**NWS Alaska Region Observation Program Priorities and Expansion**

*Scott, Carven; Fode, Louise; Fish, Aimee; Heim, Becki; Tatusko, Renee*

The National Weather Service (NWS) Alaska Region relies on a sustainable network of meteorological, hydrological, and climate observations to provide decision support services for a broad array of users to protect life and property. For instance, the State Emergency Operations Center (SEOC) consults with the NWS on a weekly basis to ensure they have situational awareness for storms and other weather and environmental-related hazards that may impact communities across all of Alaska. This information enables SEOC to “tee up” other support mechanisms to help mitigate or respond to a high-impact weather event. The USCG relies on accurate NWS products and services in support of Search and Rescue (SAR) missions. Marine products help ships transiting Alaska’s waters to avoid stormy areas that could be disastrous. Coastal and river water-level information and forecasts are necessary for coastal and riverine communities in developing hazard resilience. Observations of ocean currents and sub-surface temperatures are crucial for understanding and anticipating sea-ice development and the time of “freeze up” – a critical forecast parameter for marine transportation, offshore oil and gas operations, and Arctic coastal communities. Lightning detection information is critical for fire-weather forecasts supporting land managers and fire crews as well as for pilots and mariners. Profiles of wind speed and direction are key to understanding turbulence and icing potential and predicting where ash will be transported after a volcanic eruption.

However, there are significant gaps in the observation platforms that must be resolved. For instance, additional water level measurements are needed on the northern and western coasts of Alaska where communities are threatened by storm surge and flooding. Additional wave buoys are needed in the Arctic Ocean, Bering Sea, the western Gulf of Alaska, and the southeast. River gauges are needed on rivers on the North Slope and in the western interior as well as southwest and eastern interior. For sea ice, the main observational needs are satellite imagery, but observations are also needed from buoys to moorings, which can provide information on water temperature and salinity and can be used to forecast freeze-up dates. While potential solutions have been identified, they are highly reliant on additional funding or collaboration with outside partners. For instance, in collaboration with USGS, NASA, and Department of Energy, the NWS is currently working with a NSF-funded EarthScope project called the Transportable Array in Alaska and the Yukon, to deploy inexpensive meteorological sensors on some of the nearly 300 seismograph stations that make up this network. The NWS is also working with the Navy’s Arctic Submarine Laboratory to acquire real-time observations from their ice camps north of Prudhoe Bay. The NWS partners with USGS for access to data from their river gauges so we can monitor river levels and potential impacts due to ice jams during spring break up. The NWS utilizes web cams supported by the FAA at numerous mountain passes in order to enhance our forecast products for the general aviation community that services small communities.

Other collaboration being pursued would leverage various community-based observational networks as part of the NWS effort to expand its Cooperative Observer Program. This includes a project supported by the Arctic Domain Awareness Center (ADAC), a Department of Homeland Security center of excellence located at the University of Alaska Anchorage. There are other community-based monitoring networks with whom the NWS is trying to develop a closer partnership, such as the Arctic Risk Management Network (ARMNet).

There are many research projects that are being conducted within the Arctic region, data from which would be valuable to the NWS, not only from a real-time operational perspective but also for reanalysis and verification purposes.  One such example is an upcoming two-year international field campaign sponsored by the World Meteorological Organization (WMO) Year of Polar Prediction (YOPP), which will include intensive observation periods in the Arctic region from mid-2017 to mid-2019.  Efforts are underway to ensure the data collected from the many platforms contributing to this project will be made available in real time.

This presentation will discuss the observational challenges and gaps the NWS faces in trying to meet its mission, describe some of the partnerships in which the NWS already has established and those being pursued not only with the research community but with industry and other partners, such as Shell, and solicit feedback from the audience with the goal of identifying additional  linkages with the scientific research community that could help address our observational needs.

## *What is an Arctic Risk Management Network?*

## *ARMnet Team:*


Hina Kilioni, Disaster Coordinator, and Frederick Brower, Risk Manager

(North Slope Borough Risk Management)

Anne Garland, PhD

Anthropology/Historical Ecology

Kathleen Fischer PHD

Oceanography

(Applied Research in Environmental Sciences NonProfit, Inc. www.ariesnonprofit.com)

Liane Benoit, M.P.A., F.R.C.G.S

SAR/EM Policy Researcher
(Benoit & Associates)


### *ARMNET Origins and Aim*

The Arctic Risk Management Network (ARMNet) was conceived as a trans-disciplinary hub to encourage and facilitate greater cooperation, communication and exchange among American and Canadian academics and practitioners actively engaged in the research, management and mitigation of risks, emergencies and disasters in the Arctic regions. Its aim is to assist regional decision-makers through the sharing of:

- applied research
- best practices
- greater inter-operability

Since IPY 2007, Applied Research in Environmental Sciences Nonprofit, Inc. (ARIES) has worked with the North Slope Borough Risk Management and other NSB community organizations to improve risk reduction capability in Alaska. The Arctic Risk Management Network (ARMNET) is an ARIES initiative in partnership with the North Slope.

## Proposed ARMNEt Abstract and Model

The Arctic Risk Management Network (ARMNet) was conceived as a trans-disciplinary hub

- to encourage and facilitate greater cooperation, communication and exchange among American and Canadian academics and practitioners actively engaged in the research, management and mitigation of risks, emergencies and disasters in the Arctic regions.
- to assist regional decision-makers through the sharing of applied research and best practices
- to support greater inter-operability and bilateral collaboration
- To facilitate networking, joint exercises, workshops, teleconferences, radio programs, and virtual communications (eg. webinars).


### *ARMNet Goals and Objectives*

- To make the North American Arctic a safer, more secure region through the dissemination, application and bilateral exchange of current research and best practices in northern risk and emergency management;
- To provide opportunities for the American proponents of the ARM Network to address Canadian ARM stakeholders;
- To generate Canadian awareness, interest and participation in the Network;
- To leverage existing ARM-related Canadian forums (annual conferences and meetings) to access the greatest number of potential Canadian Network participants;
- To identify common priorities among the risks and hazards facing Canadian and Alaskan territories and triage these topics for future research and bilateral collaboration;

### *Potential Partners*

The ARMNET constituency will include all northern academics and researchers, Arctic-based corporations, First Responders (FRs), Emergency Management Offices (EMOs) and Risk Management Offices (RMOs), military, Coast Guard, northern police forces, Search and Rescue (SAR) associations, boroughs, territories and communities of the Arctic.

### *Inter-operable Communications*

Bilateral collaboration among EMO and SAR will be facilitated through improved networking, joint exercises, conference workshops, teleconferences, radio programs, and virtual communications to increase inter-operability and communication redundancy across far North regions and local communities.

***Clearinghouse: DRR Information***

Most importantly, ARMNet will be a clearinghouse for all information related to the management of the frequent hazards of Arctic climate and geography in North America, including new and emerging challenges arising from:

- climate change,
- increased maritime polar traffic
- expanding economic development in the region.

***Sponsors and Funding***

ARMNet is an outcome of the Arctic Observing Network (AON) for Long Term Observations, Governance, and Management Discussions, www.arcus.org/search-program. The AON goals continue with CRIOS (www.ariesnonprofit.com/ARIESprojects.php) and coastal erosion research (www.ariesnonprofit.com/webinarCoastalErosion.php) led by the North Slope Borough Risk Management Office with collaboration from ARIES and support from the Canadian Risk and Hazards Network (CHRNET). ARMNet is another project of the HERMYS program (Historical Ecology for Risk Management: Youth Sustainability) for which ARIES and the NSB Risk Management have collaborated since 2013. For HERMYS details, please follow the facebook journal @arieshermys.

Presentations in support of the development of ARMNet at three Canadian conferences (SARScene, Canadian Risk and Hazards Network, and ArcticNet) in the fall of 2015 were made possible through funding from the US Embassy in Ottawa.

***ARMNet Can Help Risk Reductions***

Arctic Risk Management (ARMNet) Network aims to link Risk Management Practitioners and Researchers across the Arctic Regions of Canada and Alaska to improve Risk, Emergency and Disaster Preparedness and Mitigation through comparative analysis and applied research.

The ARM Network addresses the current absence of any mechanism for the exchange of information and research on risks, hazards and the management of emergencies in the high Arctic between the USA and Canada; this represents a significant gap in the efforts of both nations to ensure the security and safety of this vulnerable region.

The beneficiaries of this project will be

- the people of Alaska and the Canadian Arctic territories whose safety and security will be enhanced through the research, exercises and best practices information exchanged through the ARM Network;
- the First Responders and EM practitioners in the far North who will be afforded a centralized platform for information and research on risk and emergency management specific to their region and sourced from academics and research communities on both sides of the border;

- the academic community will benefit from a mechanism through which to collaborate with their Canadian and American colleagues on issues of mutual concern and interest and through which they can disseminate their findings; and
- the populations of both countries who will benefit both socially and economically from a safer and more secure North American Arctic.

***Relationship of ARMNet objectives to U.S. Embassy Priority Themes***

Priority 1) Increase entrepreneurship and economic prosperity, maximize economic growth and bilateral trade, tourism, and investment, especially among youth and underserved communities

The ARM Network will support increased safety and security in the Arctic region, enhance adaptation and resilience to the impacts of climate change and development and build capacity in an underserviced population (Arctic communities) through the dissemination and application of ARM and EM research and best practices to the risks and hazards of Arctic life. The existence of a safe and secure environment is an essential condition for economic growth and prosperity;

Priority 2) Enhance civil society's ability to respond to transnational crime, natural disasters or terrorist threats

The ARM Network directly addresses this priority by providing a platform to exchange critical research, best practices and information related to Arctic risks and hazards and the management of emergencies throughout the Canadian and American Arctic. It promotes bilateral exchange and collaboration and the leveraging of resources to maximize safety and security throughout the region

3) Enhance bilateral partnerships in promotion of rule of law assistance, development, and cooperation in the Americas and beyond;

The main objectives of the ARM network is to promote bilateral partnerships and cooperation in the management of risks and emergencies throughout the Arctic;

4) Promote cultural exchange and enhance understanding of our shared history, traditions, and values.

