics of Coupled Natural and Human Systems), Ray Hilborn of UW leads a project focusing on the coupling between salmon populations and human communities in Bristol Bay. These watersheds present an ideal research location because of minimal human activity in the area. Unlike other freshwater salmon habitats in North America, where there may be logging, mining, hydroelectric impoundments, hatchery production, or exotic species, changes in salmon populations can be attributed to harvest, climate variation, or other sources of natural variation.

Hilborn and his collaborators—Thomas Quinn, Daniel Schindler, Lorenz Hauser, Jim Seeb (all of UW), Gunnar Knapp (University of Alaska Anchorage), and Chris Costello (University of California Santa Barbara) are investigating:

- the current population structure of sockeye salmon and the ways in which this structure has evolved as evidenced by genetics and population dynamics;
- climate forcing on stock components and associated life history strategies;
- the role of marine-derived nutrients in freshwater productivity;
- harvest policies, catch stability, and economic resilience; and
- fleet composition, fishermen's behavior, and resilience to natural and anthropogenic stress.

Their research indicates that the sockeye salmon population complex in Bristol Bay consists of a wide range of individual populations with different life history characteristics, and that over the past 100 years different populations have had alternating periods of high and low productivity. At various times, different stocks have sustained the bulk of the commercial harvest. In other North American waters, many of the individual stocks have been eliminated by overharvesting or habitat loss, and, when environmental conditions change, there is no stock with alternative life history strategy patterns left to fill in the void.

The role of evolution can readily be seen in the relationship between predation by bears and the traits of salmon in different spawning sites. Bears selectively kill large salmon that have just arrived at the spawning grounds. In small streams, where bears can kill over half the salmon, the sockeye mature at a young age and are short for their age and slim-bodied. They devote their energy to reproduction and die shortly after they arrive. In larger streams, where bears have more difficulty catching them, the salmon are older, longer, deeper bodied, and have extended reproductive lives. Near lake beaches, the salmon are free from predation pressure, and sexual selection drives exaggerated traits in males, notably extremely deep bodies that result from male competition and female choice. In small, shallow streams these males would be killed by bears or stranded, but they are the most reproductively successful in deep lake beach sites.

In collaboration with the Bristol Bay Native Association, the Alaska Salmon Program provides internships that enable students from local villages to spend a summer at one of the program's field camps. The program also supports a week-long summer course in salmon biology and management for middle- and high-school students operated by the Bristol Bay Economic Development Corporation.

Since its inception, the Alaska Salmon Program has addressed the applied aspects of salmon and aquatic ecology directly relevant to the salmon processing industry. The program plans to continue a close relationship with the processing industry, which provides significant financial support, and utilize the long-term datasets on climate change and biotic responses to pursue new areas of research. The program currently provides more than 11 processors and the fishing fleet with forecasts of the total run and expected catch for the next fishing season, and, during the season, daily updates of the expected number of fish coming the rest of the season.

For more information, see: www.fish.washington.edu/research/alaska/index.html, or contact Ray Hilborn (rayh@u.washington.edu).

PolarTREC Offers Much More Than a Field Experience

Although the importance of integrating inquiry-based methods in science education is well documented and included in the National Science Education Standards, mechanisms for including inquiry in classrooms are largely untested. Common sense suggests that actively involving K–12 teachers in cutting edge research through teacher research experiences (TREs) should improve teachers' ability to engage in scientific inquiry, and several funding agencies support TRE programs. A 2005 NSF-sponsored workshop identified best practices for TREs, but there is little empirical data documenting their effectiveness.

In the polar regions, NSF supports PolarTREC (Teachers and Researchers Exploring and Collaborating), a comprehensive, sustained TRE program that brings K–12 educators and polar researchers together for hands-on field experiences. Evidence from two studies suggests that participation in PolarTREC improves teacher content knowledge and classroom practices and expands student knowledge of and interest in the Arctic and Antarctic.

Teacher Ute Kaden, who participated in PolarTREC in 2005 and 2006, used archival data and 2004–2006 participant surveys to evaluate the program for her 2007 doctoral thesis. Her results showed that participation in the program improved teachers' knowledge, skills, and confidence to teach effectively, renewed enthusiasm for teaching, and promoted students' learning.

