Witness the ARCTIC

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In this Issue

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Translating Science - SEARCH's Adventures in Synthesis and Engagement

By: Brendan P. Kelly, SEARCH Executive Director

The Study of Environmental Arctic Change (SEARCH) facilitates synthesis of Arctic science and communicates our current understanding to help society respond to a rapidly changing Arctic. We focus our syntheses on the changing cryosphere (permafrost, land ice, and sea ice) and the consequences for ecosystems and society. We communicate our understanding to multiple audiences but with an emphasis on policymakers. Synthesizing and communicating to non-scientists both are acts of translation—across disciplinary languages in the case of synthesis and from technical to non-technical language in the case of conversing with policymakers.

A recent example of translating across disciplines was the *International Workshop to Reconcile Methane Budgets in the Northern Permafrost Region* (https://eos.org/meeting-reports/resolving-a-methane-mystery-in-the-arctic). SEARCH brought together over 40 international scientists with expertise ranging from atmospheric chemistry to oceanography to ecology. Translating across discipline-specific vocabularies was essential to understanding mismatches in estimates of methane emissions from permafrost based on field measurements and on atmospheric data. The common understanding established in the workshop allowed the researchers from different disciplines to create a collaborative plan to reconcile the divergent estimates.

While it is possible to coral scientists for three-day technical workshops, opportunities to communicate with policymakers typically depend on shorter convenings. Hence, SEARCH produces short, written briefs addressing policy-relevant questions about Arctic change (https://www.arcus.org/search-program/arctic-answers). Those "Arctic Answers" informed a series of recent in-person policy briefings in Alaska;[1] other states;[2], Washington, DC; [4], [5],[6] and abroad. [7], [8] The production of the briefs was

enhanced by collaboration with Congressional staff who provided guidance and feedback. In response to the briefs. SEARCH was invited to brief the Senate Arctic and Ocean caucuses on 26 September 2017. Over 30 participants represented both caucuses; three other Senate committees; 9 members' offices; the Navy's Oceanography, Space and Maritime Domain Awareness Directorate; and the Bureau of Ocean Energy Management. SEARCH followed up with visits to the offices of 9 members of Congress in September and October. Those meetings were collaborative, two-way exchanges in which SEARCH was able to convey up-to-date scientific information, and the congressional staff shared suggestions for increasing our effectiveness in addressing policy. One of SEARCH's leaders is fond of saying, "the science is not complete until the paper is published" to which another adds, "….and the science is made available to stakeholders" including policymakers.

Further information about SEARCH Action Teams and related products is available on the SEARCH website.

Or, contact Brendan P. Kelly, SEARCH Executive Director (bpkelly@alaska.edu).

Footnotes

[1]Alaska Center for Climate Assessment and Policy: https://accap.uaf.edu/SEARCH_Arctic_Answers

[2] Arctic Encounter Symposium: https://www.youtube.com/watch?v=cTXsdgO5Wv0&t=532s

[3] Middlebury Institute of International Studies:
https://www.youtube.com/watch?v=Vzo0S2sD-yk

[4] Woodrow Wilson Center:
https://www.wilsoncenter.org/event/arctic-environmental-futures-nexus-sc...

[5] American Association for the Advancement of Science:
https://www.facebook.com/ArcticChange/videos/353317338412791/

[6] Geopolitics in the New Frontier: Opportunities and Challenges in the Arctic:
https://isd.georgetown.edu/

[7] The Arctic at the Crossroads: cooperation or competition?:
http://www.ditchley.co.uk/conferences/past-programme/2010-2019/2017/arctic

[8] Arctic Science Summit Week:
https://www.czech-in.org/cmgateway/assw17/index.html?module=searchablepr...

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SEARCH Plans Meetings for Actionable Science

By: Brendan P. Kelly, SEARCH Executive Director

What understanding is needed to inform Arctic decision-making through 2050?

How can scientists better understand and contribute to Arctic policy conversations?

How might unexpected events or trends in the Arctic substantially alter policy needs by 2050?

What research is needed to avoid unmanageable change in the Arctic?

Arctic Futures 2050 will address these questions through a scenarios workshop in 2018 and a larger, open meeting of Arctic scientists and policymakers in 2019. The immediate products will include descriptions of research—jointly produced by scientists and policy staff—needed to inform Arctic policy. The longer-term outcome will be effective and iterative collaborations of scientists and policymakers.

Arctic environments are transitioning rapidly to uncertain states, and decision-makers must respond with policies informed by scientific understanding. The Study of Arctic Environmental Change (SEARCH) facilitates cross-disciplinary syntheses to improve our current scientific understanding of Arctic environments and communicates that understanding to policymakers through briefings and roundtables (see the Arctic Answers webpage). SEARCH recognizes that future scientific understanding of the Arctic will be shaped by the research questions that we ask now, and the utility of the answers for policymaking will be enhanced by early and iterative conversations between researchers and policy staff. In *Arctic Futures 2050*, SEARCH and its partners will convene a scenarios workshop to frame research needs in policy terms that will then inform a larger meeting in which scientists and policy staff will develop recommendations for future research.

SEARCH welcomes partners in the scientific and decision-making communities to plan and convene *Arctic Futures 2050*. Co-producing answers to important questions about the changing Arctic will help

break down communication barriers and ensure that the scientific community can meet the needs of decision-makers.

Further information about SEARCH Action Teams and related products is available on the SEARCH website.

Or, contact Brendan P. Kelly, SEARCH Executive Director (bpkelly@alaska.edu).

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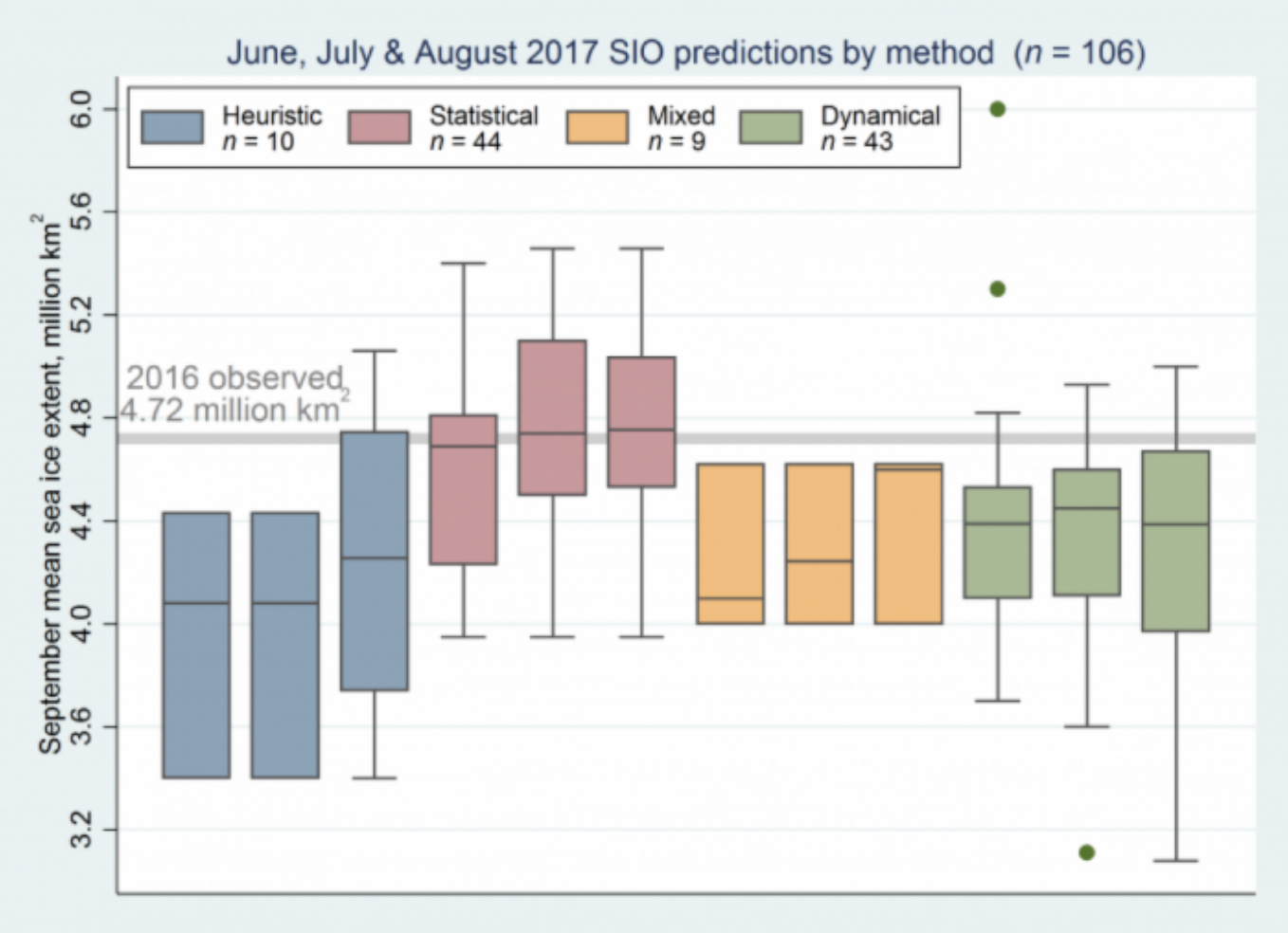
Sea Ice Prediction Network (SIPN) Updates

By: Betsy Turner-Bogren and Helen Wiggins, ARCUS

SIPN 2017

During the final months of funding for the initial Sea Ice Prediction Network (SIPN) project, efforts were focused on the core Sea Ice Outlook (SIO) activities in the summer and fall of 2017. Activities included development of the June, July, and August monthly reports, and a post-season report to synthesize results from the 2017 melt season. Additionally, SIPN Leadership Team members contributed several peer-reviewed papers for publication and made presentations to the Marine Environmental Observations, Predictions and Response Workshop in Ottawa, Ontario and to the Interagency Arctic Research Policy Committee (IARPC) Sea Ice Collaboration Team Meeting (see SIPN Presentations and Publications).

The June, July, and August SIO reports received a total of 106 contributions for pan-Arctic extent predictions (based on multiple methods: statistical, dynamical models, estimates based on trends, and subjective information) along with contributions for Alaska regional extent predictions, descriptive regional contributions, and pan-Antarctic extent predictions—a new SIO feature for 2017.



Distribution of June, July, and August 2017 Outlook contributions as a series of box plots, broken down by general type of method. The box color depicts contribution method and the number above indicates number of contributions for each type of method. The individual boxes for each method represent, from left to right, June, July and August.

The 2017 SIO Post-Season report, under development, will include discussion of the range of methods used by contributors, a review of the 2017 Arctic conditions, and discussion of the Antarctic outlooks.

SIPN will hold an open meeting during the 2017 AGU Fall Meetings to provide discussion of the 2017 Arctic sea ice/Sea Ice Outlook season, an overview of the recently-funded "SIPN 2" project and collaborations (see below), and opportunity for discussion and to share information on related efforts. The meeting will be held on Tuesday, 12 December from 12:30 to 1:30 p.m. (CST) in New Orleans, Louisiana. More information is available here. For questions and to RSVP, contact Betsy Turner-Bogren, ARCUS (betsy@arcus.org).

"SIPN2" Project Funded

As a follow-on to the current Sea Ice Prediction Network project, a collaborative proposal called "Collaborative Research: Advancing Predictability of Sea Ice: Phase 2 of the Sea Ice Prediction Network (SIPN2)" has been funded by NSF-Arctic System Science Program.

This project, which will begin in January 2018, will result in a better quantification of the role of oceanic heat and climate variations in the Pacific sector of the Arctic; new observational-based sea-ice products; and activities to improve seasonal predictability of Arctic sea ice, the limits of this predictability, and the economic value of forecasts for stakeholders.

More information about the new project will be announced via the SIPN Mailing List and discussed at the 12 December open meeting at AGU.