Many of the northern peoples in Alaska and Canada share the same ethnic and cultural heritage having, in many ways, more in common with each other than with their southern compatriots. Northerners on both sides of the border face similar threats and challenges related to climate, security and survival. The ARM Network will enhance these historic connections by fostering the bilateral exchange of applied risk and EM research, encouraging collaboration on issues of common concern and providing an essential link between Northern and academic communities.

***ARMNet Plans for 2016***

For development of ARMNet, assessments are being requested of the Arctic stakeholders who are beneficiaries. The criteria for consideration involves logistics and content infrastructure. Please see the assessment topics in the following survey tools, as part of presentations, at relevant conferences. Since ARMNet was accepted for an AGU poster, the assessment and brochure were sent to the AGU Natural Hazards Focus Group for their feedback. The ARMNet decided not to participate in the AGU poster session. After the non random sample is complete from these conferences, the tabulation of the assessment metrics will be in the report for the US Embassy to be submitted in January, 2016.

After the report and assessment outcomes are reviewed, sources of funding can be considered to develop and implement ARMNet. Based on the assessment results, development and implementation will be more relevant to the stakeholders. The aim is to ensure ARMNet's organization, infrastructure, and logistics are participatory driven. As proposals are developed for funding, assessments will continue throughout 2016. By AOS 2016, the assessment metrics, sample size, infrastructure development and proposals will be available for the presentation and further input from AOS.

See the ARMNet Project at http://www.ariesnonprofit.com/P9.php

***Results of the Feasibility Assessments***

Extensive consultations with academics and practitioners, and a questionnaire distributed to targeted stakeholders (e.g., Emergency Management Office directors, search and rescue specialists, Arctic scientists, NGO, etc.), supported the following conclusions:

- Risk and emergency managers in the far north in the US and Canada experience similar hazards than compatriots in the south;
- Few Arctic scientists see the relevance of their research (e.g., permafrost or erosion) to risk management and disaster risk reduction (e.g., threats to infrastructure, cultural and environmental resources and ecosystem services), indicating a need to clarify gaps and collaborate about applications of natural and physical science research;
- Arctic risk, disaster, and emergency management represent emerging fields of academic and applied science;

- A significant interest exists for logistics that would bridge the gap between research results and the research needs of Arctic emergency practitioners to reduce risks;
- Despite the wealth of Arctic research accomplished, no cooperative network currently exists to provide the critical link between researchers and risk/emergency managers to improve security and public safety in the Arctic territories of North America.
- A significant need for risk and emergency managers is "research facilitators" who can assist them to seek funding, coordinate, develop, implement and apply Arctic research to reduce risks to avoid disasters (i.e., mitigation for environmental and cultural resources, ecosystem services, and all hazards) using community based decision methods
- The following were considered the main obstacles to EMO/SAR/RM research applications:
    - Lack of funding/resources
    - Lack of researchers/experts educated in Arctic SAR/EM
    - No coordinating research body

***YEAR 1 Proposal***

After the feasibility study, recognition of the critical gap between Arctic research results and Arctic RM/EM practice makes it imperative to mitigate the lack of knowledge to action. With the feasibility assessment, strategies for knowledge to action are indicated by the Arctic RM/EM. The intent in Year 1 is to pursue several of these strategies collaboratively with a facilitator network to assist Arctic RM/EM with DRR (Disaster Risk Reduction). The deliverables derive from preferred choices by the Arctic RM/EM in the assessment. Alterations of these choices will include continued assessments as rapid risks and cascade effects change.

The feasibility study indicates Arctic researchers are not being funded for, aware about, or acknowledge value in applied sciences to assist risk reduction or disaster sciences. Arctic research is primarily funded about environmental conservation and change. The inclusion of local communities in this effort is for data collection about the biophysical environment. The communities are studied about how they interact with and effect the biophysical environment. They are typically included in the research as data providers or hired as local assistants for a variety of tasks.

Among Arctic research, capacity building to work with and assist local communities with risk reduction is lacking and this includes regional RM/EM. The coproduction of knowledge to strategies, and/ or participatory research with local and regional stakeholders is limited. The facilitation of applied research is critical for Arctic communities to reduce risks to the biophysical environment which also includes social-cultural considerations.

Arctic communities are experiencing unprecedented rapid change and emerging hazards. If not recognized, acknowledged, and mitigated (e.g., maritime traffic, off shore oil drilling, ocean acidification, threatened ecosystem services, extreme erosion from surges and permafrost thaw, wildfires, early thaw flooding, etc.), these risks will have vast cascade effects. The communities are facing decisions for which traditional strategies, that is, local traditional knowledge (LTK) and traditional ecological knowledge (TEK), may or may not be valuable or viable. All Arctic communities are deciding how they can respond to the rapid risks and hazards whether denying/intransient, transformative or relocating. They are in the midst of a variety of risks, hazards, and continual disasters to which they are responding.

Consider the following cascade effects if the infrastructure of Arctic communities is threatened or compromised. 1. Limited support for logistics to accomplish field work, or in situ studies, about social-ecological research that informs global change. 2. Resource capitalization, such as oil and other minerals, is limited. 3. Restrictions about economic benefits from the Northwest Passage since community infrastructure provides provisioning and ecosystem services as well as emergency services.

At the AOS 2016, all these concerns were raised and acknowledged in all six themed sessions. The AOS sessions accepted papers that provided research gaps and potential solutions for improving Arctic Observing Systems, http://www.arcticobservingsummit.org/aos-2016-white-papers-and-short-statements-public. The call for coproduction of research among local communities was a hallmark of the sessions' outcomes.

However, the "knowledge brokers" or facilitators to work with researchers, economic interests, and local stakeholders, including RM/EM, is still to be determined. AOS outcomes agree that for best practices, facilitators across sectors should have an integrated and transdisciplinary approach. Examples of Facilitators could be community members who specialize in diverse Arctic research. Another source of facilitators could be NGO, who specialize in Applied and Transdisciplinary Research.

Currently, there are few funding agencies (state or federal), or grant sponsors (e.g. maritime and oil industries) which acknowledge this critical gap nor provide a mandate for applied and transdisciplinary research with local stakeholders. The primary funding for the Arctic is biophysical investigations to observe environmental changes. These continued research studies are to inform upscale beneficiaries such as industry, USCG, DOD, Navy, BOEM, etc.

Consequently, the Year 1 funding for ARMNet, is a challenge. Most grant sponsors include broader impacts for funding that include public engagement at local and national scales (e.g., web portals for data results, local events, workshops/meetings, paid informants or technicians, etc.) However, they are rarely inclusive of participatory research with and applications to benefit the communities with capacity building, whether economic resources, ecosystem issues, health, public safety, food insecurity, etc.

While subsistence hunting and ecological knowledge are a typical focus for local engagement, collaborations with RM/EM are rare about applied research and strategies to reduce risks. However, it is clear that facilitation among Arctic research and applied practice by RM/EM is an immediate priority to reduce risks at multiple scales. To serve the RM/EM sooner, the plan is to seek funds from Arctic researchers that have funding mandates to seek social-ecological applications. Seeking leveraged funds is the objective with cost share, donations, and small grants from grant awardees with relevant engagement monies.

The following are the proposed deliverables of Year 1. These choices align with the RM/EM preferences in the initial assessment and feasibility study.

**Deliverables**

1. Searchable database of research related to Arctic risk and emergency management sorted by key word and topic (information clearinghouse)

2. List serve of Arctic RM/EM researchers, academics, experts, practitioners, etc. (constituents and contributors to ARMNet)

3. Six ARMNet newsletters highlighting research, news items, interviews, announcements etc…related to Arctic EM/RM

4. Six teleconferences linking EM/RM experts and practitioners on subjects of relevance to Arctic EM/RM

5. Three ARMNet workshops for up to 25 participants (US and Canada) linking experts and practitioners and focused on issues of critical importance to Arctic resilience and safety.

6. Report of no less than 10 pages on the outcomes of year one ARMNet activities and accomplishments to include the outcome based evaluations.

7. Financial report on all approved expenditures

Long term proposals to relevant sponsors are being considered simultaneously, that is, DHS Science and Technology, NSF Research Coordinator Network, NOAA, and the Belmont Forum. Discussions with program and research managers for grant alignments is crucial for longevity of ARMNet for DRR. This means seeking grant foci that accept a "facilitator" role, across sectors with regional communities, as knowledge brokers, for expanded proposals to CA and US sponsors.

