

Workshop Report

First SEARCH Knowledge Exchange Workshop on the Impacts of Arctic Sea-Ice Loss

September 14-15, 2016
Washington, DC



Study of Environmental Arctic Change

February 2017

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Study of Environmental Arctic Change (SEARCH):

Advancing knowledge for action in a rapidly changing Arctic

SEARCH—a collaborative program of arctic scientists, funding agencies, and other stakeholders—promotes original and collaborative research, synthesizes research findings, and broadly communicates the results. SEARCH currently focuses on how shrinking land ice, diminishing sea ice, and degrading permafrost impact arctic and global systems. SEARCH Action Teams and working groups generate and synthesize research findings, facilitate research activities across scales and disciplines, identify emerging issues, collaborate with other national and international science programs, and engage arctic stakeholders to inform their responses to environmental change.

<https://www.arcus.org/search-program>

SEARCH Sea Ice Action Team

The SEARCH Sea Ice Action Team (SIAT) advances awareness and understanding of the impacts of arctic sea-ice loss by enabling collaboration, community engagement, and communication. The SIAT is developing a coherent source of accessible, comprehensive, and timely information that synthesizes the connections between the science of arctic sea-ice loss, key societal issues, and stakeholder needs. The SIAT is co-led by Jennifer Francis (Rutgers University) and Henry Huntington (Huntington Consulting). Matthew Druckenmiller (Rutgers University and the National Snow and Ice Data Center, University of Colorado Boulder) leads science communication and community engagement efforts.

<https://www.arcus.org/search-program/sea-ice>

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EXECUTIVE SUMMARY

The SEARCH Sea Ice Action Team's *First Knowledge Exchange Workshop on the Impacts of Arctic Sea-Ice Loss* took place over two days in Washington, DC during September 2016, where the foundation for a Sea Ice Action Network (SIAN) was established. The workshop (1) exchanged best practices and opportunities for communicating with various audiences—policymakers, the media, local arctic residents and stakeholders, and other science disciplines, (2) introduced the concept of knowledge pyramids, and (3) discussed the state of scientific knowledge and engagement across three themes related to arctic sea-ice loss: arctic marine ecosystems, lower latitude weather, and human activities in the Bering, Chukchi, and Beaufort Seas.

On the topic of marine ecosystems, participants discussed the importance of communicating ecological change in terms of rates and spatial scales, where achieving a better understanding of bloom dynamics is critical; how ecological restructuring from a benthic (lowest level of the ocean) to a pelagic (non-bottom layers) dominated system will favor some species over others; the need to better understand ecological thresholds; and the knowledge gaps surrounding ocean acidification. The variability in relevance of these issues across different stakeholder groups (e.g., the fishing industry, resource managers, conservation organizations, subsistence hunters, etc.) emphasizes the importance of knowing your audience when communicating the state of the science.

Participants with expertise in the links between sea-ice loss and lower latitude weather primarily addressed the technical elements of their science that present notable challenges to effective communication. While extreme weather events provide *hooks* for communicating with the public, scientists must be mindful of the pitfalls of tying a single event to sea-ice loss. Broad statements about the atmospheric response to sea-ice loss often invite controversy, as many mechanisms are regional and/or seasonal. Due to the polarization within the science community on this topic, participants suggested the need for improved communication between specialists, especially regarding model inter-comparison studies and attribution metrics.

Within discussions regarding two-way communication with arctic coastal communities and local arctic stakeholders, participants underscored the need for new and sustained partnerships. Opportunities exist to improve how scientists communicate the relevance and capabilities of sea-ice research. For example, there is need for clear case studies evaluating how science can inform local decisions, such as related to food security or village relocation. Arctic residents and local stakeholders need informational products that communicate the rates, scales, and timing of observed sea-ice changes so they can collaborate in making the connections to local and regional activities.

Workshop participants collectively discussed how to advance scientific practice in a manner that is increasingly effective and efficient at delivering relevant and useful science to decision-makers and the public. There are both simple tools one can individually adopt to improve communicating science and instances where a well-managed broader collaboration is necessary. Knowledge pyramids were discussed as a tool to enhance science communication across a broad range of audiences and to foster science synthesis. Knowledge pyramids result in concise science briefs written to answer specific societally relevant questions, where each brief (i.e., the apex of

the pyramid) is supported by a collection of information resources and scientific literature organized across several underlying tiers with increasing levels of scientific complexity and technical detail. Together, participants made progress in envisioning how the pyramids should be structured and how to engage community members to participate. Acknowledging limited budgets and capacity to conduct engagement, groups such as SEARCH are uniquely positioned to assist arctic researchers, stakeholders, and communities in collaboratively bringing *knowledge to action*.



WORKSHOP OBJECTIVES

Responses to diminishing arctic sea ice require effective, efficient communication, as well as collaborative and actionable science. In this workshop, scientific experts, decision-makers, arctic residents, non-governmental organizations (NGOs), and other stakeholders defined and addressed important societal questions raised by sea-ice loss, and explored new approaches and partnerships for advancing awareness and understanding of the associated impacts.

Throughout the two-day workshop, discussions focused on achieving the following objectives:

- **Developing ideas and plans for constructing *knowledge pyramids*** for the three workshop science themes—the impacts of changing arctic sea ice on (1) arctic marine ecosystems, (2) lower latitude weather, and (3) human activities in the Bering, Chukchi, and Beaufort Seas. Knowledge pyramids (see Figure 1) provide tiered access to sea-ice information, organized across a series of high-level topics via a hierarchical, pyramid structure based on increasing levels of scientific complexity. Products in each level of the pyramid are developed with specific audiences in mind.

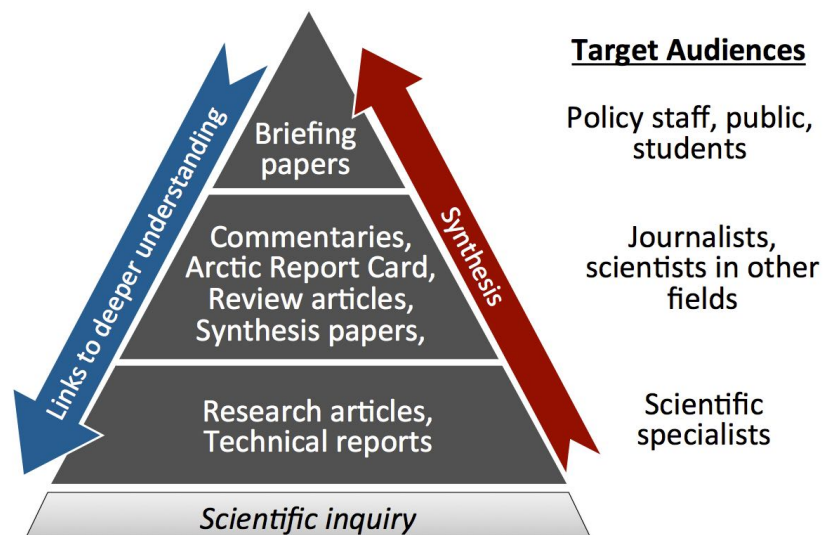


Figure 1. Knowledge pyramid tiers and associated target audiences.

- **Refining a strategy for supporting *knowledge-to-action*** through synthesis, cross-community engagement, and effective communication. *Knowledge-to-action* refers to a process where scientists and “actors” (policy-makers, practitioners, arctic residents, and other stakeholders) collaboratively develop understanding and define an arena where science-based knowledge can inform decisions.
- **Initiating a *Sea Ice Action Network*** to engage the community and facilitate knowledge-to-action in response to the various impacts of arctic sea-ice loss by, for example:
 - 1) Identifying key issues of societal importance at local to global scales;
 - 2) Co-communicating the impacts of diminishing arctic sea ice;
 - 3) Facilitating engagement with key stakeholder groups and arctic residents;
 - 4) Synthesizing scientific research and expert knowledge to develop accessible information for a broad range of users; and
 - 5) Identifying new areas for synthetic scientific inquiry.
- **Identifying important topics for short papers or science briefs on the “*state of the science*”** regarding the workshop’s science themes. Science briefs provide the apex of knowledge pyramids. See three examples of SEARCH Science Briefs in the appendix of this report, which were written primarily for media and congressional audiences.