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Research Processes and Indigenous Communities in Western Alaska: Results from a Workshop on Indigenous Perspectives

By: Brenden Raymond-Yakoubian, Sandhill.Culture.Craft Principal and Julie Raymond-Yakoubian, Kawerak, Inc., Social Science Program Director

Kawerak, Inc., the Alaska Native non-profit tribal consortium for the Bering Strait region, and Sandhill.Culture.Craft, a social science research and consulting firm based in Girdwood, Alaska, partnered to hold a two-day workshop in August 2016 to discuss key Indigenous perspectives on a variety of issues regarding the relationships between Indigenous communities and research processes. Nine workshop participants from western and northern Alaska Indigenous communities and organizations attended in addition to seven other guests and observers, including guests from the Inuit Circumpolar Council Alaska, the National Science Foundation (NSF), the National Park Service, and Kawerak. The workshop was funded by NSF's Arctic Social Science and Oceans Sciences Divisions. The Kawerak Marine Program and the National Park Service Bering Land Bridge National Preserve Alaska also provided support.

The workshop was part of a larger project conducted by Kawerak and Sandhill.Culture.Craft: an anthropology of research to examine the relationships between research and Indigenous communities from a holistic perspective. This larger project seeks to understand this "landscape" of inter-relationships. Project Leads Julie Raymond-Yakoubian and Brenden Raymond-Yakoubian see this as a valuable endeavor that can inform future work on the nexus between communities and research by grounding that work with a holistic look at the complex web of people, institutions, and processes that are involved in this nexus. The workshop and larger project take place within a backdrop of increasing attention to research processes in the north as an object of discussion and inquiry. This has included conversations about, among other things, increased research activities and impacts to communities, how to integrate communities and their concerns and knowledge into research, and changing protocols and standards.

The workshop was successful in its goal of providing a forum for discussion of key Indigenous perspectives on these issues (regarding which, these are historically the most under-represented voices).

The workshop participants focused discussion on four main topics:

1. What is the overall "landscape" of research processes that are in, near to, or otherwise affect Indigenous communities?
2. What are Indigenous concerns, perspectives, and needs regarding research?
3. What are some ways forward that can change the relationships between research processes and Indigenous communities for the better?
4. As a special case study, the group also set aside time to have expanded discussions of ship-based research regarding the three questions noted above.

Participants, special guests, observers, and facilitators for the August 2016 Nome Workshop. Photo courtesy of the Kawerak, Inc. Social Science Program.

Workshop participants and observers discussed the above topics in detail, and some gave presentations to the group about significant issues and experiences. A number of important cross-cutting themes were identified from the workshop discussions. A key perspective was that there are needs and desires for changes to occur in research processes to improve relationships between research and Indigenous communities. For example, participants noted a desire for a greater oversight of research. Another thread that arose was that research is often interconnected with existing and long-standing concerns related to

power imbalances, cross-cultural differences, and a history of colonialism. Furthermore, a noted theme was that Indigenous people are often placed in complex binds with regard to their engagement with research. It was noted that communities have a desire for greater involvement of Indigenous people —including their knowledge, concerns, and priorities—in many ways and at many levels throughout the entire scope of research processes. It was also clear during the workshop that subsistence and natural resources—and the protection of them—is of paramount importance to communities, and the consideration of this extends to research issues.

These were just some of the broader themes and findings from the workshop. The findings from this workshop will be integrated into the current and future activities of the larger project, which will include additional workshops, interviews, ethnographic observation of key events, and other activities.

More information can be found in a publicly-available report discussing the workshop and its results in greater detail. The report can be downloaded from the Kawerak Social Science Program website as a PDF.

The perspectives of all people involved in northern research are fundamental to the project, and as such the project leads would greatly welcome any perspectives from those who read this article. For inquiries about, and interest in, the project, please contact the Project Leads Brenden Raymond-Yakoubian (brenden@SandhillCultureCraft.com) and Julie Raymond-Yakoubian (juliery@kawerak.org).

About the authors

Brenden Raymond-Yakoubian is an anthropologist and the Principal at Sandhill.Culture.Craft, a social science research and consulting firm based in Girdwood, Alaska.

Julie Raymond-Yakoubian is an anthropologist and the Social Science Program Director at Kawerak, Inc., the Alaska Native non-profit tribal consortium for the Bering Strait region.

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Investigating the Health and Wellbeing of Alaska Native Elderly in Northwest Alaska Using Community-Based Research Methods

By: Jordan P. Lewis, Associate Professor (WWAMI) School of Medical Education; Director, National Resource Center for Alaska Native Elders; University of Alaska Anchorage, College of Health

Alaska Native communities have a strong sense of respect for their older residents. In many Alaskan rural communities, whose primary population is Alaska Native people, the elderly are still relied upon for their deep knowledge and understanding of the natural environment, heritage languages, and cultural practices that are important not only for economic survival but social cohesion and community wellbeing. However, change is deeply affecting Alaska Native communities and Alaska Native people are forced to adapt to the new environmental, economic, and social realities that affect their worlds. A research project entitled "Investigating the Health and Wellbeing of Alaska Native Elderly in Northwest Alaska through Community Participatory Based Research Methods," led by Jordan Lewis and funded by the National Science Foundation (NSF) Office of Polar Programs, Arctic Social Sciences, investigates how Alaska Native Elders are adapting to rapid economic, environmental, and social change by exploring their own understanding and definition of what successful aging means to them. The goal of the research project is to establish a better understanding of successful aging from the perspectives of Alaska Native elderly in Anchorage, the Northwest, and Aleutian Island regions of Alaska.

Jordan Lewis (Aleut, Native Village of Naknek, Alaska) previously conducted his dissertation study "Successful Aging through the Eyes of Alaska Native Elders: What it Means to be an Elder in Bristol Bay, AK" from 2007–2009, which was also funded by NSF Arctic Social Sciences Program. This study brought awareness of the value of positive, or strengths-based, research with Elders to gain a deeper understanding of the skills, strengths, and characteristics that enable them to age well—and how those strengths can be shared with others in the community to support healthy aging for all generations. In this research, the term "Elder" differentiates Indigenous Elders of Alaska from those who are considered older adults. Community respect for Elders is a cultural convention that distinguishes those Elders who have lived traditionally, who continue to serve as an integral part of their community, and are viewed as role models (Lewis, 2010, 2011). To shift the focus from western concepts of aging that uses a chronological age to determine status, to use of a nominative sampling approach, where community

leaders and tribal council members nominate respected and honored Elders in the community, eliminated bias in our studies. Several communities in Anchorage and the Northwest and Aleutian Island regions of Alaska subsequently reached out to Lewis to request that similar research be conducted in their region.

Figure 1. Aerial view of Native Village of Unalakleet, Alaska in the Norton Sound southern sub-region in 2017. Photo courtesy of Jordan P. Lewis.

The current research study, now in year two, will consist of 80 qualitative in-depth interviews with Alaska Native elderly to establish an Indigenous understanding of what successful aging means for Alaska Natives and what is required to age in place. Through these interviews the research team will explore the concept of successful aging and hope to gain a sense of Alaska Native beliefs about aging and how geography or place of residence (rural vs. urban) impacts views of successful aging. In the spirit of Community-Based Participatory Research (CBPR), participants have been engaged through the entire research process, from conception to data analysis and dissemination. Meetings are being held in participating communities to review the findings and receive feedback—this will ensure the findings reflect the unique perspectives of the Elders, families, communities, and regions. These findings will also be compared with the previous study on successful aging conducted in Bristol Bay to compare and

contrast experiences of aging in these three rural regions and one urban region of Alaska.

Figure 2. The late Paul and Anna Chukan, the author's Great Grandparents from Native Village of Naknek, Alaska. Photo courtesy of Melanie Brown (relative).

The lack of a definition of successful aging for Alaska Native Elders risks labeling them as aging less successfully than their non-Indigenous counterparts. This research study will answer the following questions:

1. How are experiences and characteristics of Alaska Native Elders in Northwest and Aleutian regions of Alaska different and/or similar from those of the Elders in Bristol Bay, Alaska?
2. How do Alaska Native Elders who have chosen to relocate to urban communities define successful aging?

Adhering to CBPR principles (Israel et al., 2013; Lewis & Boyd, 2013; Lewis & Boyd, 2012) and using

the qualitative research approach known as a "grounded theory framework"—in which theory is derived from the data rather than applying a theoretical framework to guide data analyses—this study will gather interviews with Alaska Native Elders (n=80) in Anchorage, Norton Sound Southern sub-region, and the Aleutian Islands region. Semi-structured in-depth interviews will be conducted with Elders nominated by their community as respected Elders in order to learn what is required to age in place, what it means to age well in their community, role of generativity (the desire to pass on your legacy to future generations to ensure they have a healthy future), as well as the joys and challenges of aging in place. Findings will inform the factors that assist communities to determine how they can support the needs of their Elders and enable them to live their remaining years as they may wish. To date, 41 interviews have been completed in the Norton Sound southern sub-region. Data collection in Anchorage and the Aleutian Islands will take place during spring 2018.

Through the establishment of a locally and culturally informed understanding of successful aging, this research advances discovery and builds on the previous Successful Aging Study (Lewis, 2010, 2011, 2013a, 2013b, 2014a, 2014b, Skewes and Lewis 2016, Lewis and Allen 2017). In addition to contributing to the academic literature on successful aging, it promotes teaching and learning from the Elders on healthy aging in rural and urban Alaska, as well as training graduate students how to work respectfully with Alaska Native communities (e.g., gain entrée, host community meetings, coordinate team and community schedules, and host dissemination presentations), and learn effective communication strategies to visit with Elders and learn from their experiences. It also educates researchers on the importance of CBPR and of allowing the elderly to subjectively define their aging process, as well as engaging the local community throughout the entire research process, which promotes the co-production of knowledge and bi-directional learning. This research project broadens the participation of underrepresented groups (Alaska Natives, Elders, rural and remote communities) and puts them on equal footing with the scientists in interpreting results and in presenting the results. This research also has the potential to contribute to the disciplines of anthropology, gerontology, community psychology, sociology, and Indigenous research methods and others by paving the way for future researchers interested in Indigenous aging. The research findings can influence health and social policy in Alaska and how healthcare and long-term support and services are delivered to older residents in rural communities.

Figure 3. The late Margaret Hemnes from Nome walking to the tribal hall in the Village of Koyuk, Alaska in 2011. Photo courtesy of Jordan P. Lewis.

The results of this research will be published and disseminated for other tribal health organizations, researchers, gerontologists, anthropologists, and students to use with the permission of the tribal governing authorities, the Alaska Native participants, and their communities. This study will also highlight that aging does not have to equal poor health and immobility; successful aging should be and can be attained by everyone and defined in their own terms—not according to others' benchmarks for successful aging that do not reflect the cultural values of these Elders and their communities. This research has the potential to inform health professionals, policy advocates, and local and state officials about the factors that determine whether or not rural Alaska communities are able to meet the needs of their elderly and enable them to live their remaining years as they may wish.

Year three of the NSF grant will focus on peer-reviewed publications, professional presentations, and dissemination of findings back to participating communities. We will work with each community to determine the most effective format to share the findings and present findings in non-academic language. Communities have requested newsletters, flyers, and other handouts that highlight the major findings of the study. In addition to dissemination efforts, we will be holding the first Indigenous successful aging conference in Anchorage in May 2019. This conference will bring together the leading scholars in successful aging and Alaska Native Elders from across the State to discuss the findings of these studies, discuss the current successful aging literature, and develop strategies and a paper to indigenize the

successful aging literature and encourage more Indigenous communities across the Arctic to engage in this research.

Further information is available on the National Resource Center for Alaska Native Elders website.

For more information, contact Jordan P. Lewis by email (jplewis@alaska.edu) or by phone: (907) 786-4708.

Figure 4. Elizabeth Fleagle (Inupiat Eskimo, Elder, Mentor, Traditional Counselor) and author, Jordan P. Lewis in Suquamish Lodge, Bainbridge Island, Washington in 2012. Photo courtesy of Jeremiah E. Lewis.

Jordan P. Lewis (Aleut from the Native Village of Naknek, Alaska) is an Associate Professor with the WWAMI School of Medical Education at the University of Alaska Anchorage. Trained as a community psychologist, social worker, and gerontologist, Dr. Lewis's research identifies characteristics that enable Alaska Native Elders to age well, become role models for their families and communities, and fill the roles of tribal leaders in the traditions passed on by previous generations. Using the lessons and experiences of Elders, Dr. Lewis develops culturally tailored approaches for family and community members to improve the health of all generations, from long term care programs to community based programs to support families caring for loved ones. His past research has explored cultural understandings of successful aging, intergenerational programming in tribal communities, as well as collecting stories to improve program and service delivery in long-term care settings. Jordan received his BSW from the University of Alaska Fairbanks, MSW from Washington University in St. Louis, and PhD from University of Alaska Fairbanks.