In conclusion, the recent UNISDR Science and Technology Conference to implement the Sendai Framework had multiple sessions to consider the limited use of risk and disaster research by local and regional communities. This includes policy and practice, especially at governmental and agency scales. Throughout the UNISDR sessions, the realization that a transdisciplinary approach with interdisciplinary facilitators, or an integrated team, is a potential solution. (http://www.unisdr.org/partners/academia-research/conference/2016/)

Relevant References:

Balee, William and Clark Erickson, editors. 2006. Time, Complexity in Historical Ecology. Columbia University Press http://ccat.sas.upenn.edu/~cerickso/fishweir/articles/Time&ComplexityInHistoricalEcologyIntro.pdf

Crumley, Carol, editor. 1994. Historical Ecology-Cultural Knowledge and Changing Landscapes. Chapter 6, SAR Press. http://anthropology.unc.edu/french/rd/rd_ch6.html

Richard Eiser n,1, Ann Bostrom 2 , Ian Burton 3 , David M. Johnston 4 , John McClure 5 , Douglas Paton 6 , Joop van der Pligt 7 , Mathew P. White 8 RIA: a conceptual framework for responses to

natural hazards, International Journal of Disaster Risk Reduction 1 (2012) 5–16
http://www.sciencedirect.com/science/article/pii/S2212420912000040

Swetnam, T.W., C.D. Allen, and J. Betancourt. 1999. Applied historical ecology: Using the past to manage for the future. Ecological Applications 9(4):1189-1206.
http://wwwpaztcn.wr.usgs.gov/julio_pdf/Swetnam_ea.pdf

http://www.researchgate.net/publication/232696576_Sustainability_or_Collapse_What_Can_We_Learn_from_ Integrating_the_History_of_Humans_and_the_Rest_of_Nature

Resilience Alliance http://www.resalliance.org/

htp://torrensresilience.org/characteristics-of-resilience

Historical Ecology Wikipedia http://en.wikipedia.org/wiki/Historical_ecology
http://www.ariesnonprofit.com/ARIESprojects.php CRIOS

http://iceandtime.wordpress.com/ Anne Jensen Blog -UIC Senior Scientist

http://www.fema.gov/video-materials#teen Teen CERT

http://www.polartrec.com/expeditions/historical-ecology-for-risk-management PolarTREC

http://www.nsbsd.org/domain/44 NSB School District Inupiaq Learning Framework —

http://www.inupiatheritage.org/our-culture Inupiat Heritage Center - Inupiaq Learning Framework

http://www.bup.edu.bd/journal/154-163.pdf Triangulation in Social Science Research

http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf 2015 Sendai Framework

http://www.irdrinternational.org/,http://www.getprepared.org.nz/excellence/

http://resiliencetoolbox.org/ Integrated Research on Disaster Risk Centers of NZ

http://www.anthc.org/chs/ces/climate/leo/upload/May21-2013b_HowardFerren-AKSC.pdf AkCCO Presentation

**Assessment Tools for Arctic Researchers (Nos. 1) and Arctic EMO/SAR/RM (Nos. 2)**

*No. 1 Arctic Researchers at AOOSM*

https://www.arcus.org/search-program/meetings/2015/aoosm/agenda

# Arctic Risk Management Network Survey: Is there a Need?

(Sponsor: Applied Research in Environmental Sciences Nonprofit, Inc. Email ariesnonprofit@yahoo.com)

ARMNet Project @ http://www.ariesnonprofit.com/P9.php

Organization Represented (Voluntary Information): ______________________________

1. Are the research needs of your organization, regarding Arctic SAR/EM, currently being met by the Canadian and US academic/research community for your region(s) of study?

   No __ Somewhat __ Adequately __ Completely ___

   Comments:

2. As an Arctic Researcher, where do you currently access relevant research/new information on Arctic SAR/EM/RM?
   (check all)

   __ Academic journals/periodicals
   __ Northern Roundtable/Workshops eg. ADAC
   __ Books
   __ Published/Participatory Tabletop exercises
   __ Field Training exercises eg. Artic Shield
   __ SAR/EM websites
   __ Arctic Conferences eg. ArcticNet, AOOSM
   __ SAR/EM Consultants
   __ National SAR/EM Conferences eg. SARScene,

   Other ______________________________________________________________

   Comments:

3. What are the biggest obstacles to research on Arctic SAR/EM/RM (check all)

   __ Lack of EMO time to partner and assist with research
   __ Lack of funding/resources
   __ Lack of researchers/experts educated in Arctic SAR/EM
   __ No coordinating research body
   __ Lack of community resources/interest

   Other: ________________________________

   Comments:

4. Rate the research topics related to Arctic risks and hazards that you think are of greatest interest/concern to your relevant region(s) of study. (scale of 0 – 3)

0 = no interest 1= some interest 2= strong interest 3 = critical interest

| | | | | | |
|---|---|---|---|---|---|
| Flooding | __ | catastrophic power failure | __ | forest/tundra fire | __ |
| Storm surge | __ | coastal erosion | __ | plane crash | __ |
| Oil spill | __ | chemical spill | __ | ship sinking | __ |
| terrorism | __ | Infrastructure failure | __ | extreme weather | __ |
| vandalism | __ | resupply failure/cut off | __ | epidemic | __ |
| SAR incident | __ | water resources | __ | water supply/drought | __ |

Other ______________________________________________________________________________

Comments:

5. Do you think an Arctic Risk Management Network (ARMNET) could support Arctic EMO by:

Please score each line according to the following scale:

0 = not likely 1 = somewhat likely 2 = likely 3 = most likely

__ compiling and synthesizing existing Arctic risk/hazard research

__ matching EMO research needs and experts

__ facilitating pan-Arctic collaboration in new research

__ fostering the exchange of research between Arctic regions

__ supporting participatory research with the involvement of communities

__ networking EMOs/communities with common research interests

__ facilitating joint research projects/funding applications/training

__ Other:

Comments:

6. AMONG EMO, SAR, AND RESEARCHER PARTNERS, REDUNDANT AND INTER OPERABLE COMMUNICATIONS CAN INCLUDE THE FOLLOWING:

VIRTUAL HUB (ANY TIME AVAILABILITY)
RADIO PROGRAMS (REGULAR DISTRIBUTION SUCH AS PER MONTH)
CDS (TELECONFERENCE RECORDINGS TO SHARE)
DVDS (SHARING CASE STUDIES AND STRATEGIES)
TELECONFERENCES (AS NEEDED OR ROUTINE)
NEWSLETTER BRIEFS (VIRTUAL HUB, E-NEWSLETTERS AND MAIL)
RISKY BUSINESS ARTWORK/MUSIC FOR SHARING ACROSS COMMUNITIES
ROLE PLAYS (E.G, TELECONFERENCE, VIDEOS OR RADIO PROGRAMS)
TABLE TOP EXERCISES (AMONG EMO, SAR AND RESEARCHERS)
TRAINING SCENARIOS (AMONG EMO, SAR AND RESEARCHERS)
APPLIED THEATER (LOCAL CREATIVE DRAMAS FOR RISK EDUCATION AND COMMUNICATION)
REGULAR ARMNET WORKSHOPS AND RECEPTIONS AT FAVORITE CONFERENCES
ANNUAL TRAVEL AWARDS FOR ARMNET PARTNERS (EMO, SAR AND RESEARCHERS) TO CONFERENCES
OTHERS?

SCORE WITH THE FOLLOWING SCALE:

0=NOT LIKELY 1=SOMEWHAT LIKELY 2=LIKELY 3=MOST LIKELY

__VIRTUAL HUB
__RADIO PROGRAMS
__CDS
__DVDS
__TELECONFERENCES
__NEWSLETTER BRIEFS
__RISKY BUSINESS ARTWORK/MUSIC
__ROLE PLAYS
__TABLE TOP EXERCISES
__TRAINING SCENARIOS
__APPLIED THEATER
__WORKSHOPS AT CONFERENCES
__ANNUAL TRAVEL AWARDS TO CONFERENCES

7. Is this initiative of interest to you? _____ (0 = no interest 1 = some interest 2 = interest 3 = strong interest)

*You are being invited to take part in this assessment because we feel that your experience in Emergency Management and/or Search and Rescue can contribute much to our understanding about development of an Arctic Risk Management Network. Your participation in this research is entirely voluntary. It is your choice whether to participate or not. We greatly appreciate your assistance to refine plans for ARMNet.*

*Thank You!*

*No. 1 Arctic Researchers at ArcticNet*

http://www.arcticnetmeetings.ca/asm2015/

## Arctic Risk Management Network Survey: Is there a Need?

(Sponsor: Applied Research in Environmental Sciences Nonprofit, Inc. Email ariesnonprofit@yahoo.com)
ARMNet Project at http://www.ariesnonprofit.com/P9.php

Researcher responding (voluntary): ____________________________________________

Note: SAR = Search and Rescue; EM or EMO = Emergency Management or Emergency Management Office; RM = Risk Management

1. Do the research programs in which you are currently involved include research that is related to Arctic SAR/ EM issues? Mark all that apply.

   __ I am currently incorporating SAR/EM issues in my research
   __ I am willing to explore including SAR/EM issues in my future research
   __ I am not currently including SAR/EM issues in my research
   __ I do not think SAR/EM issues can be incorporated into my research

Comments:

2. As an Arctic Researcher, where do you currently access relevant research or new information on Arctic SAR/EM/RM? Check all that apply.

   __ Academic journals/periodicals
   __ Northern Roundtable/workshops, e.g., Arctic Domain Awareness Center
   __ Books
   __ Published/participatory tabletop exercises (group discussions of responses to potential emergencies)
   __ Field training exercises, e.g., Arctic Shield
   __ SAR/EM websites
   __ Arctic conferences, e.g., ArcticNet, AOOSM
   __ SAR/EM consultants and professionals
   __ National SAR/EM conferences, e.g., SARScene
   __ None of the above

   Other ______________________________________________________________________

Comments:

3. What are the biggest obstacles to research on Arctic SAR/EM/RM? Check all that apply.

   __ Lack of EMO time to partner and assist with research
   __ Lack of funding/resources
   __ Lack of researchers or experts educated in Arctic SAR/EM
   __ No coordinating research body
   __ Lack of community resources/interest

   Other: _____________________________________________________________________

Comments:

4. Rate the research topics related to Arctic risks and hazards that you think are of greatest interest/concern to your geographical region(s) of Arctic study according to the following scale:
   0 = no interest 1= some interest 2= strong interest 3 = critical interest

   __ flooding
   __ catastrophic power failure
   __ extreme weather
   __ vandalism

__ forest/tundra fire
__ storm surge
__ coastal erosion
__ oil spill
__ ship sinking
__ infrastructure failure
__ water resource issue
__ resupply failure/cutoff
__ epidemic
__ plane crash
__ chemical spill
__ terrorism
__ SAR incident
__ water supply/drought

Other ___________________________________________________________________________

Comments:

5. Do you think an Arctic Risk Management Network (ARMNET) could support Arctic researchers by the following:

Score with the following scale: 0 = not likely 1 = somewhat likely 2 = likely 3 = most likely

__ compiling and synthesizing existing Arctic risk/hazard research
__ matching EMO research needs with research experts
__ facilitating pan-Arctic collaboration in new research
__ fostering the exchange of research between Arctic regions
__ supporting participatory research with the involvement of communities
__ networking EMOs/communities with common research interests
__ facilitating joint research projects/funding applications/training

Other: ________________________________________________________________________

Comments:

6. Among EM and SAR professionals and researcher partners, redundant and inter-operable communications may include various methods of communication beyond the Internet. How likely is it that you research program would be willing to participate using each of these methods of communication to reach EM/SAR/RM professionals?