PRESENTATIONS AND DISCUSSION

Connecting and Communicating with Diverse Audiences

Marika Holland (National Center for Atmospheric Research) addressed the challenges of communicating across science disciplines.

Reflecting on past collaborative sea-ice and climate modeling efforts, Dr. Holland suggested that the most effective communication across disciplines takes place over time through sustained dialogue—dialogue maintained by those willing to step out of their own disciplinary comfort zones to form a community of mutual respect for each others' varying expertise and approaches to inquiry. Importantly, cross-disciplinary collaboration requires research questions that successfully engage different disciplines. Dr. Holland also pointed out that sustained dialogue and collaboration require a significant amount of time, effort, and creativity. Therefore, for scientists from different fields to reach across disciplines, there must be incentives, for example, the promise of unique scientific advances and greater visibility for their individual contributions. The time challenge should also be addressed through an effective management structure to facilitate the collaboration.

Brenda Ekwurzel (Union of Concerned Scientists) spoke on communication with the media. Dr. Ekwurzel assessed climate science communication in terms of progress, challenges, and opportunities, and observed that:

- Climate scientists are effective at communicating the *means* (for example, average global temperatures), but face a greater challenge when communicating the *extremes* of climate and weather. Effective communication on extremes is often achieved by presenting observations in context, alongside historical data.
- Scientists should use more *social math* to communicate basic scientific facts and observations. Social math—the practice of translating large numbers into comprehensible and compelling values for non-specialists—has proven effective in engaging journalists and policymakers. (See Figure 2 as an example of social math used to communicate arctic sea-ice loss.)
- Scientists should not oversimplify science, lest actions to communicate lose substance and meaning for decision-makers, who are often more sophisticated than given credit for and may have particular interests that are unknown by the scientist. For example, scientists do a disservice to educating and advancing discussions regarding sea-ice loss when they use phrases such as “the sea ice is disappearing!” Rather scientists need to find simple ways to convey important and foundational details, for example, such as that even under the most aggressive projections of sea-ice loss, there will remain summer remnants of sea ice for many decades to come, and that arctic sea ice in winter will exist for a very long time. The key to avoiding oversimplification is to know your audience and their needs. At the same time, scientists should always avoid technical jargon and unnecessary details.

- Scientists must pay careful attention to specific key words. The meaning of *uncertainty*, for example, is very different for the public than it is for a scientist. Within science, uncertainty refers to how well something is understood through the scientific process of reducing error. When the public hears “uncertainty”, they interpret this as a scientist not knowing or as a debated topic within the science community. Rather, scientists should describe their understanding of the subject in terms of confidence. The acceptance or refusal of science within policy discussions may hinge on avoiding such confusion.

“To most of us, uncertainty means not knowing. To scientists, however, uncertainty is how well something is known. And, therein lies an important difference, especially when trying to understand what is known about climate change.”

- Union of Concerned Scientists
www.ucsusa.org

- Climate scientists are currently challenged to effectively communicate the meaning and usefulness of future projections of atmospheric greenhouse gas concentrations, namely the Representative Concentration Pathways (RCPs). These scenarios bear little relevance to the public. Rather scientists should use the 1.5 degrees of global warming underlying the 2015 Paris Agreement as a touchstone for effective communication. (The Paris Agreement established the goal to hold “*the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.*”). In response to this suggestion by Dr. Ekwurzel, it was noted that communications regarding the importance of targets to steer policy should be augmented with factual explanations that regional variations, such as in the Arctic, will be much larger than global average temperature increases, and that surface temperature changes are not the only effects of greenhouse gas increases.
- Climate science communication must balance the “doom-and-gloom” outlook on the future with positive stories that offer hope and excitement for science and solutions.

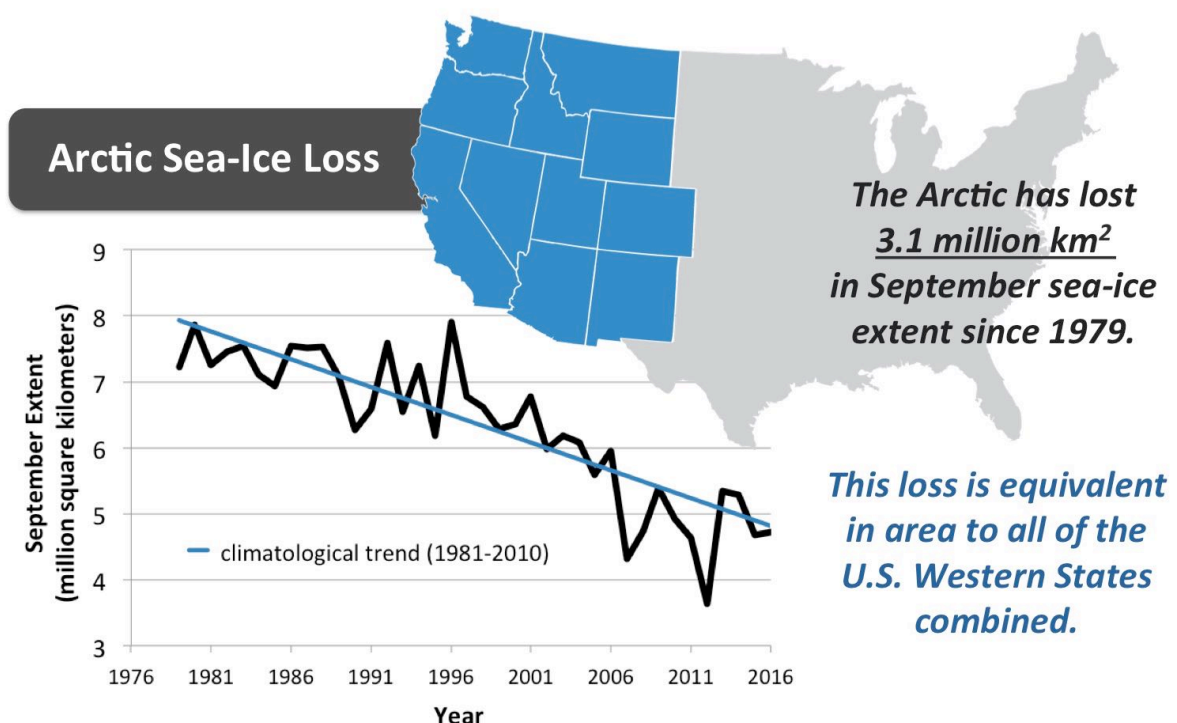


Figure 2. A social-math approach to communicating arctic sea-ice loss.

Andrew Black (American Association for the Advancement of Science) addressed communication with policymakers, focusing on the U.S. Congress.

- Why should scientists bother communicating with policymakers? Because they fund science, they regulate science, and, in some cases, they use science to make better policy.
- Scientists communicating “science for policy” should keep several key strategies in mind when delivering their message. First, “all politics is local”, which means that science will be meaningful if connected to a local issue important to the policymaker’s constituents. Second, recent stories covered by the media matter. Politicians care about what their constituents are hearing in news. If the science can be related to such stories, the more likely that the science will matter to the policymaker. For example, in 2016, anything related to the Zika virus caught the attention of U.S. Congress members. Third, consider making the science relevant to the policymakers’ particular priorities and interests.
- Scientists should pay attention to the funding streams and congressional authorizations attached to their science issue. A scientist will be most effective when their science is relevant to issues on the congressional calendar. (The Congressional record of legislative action, including the introduction of new legislation, can be found here: <https://www.congress.gov/bills-with-chamber-action/115th-congress/browse-by-date>)
- Scientists should always consider targeting their home state’s representatives first. Members of Congress highly prioritize responding to their own constituents over everyone else, mostly a result of the large volume of communications their offices handle.
- The most effective option for sharing information with a member of Congress is in-person. When that is not possible, one should deliver a concise and carefully crafted email. In general, calling is the least effective option.
- There are three important elements to every successful congressional meeting: preparation, precision, and punctuality – the “three Ps”. Take ample time before the visit to know your audience, develop a clear message without jargon or acronyms, and practice your delivery. Construct your message so that the most important information can be delivered in less than 5 minutes. You never know when a planned 30-minute visit might be condensed to 5, or visa versa. Make sure to emphasize the 1-2 sentence take-home message. Be respectful, be personable, and tell a story. The most important thing is to be remembered.
- When possible, university scientists should work through their university’s Washington, DC office. These local experts will be able to assist with identifying the most appropriate members of Congress and tailoring the message appropriately.