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Joint Science Education Project (JSEP): Mentoring the Next Generation of Polar Scientists

By: Lauren Culler, Research Assistant Professor in the Environmental Studies Program at Dartmouth College and JSEP co-Principal Investigator, and Lee McDavid, Program Manager of the Institute of Arctic Studies, Dartmouth College

Twenty high school students from Greenland, Denmark, and the U.S. learned about polar science this past summer as they gained first-hand experience of how international research teams work together and some of the challenges they face, especially when speaking different languages.

The Joint Science Education Project (JSEP) is co-sponsored by the U.S. National Science Foundation and Naalakkersuisut (Government of Greenland). Established in 2007 during the International Polar Year by the Joint Committee, a high-level forum of the Greenlandic, Danish, and American governments, JSEP is designed to inspire the next generation of polar scientists by giving young students the opportunity to learn in one of most important research locations in the world.

In 2017, JSEP brought together twenty high school students, eight educators and five Dartmouth College graduate students for three weeks of inquiry-based and hands-on polar science in Greenland—a vast ice-covered island ringed by graceful tundra. The students hailed from California, Virginia, Missouri, Massachusetts, Oregon; Copenhagen; and Greenland's four high schools in Nuuk, Sisimiut, Ilulissat, and Qaqortoq. They were joined by a U.S. high school science teacher, Erica Wallstrom from Rutland, Vermont, and educators from Greenland, Denmark, and Chile.

"Most people think that Greenland is 100% covered in ice," says Neosha Narayanan, one of the U.S. students. "My friends are surprised to hear that Greenland is habitable at all."

JSEP students look west toward the Kangerlussuaq fjord from the top of Black Ridge. Photo courtesy of Erica Wallstrom.

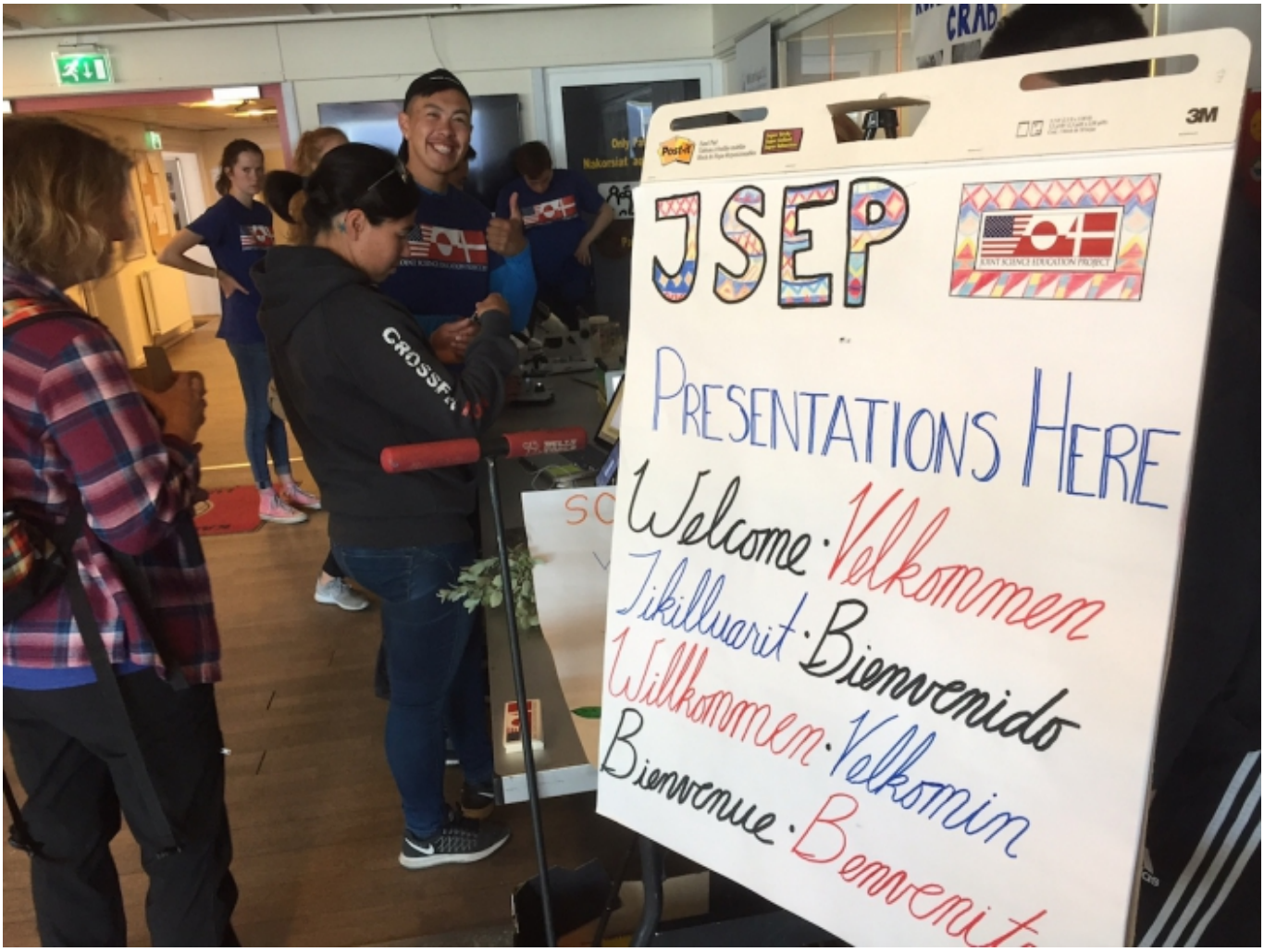
The first stop for the multicultural and multilingual JSEP team was two weeks in Kangerlussuaq, a community in southwest Greenland that, although small in population, has been supporting international scientific research in Greenland for decades. Students were able get a close-up view of important field sites, including the massive Russell Glacier, Point 660 at the edge of the ice sheet, and Sea Tomato Lake, site of mysterious baseball-sized cyanobacteria.

Students worked in groups to complete projects relevant to Greenland's rapidly changing environment and motivated by questions such as, "how do warming temperature affect permafrost?" Teachers challenged students to experience and understand the scientific process—how to ask a good question and propose a hypothesis, and how to collect and analyze data.

"The projects are one of the best parts of the program," says Melissa DeSiervo, an ecology graduate student. "The students really enjoy working in the field and designing and executing their own project."

The culmination of their work in Kangerlussuaq was celebrated during an outreach event at the Kangerlussuaq Airport, where students showed videos they had created and talked with international travelers about the significance of their science projects for Greenland, the Arctic, and the world.

"I loved doing the science experiments!" says Neosha. "It was rewarding to present our final research video at the Kangerlussuaq airport afterwards. Our research group definitely bonded a lot during the few days that we had to formulate our research question, collect data, record data, and create our video."



JSEP students talked to travelers at the Kangerlussuaq Airport in English, Danish, and Greenlandic about the effects of climate change on Greenland. Photo courtesy of Erica Wallstrom.

During the third week of the expedition, all twenty students and their teachers boarded a LC-130 cargo plane with ski-equipped landing gear. Their destination was snow-covered Summit Camp, a U.S. research base atop the Greenland Ice Sheet at over 10,000 feet in elevation and an average July temperature of 12˚ F. This year-round facility provides crucial information for understanding Earth's climate. Students learned from researchers about ice and snow and the challenges of doing science in such a remote and frigid environment.

JSEP students and educators at Summit Station, a research station at the top of the Greenland Ice Sheet. Photo courtesy of Erica Wallstrom.

For three years, JSEP has been integrating U.S. graduate students into the core curriculum. This year, five Dartmouth graduate students in earth sciences, biology, and engineering added their expertise, acting as teachers and mentors. The graduate students are also learning—practicing how to effectively communicate science to non-scientists and others not in their area of expertise, a critical skill when working in interdisciplinary and international teams.

"JSEP is a formative experience for graduate students who will increasingly engage with public audiences," says Hunter Snyder, an ecology graduate student. "It fosters a cultural understanding, a crucial part of making science that we can all care about."

The graduate students are also producing polar science lesson plans based on Next Generation Science Standards (NGSS) for high school classrooms. A sample lesson plan is "The World of Lichens". With the help of Dartmouth's Institute of Arctic Studies, the host institution for the U.S. contributions to JSEP, the lesson plans will be made available to any school free of charge.

One goal of JSEP is building a diverse international network of students, scientists, teachers, and other stakeholders who understand the necessity of collaboration and educating the next generation of scientists and engineers. "It's awesome to watch the students transform over the course of the program,"

observes DeSiervo. "When they go back to their schools and hometowns, they are real leaders and Arctic science ambassadors in their communities."

Further information is available on the JSEP website.

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Updates from NSF's Arctic Sciences and Research Support and Logistics Programs

NSF Arctic Sciences Town Hall to Convene During 2017 AGU Fall Meetings

Program Directors from NSF's Office of Polar Programs Arctic Sciences Programs will provide an overview of recent and upcoming news of interest to the research community at a town hall meeting during the 2017 AGU Fall Meetings. Topics will include staffing changes in the Arctic Section, proposal pressure in 2017 versus 2016 without proposal deadlines, and upcoming opportunities at NSF of interest to Arctic researchers (including mid-scale research infrastructure, partnerships in geosciences-cyberinfrastructure, Navigating the New Arctic, and Prediction of and Resilience against Extreme Events (PREEVENTS). Program Directors anticipate giving a brief presentation with the bulk of the time devoted to questions and discussion.

This town hall will convene 5:15 – 6:15 p.m. on Tuesday, 12 December 2017 in the ARCUS Arctic Community Meeting Room, located in Riverside Room 1 on the second floor of the Hampton Inn & Suites New Orleans-Convention Center in New Orleans, Louisiana.

For more information, contact Cynthia Suchman (csuchman@nsf.gov), Program Director, Arctic Natural Sciences, Office of Polar Programs, NSF

NSF's Research Support and Logistics: Summit Station

Summit Station is a U.S. Arctic science research hub at the apex of the Greenland Ice Sheet. CH2M Hill Polar Services operates Summit on behalf of the National Science Foundation (NSF). Summit has hosted a diverse array of science operations since its inception as the base camp for the drilling of the Greenland Ice Sheet Project 2 ice core in 1989. Summit is the only high- altitude, inland, year-round observing station in the Arctic, offering unique access to the free troposphere, stable atmosphere, and a clean air and snow sector.

To focus upcoming investments in the station infrastructure, and to provide a guide to the future of Summit as a resilient and state-of-the-art scientific platform, the Arctic Research Support and Logistics

program in NSF's Office of Polar Programs has created a vision for future operations at Summit. This vision statement evolved as a result of dialogue between NSF and the scientists and support personnel who work and live at Summit, and it will guide decision making in the years to come.

A new mobile garage (on left) has been constructed at Summit Station. The garage sits on a mobile sled-like base that allows the garage to be periodically towed into a new position to combat surrounding snow accumulation and drift. The old garage (on right) sits below the horizon and will be deconstructed and removed from station beginning in 2018. Photo courtesy of Jennifer Mercer.

NSF Vision for Research Support and Logistics at Summit Station

Summit Station will become an efficient, flexible observing platform supporting seasonal campaigns for research and training as well as a variety of research fields utilizing state-of-the-art technology to enable year-round measurements made autonomously or with minimal human presence.

Summit Station will remain an important polar research station contributing to an Arctic network of observations and supporting cutting-edge research in a variety of disciplines by international teams, as well as providing a training platform for next generation research scientists. Observations at Summit Station contribute to a broad scientific understanding of the atmosphere and cryosphere including:

tracking atmospheric pollution and Arctic-wide transport, snow chemistry, air-snow interactions, weather prediction, understanding changes in the Arctic climate system, the surface mass balance of the Greenland Ice Sheet, and the physics of snow and ice. Research involving observations of the atmosphere, cryosphere, space weather, particle physics, seismology of the ice sheet, and astronomy and astrophysics is potentially transformative and improves our understanding of the Earth, the influence of the Sun on Earth's atmosphere, and the origins of the Universe. Building on more than thirty years as a research site, Summit Station is anticipated to continue to serve as a platform for these studies and as a test bed for new sensors and technology designed for remote operation or autonomous exploration in isolated regions and harsh environments. Continued improvements in communications technology will soon allow for scientists and the public to fully participate in experiments and events at Summit Station from anywhere.