Following on Kaden's work, the program has incorporated a formative evaluation component; this involves surveys, interviews, and assessments of teachers, researchers, and nearly 1,000 students, conducted before and after the field experience. Initial findings from the 2007–2008 field season include significant increases in:

- teachers' knowledge of the polar regions and ability to teach science concepts pertinent to their field experience;
- teachers' understanding of scientific process and the logistics of conducting research in the Arctic or Antarctic; and
- students' understanding of and interest in the poles, including increased time spent in school exploring science research activities and better understanding of physical science concepts related to the poles.

Data collection is continuing, and a comprehensive evaluation and data analysis of program activities and impacts is planned for release in 2010.

For more information on PolarTREC, see: www.polartrec.com, or contact Janet Warburton (warburton@arcus.org) or Kristin Timm (kristin@arcus.org) at ARCUS. The proceedings from the 2005 TRE workshop are available on the University of Rhode Island Office of Marine Programs website (http://omp.gso.uri.edu/ompweb/ctre/index.html).

Arctic Council Releases Oil and Gas Assessment

The Arctic Monitoring and Assessment Programme (AMAP), one of six working groups of the Arctic Council, recently released an assessment of oil and gas activities in the Arctic.

Fourth in a series of scientifically based council assessments of pollution in the Arctic, AMAP coordinated the effort with contributions from the other five working groups and scientific and technical experts from academia, industry, non-governmental organizations, and indigenous peoples' organizations. Two resulting reports describe the environmental, social and economic, and human health impacts of current oil and gas activities in the Arctic, and evaluate the likely course of development of arctic oil and gas activities and their potential impacts in the near future.

An overview report for policy makers and the general public, *Arctic Oil and Gas 2007*, which condenses hundreds of pages of technical background information into a series of messages reflecting the findings of the scientific assessment, offers a balanced and reliable document in support of sound future management. The 12 key findings described in the report include:

- Extensive oil and gas activity has occurred in the Arctic, with much oil and gas produced and much remaining to be produced.
- Natural seeps are the major source of petroleum hydrocarbon contamination in the arctic environment.
- Petroleum hydrocarbon concentrations are generally low.
- On land, physical disturbance is the largest effect.
- In marine environments, oil spills are the largest threat.
- Impacts on individuals, communities, and governments can be both positive and negative.
- Human health can suffer from pollution and social disruption, but revenues can improve health care and overall well-being.
- Technology and regulations can help reduce negative impacts.
- Responding to major oil spills remains a challenge in remote, icy environments.
- More oil and gas activity is expected.
- Many risks remain.
- Planning and monitoring can help reduce risks and impacts.

The complete scientific documentation, including sources for all figures reproduced in the overview, is contained in a related report, *Oil and Gas Activities in the Arctic: Effects and Potential Effects*, which is fully referenced and began being released in sections in October 2008.

For more information, go to: www.amap.no/ or contact co-chairs Dennis Thurston (dennis.thurston@mms.gov) and Hein-Rune Skjoldal (hein.rune.skjoldal@imr.no).

Observing Community Charts SAON Recommendations

In their 2006 Salekhard Declaration, the Arctic Council (AC) agreed to "urge all member countries to maintain and extend long-term monitoring of change in all parts of the Arctic, and request the Arctic Monitoring and Assessment Programme (AMAP) to cooperate with other AC Working Groups, the International Arctic Science Committee (IASC; see page 23), and other partners in efforts to create a coordinated arctic observing network that meets identified societal needs."

This initiative, Sustaining Arctic Observing Networks (SAON), is intended to capitalize on International Polar Year (IPY) activity and build a lasting legacy of sustained arctic observations and data. The goal of SAON is to achieve long-term arctic-wide observing activities that provide free, open, and timely access to high-quality data that will realize pan-arctic and global value-added services and provide societal benefits. Examples of societal benefits include contributions to scientific research, data product development, forecasting and prediction for the purpose of improved decision making, and policy development and implementation.

In January 2007, a Sustaining Arctic Observing Networks Initiating Group (SAON IG), composed of representatives of international organizations, agencies, and northern residents involved in research and observing, was formed to solicit information and advice contributing to recommendations on achieving SAON goals.

To lead the launch of the SAON initiative, the SAON IG together with the Swedish and Canadian IPY Committees and the Finnish Meteorological Institute agreed to organize a succession of three workshops to be held during the IPY. The series was aimed at developing this set of SAON recommendations and providing an opportunity for the arctic observing community to meet and contribute experience and expertise to the process.