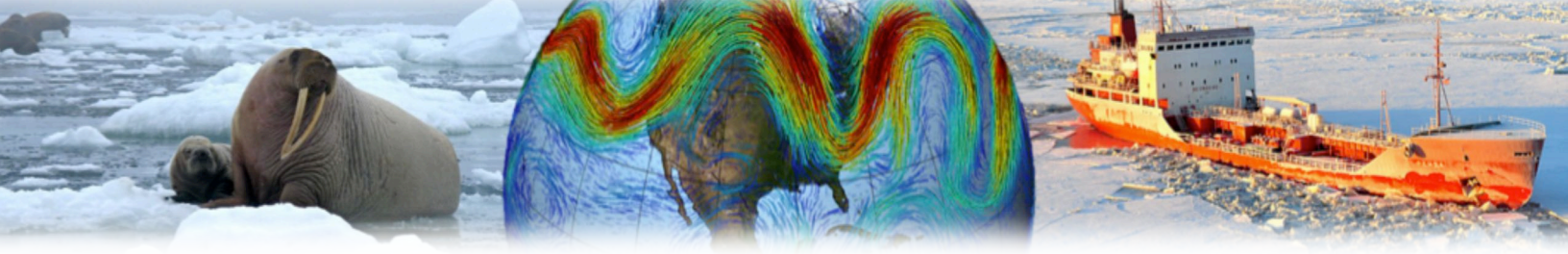
Figure 3. The U.S. Capitol (Credit: The Capitol Architect)

Gifford Wong (AAAS Congressional Fellow with U.S. Senator Whitehouse) shared some additional thoughts regarding engaging Congress.

- Try to schedule your congressional visit prior to “Passback Day”, which is the deadline for input to the appropriations calendar. Passback Day (the last Monday of November) is when the White House and the Office of Management and Budget pass back drafts of proposed budgets for the next fiscal year to agencies and departments and begin a series of negotiations in hopes of completing a final budget proposal by January. More information on the federal budget process can be found here: <https://www.aaas.org/news/federal-budget-process-101>.
- Attach your science to the coat-tails of issues that are up for a vote, or are in the process. For this, your university public affairs (or legislative/congressional affairs) office may be a great resource.
- After submitting a request by email, send weekly reminder emails, bringing your issue to the top of the staffer's inbox and politely reminding them of your intent.
- When scheduling a congressional visit or science briefing, it is helpful to associate your visit with a high profile event (e.g., a conference or press event) taking place in Washington, DC around the same time. Congressional attention on particular issues often comes in waves.
- You may generate congressional interest in your issue by actively working to have it covered by the press. For this, your university press office may be a great resource. After a high-profile news article, you may be more successful finding interest within Congress.

Austin Ahmusuk (Kawerak, Inc.) shared thoughts on how to best partner with local arctic communities and engage community leaders.

- The best foundations for close and sustained partnership between arctic communities and the science community exist when researchers invest both personally and professionally in a community.
- In rural arctic communities, *food security* is the most logical and important pathway to collaboration. By relating research to food security, scientists are most likely to attract attention on issues of local importance.
- Community members and local experts offer “eyes and ears on the ground without an agenda”. They bring a broad perspective on local topics; however, as a result, their traditional knowledge does not come in silos. This makes it difficult for scientists, who are often trained within a particular discipline, to fully process traditional knowledge. *Listening* is, therefore, of critical importance.
- In general, communities can't look at the interests and objectives of science as an isolated consideration. They are very often looking holistically across a whole range of outside entities with local interests (e.g., Army Corp of Engineers on future infrastructure projects, U.S. Coast Guard on marine access issues, marine protection officials on issues pertaining to the endangered species act, etc.). Communities try, but are often challenged, to remain engaged on all issues because they worry that society will go down a path where their interests are not considered.



Opportunities and Approaches for Actionable Science

Breakout groups across the three science themes—the impacts of arctic sea-ice loss on arctic marine ecosystems, lower latitude weather, and human activities in the Bering, Chukchi, and Beaufort Seas—were asked to discuss: (1) existing frameworks for organizing knowledge, (2) key areas of agreement within sea-ice related science, and (3) areas where important questions remain and where the science should be headed.

Within the arctic marine ecosystems group, participants discussed:

- The arctic science community needs to collaboratively communicate on a joint front and define where there is common knowledge and understanding of the science. Agreement is needed on definitions and the usage of key terminology. Following this, key interdisciplinary science questions must be defined. Additionally, an effort to effectively and systematically communicate science should be constructed in accordance with some agreed upon science-based structure. For example, within marine ecology, key terms around which to communicate the impacts of sea-ice loss are: pagophilic (species with an affinity for sea ice), pelagic (species with an affinity for the upper ocean layers), and benthic (species with an affinity for the lower ocean layers and subsurface). Communication across disciplines will be improved by non-ecologists becoming more familiar with such terms.

- Several key science questions were identified:

- 1) **With reductions in arctic sea ice, will there be a shift from a benthic-dominated to a pelagic-dominated system? How do you assess the magnitude of a shift when there is nothing to compare it to? If this shift happens, which species will be the winners and losers?** It is clear that ecosystem restructuring is taking place (e.g., by the evidence of change within the Bering Sea); however, hypotheses regarding the species that will benefit from shifts are less clear. To a large degree, this is not simply a spatial problem as ice retreats, but is rather a complicated timing issue that involves many interrelated species and factors. Understanding bloom dynamics is fundamental and critical.

The importance of these particular questions varies across audiences. For example, earth system modelers are concerned about how marine ecosystem change is affecting the carbon cycle. Subsistence hunters and resource managers are more concerned with potential impacts on food security. The fishing industry is concerned about what change may mean for regulations. The media may be focused on charismatic species, while the conservation community is more interested in overall biodiversity.

- 2) **To what extent will species behaviorally adapt so that ecosystems services are preserved?** This topic matters to conservationists as species may be lost, but it might matter less to subsistence hunters if lost species are being replaced with another of equal value.

- 3) Will changes in the arctic ecosystem have cascading impacts on other ecosystems and migrating species? How might change promote invasive species?
- 4) How might ecological change vary geographically across the Arctic? This question has clear implications for the adaptive responses from stakeholders, many of whom are locally or regionally focused, such as subsistence hunters and the fishing industry.
- 5) To what extent will ocean acidification occur in the Arctic Ocean and how will it affect arctic ecosystems? This question identifies an important gap, as there is little field research on linking ocean acidification to ecosystems change in the Arctic.
- 6) What are the rates of and thresholds of change? Answers to this question will likely be useful to stakeholders by informing decisions on whether and when to be proactive versus reactive to change.

Within the lower-latitude weather group, participants discussed the following topics:

- There is not enough basic communication regarding why arctic sea-ice loss matters. For example, an effective take-home message could address how sea-ice loss is related to the “Ridiculously Resilient Ridge” (the persistent high-pressure region in the northeastern Pacific) or the California drought.
- While particular notable weather events (e.g., extreme winter snowfall events or prolonged droughts) provide hooks for communicating with the public, scientists must be mindful of the challenge of tying a single event to sea-ice loss, and instead speak in terms of changing probabilities of types of extremes. Examples of how to best walk this fine line should be highlighted and shared to assist others in taking advantage of these *hooks*. Additionally, such examples should address why sea-ice loss matters in terms of both the impact on seasonal forecasting and the probabilistic challenge of linking loss to particular weather events.
- Broad statements about the atmospheric response to sea-ice loss may not be helpful and often become a source of controversy, as many of the mechanisms are regional and/or seasonal. General concepts should be presented along with caveats to underscore the complexity of the problem.
- A communication tool, such as a *thermometer of consensus*, may be helpful for conveying the degree of agreement across the science community regarding the mechanisms for linking sea-ice loss to particular types of weather events. The research community is relatively polarized on this topic, which is often demonstrated by the diversity of reviewers’ views toward any particular study or proposal. This polarization, which is not always objective, is obstructing progress.
- In terms of where the science should be heading, the group identified:
 - 1) The relative importance of sea-ice loss in contributing to specific types of weather events, paying consideration to the potential role of interactions with other factors such as the Pacific Decadal Oscillation, El Niño Southern Oscillation, etc.;
 - 2) The potential connection between Northern Hemisphere snow cover and sea-ice loss and weather;

- 3) The regional and seasonal factors that affect correlations between extreme events and sea-ice loss; and
- 4) Greater clarity amongst the science community regarding how different scientists are constraining and parameterizing their modeling studies. Similarly, consensus is needed on designs for model inter-comparison studies and targeted model simulations.