Summit Station will be maintained, augmented, and upgraded as a research support and infrastructure hub subject to available funds and successfully competed NSF science projects as well as research funded by other U.S. and International organizations, as appropriate. The vision includes the following objectives:

- Preserve Summit Station's clean air and snow sectors for science investigating processes in the coupled atmosphere-cryosphere-climate systems, while also providing and allocating space for science not reliant on pristine air and snow.
- Continue to serve as a platform for training next generation scientists.

To achieve this vision, we will:

- Develop a flexible site with facilities that meet changing requirements through designs aimed towards efficiency and safety that allow for easy reconfiguration of space and autonomous operation of heat, energy, and other requirements, including the capability to safely and easily winterize all infrastructure for unmanned periods and subsequently reactivate it.
- Provide scalability to allow for future project additions or reductions, depending on the demands of the NSF science community.
- Implement systems that allow for autonomous data collection.
- Develop the capability to support funded research during unmanned periods.

For more information, visit the Summit Station website or contact Jennifer L. Mercer (jmercer@nsf.gov), NSF Program Manager, Arctic Research Support and Logistics (RSL).

Governing Across the Waves: An International Workshop on Managing Maritime Traffic in the Bering Strait

By: Cara Condit, Director for Arctic Study and Policy, U.S. Coast Guard Academy

The U.S. Coast Guard Center for Arctic Study and Policy (CASP) organized the recent "Governing Across the Waves Workshop: Global Insights for Transboundary Waterways Management in Sensitive and Congested Maritime Spaces," which aimed to support the ongoing efforts by the U.S. and Russian governments to achieve the shared objectives in the Bering Strait region of safe, secure, and environmentally responsible maritime traffic.

Established in September 2014, CASP serves as the Coast Guard's leading Arctic policy research center and think tank, and brings together diverse maritime specialists to collaborate on effective solutions to challenges in the Arctic and beyond. CASP is located on the grounds of the U.S. Coast Guard Academy in New London, Connecticut. CASP fulfills a key initiative to accomplish strategic objectives in the U.S. Coast Guard Arctic Strategy and Implementation Plan.

With a small but experienced staff, CASP's mission is "[t]o increase the effectiveness of governance and operations in the Arctic by promoting research and academic thought, broadening collaborative partnerships, and educating future leaders about the complexities of this unique region." CASP accomplishes this mission through research and the organization of academic conferences. The Governing Across the Waves workshop held 26–27 September 2016 is an example of how effective CASP can be for the Coast Guard.

During the two-day workshop, the question posed was simply: what lessons might be learned from other regions of the globe? To answer this question, CASP partnered with Bowdoin College and the World Wildlife Foundation to convene a globally and disciplinarily diverse group of over fifty experts with a breadth and depth of maritime transboundary expertise. Official delegations from Japan, Argentina, Chile, and Indonesia provided critical context to panels of national and international scholars and advocates. The United States and Russia participated in the workshop as observers.

"This meeting was a real opportunity to learn from our counterparts who have experience with the challenge of managing shared straits and waterways," offered Mike Emerson, the Coast Guard's Director

of Maritime Transportation Systems, "as well as tap into the work of the academic community on issues like coastal planning and protected areas."

Cadet Lucy Daghir, a student at the U.S. Coast Guard Academy, echoed this sentiment: "It was incredible to be in the room," she noted, adding that the workshop "opened my eyes to the possibility of international collaboration in the search for creative problem solving and policy implementation."

Mr. Michael Emerson, Director, Maritime Transportation Systems, (center) and RADM Michael McAllister, Coast Guard District 17 Commander, (right) recognized by the Russian Ministry of Transport, Andrey Viktorovich Khaustov, General Director of the State Marine Pollution Control, Salvage and Rescue Administration of the Russian Federation (left). Photo courtesy of Rachel Perron.

The workshop started with the baseline acknowledgement that, as Arctic ice retreats and ship traffic increases through the narrow Bering Strait, the U.S. and Russia have an ever-increasing interest to manage this emerging maritime chokepoint. By learning from other countries with shared responsibility for transboundary waterways, the workshop's objective included a product aimed at informing a Bering Strait model of management. To collect the data, CASP asked the experts to address issues broadly organized into five substantive panels:

1. Introduction to Bering Strait region.
2. Ensuring safe and secure maritime activity.
3. Ensuring environmentally responsible maritime activity.
4. Ensuring resilience in a dynamic social-economic-environmental context.
5. Ensuring coordinated decision-making and management.

Each panel submitted recommendations regarding: 1. best practices; 2. lessons learned; and 3) further research needs as developed during the guided discussion. CASP assimilated and summarized these recommendations into the Waves 2016 Report detailing the findings as well as plans to complete a more in-depth, scholarly volume in the near future. The key findings included the importance of regular dialogue between cooperating nations, conforming to a shared vision, ensuring political and financial support, and putting forth efforts to change human behavior to promote policy compliance.

Governing Across the Waves Workshop participants at Bowdoin College, Maine. Photo courtesy of Rachel Perron.

The relationships established during the workshop, buoyed by the in-depth discussions, are already having an impact on Coast Guard policy in the Bering Strait. In October 2017, a Coast Guard delegation, including CASP Arctic Scholar Dr. Rebecca Pincus, traveled to London to meet with the Russian Ministry of Transport on possible shipping route options. Through CASP's unique ability to bring together international delegations and academic scholars, the Coast Guard found a forum for engaging the Russian Ministry of Transport on crucial issues not limited to one nation's waters. Since the London meeting, the Coast Guard continues to work with its Russian counterparts. Mr. Emerson anticipates a joint U.S.-Russia submission to the International Maritime Organization shortly: an agreement that will ensure the safe transit of vessels through this sensitive ecological environment and secure the economic viability of the sea passage.

Further information is available on the CASP website.

Cara Condit is the Executive Director of the USCG Center for Arctic Study and Policy (CASP), where she is guiding the next era of Arctic research and collaborative policy advancements. Cara received her J.D. from Suffolk University Law School in Boston, Massachusetts, and her LL.M. in National Security and U.S. Foreign Relations Law from the George Washington University Law School in Washington, D.C. Cara specializes in policy and legislation to further environmental compliance and enforcement efforts in the maritime domain.

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IARPC Seeks Comments on Revision of Principles for Conduct of Research in the Arctic

By: IARPC Staff

The Interagency Arctic Research Policy Committee (IARPC) is seeking comments on how best to revise and strengthen the NSF Principles for the Conduct of Research in the Arctic. A Federal Register Notice has been published to solicit community input. Comments can be submitted to the Principles Revision Working Group of IARPC by email (iarpcprinciples@nsf.gov) or to the Principles Revision Working Group co-chairs, Roberto Delgado of National Institutes of Health (roberto.delgado@nih.gov) and Renee Crain of NSF (rcrain@nsf.gov). Comments can be submitted by 16 January 2018.

The current Principles were prepared by the Social Science Task Force of the U.S. Interagency Arctic Research Policy Committee, approved by the IARPC on 28 June 1990 and published by IARPC in volume 9 (Spring 1995, pp.56-57) of the journal "Arctic Research of the United States." (Download PDF of Volume 9)

Since 1990, community engagement and Arctic research have advanced both in theory and in practice, necessitating a review and update of the current Principles. The Principles Revision Working Group of IARPC is seeking input from all stakeholders to revise and update the Principles. The update will focus on communicating clearly the Principles for community engagement by Arctic researchers and including language that describes partnerships and collaborations with Indigenous scholars, enhanced community-based observations, fostering community-based participatory research, and the integral contributions of Indigenous knowledge in the co-production and dissemination of knowledge. Input is also sought on enhancing the dissemination and implementation of the Principles.

The Interagency Arctic Research Policy Committee (IARPC) will host a listening session to hear

comments on how best to revise and strengthen the Principles during the 2017 AGU Fall Meetings in New Orleans, Louisiana. The listening session will be held on Thursday, December 14th from 3:00-4:00 CT in the Arctic Community Meeting Room, in Riverside Room I at the Hampton Inn & Suites New Orleans-Convention Center (2nd floor, 1201 Convention Center Blvd., New Orleans, Louisiana).

Further information is available on the IARPC Collaborations website.

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New Agreement to Enhance International Arctic Scientific Cooperation

By: John Farrell, Executive Director, U.S. Arctic Research Commission

Editor's Note: This article, originally published in the October 2017 issue of Witness Community Highlights, has been updated with new information and the newly-released map of "Identified Geographic Areas" related to the Agreement on Enhancing International Arctic Scientific Cooperation.

The eight member states of the Arctic Council vowed to improve cooperation on Arctic science via a legally binding agreement, entitled "Agreement on Enhancing International Arctic Scientific Cooperation" signed on 11 May 2017 at the Arctic Council Ministerial meeting in Fairbanks, Alaska. This was the third binding agreement initiated in the 20-year history of the Arctic Council. The first two focused on search-and-rescue and on oil-spill response.

In short, the goal of this science agreement is to facilitate access, whether to territory and research areas, platforms, infrastructure, facilities, materials, samples, data, or equipment. In the words of Secretary of State Rex Tillerson, the document promises to ease "the movement of scientists, scientific equipment and, importantly, data sharing" across the North. Barriers to research, such as denied visas, the inability to carry equipment and samples across national borders, or denial of access to data, preclude scientific investigation, slow progress, increase cost, and retard the growth of knowledge.

In addition to access, the agreement, which was designed to be inclusive, contains articles that discuss education, career development and training, traditional and local knowledge, and cooperation with parties other than the eight Arctic nations.

The U.S. and Russia successfully co-led the effort to reach this agreement, which required several years of discussion and negotiation under the auspices of an Arctic Council Task Force. This cooperative effort was an uncommon bright light in a currently dark chapter of U.S.-Russia relations. This agreement, and the Arctic Science Ministerial meeting held at the White House on 28 September 2016, are examples of how science and research across borders can advance diplomatic efforts through soft power, rather than coercion. Paul Berkman and co-authors published a paper on this agreement titled, "The Arctic Science Agreement propels science diplomacy" in the 3 November 2017 issue of *Science*.

Although signed, the agreement will not "enter into force" until 30 days after all eight parties have

indicated that they have completed all necessary internal procedures required to enforce the agreement. At the time of this publication, the U.S., Sweden, Norway, and Finland have informed Denmark, the "depositary" for the agreement, that they have completed the steps necessary to implement the agreement. The final four signatories (Russia, Canada, Iceland, and Denmark) have yet to inform the depositary.

Each party identified geographic areas over which the agreement pertains. These are contained in an annex to the agreement. The U.S. Department of State has created a map that graphically displays these areas (see Figure 1).

Figure 1: Map of the Agreement on Enhancing International Arctic Scientific Cooperation. U.S. Department of State, OES/OPA. October 2017.

For the U.S., the area is the Arctic region as defined in the Arctic Research and Policy Act of 1984 as amended, and is "All United States territory north of the Arctic Circle and north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; the Aleutian chain; and adjacent marine areas in the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas." Maps of the U.S. Arctic may be found on the U.S. Arctic Research Commission (USARC) website.

In practice, will this agreement enhance Arctic scientific cooperation? While the intent is positive, some question whether it will do so, as the document has several escape clauses.

For example, the agreement includes phrases such as, "*...shall use their best efforts…,*" and "*Implementation of this Agreement shall be subject to the availability of relevant resources.*" And Article 10 reads, "*Activities and obligations under this Agreement shall be conducted subject to applicable international law and the applicable laws, regulations, procedures, and policies of the Parties concerned. For those Parties that have subnational governments, the applicable laws, regulations, procedures, and policies include those of their subnational governments.*"

So, it remains possible to deny access despite best efforts that fail, or to insufficient resources to facilitate access, or to existing procedures or policies that run counter to the goals of the agreement.

In essence, the validity of the agreement will only be determined when it is exercised. If denials of access and other challenges can be overcome through discussion and negotiation facilitated under this agreement, then it will have merit. The proof will be in the pudding.

The parties to the agreement are currently in the process of establishing specific procedures and processes necessary to implement the agreement, and a Terms of Reference may be established.

Generally speaking, Arctic researchers have benefitted from good access to the pan-Arctic region, but this is not always the case. For example, entering the Russian Federation has sometimes proven difficult. Between 1990 and 2014, the U.S. Department of State submitted 48 requests to Russia for U.S. vessels to conduct marine scientific research in the Russian Exclusive Economic Zone. Of those requests, 20, representing 42%, were either denied or elicited no response, which the State Department considers to be denial of access (See Figure 2).