Score with the following scale: 0=not likely 1=somewhat likely 2=likely 3=most likely

__Virtual hub
__Radio programs
__CDS
__DVDs
__Teleconferences
__Newsletter briefs
__Training scenarios
__Workshops at conferences
__Annual travel awards to conferences

Comments:

7. Is this initiative of interest to you? _____ (0 = no interest; 1 = some interest; 2 = interest; 3 = strong interest)

Comments:

You are being invited to take part in this assessment because we feel that your experience can contribute much to the design and development of an Arctic Risk Management Network. Your participation in this research is entirely voluntary. It is your choice whether to participate or not. We greatly appreciate your assistance to refine plans for ARMNet.

Thank You!

*No. 2 Arctic EMO/SAR/RM at SARScene* http://www.sarscene.ca/

# Arctic Risk Management Network Survey: Is there a Need?

(Sponsor: Applied Research in Environmental Sciences Nonprofit, Inc. Email ariesnonprofit@yahoo.com)
ARMNet Project @ http://www.ariesnonprofit.com/P9.php

1. Are your research needs on Arctic SAR/EM currently being met by the Canadian academic/research community?

   No __ Somewhat __ Adequately __ Completely ___

   Comments:

2. Where do you currently access relevant research/new information on Arctic SAR/EM/RM (check all)

   __ Academic journals/periodicals
   __ Northern Roundtable meetings
   __ Books
   __ Tabletop exercises
   __ Training exercises
   __ SAR/EM websites
   __ Arctic Conferences eg. ArcticNet
   __ Consultants
   __ National SAR/EM Conferences eg. SARScene

   Other ____________________________________________________________

   Comments:

3. What are the biggest obstacles to research on Arctic SAR/EM/RM (check all)

   __ Lack of EMO time
   __ Lack of funding/resources
   __ Lack of researchers/experts educated in Arctic SAR/EM
   __ No coordinating research body
   __ Lack of community resources/interest

   Other: ______________________________

   Comments:

4. Rate the research topics related to Arctic risks and hazards that are of greatest interest/concern to your region (scale of 0 – 3)

0 = no interest 1= some interest 2= strong interest 3 = critical interest

| | | | | | |
|---|---|---|---|---|---|
| Flooding | __ | catastrophic power failure | __ | forest/tundra fire | __ |
| Storm surge | __ | coastal erosion | __ | plane crash | __ |
| Oil spill | __ | chemical spill | __ | ship sinking | __ |
| terrorism | __ | Infrastructure failure | __ | extreme weather | __ |
| vandalism | __ | resupply failure/cut off | __ | epidemic | __ |
| SAR incident | __ | | | | |

Other ______________________________________________________________________________

Comments:

5. Could an Arctic Risk Management Network (ARMNET) support your EMO by:

Please score each line according to the following scale:

0 = not likely 1 = somewhat likely 2 = likely 3 = most likely

__ compiling and synthesizing existing Arctic risk/hazard research

__ matching EMO research needs and experts

__ facilitating pan-Arctic collaboration in new research

__ fostering the exchange of research between Arctic regions

__ supporting participatory research with the involvement of communities

__ networking EMOs/communities with common research interests

__ facilitating joint research projects/funding applications/training

__ Other:

Comments:

6. AMONG EMO, SAR, AND RESEARCHER PARTNERS, REDUNDANT AND INTER OPERABLE COMMUNICATIONS CAN INCLUDE THE FOLLOWING:

VIRTUAL HUB (ANY TIME AVAILABILITY)
RADIO PROGRAMS (REGULAR DISTRIBUTION SUCH AS PER MONTH)
CDS (TELECONFERENCE RECORDINGS TO SHARE)
DVDS (SHARING CASE STUDIES AND STRATEGIES)
TELECONFERENCES (AS NEEDED OR ROUTINE)
NEWSLETTER BRIEFS (VIRTUAL HUB, E-NEWSLETTERS AND MAIL)
RISKY BUSINESS ARTWORK/MUSIC FOR SHARING ACROSS COMMUNITIES
ROLE PLAYS (E.G, TELECONFERENCE, VIDEOS OR RADIO PROGRAMS)
TABLE TOP EXERCISES (AMONG EMO, SAR AND RESEARCHERS)
TRAINING SCENARIOS (AMONG EMO, SAR AND RESEARCHERS)
APPLIED THEATER (LOCAL CREATIVE DRAMAS FOR RISK EDUCATION AND COMMUNICATION)
REGULAR ARMNET WORKSHOPS AND RECEPTIONS AT FAVORITE CONFERENCES
ANNUAL TRAVEL AWARDS FOR ARMNET PARTNERS (EMO, SAR AND RESEARCHERS) TO CONFERENCES
OTHERS?

SCORE WITH THE FOLLOWING SCALE:

0=NOT LIKELY 1=SOMEWHAT LIKELY 2=LIKELY 3=MOST LIKELY

__VIRTUAL HUB
__RADIO PROGRAMS
__CDS
__DVDS
__TELECONFERENCES
__NEWSLETTER BRIEFS
__RISKY BUSINESS ARTWORK/MUSIC
__ROLE PLAYS
__TABLE TOP EXERCISES
__TRAINING SCENARIOS
__APPLIED THEATER
__WORKSHOPS AT CONFERENCES
__ANNUAL TRAVEL AWARDS TO CONFERENCES

7. Is this initiative of interest to you? _____ (0 = no interest 1 = some interest 2 = interest 3 = strong interest)

*You are being invited to take part in this assessment because we feel that your experience in Emergency Management and/or Search and Rescue can contribute much to our understanding about development of an Arctic Risk Management Network. Your participation in this research is entirely voluntary. It is your choice whether to participate or not. We greatly appreciate your assistance to refine plans for ARMNet.*

*Thank You!*

*No. 2 EMO/SAR/RM Practitioners at CRHNet* http://www.crhnet.ca/symposium/2015

# Arctic Risk Management Network Survey: Is there a Need?

(Sponsor: Applied Research in Environmental Sciences Nonprofit, Inc. Email ariesnonprofit@yahoo.com)

ARMNet Project @ http://www.ariesnonprofit.com/P9.php

Organization Represented (Voluntary Information): ____________________________________________

1. Are the research needs of your organization, regarding Arctic SAR/EM, currently being met by the Canadian academic/research community?

   No __ Somewhat __ Adequately __ Completely ___

   Comments:

2. Where do you currently access relevant research/new information on Arctic SAR/EM/RM (check all)

   __ Academic journals/periodicals
   __ Northern Roundtable meetings
   __ Books
   __ Tabletop exercises
   __ Training exercises
   __ SAR/EM websites
   __ Arctic Conferences eg. ArcticNet
   __ Consultants
   __ National SAR/EM Conferences eg. SARScene

   Other ______________________________________________________________

   Comments:

3. What are the biggest obstacles to research on Arctic SAR/EM/RM (check all)

   __ Lack of EMO time
   __ Lack of funding/resources
   __ Lack of researchers/experts educated in Arctic SAR/EM
   __ No coordinating research body
   __ Lack of community resources/interest

   Other: ________________________________

   Comments:

4. Rate the research topics related to Arctic risks and hazards that you think are of greatest interest/concern to their regions (scale of 0 – 3)
0 = no interest 1= some interest 2= strong interest 3 = critical interest

| | | | | | |
|---|---|---|---|---|---|
| Flooding | __ | catastrophic power failure | __ | forest/tundra fire | __ |
| Storm surge | __ | coastal erosion | __ | plane crash | __ |
| Oil spill | __ | chemical spill | __ | ship sinking | __ |
| terrorism | __ | Infrastructure failure | __ | extreme weather | __ |
| vandalism | __ | resupply failure/cut off | __ | epidemic | __ |
| SAR incident | __ | | | | |

Other ___________________________________________________________________________

Comments:

5. Do you think an Arctic Risk Management Network (ARMNET) could support Arctic EMO by:

Please score each line according to the following scale:

0 = not likely 1 = somewhat likely 2 = likely 3 = most likely

__ compiling and synthesizing existing Arctic risk/hazard research

__ matching EMO research needs and experts

__ facilitating pan-Arctic collaboration in new research

__ fostering the exchange of research between Arctic regions

__ supporting participatory research with the involvement of communities

__ networking EMOs/communities with common research interests

__ facilitating joint research projects/funding applications/training

__ Other:

Comments:

6. AMONG EMO, SAR, AND RESEARCHER PARTNERS, REDUNDANT AND INTER OPERABLE COMMUNICATIONS CAN INCLUDE THE FOLLOWING:

VIRTUAL HUB (ANY TIME AVAILABILITY)
RADIO PROGRAMS (REGULAR DISTRIBUTION SUCH AS PER MONTH)
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OTHERS?