Within the human activities group, which mostly focused on local arctic communities, participants discussed:

- The development of any science or knowledge communication framework must be sensitive to how it may serve, or potentially exclude, different forms of knowledge. This is particularly important in the Arctic where there is growing recognition of the value of traditional knowledge.
- As a best practice, we must make sure communications between scientists and communities focus on explanations, not just facts. Knowledge levels are not fixed. We must always view communications as an opportunity for education on both sides.
- There is no substitute for two-way dialogue. This is a core principle for working with communities.
- While the research community regularly assesses gaps in knowledge as an important element of the scientific process, they must also explore opportunities to listen to traditional knowledge holders regarding knowledge gaps from their perspective.
- When communicating with the general public and those outside the Arctic, we need to develop clear and illustrative examples of how sea ice is affecting people in coastal communities (e.g., using social math).
- When communicating with local arctic communities, we need to develop examples of how science can benefit them and be useful in their decision-making.
- Examples of sea-ice science informing decisions should not only include straightforward and simplistic cases. Examples that highlight local dilemmas are also needed. For example, along many arctic coasts, shallow beaches promote slush berm formation (see Figure 4), which buffers the coast from wave-induced erosion. However, shallow beaches off villages are bad for local



Figure 4. Slush berm off Utqiagvik (previously Barrow), Alaska in fall.

fishing, as residents must go farther to reach fish in deeper waters. This dilemma has implications for decisions regarding where to relocate a village or where to dredge coastlines.

- Coastal communities' ability to both partner with scientists and provide useful feedback is improved when they have knowledge and information on the modeling and observational capabilities of science. Too often there is a large disconnect between what science can do and what communities hope science can do. As a step toward addressing this divide, SEARCH might consider developing a short information resource for communities (e.g., a poster to hang in the villages) that outlines the capabilities of sea-ice research, modeling, and monitoring. Such products, however, would need to be regularly updated to keep up with the science.
- In terms of where the science should be heading, the group recommended:
 - 1) **Developing a more sophisticated understanding of the contexts in which sea ice connects to coastal community activities and issues, and of the corresponding governance capacities that exist;**
 - 2) **Connecting our understanding of the scales of sea-ice change to the impacts on local and regional communities.** Too often there is disconnect between how dramatic sea-ice change is reported and the actual effects on local communities.
 - 3) **Communicating impacts of sea-ice variability on arctic communities in terms of both the potential policy responses and the economic implications, while bearing in mind the political sensitivities of such information for local agendas.**
- Communicating with arctic communities and local arctic stakeholders requires a commitment to staying connected. This is best accomplished by:
 - Working within pathways that already exist (e.g., USGS Climate Science Center Tribal Coordinators; Indian General Assistance Program Coordinators; designated Facebook pages, such as is used by the Sea Ice for Walrus Outlook).
 - Establishing scientist-community dialogue networks along specific themes, such as coastal resilience. Any type of network must consider ways to encourage both open and private conversations (e.g., open Facebook exchanges may not work for everyone, especially when addressing sensitive issues).
 - Maintaining working relationships underpinned by an ability and commitment to responding to local questions with meaningful and relevant information.
 - Investing in people, for example, by supporting the roles of community liaisons, whether formal or informal, in bridging local communities and researchers, or by seeking opportunities for local people to visit universities or other research hubs.
 - Getting involved in outreach with the village schools.

Toward Improved Communication

Breakout groups consisting of various communication audiences—the media, policymakers, and local arctic residents and stakeholders—were asked to discuss: (1) ways to identify the audience; (2) lessons learned regarding successful approaches for communicating effectively, accurately, and efficiently; (3) desired outcomes as a result of effective communication; (4) ways to gain traction for these types of communication; and (5) ways the Sea Ice Action Network could support these efforts.

Communicating with the media. Participants suggested that:

- Scientists need to embrace and prepare carefully for all opportunities to interact with media, whether phone interviews, television interviews, requests to write guest blogs, etc. One must understand the audience beforehand and anticipate questions. Answer the questions asked, but then segue to information that is important for them to know. Provide scientific information in a broader context—why it matters to the audience and how challenges are being addressed.
- Scientists must recognize when their audience is unwilling to listen. They should avoid engaging with stalwart deniers, but be willing to engage with receptive skeptics. They should be able to counter misinformation and address sticky issues through clear and factual responses.
- Participants also noted the value of:
 - Organized networks of experts, such as UCAR’s Climate Voices Science Speakers Network (<http://climatevoices.org/>);
 - Blogs and specialist websites, which often have loyal followers who can amplify messages (e.g., see Vlob Brothers, Crash Course Channel, SkepticalScience.com, Arctic Sea Ice Blog, or Climate Central);
 - Social media, as a mechanism for relaying trusted information that can combat misinformation;
 - Press releases, which can be written whenever a newsworthy study is published;
 - Using sound-bites and catchy terms, for example “drunk jet stream” or “sticky weather”;
 - Name recognition, for example, the National Snow and Ice Data Center;
 - Associating a scientist’s face to the science (i.e., personalizing science); and
 - Simple easy-to-use communication tools, such as message boxes (see appendix).

Communicating with policymakers. Participants identified the need to:

- Be proactive in the dissemination of information by creating opportunities to engage with policymakers, as opposed to waiting for policymakers to come to the scientists.
- Have clear and succinct communication resources readily available (e.g., 1-2 page briefs suitable for policymakers). This does not negate the need to tailor information for particular inquiries, but will greatly expedite the process.

- Have established knowledge networks so that one can quickly refer a policymaker's question to the most relevant expert. It was noted that this is a role for SEARCH—steering and connecting decision-makers' questions to the science community.
- Prepare an internal guidance document regarding how to effectively communicate uncertainty.