More than 100 participants attended the first workshop, which took place in Stockholm, Sweden, in November 2007 and addressed the question: *Are current arctic observing and data and information management activities sufficient to meet users' needs?* This workshop resulted in an overview of user needs as seen from the science community, governmental agencies, and local residents. Break-out groups identified present observing sites, systems and networks, and analyzed spatial, temporal, and disciplinary gaps.

Approximately 200 participants attended the second workshop, which took place in Edmonton, Canada, in April 2008 and addressed the question: *How will arctic observing and data and information management activities be coordinated and sustained over the long-term?* Specific session topics were developed in response to discussions at the first meeting and included: Earth observation platforms, community based observations, coordination of international arctic observing networks and of national funding, operational observing, new and emerging technologies, integration across networks, observations and modeling, and data management.

The third workshop, attended primarily by chairpersons of previous workshops and representatives of funding agencies and science organizations, was held in October 2008 in Helsinki, Finland. The goal of this meeting was to synthesize the advice and information gathered at the previous workshops into the final set of recommendations for the coordination and promotion of sustained, integrated arctic observing activities. At the completion of IPY in March 2009, these final recommendations will be delivered to the AC, IASC, and the International Council for Science–World Meteorological Organization IPY Joint Committee, and distributed to all those who contributed to their development.

Workshop reports summarizing these meetings and the working group discussions are available at www.arcticobserving.org. For further information, contact Odd Rogne at AMAP (odd.rogne@amap.no).

ISAC Science & Implementation Plan Under Development

The science plan and implementation strategy to guide research activities contributing to the International Study of Arctic Change (ISAC) will be available for public comment in early 2009 and then widely released in the spring. The document identifies key scientific priorities and recommends an implementation strategy for an international effort to observe, understand, and respond to arctic change.

Emerging from the interagency Study of Environmental Arctic Change (SEARCH; see page 9) and initiated in 2003 by the International Arctic Science Committee (IASC; see page 23) and the Arctic Ocean Sciences Board (AOSB; see page 23), ISAC is an open-ended, international, interdisciplinary science program. The goal is to provide scientifically based information for the development of response strategies to society and decision makers in the face of pan-arctic system-scale changes. ISAC will engage in multidisciplinary observational, synthesis, and modeling activities to provide an integrated understanding of arctic change and projections for future change. The intent is not to duplicate ongoing and developing arctic research initiatives but rather to foster communication and collaboration among these and to facilitate the growth of international arctic research. Updates on ISAC progress will be available via a new website, which is under construction, and biannual newsletter, which will be sent out in early 2009.

A new ISAC executive director has been appointed—Maribeth Murray assumed this position in October 2007. Murray is also currently an associate professor at the University of Alaska Fairbanks (UAF) and director of the Human Dimensions of the Arctic System (HARC) Core Office at the UAF Center for Global Change.

ISAC activities and organizational needs are supported by the International Program Office, which is housed at the Swedish Polar Research Secretariat.

For more information, contact Maribeth Murray (ffmsm@uaf.edu).

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ARCUS is a nonprofit organization consisting of institutions organized and operated for educational, professional, or scientific purposes. Established by its member institutions in 1988 with the primary mission of strengthening arctic research, ARCUS activities are funded through cooperative agreements with NSF and the National Park Service, grants from NSF, a contract with the U.S. Fish and Wildlife Service, and membership dues.

Witness the Arctic is published annually by ARCUS. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of NSF. Submit suggestions for the next issue of the newsletter by July 2009.

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wit·ness (wit nis) *n.* **1.a.** One who has heard or seen something. **b.** One who furnishes evidence. **2.** Anything that serves as evidence; a sign. **3.** An attestation to a fact, statement, or event. —*v. tr.* **1.** To be present at or have personal knowledge of. **2.** To provide or serve as evidence of. **3.** To testify to; bear witness. —*intr.* To furnish or serve as evidence; testify. [Middle English *witnes(se),* Old English *witnes*, witness, knowledge, from *wit,* knowledge, wit.]

IASC Plans to Merge with AOSB as Part of New Structure

Since the International Arctic Science Committee (IASC) was founded in 1990, there have been significant changes in the science, environment, economics, and politics of the North. To address these changes and reflect the more integrative nature of polar science today, IASC is in the process of adopting a new organizational structure, which includes a merger with the Arctic Ocean Sciences Board (AOSB).