SCORE WITH THE FOLLOWING SCALE:

0=NOT LIKELY 1=SOMEWHAT LIKELY 2=LIKELY 3=MOST LIKELY

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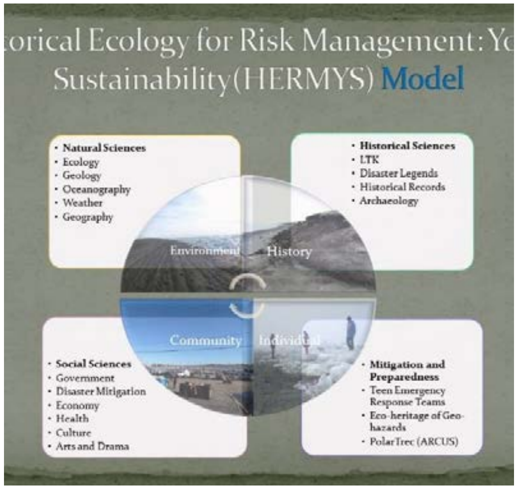
*Thank You!*




**The Inupiaq Learning Framework and the HERMYS model** align since the traditional knowledge of the Inupiaq includes the integration of historical, social and natural sciences which recognizes complexity of SES (Social-ecological Systems).
The relevancy of the HERMYS model about the North Slope (whole community) guides the applied research for risk reduction activities with the varied stakeholders (http://www.inupiatheritage.org/our-culture).

## Applied Research Projects

- PolarTREC for 2 years, 2013-2014, (http://www.polartrec.com/expeditions/historical-ecology-for-risk-management-2014),
- TEACH (Teachers of the Arctic Collaborating about Hazards) a new initiative for 2016 with NSBSD as a research, practitioner, and teacher partnership for youth education and applied STEAM projects.
- Teen Community Emergency Response Team (fb @North Slope Teen CERT), with College Coop Extension, NSB RM, and Tuzzy Library
- Community Based Beach Monitoring of Coastal Infrastructure (fb @COBCBM, Coastal Observers of Barrow) with NSB RM and Tuzzy Library, using AkCCO methodology (Alaska Corps of Coastal Observers).
- PERCIAS Applied Theater (Perceptions of Risk, Communication, Interpretation, and Action in Social-Ecological Systems) with KnowInnovation Inc. and Joint Center for Disaster Research Massey University for role plays, shadow puppet theater, creative drama games, training scenarios, interactive performances (e.g., script readings), disaster legends/storytelling, etc. to explore the RIA framework (http://www.irdrinternational.org/projects/ria/).
- Youth Habitat Corps (YHC) with the US Fish and Wildlife Service, Cooperative Extension and Indian Health Services, Dietician) about Arctic Gardens (Tundra, Community, and Home) for health risks, wellbeing, and food insecurity,
- Risky Business Camps through Risk Management, Ilisagvik Community College and Cooperative Extension, and Tuzzy Consortium Library
- Community Archaeology of Threatened Sites with UIC Science Cultural Resource Management

# Applied Research in Environmental Sciences Nonprofit Inc.
# ARIES

## Mission

We are a research association promoting collaborative research, public education, and public outreach designed to enhance corporate and community-based decision-making.

## Contact Us

Phone: 757-357-0431
Email: ariesnonprofit@yahoo.com
Web: www.ariesnonprofit.com
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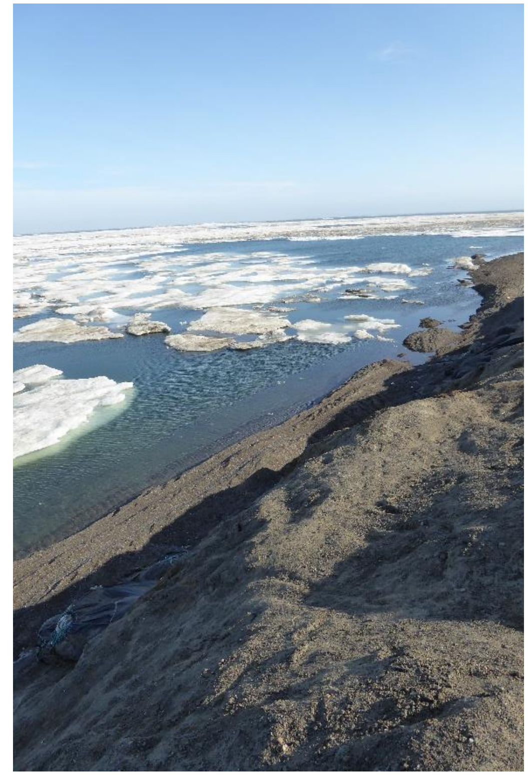
See HERMYS Facebook Journal @arieshermys

**NORTH SLOP[E BOROUGH RISK MANAGEMENT**

1274 Agvik Street
Barrow, Alaska 99723

**APPLIED RESEARCH IN ENVIRONMENTAL SCIENCES NONPROFIT, INC.**

1042 Maple Ave. Suite 106
Lisle, Illinois 60532



# HERMYS
## NORTH SLOPE, AK.

*Historical Ecology for Risk Management: Youth Sustainability*

## Historical Ecology Application for Risk Reduction

### What is Historical Ecology?

Historical ecology (HE) is an applied research program that focuses on interactions of people and their environments (social-ecological systems, i.e., SES) in both time and space to study its long term effects. Historical sciences are utilized to consider comparative SES, long term changes, and to extend baselines that can improve predictive capabilities (https://en.wikipedia.org/wiki/Historical_ecology).

HE research can be applied to community landscapes that assist land management strategies including cultural resources, environmental conservation, ecosystem services, and hazard mitigation. HE applications consider the SES dynamics of complex systems to learn about past strategies and outcomes.

Photo: August 4 2015 Surge impacting gravel sand berm & bags near critical infrastructure

### Emerging Approach: HERMYS

This emerging approach addresses historical ecology for risk management with "risks" among cultural resources, environment, ecosystem services, and hazards being mutually inclusive and interrelated. An integrated team expands as interrelated risks are realized with community partners and included in participatory research, educational activities, and public outreaches.

*Research gaps for risk reduction are driven by the varied community partners whether by region or locality.*

### Alignments of HERMYS: TEK and the Whole Community

The application of ecological heritage for risk and disaster management resonates with traditional ecological knowledge (TEK) across tribal inclusive geographic areas (TIGA ) and/or regional jurisdictions in the US and other countries. The recognition that the past can inform the present and future aligns with the whole community approach and its transdisciplinary outcomes to continually reduce risks of disasters (DRR). (http://www.fema.gov/whole-community).

### Alignments of HERMYS: 2015 Sendai Framework

With the 2015 Sendai Framework, the Preamble (7) calls for preventive risk reduction to be multi sectoral, inclusive of stakeholders, and "for the public and private sectors and civil society organizations, as well as academia and scientific and research institutions, to work more closely together and to create opportunities for collaboration."
(http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf)

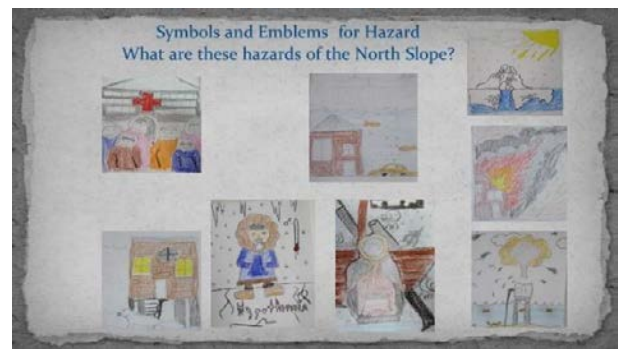
TEEN CERT
COMMUNITY EMERGENCY RESPONSE TEAM

*Risky Business Camp Summer 2015 : Risk Ranking Hazards & Teen CERT Poster for North Slope Recruits*

## Whole Community Approach

### HERMYS Participatory Research & Services

Beginning in IPY 2007-2008 Applied Research in Environmental Sciences Nonprofit, Inc. (ARIES, www.ariesnonprofit.com), North Slope Borough (NSB) Risk Management (http://www.north-slope.org/departments/administration-finance/risk-management), Tuzzy Consortium Library, UIC (Ukpeaġvik Iñupiat Corporation**)** Science for Cultural Resource Management, Cooperative Extension of Ilisagvik Community College and in 2014 the NSBSD (North Slope Borough School District), Instructional Coordination, and KnowInnovation, Inc. (www.knowinnovation.com) are collaborating to implement a historical ecology model for the North Slope Coastal Region of Alaska. Relevant researchers are recruited as risks are prioritized and funding becomes available. Current researchers include a coastal engineer, oceanographer, geographer, Arctic archaeologists, tundra ethnobotanist and dietician, relocation planner, and an applied anthropologist.



**Short Statement for the 2016 Arctic Observing Summit**
Submitted to Theme 4: Actor and Stakeholder engagement and needs in sustained Arctic observations

January 13, 2016 (revised submission), October 18, 2015 (original submission)

# Communicating why sea ice matters: A focus of the SEARCH Sea Ice Action Team (SIAT)

Matthew L. Druckenmiller (Rutgers University & National Snow and Ice Data Center, University of Colorado Boulder); Jennifer Francis (Rutgers University); & Henry Huntington (Huntington Consulting)

## Introduction

With dramatic reductions in arctic sea ice observed over the last several decades, various efforts and organizations have emerged as leaders in providing information on the state of sea ice, relying primarily on the use of remote sensing, modeling, buoy networks, and coastal observations. Similarly, interdisciplinary and cross-cultural "communities" of scientists, arctic residents, and stakeholders have developed to address questions pertaining to understanding the driving mechanisms, rate of loss, and implications. Such efforts extend far beyond the geophysics of sea ice and far beyond Arctic boundaries to address climate-weather linkages, arctic ecosystems, coastal community well-being, commercialization of the Arctic, geopolitics, etc. Arctic sea ice loss has morphed into an icon of global climate and environmental change with a seemingly endless stream of emerging "stakeholders" and "decision-makers". Despite this high-profile nature, there does not yet exist a coherent source of accessible, comprehensive, and timely information that synthesizes the connections between the science, key societal issues, the specific values and operational environments of stakeholders, and why the general public should care about arctic sea ice. Encouragingly, however, the major foundational building blocks for such a source exist. Here, we describe an evolving effort to work toward this need, in full recognition that such an endeavor is reliant on mobilizing the scientific prowess, integrity, experience, and energy of interdisciplinary arctic observing and research communities.