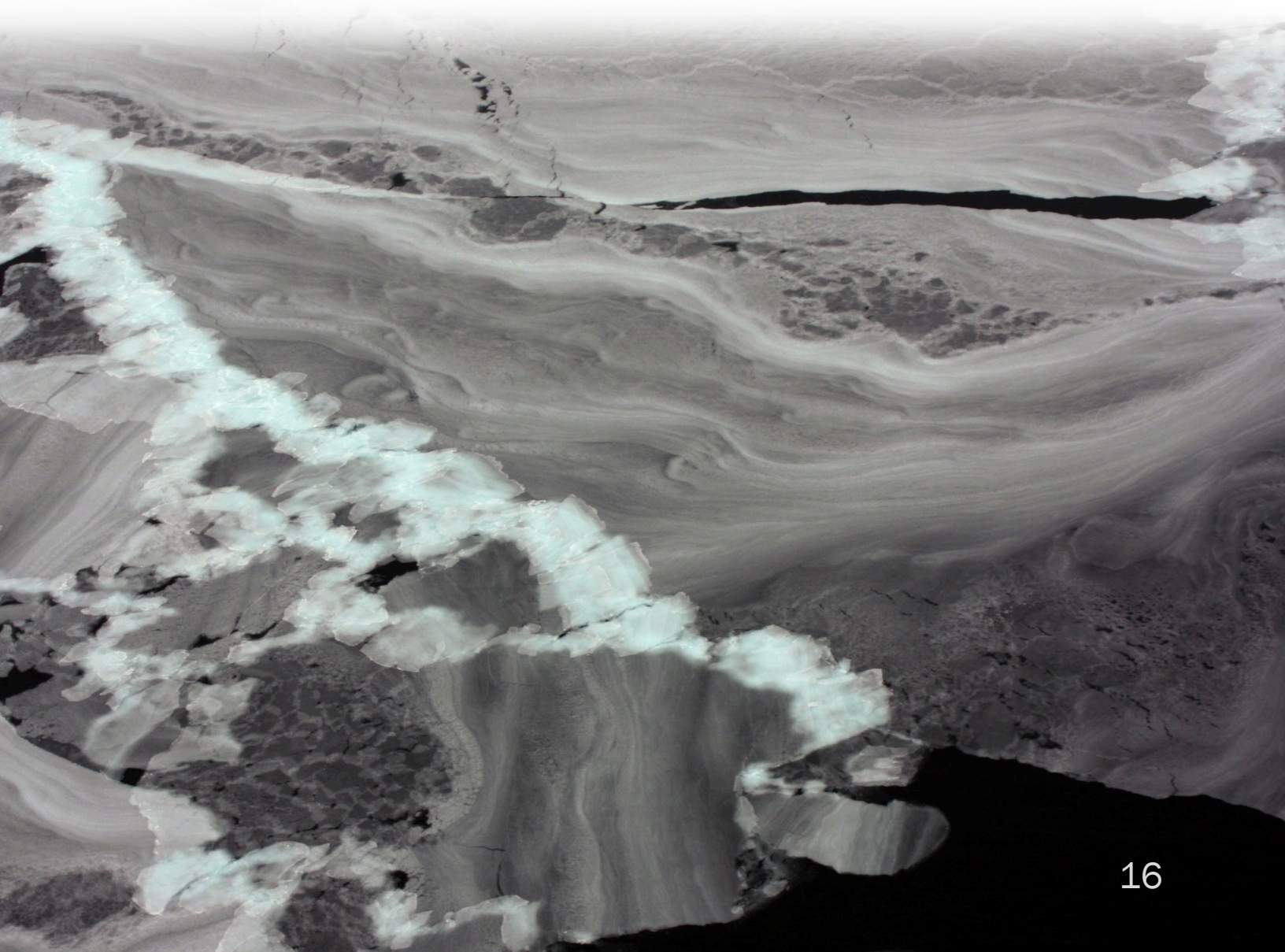
Communicating with local arctic residents and stakeholders. Participants noted that:

- In general, enhanced communications between science and local arctic residents and stakeholders is intended to increase collaboration; foster more applied locally relevant science; educate the science community on local community needs; support more resilient, knowledgeable, and prepared communities; and allow for improved communication to the media and state and federal decision-makers on the local impacts of arctic change and sea-ice loss.
- Scientists should look to capitalize on the high science literacy that is often found in rural Alaskan communities. Their general awareness of climate science and familiarity with visiting researchers often allows local arctic communities to engage in insightful, efficient discussions with scientists.
- A student exchange between local arctic communities and universities or high schools could provide both collaborative outreach to communities, educational opportunities for youth, and a means to sustain communications with communities.
- Inviting local community experts to serve on academic and research advisory committees is a worthwhile way to (1) invest in community relationships and in specific community members' roles as liaisons, (2) work toward community relevant research, and (3) provide a pathway for traditional knowledge to interface with science.
- Science communication with communities must be localized. Presenting scientific results at the state or regional scale may not have any relevance to a local community. Maps and spatial data should always include local landmarks and coastlines, and use traditional place-names when possible.
- Various audiences may include: Native villages, borough governments, regional non-profit organizations and their board members, advisory committees, Alaska Eskimo Whaling Commission, community ambassadors, the Alaska Federation of Natives and their Elders and Youth Conference, Norton Sounds Health Corporation, industry representatives, etc.

Regarding the role of a Sea Ice Network (SIAN), participants discussed opportunities to:

- Facilitate connections between scientists and local communities, policymakers, and other stakeholders—steps that are difficult for many researchers.
- Be a resource to share ideas, make discrete contributions, and provide continuity across related efforts.
- Provide a platform for scientists to offer their educated opinions on science topics—views that may not yet be ready for peer-reviewed literature.

- Use the urgency or visibility of current events to encourage contributions from across the science community, local partners, and stakeholder groups.
- Use existing conferences and gatherings, such as the AGU Fall Meeting or the Alaska Marine Science Symposium (AMSS), to host network events.
- Promote collaboration (e.g., towards building knowledge pyramids), where benefits include:
 - 1) Community building within and beyond the science community, and being part of a larger network;
 - 2) A way to address *Broader Impacts*;
 - 3) Valuable outreach for universities and home institutions;
 - 4) Greater visibility for your science; and
 - 5) Opportunities to share data and model output.



CONCLUSIONS

Key Takeaways

- The societally relevant questions to be addressed by knowledge pyramids should be identified with specific input from stakeholders. Additionally, the resulting answers to such questions will require iteration with stakeholders.
- The potential usefulness of knowledge pyramids and the associated engagement with stakeholders provide important incentives for scientists to collaborate. The success of the Sea Ice Action Network should be defined not only by getting other scientists to make written science contributions, but also by how they engage in the entire process underlying *knowledge-to-action*.
- Policymakers, local communities, and other stakeholders may believe an issue to be important but are often unclear about what they want to know and what is knowable from a scientist. Often they are looking for information or specific guidance related to a particular course of action, which is outside the realm of what objective science can offer. The primary opportunity for scientists is to participate in two-way conversations so that they can learn what questions are of societal relevance and "users" can learn what practical guidance the science can provide.
- Effective science communication accomplishes two important things: it provides some level of education on the state of science and relates that knowledge to something of importance to society. For local arctic communities, food security offers an overarching issue for research to connect with.
- Science communication to audiences outside a scientist's discipline must avoid using technical jargon. This is a well-recognized best practice, yet often overlooked in practice.
- The usefulness of scientific information often hinges on whether it can be presented at the appropriate level of understanding, as well as the useful spatial and temporal scales. The Arctic is a big place. Annual or seasonal mean metrics presented at the pan-arctic scale are often too coarse to be useful to stakeholders. Science must often understand the impact of arctic change at local-to-regional scales in order to better address stakeholder needs, which are often constrained to very specific places and times of the year.
- While science has provided valuable information on overall trends, more attention should be given to understanding relative rates of environmental change, thresholds within systems (e.g. ecological tipping points), and the impacts of extreme events.
- Misinformation (and even deliberate disinformation), climate-change denialism, and public confidence in the science community's ability to reach consensus represent critical barriers to effective communication. Science communication should (1) focus on the frequent delivery of concise messages that summarize reliable and accurate information, and (2) discuss scientific understanding in terms of confidence, as opposed to uncertainty.
- Science communication can have the greatest reach during periods of high political, media, and public attention to high-profile current events (e.g., record sea-ice loss and extreme weather).

Next Steps

- The SEARCH Sea Ice Action Team will continue to build the Sea Ice Action Network. The Action Team will continue to serve as a core advisory group, while the Network will provide opportunities for a greater cross-section of the arctic community—scientists, policymakers, local residents, and stakeholders—to collaborate toward synthesizing and communicating the science of arctic sea-ice loss and its impacts on the arctic system and the globe as a whole. The success of SIAN will hinge on finding ways to incentivize participation, building on what people are already doing, and finding creative ways to bring people together (e.g., through a blog, side-meetings at existing conferences, personal invitations to contribute specific additions to knowledge pyramids, etc.).
- Several products are being considered; most of which will be prepared in the near future:
 - Science briefing materials and/or knowledge pyramids that address (1) the economic costs and opportunities related to sea-ice loss, (2) local food security in the coastal Arctic, (3) linkages between arctic sea-ice loss and the California drought, and (4) the connections between political views and public perceptions and understanding of arctic climate and environmental change;
 - A collection of communication examples that effectively address the uncertainty and attribution challenges in conveying the linkages between arctic sea-ice loss and lower latitude weather;
 - Specific stories (i.e., case study examples) of how scientific knowledge and information can inform stakeholder and local community actions. We must begin to more clearly illustrate the concept of *knowledge-to-action*; and
 - Posters or other community-friendly resources to outline the capabilities and existing methods for researching, modeling, and observing arctic sea ice, especially at spatial and temporal scales most relevant to communities.