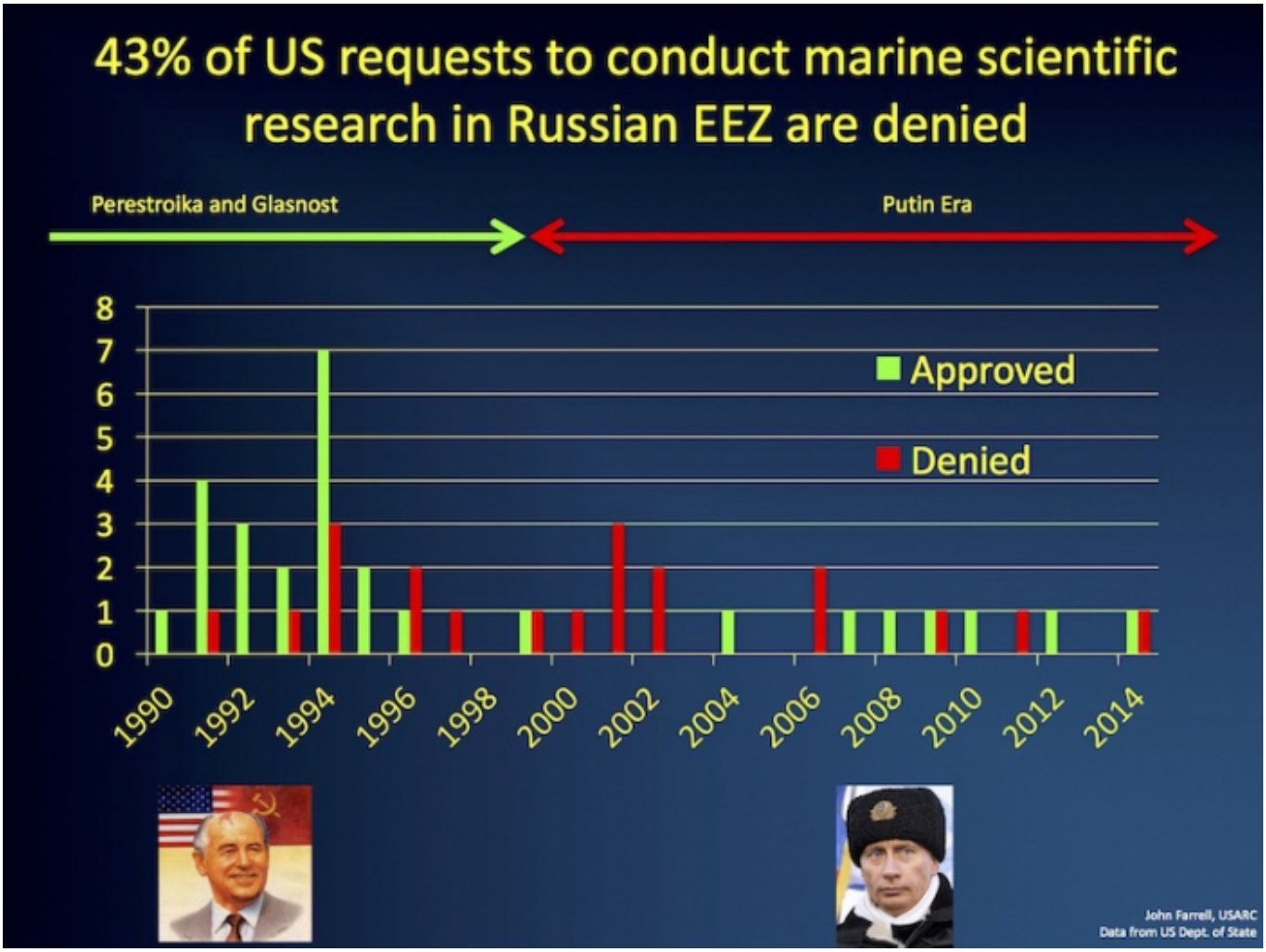

Figure 2. Outcome of U.S. requests to conduct marine scientific research in the Russian Exclusive Economic Zone. Over the 25-year period, access was granted 58% of the time. Image courtesy of J. Farrell. Data from the U.S. Department of State.

In the agreement, each party designated an entity to serve as the "competent national authority" as the responsible point of contact for the agreement. The United States selected the U.S. Arctic Research Commission. Projecting forward, we look forward to exercising the optimism and enthusiasm for cooperation displayed in the effort to reach this agreement and to facilitating research for the greater good.

Who do you call if there is a problem?

If you are a U.S.-based scientist facing a challenge covered by the agreement, please contact the U.S. Arctic Research Commission by phone (703-525-0111) or via email (info@arctic.gov).

The Agreement on Enhancing International Arctic Scientific Cooperation is available online here.

Or, download a PDF here.

More information about the USARC is available on the USARC website.

John Farrell is the Executive Director of the U.S. Arctic Research Commission, an independent federal agency of Presidential appointees that advises the White House and Congress on Arctic research matters and works with executive branch agencies to establish and execute a national Arctic research plan. The Commission also facilitates cooperation with local and state governments and recommends means for developing international scientific cooperation in the Arctic.

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Recent Icebreaker Report from the National Academies of Sciences, Engineering, and Medicine

By: The National Academies Staff

The National Academies of Sciences, Engineering, and Medicine Committee on Polar Icebreaker Cost Assessment released a report in July that advises the U.S. Congress on strategies to minimize life-cycle costs of polar icebreaker acquisition and operations.

A U.S. presence in the high-latitude regions requires reliable year-round access in order to support economic interests, search-and-rescue needs, defense and security readiness, environmental protection, maritime mobility, and scientific research. In the Antarctic, the U.S. maintains three year-round research facilities and verifies compliance with international treaty obligations, both of which require icebreaking ability during any season.

The U.S. Coast Guard (USCG) currently has three multi-mission polar icebreakers in its inventory: the USCG Cutter *Polar Star*, the USCG Cutter *Polar Sea*, and the USCG Cutter *Healy*. However, the *Polar Sea* was removed from service in 2011 after a major engine casualty in 2010 and is being used for parts. Only the *Polar Star*— built in 1976 and nearing the end of its useful life in the next three to seven years—is capable of independently performing the annual breakout and resupply of McMurdo Station in the Antarctic.

The report states that four heavy icebreakers would allow the USCG to meet its statutory mission needs at a lower cost, and would provide three ships for a continuous presence in the Arctic and one ship to service the Antarctic.

The committee recommended an acquisition strategy that includes block buy contracting with a fixed-price incentive fee contract to ensure the best value for investment of public funds. By taking advantage of the approach outlined in the report and based on the acquisition of four ships of common design, the average cost per heavy icebreaker is estimated to be $791 million. Four heavy icebreakers of common design will reduce operating and maintenance costs over the life of the vessels, improve continuity of service, increase USCG's icebreaking capability, and improve operational effectiveness.

The report also states that the USCG should ensure that the new icebreakers are "science-ready," and one should have full science capability to be used as a replacement for the *Healy* as it is approaching the end

of its life. Including science readiness in the design is a more cost-effective way to fulfill both the USCG polar missions and the nation's future polar research needs. Science-ready design includes several critical elements that cannot be retrofitted cost-effectively into an existing ship, such as flexible accommodation spaces and weight and stability latitudes to allow installation of scientific equipment. A fully science-capable ship would include features such as oceanographic over-boarding handling equipment and ship-supplied instrumentation and facilities comparable to other modern oceanographic research vessels. Given the pivotal role of polar oceans in global circulation and Earth and ecosystem processes, and their national security importance, maintaining U.S. polar oceanographic research capability is vital for the nation, the report says.

The report is mandated by the Coast Guard Authorization Act of 2015 and sponsored by the USCG. Additional information and a copy of the report can be found on the Transportation Research Board webpage.

The U.S. Coast Guard awarded five firm fixed price contracts for heavy polar icebreaker design studies and analysis 22 February 2017. The studies will inform the Coast Guard's acquisition of heavy polar icebreakers to replace the current operational fleet that includes one heavy polar icebreaker, USCGC POLAR STAR (foreground, shown cutting a channel in the Ross Sea as part of Operation Deep Freeze 2017). U.S. Coast Guard photo by Chief Petty Officer David Mosley.

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Highlights from the International Arctic Science Committee (IASC)

By: Gunnar Gunnarsson, International Arctic Science Executive Officer and Allen Pope, International Arctic Science Committee Executive Secretary

The Arctic is a huge natural laboratory offering a surprising diversity of research possibilities in every branch of science. The International Arctic Science Committee's (IASC) mission is to encourage and facilitate cooperation in all aspects of Arctic research, in all countries engaged in Arctic research, and all areas of the Arctic region. For nearly three decades, IASC has worked to transform the conditions for cooperation in Arctic science by planning and supporting major multinational research initiatives; by organizing the Arctic Science Summit Week (ASSW) and other meetings each year; and convening and empowering international scientific working groups.

IASC facilitates international and interdisciplinary connections for Arctic science. Students pictured above are moored to an ice-flow next to the Norwegian Polar Institute's RV Lance. Photo courtesy of Lawrence Hislop, Norwegian Polar Institute.

Working Across Disciplines

IASC's main scientific working bodies are the five Working Groups: Atmosphere (AWG), Cryosphere (CWG), Marine (MWG), Social & Human (SHWG), and Terrestrial Sciences (TWG). While the IASC Working Groups are set up along disciplinary lines, they have dedicated resources to support interdisciplinary projects proposed by Arctic scientists from IASC member countries. In this way, IASC is committed to fostering interdisciplinary activities, in particular across the natural and social sciences and humanities. Last April, the Social and Human Working Group launched a new crosscutting thematic activity, the "Long-Term Perspectives on Arctic Social Ecological Systems (SESs)." This SESs activity promotes an interdisciplinary approach to understanding past human responses to changing Arctic environments and, in turn, strengthens the knowledge base for future sustainability strategies. The first session focused on the paleo aspects of Arctic SESs by integrating historical, archaeological, and long-term environmental and climate records. In coming years, the SHWG will develop further initiatives to examine contemporary and future perspectives.

Enhancing and Extending Polar Partnerships

With the goal to develop and stimulate shared initiatives that are of high interest to the broader Arctic research community, IASC maintains close partnerships with several other Arctic and Polar organizations. The recent "Arctic Vegetation Archive and Classification" workshop—jointly organized by the Terrestrial Working Group and the Arctic Council's CAFF Flora Group—is an illustrative example. The primary goal of the workshop was to develop an Arctic terrestrial monitoring program and provide a standardized vegetation framework and data enabling each country to assemble its own archive. By developing common protocols, the databases can later be united into a single circum-Arctic Vegetation Archive.

Building Capacity of Early Career Researchers

IASC recognizes that the next generation of Arctic researchers will be faced with increasingly critical Arctic and global challenges. The Committee, therefore, works to support international and interdisciplinary experiences for early career researchers. This year, the Marine Working Group supported five early career scientists to participate in the Ecosystem Studies of Sub-Arctic Seas (ESSAS) Open Science Meeting in Norway. Here the young researchers got the opportunity, as speakers or co-conveners, to share their research with scientists from around the North.

The Working Groups not only provide travel support for young researchers, they also integrate the IASC Fellowship Program with their activities. A call for applications is released each year in October through the IASC and APECS mailing lists, websites, and Facebook.

IASC Fellows gathered at ASSW 2017, Prague, Czech Republic. Photo courtesy of IASC.

Upcoming Activities

IASC continues to support the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC), scheduled to start in autumn 2019. MOSAiC was born out of the Atmosphere Working Group and will be the first year-round expedition into the central Arctic exploring the Arctic climate system. MOSAiC's overall goal is to understand more thoroughly how the coupled Arctic climate system functions, in particular under rapid Arctic climate change that will not only affect the local Arctic climate but might also be affecting hemispheric circulation patterns and global change. Visit the project's IASC website for more information. IASC is excited to support and foster MOSAiC and aims to incubate other such transformative Arctic science activities.