## Background

The Study of Environmental Arctic Change (SEARCH)[1], ongoing since the early-2000s, aims to develop scientific knowledge to help society understand and respond to the rapidly changing Arctic. Through collaboration with the research community, funding agencies, national and international science programs, and other stakeholders, SEARCH facilitates research activities across local-to-global scales, with increasing emphasis on addressing the information needs of policy and decision-makers. SEARCH's recent shift toward a "Knowledge to Action" vision has led to focused Action Teams, one of which is addressing changing arctic sea ice[2]. The SEARCH Sea Ice Action Team (SIAT), with a focus on science communication, hosted its first workshop[3]

[1] https://www.arcus.org/search-program
[2] SEARCH's other two Action Teams are focused on land ice, primarily the Greenland Ice Sheet, and permafrost.
[3] The workshop summary is available at: https://www.arcus.org/files/page/documents/23272/siat-strategy-workshop-summary_201509291.pdf

in Bristol, Rhode Island in September 2015 to develop a strategy for mobilizing the research community to organize, synthesize, and disseminate scientific knowledge for a broad range of arctic sea ice stakeholders.

## Communication Strategy

Key elements to the SIAT's communication strategy are to (1) support and promote SEARCH and the SIAT as a trusted and timely source of information about arctic sea ice and impacts of its loss, (2) develop sustained and sophisticated dialogues between the research community and decision-makers, (3) co-communicate the importance and state-of-the-art of arctic research using a range of voices, including those beyond scientists, and (4) build complementary collaborations with arctic-focused institutions, research programs, and scientists.

The core product of the strategy will be a website to comprehensively communicate why and how *Sea Ice Matters*. This website will 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. This resource will depend on collaboratively developed, peer-reviewed, and concisely edited scientific content, which will serve to coordinate the scientific community, disseminate important findings to broad audiences, and provide a take-away "go-to" resource for decision-makers and the media. In addition, *Sea Ice Matters* will facilitate and host guest perspectives from across both the science and stakeholders communities and provide timely scientific information on emerging high-interest topics, such as notable weather events or recent high-profile science publications.

Tracking and evaluating how scientific information from arctic science reaches stakeholders and informs decisions are critical for interactions that allow the research community to keep pace with an evolving landscape of arctic decision-makers. Therefore, evaluating SIAT activities through targeted outreach and user feedback represents a strategic focus for the team. Furthermore, the Team hopes to establish connections with those in the science community with similar interests in evaluation, recognizing that there is considerable potential for such practice to grow within the arctic, climate, and cryospheric research communities. A recent NSF workshop report on *Motivating Research on the Science Communications Front*[4], which focused primarily on the cryosphere, recommended that "improved understanding on how bureaucracies affect the translation of science communication into the decision-making process requires new research". SEARCH's efforts may establish important case studies to support such future research as well as illuminate the breadth of relevant institutions.

## Next Steps

The SIAT's science communication endeavor will require organizing complementary interests and efforts within SEARCH and across related organizations and broader science communities. The Team is currently developing a prototype website and accompanying resources (e.g., concise primers on how sea ice relates to specific societal topics) to demonstrate the full concept for the *Sea Ice Matters* resource. The Team will facilitate feedback, for example, through SEARCH, the Interagency Arctic Research Policy Committee (IARPC) Collaborations effort, and, ideally, during discussions at the 2016 Arctic Observing Summit.

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[4] Vorosmarty, C.J, Davidson, P.A., Muir, M.A.K. and Sandford, R.W., eds. 2015. 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. Workshop summary, Washington, DC, Nov. 12-14, 2014, 48 p.

**Data Portals as Institutional Bridges: Connecting Scientific Observations to Stakeholder Needs in Sea Ice Social-Environmental Systems**

Amy L. Lovecraft[1], Chanda Meek[1], Hajo Eicken[2]

1: Department of Political Science, University of Alaska Fairbanks, Fairbanks, AK 99775, USA; allovecraft@alaska.edu; clmeek@alaska.edu
2: International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK 99775, USA; heicken@alaska.edu

**Abstract**

This paper explores the linkages between scientific data production and related to sea ice loss in the Arctic. How can an arctic observing system prioritize data collection, facilitate its translation into usable information and deliver it in a manner that diverse interests can use it for adaptive governance in the sea ice system? The rapid decline of arctic summer sea ice is currently tracked and studied intensively but a comprehensive approach to address the changes is lacking. Scientific endeavors are more likely to respond to the needs of policymakers and stakeholders when those affected by change have the capacity to participate in decision-making. Currently, specific uses of sea ice are governed individually by a patchwork of institutions that have evolved independently over time; there is no interconnected suite of institutions or a single comprehensive process that governs the sea-ice system as a whole. Conflict arises when the objectives of one institution contradict or otherwise negatively affect another. High numbers of institutions found in the coastal zone (i.e. "density") also imply a higher probability of policy debate over the uses of a particular ecosystem service or resource. Our work builds upon earlier research establishing the need to approach sea ice as a complex multi-jurisdictional geophysical-social-ecological system. We argue that in order to maximize data production, dissemination, and participatory capacity across stakeholders, scientific observations should be tied to institutional density and sea ice service. Secondly, information bridges across major institutional actors will facilitate creation and exchange of information and increase the availability and transparency. This can be in part achieved by mapping the institutional geography across the Arctic modeled on the NOAA Alaska region Environmental Response Management Application (Arctic ERMA) portal.

## 1. The Problem: Systems, Interests, and Science

The Arctic Ocean's rapid loss of sea ice is shifting a system with a long history of indigenous subsistence use that was once closed to all but a few vessels during a short summer window to a more open system with attributes of great appeal to many interests in society. In the last half a century, the rule sets governing the Arctic that are tied to the annual cycle of sea ice (e.g., those related to oil and gas development or protected species) have grown more dense as the range of activities in Arctic has expanded. In parallel, Arctic Ocean regional interests have developed that represent a powerful set of actors with strong state, national and international lobbies to promote stability or change in governing institutions. For example, the number of whales that can be harvested using the ice as a platform, how the presence of ice affects oil and gas exploration, the quality of snow and sea ice that can serve as a polar bear or seal habitat, or the thickness and roughness of ice to support travel, subsistence hunting, and industrial activities are all linked to sets of rules governing human activity. In each case, governmental, indigenous rights, environmental, and other interest groups pursue their goals in relation to these rules.

Here, we briefly outline how such rule sets ("institutions" in the context of policy studies) may help in the design and prioritization of sustained observing programs. Policy- or decision-relevant research, largely funded by taxpayers, requires careful consideration of what to measure where and when in order to best benefit society as a whole. This challenge leads to a concern of balancing the information needs of different Arctic stakeholders. ***Given this problem context how can an arctic observing system prioritize data collection, facilitate its translation into usable information and deliver it across diverse interests to promote opportunities for adaptive governance in the sea ice system?***

Scholarly literature indicates that scientific endeavors are more likely to respond to the needs of policymakers and stakeholders when those affected by change have the capacity to participate in decision-making. Research indicates adaptive governance functions best when diverse networks of actors are involved to bring topic area or scale-specific knowledge to bear on conservation dilemmas and set the stage for a comprehensive approach focused on learning (Folke et al. 2005, Webster 2009, Brunner and Lynch 2010). In short, as stakeholders pursue their interests in the institutional milieu most familiar to them they will gather information. This learning can be facilitated, and thus the policymaking environment enriched through *information bridges* that can overcome institutional fragmentation (Sarker et al. 2008) to better connect scientific production of data to diverse stakeholders in meaningful ways.

While we focus on Alaska sea-ice management regimes in this case study, we also address trans-jurisdictional and global concerns. Building on three elements of the sea ice system in the Alaska region, we arrive at broader conclusions relevant for sustained observations at the pan-Arctic level. First, we explain why the nature of sea ice services requires cross-scale observations and data delivery channels. Second, to determine where and what kind of observations are of greatest societal interest we explain the institutional geography tied to its services. The capacity of society to obtain and use data related to government decision-making must be considered in order to provide varied stakeholders with information usable for debate and planning of resource management. By tying observations to institutional priorities the information produced is more likely to be taken-up by interested parties across sectors. Third, in order to ensure such a use of information within the competitive arena of democratic politics, we propose information bridges across formal institutions that prevent information from being "siloed" and potentially used in a hegemonic fashion to produce policy. Our case study examines the potential of a decision-support environment used in the United States, the Arctic Environmental Response Management Application (Arctic ERMA, Merten 2013) hosted by the National Oceanic and Atmospheric Administration's (NOAA) Office of Response and Restoration (ORR).

## 2. Background

### *2.1. The Sea Ice System and its Services*

Sea-ice retreat is one aspect of a broader suite of transformations in the North comprising climate and large-scale socio-economic change that are fundamentally altering the ecosystems upon which human livelihoods depend (Chapin et al. 2006). The Arctic, and in particular its sea-ice cover, is both amplifier and driver of global climate change (Alley 1995, Serreze et al. 2007). Beginning in 2007, summer sea-ice extent has experienced a major decline compared to diminishing ice extent trends observed prior (Serreze and Stroeve 2015). With projections indicating a near-complete loss of Arctic summer sea ice by the late 2030s, the impacts of such changes on coastal communities, ecosystems, marine shipping and Arctic security have received increasing attention (Meier et al. 2014). While the loss of Arctic summer sea ice has clearly been documented as a concern of many governments, comprehensive plans to address the problem are only in their early stages. There are not yet mechanisms in place to consider the diverse and interdependent changes across scales; sea ice prediction and data delivery remains a challenge at the local scales (e.g., coastal villages). Additionally, while more data is required to ascertain long-term trends, the need to effectively manage new and existing data and design and optimize observing systems remains.