WORKSHOP AGENDA

September 14-16, 2016

Arctic Research Consortium of the U.S. (ARCUS) DC Office/
Consortium for Ocean Leadership, 1201 New York Avenue, Washington, DC 20005

Wednesday, September 14

8:30–8:50 AM	Welcome and Introductions – <i>SIAT Leadership and Bob Rich, ARCUS</i>
8:50–9:05 AM	Overview of the Study of Environmental Arctic Change (SEARCH) – <i>Brendan Kelly, SEARCH</i>
9:05–9:20 AM	Overview of the SEARCH Sea Ice Action Team’s mission to foster collaborative science, community engagement, and effective communication – <i>Matthew Druckenmiller, Rutgers University and NSIDC</i>
9:20–10:40 AM	<u>Connecting and Communicating with Diverse Audiences:</u> <ul style="list-style-type: none">• Across Science Disciplines – <i>Marika Holland, NCAR</i>• The Media – <i>Brenda Ekwurzel, Union of Concerned Scientists</i>• Policy Makers – <i>Andrew Black, AAAS</i>• Local arctic residents and stakeholders – <i>Austin Ahmasuk, Kawerak, Inc.</i>
10:40–11:00 AM	Break
11:00–12:00 AM	<u>Overview Presentations on Workshop Science Themes: Fostering effective communication, collaborative science, and actionable knowledge regarding:</u> <ul style="list-style-type: none">• Human activities in the Bering, Chukchi, and Beaufort Seas – <i>Henry Huntington, Huntington Consulting</i>• Arctic ecosystem change – <i>Brendan Kelly, Univ. of Alaska Fairbanks</i>• Arctic linkages to lower latitude weather – <i>Jennifer Francis, Rutgers Univ.</i>
12:00–1:30 PM	Lunch
1:30–1:45 PM	Defining the state and opportunities for actionable science
1:45–4:15 PM	Breakout groups by science theme: <i>What do we know? What do we need to know? What is our message to other audiences?</i>
4:15–5:00 PM	Summaries and wrap-up
6:30PM–	Workshop dinner

Thursday, September 15

8:30–9:00 AM	Synthesis through targeted communication
9:00–11:30 AM	Breakout groups by communication audience (Other science disciplines, the media, policy makers, local arctic residents and stakeholders): <i>How do we state what we know, clearly and accurately? How do we communicate what we know to various audiences? How do we support what we are saying?</i>
11:30–12:00 PM	Summaries
12:00–1:30 PM	Lunch
1:30–3:30 PM	Discussion: Developing strategies for better understanding the consequences of and informing societal responses to sea-ice loss
3:30–3:45 PM	Break
3:45–5:00 PM	Discussion on next steps: Tangible outcomes, Establishing a <i>Sea Ice Action Network</i> , etc.

Friday, September 16

9:00–12:00 PM	Meeting of the SEARCH Sea Ice Action Team (closed)
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PARTICIPANTS

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** Members of the SEARCH Sea Ice Action Team*

APPENDIX

Related Resources

Reports:

Arctic Research Plan FY2017-2021. This 2016 report by the Interagency Arctic Research Policy Committee (IARPC) focuses on those arctic research activities that would be substantially enhanced by multi-agency collaboration. Research Goal 3 to “Enhance Understanding and Improve Predictions of the Changing Arctic Sea Ice Cover” identifies the SEARCH Sea Ice Action Team in order to “Support collaborative networks of researchers and stakeholders, including northern residents, to advance knowledge, understanding, and prediction of the sea-ice system.”

http://www.iarpccollaborations.org/uploads/cms/documents/iarpc_arctic_research_plan_2017-2021.pdf

GeoPolicy Connect: Bringing A Collaborative Lens to Science and Policy Issues. The following report is from the American Geophysical Union’s 2016 inaugural GeoPolicy Connect workshop—an event focused on making recommendations for improving science policy for decision-making. One recommendation states that the science community must build up easily accessible resources for science information to be used by different audiences to ensure access to unbiased sources of science information.

http://geopolicyconnect.agu.org/wp-content/uploads/2016/12/AGU_AfterEvent_WriteUp_FINAL-1.pdf

Motivating Research on the Science Communications Front: Conveying the Nature and Impacts of Rapid Change in Ice-dominated Earth Systems to Decision Makers and the Public. This 2015 workshop report to the National Science Foundation discusses the need and offers recommendations for science communication research.

https://geo-prose.com/pdfs/motivating_research_high.pdf

Websites:

The Federal Budget Process 101. This website of the American Association for the Advancement of Science summarizes the complicated annual federal budget cycle.

<https://www.aaas.org/news/federal-budget-process-101>

"Yesterday in Congress". This official website provides easy access to legislation introduced, reported, passed, and considered by the House or Senate each legislative day.

<https://www.congress.gov/bills-with-chamber-action/115th-congress/browse-by-date>

Books:

Escape from the Ivory Tower: A Guide to Making Your Science Matter. This 2010 book by Nancy Baron is a practical guide to communicating science to policymakers and the media.

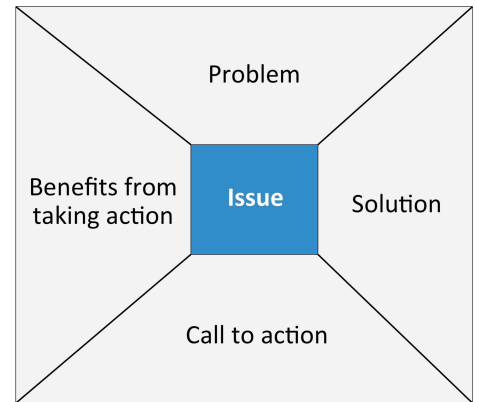
<http://www.escapefromtheivorytower.com/>

Working With Congress: A Scientist’s Guide to Policy. This book, published by the American Association for the Advancement of Science, provides background on congressional organization and the legislative process, offers communication strategies that one can utilize, and presents a list of the top ten rules for working with Congress.

<https://www.aaas.org/page/working-congress-scientist-s-guide-policy>

Communication Using Message Boxes

Brenda Ekwurzel from the Union of Concerned Sciences suggested the use of *message boxes* as a tool for communicating with diverse audiences. Message boxes are intended to help by prioritizing information most salient to your audience. These consist of four categories of information—the problem, the solution, a call to action, and the benefits of taking action—around a central issue. Message boxes are effective as they support non-linear thinking about communication; you can start a conversation in any quadrant. See the example message box below for communicating the global impacts of arctic warming.



Nancy Baron’s book “Escape from the Ivory Tower: A Guide to Making Your Science Matter” (2010) explains in more detail the strategy and advantages of message boxes. Baron suggests these as useful for preparing for interviews with the media, developing thirty-second elevator pitches to policymakers, writing an op-ed for a newspaper, or creating content for a website.