The new IASC structure emphasizes broad participation of its member countries in science planning activities primarily through the formation of two new core elements—Scientific Standing Committees and Action Groups—that will work with the existing Council, Executive Committee, and Secretariat to more effectively support science development.

Scientific Standing Committees will be composed of top scientists from IASC member countries and other arctic science organizations. The discipline-focused committees (marine, terrestrial, cryosphere, atmosphere, and social) will constitute the main scientific working bodies of IASC.

As part of these changes, the AOSB, which facilitates Arctic Ocean research through support of multinational, multidisciplinary natural science and engineering programs, will merge with IASC and become one of the five Scientific Standing Committees. The partnership will strengthen both organizations: IASC will gain the expertise of an organization with membership from 15 countries, active and ongoing programs, and a long history of contributions to arctic science; and AOSB will become part of an organization with strong outreach to disciplines beyond the marine system and with links to the larger policy community in the Arctic.

Another significant addition to the IASC structure, Action Groups, will make strategic recommendations concerning long-term activities and urgent needs for action. Members of these groups will be appointed by the Council. In exceptionally urgent cases, appointments can be made by the Executive Committee.

The Secretariat, which is currently hosted by the Swedish Polar Research Secretariat and is located at the Royal Swedish Academy of Sciences in Stockholm, will expand its functions in order to meet the organizational needs of increased community involvement. Under the new structure, the Secretariat will implement the decisions of the Council and Executive Committee, support the Scientific Standing Committees and Action Groups, maintain international communication, manage IASC finances, and conduct outreach and communication activities.

The Council and Executive Committee elements of current IASC structure will remain, for the most part, unchanged. The Regional Board, however, which was formed to ensure that IASC activities were consistent with interests of the eight arctic countries, will disband. The Council is composed of representatives of scientific organizations from IASC member countries (currently 18) and functions to represent national arctic science priorities. The six-member Executive Committee appointed by the Council directs the affairs of IASC and attends to matters requiring consideration by IASC.

The structural changes will allow IASC to encourage and facilitate cooperation of future arctic research pursuits, through assessments, science planning initiatives, long-term programs, workshops, networks, and other activities.

A description of the new structure was presented at Arctic Science Summit Week 2008, which provided an opportunity for representatives from IASC member countries and others to contribute to the development of these changes. IASC is currently in the process of developing the new bylaws and rules of procedure to accommodate the structural changes. The new structure will become effective after final approval by Council at the ASSW 2009.

For more information, see the IASC website (www.iasc.se), or contact Volker Rachold at the Secretariat (volker.rachold@iasc.se).

A Thank You From the ARCUS President and Board of Directors

After 17 years of service to ARCUS, Wendy K. Warnick stepped down as executive director in January 2009.

Wendy began working at ARCUS in 1992, building on 20 years of experience in planning, coordination, program administration, community health and policy education, and arctic issues. Near the beginning of her long tenure, she identified broadening the community of arctic researchers as one of her main goals. Evidence shows that Wendy has met that challenge. Community interest in arctic research has grown remarkably. In 1994, the Directory of Arctic Researchers held 650 entries—today, it includes more than 4,000. ArcticInfo reaches more than 6,000 people and *Witness the Arctic* has nearly 14,000 subscribers. ARCUS membership became international in scope and has grown from 21 to 50 institutions.

Under her guidance, ARCUS has developed a reputation for professionalism and has greatly broadened its capacity. Its role as liaison between the arctic research community and agencies, national organizations, policy makers, and the public has expanded as well. In 1994, ARCUS initiated the *Arctic Forum* and, since that time, this annual event has been one of the few interdisciplinary arctic science meetings—each year attendance has grown, and many successful collaborations have resulted.

These accomplishments, and many others not described here, reflect Wendy's success in shaping, funding, and implementing the leadership of ARCUS in advancing knowledge and understanding of the Arctic. The president and board of directors would like to express sincere gratitude for Wendy's contributions to ARCUS. As members of the arctic research community, we have all benefited from and greatly appreciate the role that the organization has played under her leadership in fostering planning, coordination, and support for arctic science.

While the search for Wendy's replacement is underway, Helen Wiggins, Director of Programs, and Ada Bower, General Manager, are providing interim management.

The board of directors expects to make an announcement regarding the executive director in the near future. Further information will be made available on the ARCUS website (www.arcus.org) and via ArcticInfo. Wendy remains as ARCUS Senior Adviser and can be contacted at warnick@arcus.org.

—Vera Alexander

Inside

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