### *2.2. Institutions and Interests*

Currently, specific uses of sea ice are governed individually by a patchwork of institutions that have evolved independently over time; there is no interconnected suite of institutions or a single comprehensive institution that governs the sea-ice system as a whole. Drawing on interdisciplinary research related to sustainability science, Eicken et al. (2009) have proposed the concept of Sea Ice System Services (SISS) to comprehensively address the hazards and opportunities presented by diminishing sea ice. By considering sea ice as a productive system, not simply a geophysical feature, one can recognize a suite of services or benefits that humans gain and identify the information needs relevant for different sea-ice users. We view sea-ice institutions as rule sets designed to govern human behavior, specifically in the context of sea ice services. Examples would be laws and policies affecting ice-dependent marine mammal hunting or the rules of ship passage in arctic waters.

Institutions matter because they create and channel power in social-environmental systems (Lovecraft 2008, Robards and Lovecraft 2010). Institutional linkages between the resources and places governed and the actors subject to governance create avenues of influence for particular actors over policy implementation (Selin and DeVeer 2003). In modeling different institutional types Chapin et al. (2006) categorize institutions into four major categories of human use of or benefit from environmental resources: resource harvest, resource conservation, hazard reduction, and externality producing (see Table 1 for examples from our case study). Conflict arises when the objectives of one institution contradict or otherwise negatively affect another.

## 3. Institutional Density as a Guide to Implementation of Sustained Observations: An Alaska Case Study

Rules tied to the sea ice system have grown alongside social priorities (e.g. conservation, harvest of subsistence foods), temporally based concerns (e.g. human overharvesting of marine mammals in the 19$^{th}$ and early 20$^{th}$ century, economic boom or bust), and the “institutional thickening” of the organization and cultures of administrative bureaucracies whose design is historically neither interdependent nor collaborative (Meek 2011). We use the phrase “institutional density” building on this three-fold phenomenon as a measure of the number of institutions associated with a particular location but which may focus on different attributes of the system. The Alaska coastline and nearshore waters have high institutional density because there are many sets of rules targeting different attributes of this particular social-environmental system, with some examples applicable in our sea-ice case study listed in Table 1.

A measure of the distribution and spatial density of a subset of these institutions is shown in Fig. 1 in relation to sustained observing program measurement sites. The map shows the spatial extent over which specific rule sets apply, such as the extent of U.S. territorial waters or the designation of critical habitat for protected species. Other categories plotted in the map are related to information needs or interests derived from specific institutions. These include the distribution density of walrus, the location of polar dens or the subsistence use areas by coastal communities all shown in the map. Similarly, sites for specific sustained observations plotted in the map are in part related to information needs or regulatory requirements derived from some of the same institutions. These elements of the map shown in Fig. 1 represent a subset of the full-scale institutional analysis carried out by Lovecraft et al. (2013) and summarized in Table 1.

The density of such institutions (or relevant proxies) reflects the breadth and urgency of data and information needs because this density to some extent reflects society's response to pressing issues in a complex local context impacted by arctic change. High institutional densities also imply a higher probability of conflicting uses of a particular service or resource. At present, it is not yet possible to simply map the number of institutional regimes per unit area relevant for sea-ice use for a specific location to determine institutional density. While such efforts are part of the recommendations of this white paper, currently a map such as shown in Fig. 1 provides insight into spatial patterns, including key sea ice system services such as the distribution of sea ice as a platform for marine mammals and hunters and as a potential hazard for maritime activities. Figure 1 reflects the challenge to provide relevant data to actors across a range of different sectors in a region with major impacts as a result of rapid environmental change. The distribution of walrus densities in the map illustrates this issue with a major feeding area near the center of the map now less accessible due to lack of sea ice in the summer. This has forced walrus to congregate in large numbers on shore to rest (coastal location in southwestern part of map) with migration between these two sites during the summer. The distribution of measurement sites does not reflect these patterns, nor does it seem to fully reflect the distribution and density of associated institutions.

Analysis of such patterns can provide important guidance for and help prioritize sustained observations. For example, note that despite some of the highest institutional densities occurring in coastal areas where uses of the environment by hunters and villagers, industry and key protected species overlap, these regions do not exhibit corresponding densities of sustained observations. Instead, many of the sustained observations are clustered around lease areas and drill sites in the western and eastern parts of the map, where institutional density is also high due to regulatory requirements and industry standards. However, as illustrated by information derived from traditional knowledge and surface based measurements, prevailing patterns of currents and ice movement provide a direct link between offshore regions and coastal areas. In part of the region some of the oceanographic transect lines seem to reflect this circumstance. A key challenge throughout the Arctic is reduction in ice extent that puts potential stress on ice-associated organisms who utilize ice as an increasingly scarce resource, with Fig. 2 presenting an example for walrus. Such changes in ice conditions need to be related to associated institutions and the types of information storehouses and geospatial tools exemplified by NOAA Arctic ERMA environment shown here can also serve as resources to examine institutional mismatches.

Because institutions reflect and attract interests, an inventory and spatial mapping as shown in Table 1 and Figure 1 will increase the relevance of data collection and information gathering of interest to stakeholders. Nevertheless, we must still address the problem of translation from "policy elites" and "technocrats" to laypersons. Using the model of Chapin et al. (2006), Table 1 thus categorizes the major institutions governing use or protection of sea ice services with a focus on Arctic Alaska as a region that represents most if not all of the relevant interests and uses prevalent throughout the pan-Arctic. As noted earlier, the relative needs across the institutions for data are narrow but the span of interests is broad. To avoid duplication, maximize accuracy, and minimize costs, a better method of setting data priorities and sharing results must be developed.

**4. Translating Observations into Stakeholder Information through Information Bridges: The Potential of Arctic ERMA**

Mostly, decision-makers require information and not merely raw data sets to act on. The ability to extract information from a given data set can vary substantially among stakeholders. Hence, the acquisition and dissemination of data and information related to the sea ice system plays a vital role in the adaptive capacity of people affected by existing rule sets to both enforce current standards or change management to meet stakeholder needs. We separate the concepts with *data* referring to raw scientific observations and *information* as translated findings based on data sets (Zins 2007). This issue is not merely of semantic interest since any environmental observing system aiming to provide information relevant to decision-makers needs to explore effective ways in achieving this goal. A major challenge is the fact that typically scientific data acquisition is driven by the need to test a set of postulates in the context of an overarching scientific problem or question. Data collected under this premise may not easily lend themselves to interpretation and evaluation in the context of applied problems. Rather, obtaining data and more importantly information derived from such data that responds to decision-maker information needs requires a substantial engagement by both academia and stakeholders and needs to be part of an interactive process (van Kerkhoff and Lebel 2006). Information Bridges – with Arctic ERMA serving as an *ad hoc* example – can play important roles in this context.

As a first step, an objective survey and prioritization of information needs must occur. We argue that this goal is achieved through analysis of the institutions governing resource uses or ecosystem services. For the case of sea ice services the results of research into the applicable rules and regulations for northern Alaska listed in Table 1 provide an indication of the scope of information needs. Moreover, through the link to specific ice services, institutions typically specify the type of information that is required for the regulation or management of a given service. Such information is mostly one or several steps removed from observable data and comes with requirements for the sampling design and data processing to meet the information need. For example, resource conservation for ice-associated marine mammals is closely linked to the habitat qualities of drifting and shorefast ice. Deriving suitable indices or parameters as measures of habitat quality from raw data is not straightforward and requires observation of a series of variables, such as ice thickness, morphology, and seasonality along with snow depth and the presence of sea-ice microbial communities (Table 1). Prioritization of such observations can be achieved by the institutions themselves, as the rules and regulations shown in Table 1 reflect the stakeholder concerns best represented in the governing system to date. A major challenge, nonetheless, is the compilation of an exhaustive inventory of applicable institutions across scales. Here, the scientific community and different stakeholder groups and decision-makers are located on either side of a divide that needs to be bridged. Mostly this is due to a lack of awareness or understanding of the frameworks that govern utilization of resources or services on the one hand, and misconceptions about the way scientific research operates on the other hand.

A key point is the fact that institutional density does not imply the presence of communication channels between institutions or between scientific data collection and institutions. Due to the sectoral management and regulation approaches, institutional regimes and associated data collection effort are often fragmented, as illustrated in parts of Figure 1 and Table 1. Information bridges in the form of structures that link stakeholder or actor structures and reduce duplicity can play an important role in observing system design. Such bridging organizations can also better identify long-term data needs than any single agency or management network.

In this context Arctic ERMA may serve as an illustrative example of the type of entity and associated tools that can evolve into information bridges. As stated on the relevant website, "ERMA integrates and synthesizes various real-time and static datasets into a single interactive map, thus provides fast visualization of the situation and improves communication and coordination among responders and environmental stakeholders" (ERMA 2014). This application is as close as we currently get to an interactive collection of rule sets that can be used by competing interests to evaluate their own priorities, data gaps, and the location of their goals in an institutionally crowded region. The key driver for implementing Arctic ERMA is its proven value in the context of emergency response planning with a focus on system services related to hazards or threatened assets, which includes not only the hazard-reducing institutions highlighted in Table 1, but all other relevant categories (resource conservation and harvesting, externalities producing) as well. What is missing in the context of the ERMA interface as currently implemented is an effective key, or legend, to categorize the system services clearly. It is not that ERMA is flawed, it is that it has great potential.