In addition to broad changes in Arctic snow and sea-ice coverage, climate change is expected to affect the occurrence and intensity of cryospheric extremes such as heavy snowfall, icing, avalanches, and the thawing season of permafrost; and sea-ice motion, compression, and ridging. Although extreme events

are a core climate research focus, cryospheric extremes have not yet received much attention. The Cryosphere Working Group is organizing a series of workshops and meetings in 2018 to enhance this research area. One of the meetings is projected to take place at Polar2018, a joint event from the Scientific Committee on Antarctic Research (SCAR) and IASC.

Want to find out more about how to get involved with IASC, find collaborators, or how IASC supports Arctic science? Email the IASC Secretariat (info@iasc.info), your national representatives, and/or your Working Group representatives, whose names you will find on the website. To hear more about upcoming IASC activities and opportunities, join the IASC mailing list and Facebook group.

Gunnar Gunnarsson is the IASC Executive Officer, based in Akureyri, Iceland. His research activities include participation in the Nordic Centre of Excellence ARCPATH (Arctic Climate Predictions - Pathways to Resilient, Sustainable Society).

Allen Pope is the IASC Executive Secretary, based in Akureyri, Iceland. A glaciologist and remote sensing scientist, Allen has been with IASC since the beginning of 2017. The IASC Secretariat is generously supported by Rannís, the Icelandic Center for Research.

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The Year of Polar Prediction

By Kirstin Werner, Year of Polar Prediction International Coordination Office, Project Officer

Environmental and climate changes in the Arctic have significant impact on maritime traffic related to fisheries, scientific efforts, and tourism, and create potential risks to both humans and the natural environment. Precise weather and sea-ice predictions will play an increasingly important role in managing related safety issues in polar regions. The World Meteorological Organization (WMO) under the auspices of its World Weather Research Programme (WWRP) and the Polar Prediction Project (PPP) has initiated the Year of Polar Prediction (YOPP), a two-year international and interdisciplinary research initiative that will run from mid-2017 to mid-2019. The goal of the project is to significantly improve environmental prediction capabilities for the polar regions and beyond, on time scales from hours to seasons. YOPP was officially launched in May this year and entails intensive observing and modeling efforts in both the Arctic and the Antarctic.

Coordination

The German Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research hosts the International Coordination Office (ICO) for Polar Prediction, which serves as a focal point for the communication and coordination among the academic community and stakeholders involved with polar prediction topics. The ICO was established to support the PPP Steering Group in managing everyday activities and to coordinate, plan, and prepare details for the Year of Polar Prediction. Members of the PPP Steering Group represent both operational forecast centers and the science community within different WMO member states. YOPP Task Teams have been established in order to promote and coordinate specific activities during the Year of Polar Prediction.

Key Activities and Products

Two Special Observing Periods are planned for the Arctic region: 1 February–31 March and 1 July–30 September 2018. In the Antarctic, the Special Observing Period will take place 16 November 2018–15 February 2019 (See Figure 1). During these intensive observation phases, routine observations will be increased in an attempt to close gaps in the current observing systems. Extra observations, such as

radiosonde launches and ocean buoy deployments, will allow for forecasting system experiments aimed at optimizing observing systems in the polar regions and providing insight into the impact of better polar observations on forecast skill. To ensure that all observations are considered in forecasting experiments, all data will be shared through WMO's Global Telecommunication System (GTS).

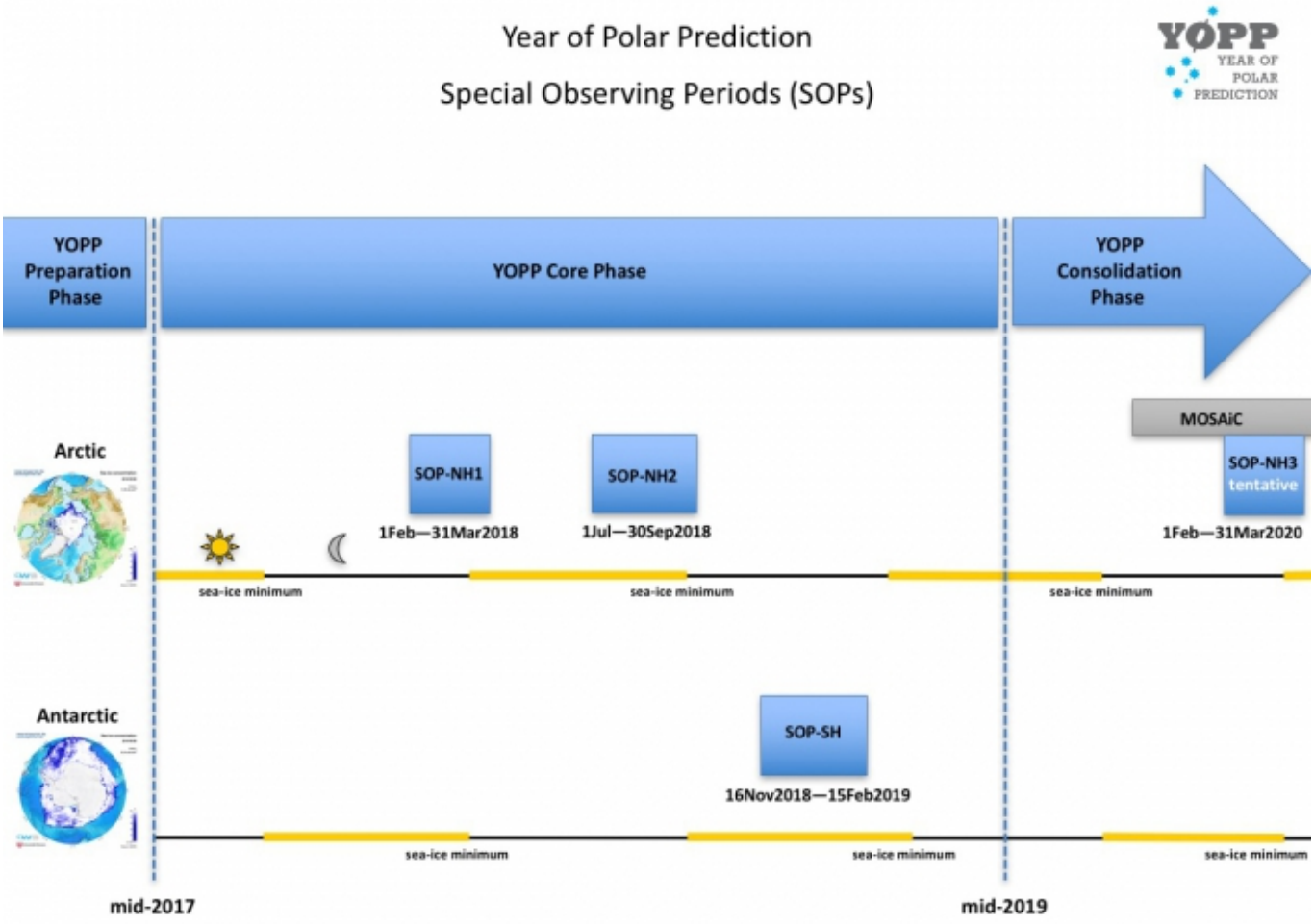

Figure 1: Key activities of the Year of Polar Prediction include three Special Observing Periods (SOPs) dedicated to enhance routine measurements and investigations of physical phenomena in polar regions, feeding into the development and improvement of numerical forecasting models, and the verification and improvement of forecasting services. Image courtesy of the International Coordination Office for Polar Prediction.

Endorsement

YOPP endorsement allows for improved coordination of activities relevant to its goals. Projects, programs, and initiatives that contribute to improving forecasting skills in polar regions can request endorsement by the YOPP initiative—about 65 activities have been endorsed to date (See Figure 2). Detailed information on timing and plans of YOPP-endorsed projects can be viewed via the YOPP Explorer. The endorsement process is also open for research institutes and operational forecasting centers whose activities contribute to the success of the YOPP initiative.

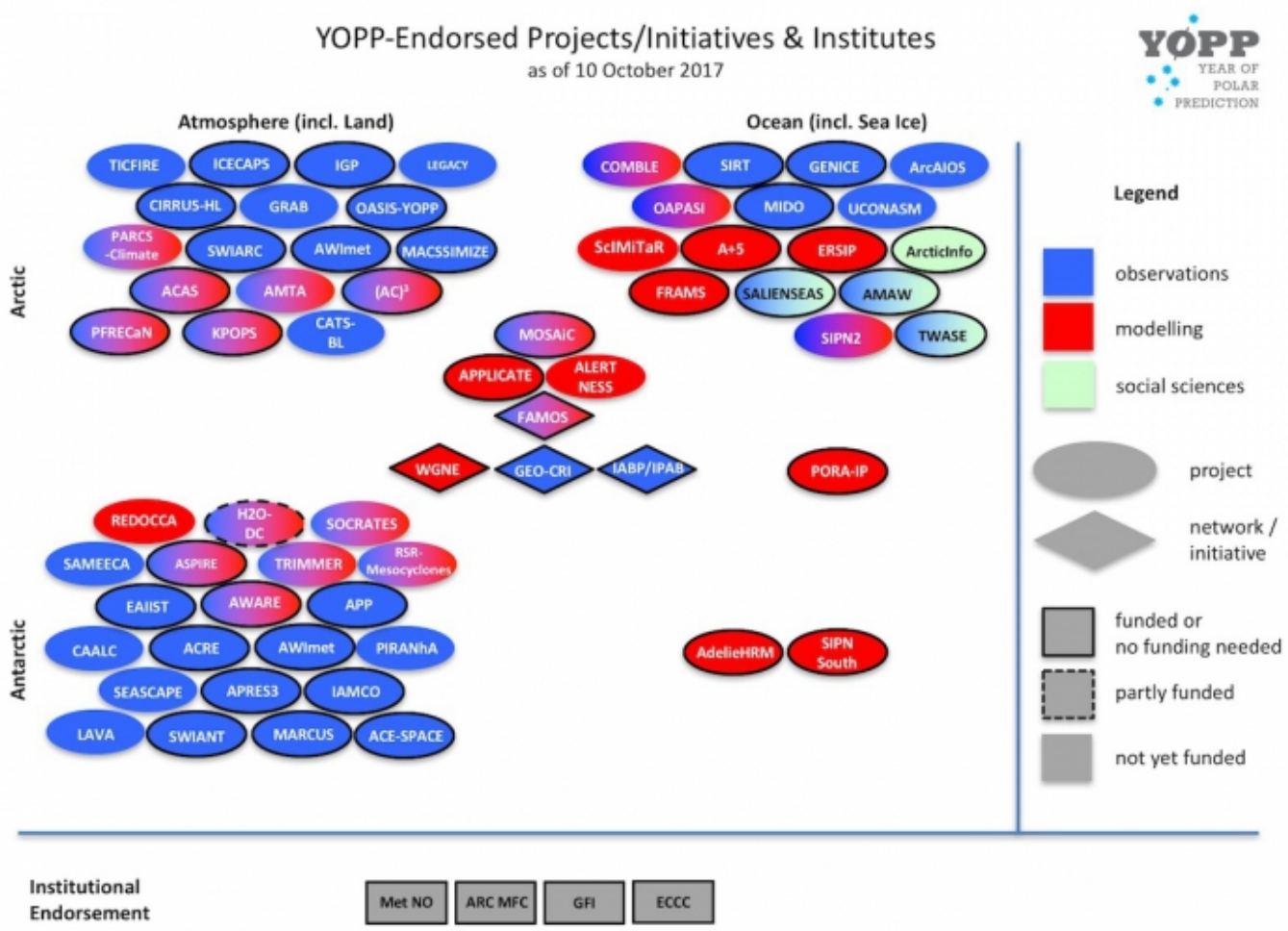

Figure 2: YOPP-endorsed research benefits from increased visibility and often increases chances of funding from national sources. In turn, endorsement allows the YOPP network to coordinate activities and enhance networking and communication amongst stakeholders. Image courtesy of the International Coordination Office for Polar Prediction.

YOPP Observations Layer

Information about extra observations such as buoys, automatic weather stations, and radiosonde launches, as well as aircraft campaigns during the YOPP Special Observing Periods, can be browsed along different time slots (See Figure 3). Observations made during field campaigns of YOPP-endorsed projects are also included. As a living resource, the YOPP Observations Layer will be continuously updated in response to any new information received.

Figure 3: In order to provide a better overview of observational activities that will take place during the Year of Polar Prediction, the ICO has developed a kmz file to be opened, e.g., with Google Earth. Image courtesy of the Google Earth/International Coordination Office for Polar Prediction.