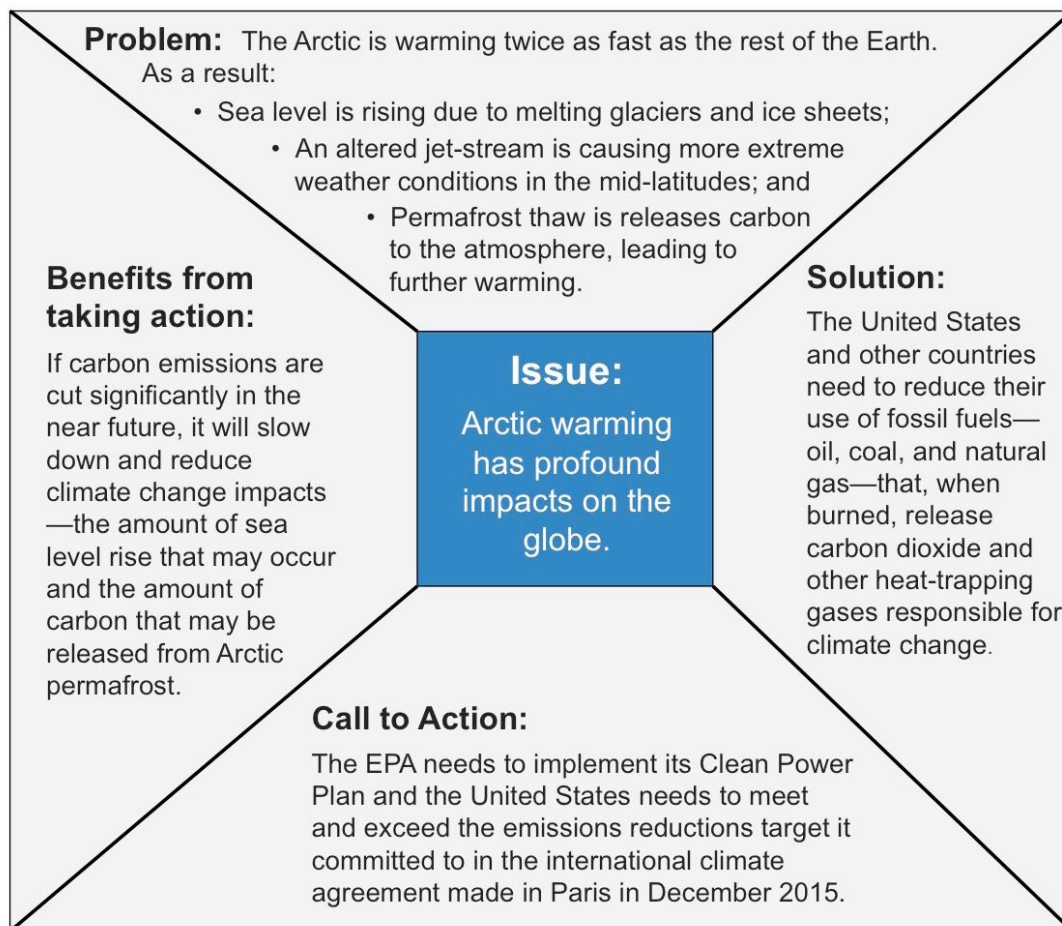


Figure 5. Example message box for communicating the global impacts of arctic warming.

Example SEARCH Science Briefs

The following pages provide three examples of SEARCH Science Briefs, which were prepared in July 2016, primarily for media and congressional audiences. These are:

1. “Rapid Arctic Environmental Change Disrupts Marine Ecosystems” by Brendan Kelly
2. “Effects of the Arctic Meltdown on U.S. Weather Patterns ” by Jennifer Francis and Stephen Vavrus
3. “A Warming Arctic Threatens Rural Community Resilience” by Henry Huntington and Matthew Druckenmiller





Rapid Arctic Environmental Change Disrupts Marine Ecosystems

THE ISSUE. Diminishing sea ice, changing snow patterns, and increasing water temperatures threaten organisms—from algae to mammals—adapted to the sea ice ecosystem.

WHY IT MATTERS. Globally, climate change is decreasing biodiversity (variety of life) with the potential to cause the sixth mass extinction in the Earth's history¹. Arctic marine organisms are particularly vulnerable owing to their dependence on snow and ice and to the rapid pace of warming in the region — at least twice the global average. The well-being and economies of Arctic people are disrupted by changes in the Arctic marine ecosystems on which they depend for food and cultural affirmation². Changing ice conditions have already diminished indigenous hunters' access to whales and walrus in Alaska.

STATE OF THE SCIENCE. The timing and extent of sea ice directly and indirectly influence the abundance and seasonal behavior of many species³. In recent decades, rapid warming has contributed to a year-round decline in sea ice thickness and a 50% reduction in ice area during summer months. Models consistently forecast a continued reduction in ice coverage and thickness as greenhouse gases continue to accumulate. While Arctic sea ice likely will persist in the dark winter months, summers will see little ice cover in coming decades.



Algae growing on the underside of sea ice is visible in ice cores. (Credit: S. Carpenter)

Over half of the organisms capturing the sun's energy (primary producers) in the Arctic Ocean are algae and phytoplankton that grow on or under sea ice. As ice diminishes, so will these primary producers along with the higher-level organisms that depend on them. Other species of phytoplankton may increase as more light penetrates thinning ice, although the effect of increased light may be offset by decreased nutrients. A massive bloom of phytoplankton observed under ice in the Chukchi Sea in 2011 was believed to be enhanced by thinning ice⁴. Whether a new suite of phytoplankton will support an abundance of higher organisms will depend on timing, location, nutrient availability, and the ability of different species to adapt to polar environments. A consensus on the net impact on Arctic Ocean productivity has yet to emerge from ongoing research.

Changes in the physical Arctic environment will result in winners and losers; some sub-Arctic species will shift their ranges northward into Arctic waters while some current species will be displaced by these new migrants through competition or predation. For example, Arctic cod—a species key in the diet of many Arctic fish, birds, and mammals—is adapted to sea ice habitats and, as ice diminishes, the species is being displaced by an Atlantic Ocean cod⁵. On the other hand, a species of amphipod that specializes in feeding on ice algae, may be resilient in the face of diminishing ice due to an ability to ride pole-ward currents that keep them in the ice⁶.

More southerly species of marine mammals, such as Steller sea lions, are expanding northward as ice diminishes, while ice-dependent mammals are facing increasing challenges. Diminished sea ice has reduced food availability for some populations of polar bears⁷ and walrus⁸. Walrus that

used to rest and nurse their young on sea ice in summer are now forced to come ashore in large aggregations on land where they are vulnerable to predation and trampling⁹. Declining ice and, especially, snow cover are projected to reduce the birthing habitat for ringed seals by 70% by 2100¹⁰.

The net impact of these dynamics on biodiversity of the region is uncertain. Increased primary production might favor increased biodiversity, while decreased habitat diversity would disfavor it. Adaptive strategies will, in part, be driven by genetic diversity and generation time (the average time between subsequent generations within a species). Species with high genetic diversity and short generation times have a greater likelihood of adapting to new environments. Conversely, species with unfavorably long generation times and low genetic diversity, such as the large marine mammals (polar bears, seals, whales, etc.), will be at greater risk.

WHERE THE SCIENCE IS HEADED. Ecological observations and models of the Arctic Ocean are sparse. While such studies have accelerated in recent decades, they are proceeding slowly relative to the pace of environmental change¹¹. We know from more thoroughly studied regions that ecosystems can experience sudden and rapid reorganization when thresholds are exceeded. Such thresholds are inadequately known for the Arctic Ocean. Multi-disciplinary and multi-scale studies are needed to understand how diminishing sea-ice and warming waters will ultimately alter Arctic marine ecosystems, including the health and behavior of key species on which Arctic people depend.



Ringed seals rest, give birth, and nurse their young in snow caves above Arctic sea ice. Early snow melts have led to the deaths of large numbers of ringed seal pups by predation and freezing. (Credit: B. Kelly)

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The Study of Environmental Arctic Change (SEARCH)

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<https://www.arcus.org/search-program>

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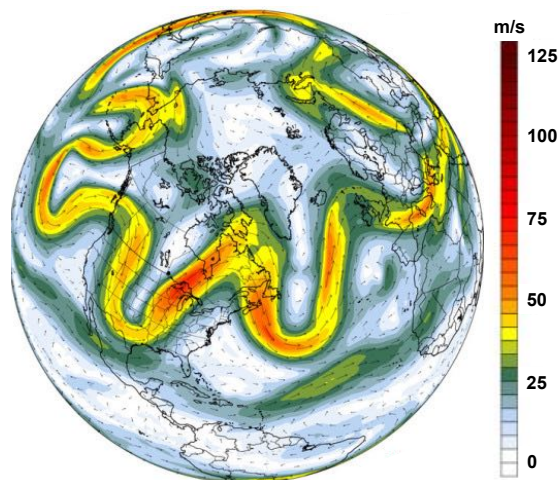
Effects of the Arctic Meltdown on U.S. Weather Patterns

THE ISSUE. In recent decades, the pace of Arctic warming was at least double that of the globe. A growing body of research suggests this differential warming will increase the frequency of extreme weather events in the United States and elsewhere in the northern hemisphere.