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YOPP Data Portal

The majority of data generated and collected during YOPP observational campaigns, as well as by modelling and verification efforts, will be stored at separate national data centers and portals. The YOPP Data Portal provides metadata and links to these respective datasets. As a legacy for YOPP, this data portal takes into account the various requirements of end-users working with the YOPP data collection. The YOPP Data Portal is hosted by the Norwegian Meteorological Institute. The data publisher for Earth and Environmental Science PANGAEA, hosted by the German Alfred Wegener Institute, will be one of the data hubs. YOPP-relevant data will be flagged as a "YOPP" dataset in the label field of the PANGAEA database submission form.

How to Get Involved

Community members can receive updates on YOPP through various communication channels: mailing list, website, newsletter, and twitter. Additional ways to get involved with the Year of Polar Prediction include engaging in one of the YOPP Task Teams; requesting a YOPP endorsement; and as a researcher, making observation data available via the WMO Global Telecommunication System (WMO Information System WIS) and the YOPP Data Portal. Another great way of contributing to YOPP is to share deployment opportunities for instruments, such as buoys and floats. Any questions, comments, or ideas can be directed to the ICO at office@polarprediction.net.

For More Information

The first YOPP online conference, held on 17 October 2017, provided an update on the current status of preparations and planning of the initiative. Listen to the first YOPP online conference on YouTube.

Register for the next YOPP online conference, which is scheduled for Friday, 1 December 2017 at 4:00 p.m. (GMT). It is open to everyone interested in improving forecast skills in the polar regions. For more information, go to the Polar Prediction website.

Prior to joining the International Coordination Office for Polar Prediction as project officer, Kirstin Werner studied the variability of heat transfer to the Arctic Ocean and corresponding changes in the sea-ice extent during the past ca 12,000 years at GEOMAR (Kiel, Germany), the Institute of Arctic and Alpine Research (Boulder, Colorado, USA), and the Byrd Polar and Climate Research Center (Columbus, Ohio, USA). Her new focus at the Alfred Wegener Institute in Bremerhaven, Germany, is on the science management aspects of short-term polar weather and climate variability during the Year of Polar Prediction. Kirstin recently completed an on-the-job MSc program in Science Marketing at the Technical University Berlin, Germany.

Photo courtesy of Martina Buchholz, Alfred-Wegener-Institut.

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Greenland Ecological Monitoring Program's Treasure Trove of Arctic Research Data Publicly Available

By: Catherine Jex, Journalist for ScienceNordic.com

Editor's Note: This article is based on one published online by ScienceNordic on 15 November 2017, "Treasure trove" of Arctic research data now publicly available, also written by Catherine Jex.

The Greenland Ecosystem Monitoring program (GEM) was established in 1994 by research institutions throughout Denmark and Greenland to conduct long-term inter-disciplinary data collection. As part of the program, scientists have been collecting data on snow cover, wind, rain, temperatures, fjord water chemistry, glaciers, and populations of musk oxen, spiders, insects, birds, and more from around Greenland for decades. By visiting the same locations to sample the same characteristics with the same methods year after year, they have steadily built a valuable database.

"It is laborious and repetitive work but the result is a treasure trove of data that is helping scientists from across the world to better understand changes in the Arctic," says program leader Torben Røjle Christensen from Aarhus University, Denmark. "We now have a twenty-year record of operational data that cannot be found anywhere else in the circumpolar north. As a coordinated program, it's unique."

Take a tour of an Arctic monitoring site.

Free Data for Researchers, Students, or Interested Citizens

All of the data are now freely available on the GEM data website and a summary of the most significant discoveries from the past year is available in the recently launched Annual Report Cards.

GEM has 180 registered users from around the world—mainly researchers who are aware of the program. Now, the goal is to reach the education sector, says Christensen, who hopes that university students and school teachers will use the data. "Anyone can go in and download the data. There's a boatload available," says Christensen, "more than 1,500 parameters to be exact."

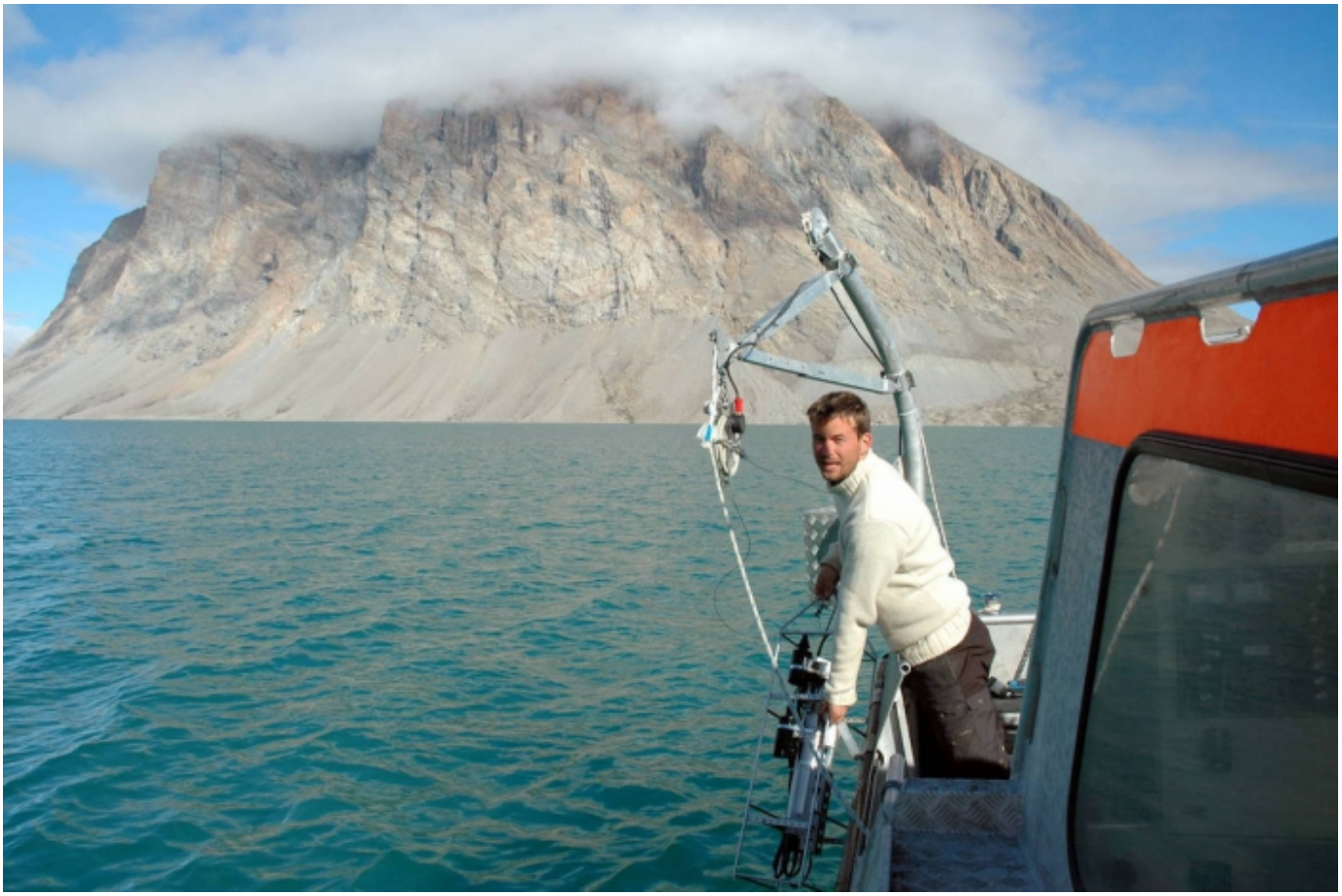
Below are four recent discoveries from the GEM program.

1) Glacial Melt from Greenland is Making the Sea Fresher

A recent study presented the first long data series documenting the impact of melting ice on the water chemistry of a fjord in north east Greenland.

One question posed by climate change is "will melting land ice and sea ice in the Arctic slow down or even shut down a vital part of the ocean circulation in the North Atlantic?" The consequences of that outcome could be severe and possibly even cut off the supply of mild, wet weather to north and west Europe. Whether or not this is already under way is a contentious topic, but one clear indication would be a long-term reduction of temperature and salinity in the seas around Greenland.

"This is just what we saw," says lead-author Mikael Sejr from Aarhus University, Denmark. "We looked at two of the most basic parameters, it's as simple as it gets: the temperature and salinity of water in a Greenland fjord. But it's a game changer," says Sejr.



Marine biologist Mikael Sejr from Aarhus University measures temperature and salinity in Young Sound, Northeast Greenland, for the GEM database. Photo courtesy of Mikael Sejr.

Sejr and colleagues studied GEM data collected over 13 years and saw a four-fold increase in the fresh water contributions to the Young Sound in Northeast Greenland that were associated with melting glacier ice further north.

"It isn't surprising, but it's the first long data series to show it," says Sejr. The next step is to see how far

this freshening extends in the seas around Greenland, he says.

Read More: Is a vital pattern of ocean circulation about to shut down?

2) Greenland's Glaciers are Melting Faster than the Ice Sheet

Independent of the Greenland ice sheet, there are approximately 19,000 individual glaciers on Greenland. Scientists are monitoring five of these, three of which are part of the GEM network.

These 19,000 glaciers cover a relatively small area—just 5% of all ice-covered land in Greenland—but studies over the past decade, using monitoring data from GEM among others, indicate that they contribute up to 14% of all ice loss from Greenland.

Some of these glaciers terminate in fjords, where a recent study demonstrated their importance for maintaining some of Greenland's most productive fisheries.

"We see that the most productive halibut fisheries are located close to marine-terminating glaciers," says lead-author Lorenz Meire from the Greenland Climate Research Centre (GCRC) at the Greenland Institute of Natural Resources in Nuuk, Greenland. "Today, productivity in these fjords is stimulated by these types of glaciers, but this will all change in the future as they retreat on land," he says. The results contradict the more positive picture often painted of the economic benefits expected for fisheries. For example, as fish migrate north into warmer waters and new Arctic shipping routes and fisheries open up as sea ice continues to retreat.

3) Frozen Soils "Push" Methane Out of the Tundra

Shortly after the Zackenberg Research Station was established in Northeast Greenland, scientists observed a phenomenon that had never been seen before: frozen tundra releasing more greenhouse gas than thawing tundra.

We often hear that thawing permafrost is a ticking time bomb that could release large quantities of greenhouse gases into the atmosphere, further exacerbating global warming. But the ability of frozen soils to emit large quantities of methane gas was entirely new.

"Nobody knew this before. We first had a chance to measure it in 2007 and 2008, and since then it's received a lot of scientific attention," says GEM program leader Christensen, who has subsequently observed similar events in Alaska and Svalbard.

Their measurements at Zackenberg showed that more methane was released during a single event than during all of the previous summer. It was caused by frozen soils sitting above permafrost, which created enough pressure to "push" the methane out of the tundra. Subsequent monitoring showed the effect to be

much smaller and variable in the following years.

"It doesn't happen every year, so we need to have these long time series to see these events. Otherwise, we don't have a complete picture," says Christensen.

Read more: One quarter of the Arctic is a hotbed for overlooked greenhouse gas.

4) The Arctic is More Dynamic than Previously Thought

Scientists have captured other extreme events as part of the GEM network.

On 11 April 2016, a series of avalanches occurred across Kobberfjord, just outside Nuuk in Southwest Greenland. The events were triggered by a period of intense rainfall and a rapid rise in temperatures, which rose by 27˚C in a little over two days. This initiated a flow of slushy snow, churned up with mud, rocks, and vegetation, in what the scientists called a slush flow.

The event caused the water level of a nearby lake to rise rapidly to its second highest level on record and took out some of the monitoring equipment installed at the Nuuk site.

"We coincidentally observed this rare event during one of our regular monitoring tours and are now benefiting from the wealth of ground-based GEM data available during this period," says Jakob Abermann from Asiaq Greenland Survey, and the lead scientist of ClimateBasis—the climate monitoring sub-program of GEM.

Abermann and colleagues are now assessing the spatial scale of this event using high-resolution satellite images, and have since identified several hundred other similar slush flow from the same event.

Further information about GEM and other GEM projects is available on the GEM website.