WHY IT MATTERS. Extreme weather events cause billions of dollars in damage, scores of deaths and injuries, and thousands of disrupted lives each year. The frequency of these events is increasing, and certain types have clear links to climate change. Rapid Arctic warming is expected to cause more persistent weather regimes that can lead to devastating drought, heat waves, fire seasons, stormy winters, and flooding, many of which have been prominent weather stories across the U.S. in recent years.

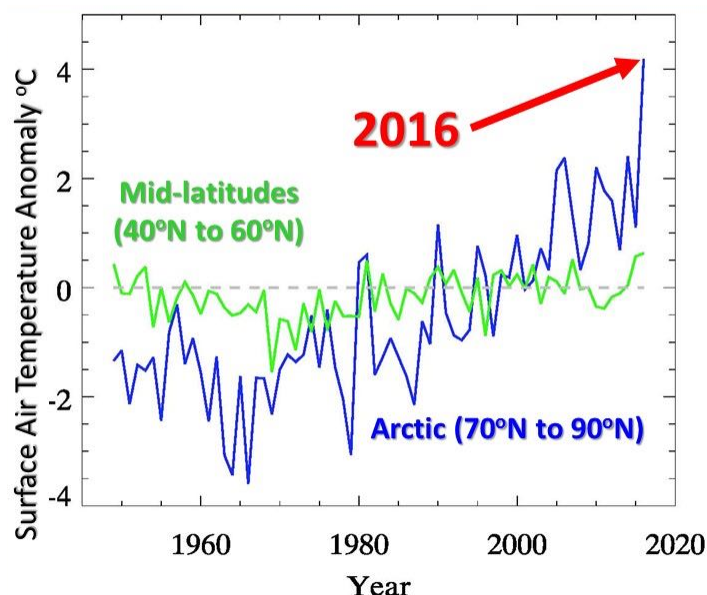
STATE OF THE SCIENCE. The major wind systems of the globe are driven by temperature differences; the jet stream exists because the Arctic is much colder than regions farther south, the so-called mid-latitudes. The larger the temperature difference, the stronger the jet stream. Any changes that affect the Earth's temperature patterns will also affect jet streams, and because jet streams create and steer weather patterns, those changes will also affect mid-latitude weather. The dramatic Arctic warming during recent decades is reducing this temperature difference, which is weakening the jet stream's west-to-east winds.¹ Instead of a coherent river of strong winds, a weaker jet tends to waver, split, and wander north and southward on its path around the northern hemisphere.^{2,3} These wavier jet streams are responsible for a variety of extreme weather events, which have become more frequent in the U.S., Canada, Europe, and Asia.^{4,5}

The linkage between amplified Arctic warming and mid-latitude weather is a rapidly evolving field of research. New evidence suggests that diminished sea ice in particular regions and seasons has distinct effects on weather extremes.⁶ Ice loss and warming north of Alaska, for example, allows extra summer sunshine to warm those waters. Come autumn, that heat is released back into the atmosphere, which intensifies northward swings in the jet stream – known as ridges – in the area of ice loss. The “Ridiculously Resilient Ridge” largely responsible for California's ongoing extreme drought was likely strengthened by the warm Arctic.⁷ Like a whipped jump rope, the effect downstream was a more southerly jet excursion – or trough – which allowed cold air to plunge into eastern states during winters of 2013/14 and 2014/15. Larger jet waves tend to linger in one place, favoring persistent weather patterns: relatively warm and dry under the ridge, cold and stormy in the trough. Prolonged summer heat waves and flooding caused by slow-moving storms may also get a boost from the Arctic meltdown.²



Wandering jet stream from May 14, 2014. Colors represent wind at 250 millibar from the GFS Model. (Credit: Climate Change Institute, University of Maine)

WHERE THE SCIENCE IS HEADED. While some mechanisms linking the rapidly warming Arctic and changes in mid-latitude weather are becoming clear, others are more difficult to identify because the atmosphere is such a chaotic beast. Challenges arise because the era of rapid Arctic warming began only a decade or two ago, other changes in the climate system are happening simultaneously, and natural fluctuations (such as El Niños/La Niñas) obscure signals.⁸ Standard analysis methods that average over large areas or time periods may smear unusual jet features that don't appear in the same location each year. Computer models of the climate system struggle to realistically simulate very wavy jet features and complex Arctic processes, thus their utility for studying mechanisms of Arctic/mid-latitude linkages is imperfect. Much is left to unravel, but research is progressing quickly.



January to May air temperature anomalies. These anomalies, which are deviations from average temperature, are relative to the 1981-2010 average. (Data from NOAA/NCEP/ESRL)

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A Warming Arctic Threatens Rural Community Resilience

THE ISSUE. Loss of sea ice, thawing permafrost, reduced snow cover, and rising sea level are reducing hunting and fishing opportunities and degrading infrastructure for rural Arctic communities. Most Alaska Native communities are affected by erosion and flooding, with 31 communities imminently threatened and 12 planning to relocate. Local responses to these stresses are hampered by the nation's highest prices for food and fuel and widespread poverty across rural Alaska.

WHY IT MATTERS. Climate change amplifies challenges confronting Arctic communities, where 60-80% of households depend on wild game and fish for food, harvesting several hundred pounds per person annually. Already faced with economic, social, and cultural changes, traditional ways of life in rural Alaska are further threatened by climate change impacts on diminishing food security, deteriorating water and sewage systems, increasing risk of accidents, and greater expenditures to construct and maintain infrastructure. Government agencies and other institutions need to promote policies that reduce stresses on Arctic communities and foster responses consistent with local economies and cultures.

STATE OF THE SCIENCE. Arctic communities and scientists have worked together to document local observations of climate change; the associated impacts on hunting, fishing, safety, and food security; and the potential impacts of projected changes into the future. More recently, researchers have been assessing the efficacy of local responses. For example, subsistence whalers on St. Lawrence Island in the Bering Sea have initiated a fall harvest to help make up for spring whaling seasons made shorter by changing ice conditions. At Kivalina—a village that is also facing relocation due to erosion—changing spring ice conditions have prevented the harvest of bowhead whales for over 20 years. In other cases, changes can amplify one another. Limited time off from jobs means that whalers from Nuiqsut now have much shorter time available for whaling in fall. In Alaska's Arctic region, 78% of Native Iñupiat households combine jobs and subsistence to meet their economic, cultural, and nutritional needs. The benefits of employment are lessened, however, by the reduction in time devoted to harvesting wild foods. Less time to hunt means less chance to wait out fall storms or to adapt to other changes in weather or animal migration patterns. Those migration patterns may be further altered as diminishing sea ice opens opportunities for industrial activities (for example, shipping and offshore petroleum development). The cumulative effects of stresses and changes are broadly recognized but difficult to measure.



Map of the 11 Alaska traditional whaling communities, with the 2015 and 1981-2010 median September ice extents shown. (Courtesy: M. Druckenmiller)

WHERE THE SCIENCE IS HEADED. More work is needed to understand how local responses can be effective (such as the St. Lawrence Island fall whaling season) as well as how they fall short of what is needed (such as Kivalina's inability to hunt in spring). In addition, future research must address ways that policies exacerbate or mitigate such impacts, for example by imposing additional constraints on what communities can do, or by supporting flexibility and local initiative to solve problems. Actions made without adequate knowledge of local conditions, no matter how well intentioned, may undermine local well-being by promoting ineffective responses or fostering dependence on outside intervention rather than on local talent, capacity, and creativity. Ultimately, communities need support to identify local solutions.



Iñupiat hunters establish a whaling camp on coastal sea ice near Barrow, Alaska, where thinning ice and warming temperatures in Spring are reducing hunting opportunities and increasing risks to personal safety. (Courtesy: M. Druckenmiller)

FURTHER READING

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A Report of the SEARCH Sea Ice Action Team

Advancing awareness and understanding of the impacts of Arctic sea-ice loss