GEM Project Facts

The GEM project has five main themes:

-ClimateBasis: records meteorology and hydrology parameters

-BioBasis: monitors plant and animal populations and interactions

-GeoBasis: measures greenhouse gases from the tundra and collects geological data

-GlacioBasis: monitors the three glaciers in Greenland

-MarineBasis: records physical, chemical, and biological changes in the sea

The GEM project has four permanent monitoring stations:

-Zackenburg: High Arctic, Northeast Greenland

-Nuuk: Low Arctic, Southwest Greenland

-Arctic Station: Low Arctic, Disko Island, West Greenland

-Sermilik Station: Low Arctic, East Greenland

There are also a number of smaller sites throughout Greenland.

GEM is funded and operated by authorities in Denmark and Greenland.

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ARCUS Program News

ARCUS staff manage a diverse portfolio of projects to connect Arctic research across disciplines, organizations, knowledge systems, and geography. A few recent highlights include:

American Geophysical Union (AGU) 2017 Fall Meeting

We have been busy preparing for the upcoming AGU Fall Meeting in New Orleans, Louisiana:

ARCUS Annual Meeting - ARCUS' annual meeting will take place on Wednesday, December 13 from 6:00–7:00 p.m. Central Time in the Riverside I Room at the Hampton Inn & Suites New Orleans Convention Center. There will be a simultaneous videoconference for those who can't travel to New Orleans. ARCUS members and any others interested in Arctic research are invited to participate. More information is available here.

Arctic Research Community Reception - The Arctic Community Reception will be held Wednesday, 13 December from 7:00–8:30 p.m. Central Time in the Riverside I Room at the Hampton Inn & Suites New Orleans Convention Center. Members of the Arctic research community are invited to join in conversation, networking, and socializing. Co-sponsors for the event include: the International Arctic Science Committee, the Interagency Arctic Research Policy Committee, the University of Alaska Fairbanks, Ice911 Research, and the U.S. Association of Polar Early Career Scientists. More information is available here.

Community Meeting Room - ARCUS will again be hosting two Arctic Community Meeting Rooms to provide meeting space for groups working on Arctic research and education. These rooms are funded by the NSF-Arctic Sciences Section. If you would like to request meeting space, please fill out the online form here.

Guide to AGU Arctic Sessions - We have compiled an online list of Arctic-related sessions at AGU as a tool to help attendees to find Arctic-related sessions, talks and posters. The list is available [here]; If we have missed your session, email Lisa Sheffield Guy at lisa@arcus.org and we will add it.

ARCUS Presentations and Sessions – Finally, we hope to see you at one of ARCUS' posters, sessions, or related events!

New Webpage: Conducting Research with Northern Communities

ARCUS launched a new webpage, "Conducting Research with Northern Communities: Documented Practices and Resources for Productive, Respectful Relationships Between Researchers and Community Members."

Scientific research in the Arctic necessitates good communication and cooperation with northern communities. This new webpage is a compilation of resources, recommendations, and documented practices from a variety of organizations on working with northern communities. View the webpage here.

New Project: Empowering Arctic Indigenous Researchers

ARCUS and the Inuit Circumpolar Council Alaska are collaborating on a new pilot project called "Empowering Arctic Indigenous Scholars and Making Connections". The project will feature two seminar/webinars in Washington, D.C. during spring of 2018 featuring leading Arctic Indigenous scholars. While the scholars are in D.C. for the seminar, we will facilitate meetings with officials at key U.S. government agencies, non-governmental organizations, and other groups, where the scholars will be able to share their interests, learn of available resources, build collaborative relationships, and provide on-the-ground perspectives. Funding is provided by the National Science Foundation-Arctic Sciences.

Robert Rich, ARCUS Executive Director, and Carolina Behe, Inuit Circumpolar Council Alaska and ARCUS Board Member, will lead the project with guidance from a selection committee.

For more information, contact Lisa Sheffield Guy, Project Manager, at lisa@arcus.org.

Arctic Research Seminar Series

The ARCUS Arctic Research Seminar Series invites leading Arctic researchers and community leaders to Washington, D.C. to share both in person and via simultaneous webinar the latest findings in Arctic research and what they mean for decision-making. The events are free, open to the public, and highly rated by participants. Upcoming seminar/webinars include:

- 12 February 2018: Roberto Delgado and Andrea Marques Horvath (U.S. National Institute of Mental Health NIMH) - Roberto and Andrea will highlight the National Institute of Health's support of mental health research in the Arctic, focusing both on suicide prevention initiatives of the Arctic Council as well as new collaborations to reduce the burden of suicide among Alaskan Native youth.
- 29 March 2018: Matthew Jull (Assistant Professor for the University of Virginia School of Architecture) - Matthew is Co-Director of the Arctic Design Group; his research focuses on architecture and urban design within the frame of extreme climates.

If there are any topics or research areas that you would like to see featured in a future Arctic Research Seminar, please contact Brit Myers at brit@arcus.org.

More information, registration, and archives of past seminars can be found here.

PolarTREC: Teachers and Researchers Exploring and Collaborating

Since 2004, ARCUS has managed PolarTREC–Teachers and Researchers Exploring and Collaborating, a professional development program for classroom teachers. Through participation in polar-focused field research experiences, educators improve teaching strategies, connect with the public and their classrooms, develop resources for their careers, and integrate what they have learned into their classrooms.

Outreach results from the fifteen 2016 teacher-researcher teams is highlighted in Figure 1. We also encourage you to take a moment and read teachers' "Experience Reports", in which they reflect on the value of the PolarTREC experience.

As the 2017 season comes to a close, one Antarctic team remains in the field at the South Pole Station, working with the IceCube research project. Anyone can follow expeditions here. In addition, preparations for Antarctica Day on 1 December 2017 are underway. ARCUS will be celebrating Antarctica Day by hosting a live, real-time event with PolarTREC teacher Lesley Anderson from the South Pole Station on Monday, 4 December. More information and registration is available here.

In early October, the application period for educators to apply to the next round of PolarTREC projects

closed. We received over 150 applications and are currently working with a selection committee on final selections.

Keep up with PolarTREC events through the website, PolarTREC on twitter at @PolarTREC, the PolarTREC Facebook group, or by joining the Polar Education Mailing List.

PolarTREC is funded by NSF Office of Polar Programs (awards 1525880 & 1630463). Additional funding was received through NASA for teachers in 2016 and 2017 who worked with Operation IceBridge. The University of Alaska and NOAA Teachers at Sea supported a teacher in 2016.

Anchorage Arctic Research Day 2018

For those who live or work in Anchorage, Alaska, save the date for the 2nd Anchorage Arctic Research Day 2018, which will take place on Thursday, 26 April 2018 at the Anchorage Museum. Organized by ARCUS, the University of Alaska Anchorage, the Institute of the North, and the Anchorage Museum, this event will include a broad range of speakers on Arctic research and offer great opportunities for networking. Updates will be announced via ArcticInfo. For more information, contact Betsy Turner-Bogren at betsy@arcus.org

Sea Ice Prediction Network (SIPN)

An update on SIPN activities, including the 2017 Sea Ice Outlook season, an upcoming meeting at the AGU Fall Meeting, and a newly-funded "SIPN2" project, is available in the Arctic Systems Science news section of this issue.

Study of Environmental Arctic Change (SEARCH)

ARCUS staff provide a variety of project office support tasks for the SEARCH program. An update on SEARCH activities from SEARCH Executive Director Brendan Kelly is available in the SEARCH News section of this issue, and a schedule of SEARCH events at the AGU Fall Meeting can be found through the SEARCH website.

Keep up with ARCUS and Arctic Events

Stay in touch with ARCUS and the broader Arctic research community through these communication tools:

ARCUS Website

ARCUS on Twitter

ArcticInfo Mailing List

Polar Education Mailing List

Witness Community Highlights

Witness the Arctic Newsletter

Arctic Calendar

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2017: An Interesting Year for Arctic Research

By: Robert H. Rich, Ph.D., CAE

Joseph Chamberlain (the father of the late British prime minister) said "I think that you will all agree that we are living in most interesting times. I never remember myself a time in which our history was so full, in which day by day brought us new objects of interest, and, let me say also, new objects for anxiety." Chamberlain could easily have been talking about today's Arctic research, with its amazing discoveries, the worrying attacks on research funding, and the emergence of new objects of interest and anxiety every day.

Your Arctic Research Consortium (of the U.S.) is being buffeted by the Arctic region's interesting times, while also helping to lead the effort to maximize the increase of Arctic knowledge. This fall, we released an elevator speech with the following main points:

1. The Arctic is changing rapidly in many ways that will affect people everywhere.
2. We need Arctic research: To understand and respond to Arctic change.
3. ARCUS connects, supports, and advances Arctic research.

Earlier this year, significant cuts were proposed to key Arctic research agencies that would have a devastating impact if they were enacted. ARCUS rose to the challenge, raised non-government funding, and organized the Campaign to Defend Arctic Research, which empowered the Arctic research community to reach out to their legislators and make a difference.

In March, we partnered with the University of Alaska, Anchorage to organize the first-ever Anchorage Arctic Research Day, which brought together researchers across the city from varying sectors, disciplines, and research organizations to share their interests and form productive relationships. This sold-out event was so popular and well-received that we are doing it again in Anchorage during 2018 (in a bigger venue) and also planning to roll out such "pop-up" community building events in other big Arctic research centers. If your city is ripe for hosting such an event, please let me know.

The changes in the Arctic environment remain dramatic, and ARCUS worked as the SEARCH project office to help support a week of researchers reaching out to policymakers, the media, and the interested public this fall. The events included a workshop to develop communications skills of researchers, a press conference at the American Association for the Advancement of Science livestreamed on Facebook, a Capitol Hill briefing, and a panel at the Wilson Center. We also hosted one of our Arctic Research Seminar Series events, which continue to attract outstanding researchers to Washington, DC for discussions with the Arctic research and policy community and worldwide through live stream access and archives online.

We were excited to release a new web portal with resources for "Conducting Research with Northern Communities." This page includes documented practices across various regions of the Arctic and around the pole, resources for community-based monitoring, and even resources beyond the Arctic. We worked closely with Northern Community leaders to create this resource, and continue to engage in multiple projects to better strengthen the important ties between Arctic researchers and those who live in the places you study.

ARCUS also supports connections between Polar researchers and pre-college educators. The pilot projects continue enabling partnerships between Alaska educators and researchers through The Arctic in the Classroom and, as I write this, PolarTREC expeditions are occurring in Antarctica and expeditions to the Arctic have recently concluded.

We are gearing up for a big week in connection with the American Geophysical Union (AGU) meeting 11-15 December. This year, there will be a terrific open reception for the Arctic research community on Wednesday, 13 December. Right before the reception, we will be holding our annual open meeting to discuss progress, elect new ARCUS Board members, and hear feedback. If you are interested in learning more about ARCUS, I'd encourage you to attend (and there is a live stream version if you won't be in New Orleans.) If you will be in town, you are invited and I hope to see you there. Also at AGU, there will be many Arctic Research Community Meeting Rooms events we're hosting, lots of presentations, posters, and panels, and much more.

These activities are just the tip of the iceberg of what ARCUS offers to the Arctic research community, and we continue to innovate. If you have an idea for what we might do to better support you and your research aspirations, please send me an email at bob@arcus.org. I'd love to hear from you. Even better, if you are able to formally commit to being part of the Arctic research community, you can sign up as an ARCUS member either on behalf of your organization or as an individual. No matter how "interesting" our times become, rest assured that ARCUS will remain as your champion, catalyst, and cheerleader.

Welcome New ARCUS Members (Since June 2017)

Alaska Ocean Observing System

Asiaq - Greenland Survey

Ice911 Research Corporation

Smithsonian Institution Arctic Studies Center

Plus nine new individual members!

ARCUS Membership Information

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Editors: Betsy Turner-Bogren and Helen Wiggins

Contributors: C. Condit, L. Culler, J. Farrell, G. Gunnarsson, C. Jex, B. P. Kelly, J. P. Lewis, L. McDavid, J. L. Mercer, A. Pope, B. Raymond-Yakoubian, J. Raymond-Yakoubian, R. Rich, C. Suchman, B. Turner-Bogren, K. Werner, H. Wiggins, the IARPC Staff, and the National Academies Staff.

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Arctic Research Consortium of the
United States
3535 College Road
Suite 101
Fairbanks, AK 99709 USA
Phone: 907-474-1600
Fax: 907-474-1604
info@arcus.org