Moreover, while ERMA has been designed with emergency responders and environmental resource managers in mind, similar futures thinking – considering the future carefully in case of hazard and disaster scenarios – can be very useful to a wide range of interests and thinking about the future need not be limited to preparing for crisis. Those planning scientific observations, industry plans for development, Indigenous concerns related to activity near and offshore, conservationists, and communities can all benefit from a system that can plot major institutional regimes in geographic space. The key challenge is to allow for a system such as Arctic ERMA to serve both its core functions and grow into or spawn a tool and associated information bridge that helps address the broader mandate implicit in the approach to observing system design and prioritization proposed here. Some aspects are readily addressed, in particular as they relate to core aspects of Arctic ERMA's objectives & mission. For example, datasets and information reflecting Traditional Knowledge or other proprietary information can be made accessible in formats or altered forms that come with a permission to share or with access limited to specific decision-makers or researchers. The information shown in Figure 1 on current and ice movement patterns was obtained through such a process (Johnson et al. 2014).

A more challenging issue is the availability of relevant data sets on institutions and ongoing observations. In regards to the latter, Arctic ERMA draws on resources by the Alaska Ocean Observing System (AOOS), but the former can be more challenging to compile. What incentives are there for self-interested actors to facilitate the planning of data production and sharing of results required for an information bridge? Goldman et al. (2007) discuss the benefits and drawbacks of voluntary cooperation in ecosystem service conservation. In their work they seek to encourage landscape-scale coordination across local to global production of farm services and move away from farms as "independent units." In a similar fashion the sea ice system actors tend to function as independent units tied to one or more services.

Goldman and co-authors propose three major incentives; we retain their original labels but have altered their function to relate to data and information design rather than conservation: (1) *cooperation bonuses* where system users are rewarded for individual activities that facilitate broader scale data collection and dissemination, such as that implemented in the context of AOOS or the Arctic ERMA mapserver, (2) *competitive design incentives* tied to cooperation that would reward individual or group proposals of new ways to share data (such as through cooperative proposals for exploratory research), and (3) *ecosystem service districts* that would use legal means to create data sets to be used at the system scale, possibly mandated by stipulations that are part of resource leasing agreements or through other means such as voluntary cooperation and sharing as in the case of an extant data sharing agreement between NOAA and Shell for Alaska Arctic waters. Arctic Council Working Groups, such as the Emergency Preparedness, Prevention and Response (EPPR) may play an important role in setting the stage for such national or international strategies.

**5. Recommendations for the Design and Implementation of Sustained Observations and Coordinated Observing Systems**

Drawing on the examples discussed above, we propose next steps and recommendations to help implement information bridges that can foster the use of institutional density as a criterion in guiding observing system design and implementation. This approach relates to a key goal of AOS 2016 Thematic Working Group #4 on Stakeholder and Actor Engagement, i.e., the call for contributions that discuss "capacity building or development of observing systems that can support community emergency response plans and adaptation". Specifically, we identify the following action items, with a focus on marine and coastal environments.

(1) Build pan-Arctic databases of institutions associated with Arctic system or ecosystem services relevant to actor and stakeholder activities (i.e., along the lines of examples given in Table 1 and Fig. 1). Arctic ERMA represents an ad hoc model of what such an approach might look like, but there are a number of efforts underway both within Arctic Council Working Groups, as part of regional assessments (e.g., Beaufort Sea Regional Environmental Assessment) or through initiatives such as the World Wildlife Fund's ArkGIS system (http://arkgis.org). The objective of this effort would be to provide the foundation for any type of evaluation of institutional geography. Ideally, such a resource would link to or tie into a database with up-to-date information on sustained observations. Efforts by the Arctic Council's Sustaining Arctic Observing Networks (SAON) Initiative to keep track of such programs at the national level are an important step in the right direction.

(2) As a first step in implementing recommendation #1, the focus could be on regions of particular interest or hotspots. This should not simply reflect ongoing activities, but also draw on future projections, such as those reviewed by the Arctic Council's Adaptation Actions for a Changing Arctic Project. One region of interest would be the Pacific Arctic sector that covers Russian, U.S. and Canadian waters with numerous international research programs (Lee et al. 2015).

(3) For a specific problem or subregion, a full-scale evaluation of institutional geography and its application in guiding observing system design and implementation would be an important case study and identify the efficacy of this approach. Drawing on the example of Arctic ERMA

(and referencing a white paper submitted to the AOS 2016 by Eicken et al.) the topic of community emergency prevention, preparedness and response lends itself readily for such an effort. The mandate for such an EPPR framework is clear and sufficiently focused, while at the same time the benefits of sustained observations in providing background information for situational awareness are recognized. Moreover, by default such an effort would focus on areas of higher vulnerability and exposure, such as coastal regions (see discussion above) and areas of high maritime activity. Such an effort could also link to recommendations and action items emerging from two other AOS 2016 Working Groups, #6 Traditional Knowledge Interface, where the role of local and indigenous experts in identifying relevant institutions and informal rule systems can be explored, and #3 Private-Public Partnerships with a focus on platforms of opportunity which by default are active in regions experiencing higher levels of activity and associated higher institutional density.

**References**

Alley, R. B., 1995, Resolved: The Arctic controls global climate change, *in* Smith, W. O., Jr., and Grebmeier, J. M., eds., *Arctic oceanography: Marginal ice zones and continental shelves*, Washington (Coastal and Estuarine Studies, vol. 49), American Geophysical Union, p. 263-283.

Brunner, R. D. and A. H. Lynch (2010). *Adaptive Governance and Climate Change*. Boston, American Meteorological Society.

Chapin, F.S., III, A.L. Lovecraft, E.S. Zavaleta, J. Nelson, M.D. Robards, G.P. Kofinas, S.F. Trainor, G.D. Peterson, H.P. Huntington, and R.L. Naylor. 2006. Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. *Proceedings of the National Academy of Sciences* 103(45):16637-16643.

Eicken, H., A.L. Lovecraft, M. L. Druckenmiller. 2009. “Sea-ice system services: A framework to help identify and meet information needs relevant for Arctic observing networks” needs” *Arctic* 62(2): 119-136.

Environmental Response Management Application. 2014. Web application. Arctic Region. National Oceanic and Atmospheric Administration. http://response.restoration.noaa.gov/erma/.

Folke, C., T. Hahn, et al. (2005). "Adaptive governance of social-ecological systems." *Annual Review of Environment and Resources* 30: 441-473.

Goldman, Rebecca L., Barton H. Thompson, Gretchen C. Daily. 2007. Institutional Incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics*, doi:10.1016/j.ecolecon.2007.01.012

Johnson, M.A., Eicken, H., Druckenmiller, M.L., Glenn, R., 2014. Experts Workshops to Comparatively Evaluate Coastal Currents and Ice Movement in the Northeastern Chukchi Sea; Barrow and Wainwright, Alaska, March 11-15, 2013. University of Alaska Fairbanks, Fairbanks, Alaska, 48pp. (available online at: https://www.researchgate.net/publication/263653450_Experts_Workshops_to_Comparatively_Evaluate_Coastal_Currents_and_Ice_Movement_in_the_Northeastern_Chukchi_Sea#full-text)

Lovecraft, A.L. Climate Change and Arctic Cases: A Normative Exploration of Social-Ecological System Analysis, In Steve Vanderheiden, Ed. 2008. *Political Theory & Global Climate Change*. The MIT Press: Cambridge, MA, 91-120.

Lovecraft, A.L., C. Meek, H. Eicken. 2013. Connecting Scientific Observations to Stakeholder Needs in Sea Ice Social-Environmental Systems: The Institutional Geography of Northern Alaska. *Polar Geography* (36): 105-125.

Meek, C.L. 2011. Conservation of marine mammals in Alaska: the value of policy histories for understanding contemporary change. in A.L. Lovecraft and H. Eicken (eds.), *North by 2020: Perspectives on Alaska's Changing Social-ecological Systems. Fairbanks*: University of Alaska Press, 359-375.

Meier, W. N., et al. 2014. Arctic sea ice in transformation: A review of recent observed changes and impacts on biology and human activity, Rev. Geophys., 51, 185–217, doi:10.1002/2013RG000431.

Merten, A. 2013. New Tool for First Responders in the Arctic: Arctic ERMA. Witness The Arctic, Spring 2013, Issue 2, www.arcus.org/witness-the-arctic/2013/2/article/19951

Robards, M.D. and A.L. Lovecraft. 2010. Evaluating co-management for social -ecological fit: Indigenous priorities and agency mandates for Pacific Walrus. *Policy Studies Journal* 38(2): 257-279.

Selin, H. and S. D. VanDeveer (2003). Mapping Institutional Linkages in European Air Pollution Politics. *Global Environmental Politics* 3(3): 14-46.

Serreze, M. C., Holland, M. M., and Stroeve, J., 2007, Perspectives on the Arctic's shrinking sea-ice cover: Science, v. 315, p. 1533-1536

Serreze, M.C., and Stroeve, J. 2015. Arctic sea ice trends, variability and implications for seasonal ice forecasting, *Philos T R Soc A*, *373*(2045).

van Kerkhoff, L., and Lebel, L., 2006, Linking knowledge and action for sustainable development: Ann. Rev. Environm. Resources, v. 31, p. 445-477.

Webster, D.G. (2009). *Adaptive governance: the dynamics of Atlantic fisheries management. MIT Press,* Cambridge. MA.

Zins, C. (2007). "Conceptual approaches for defining data, information, and knowledge." Journal of the American Society for Information Science and Technology 58(4):

| **Type of institution** | **Sea ice system service** | **Institution** | **Monitoring variable** |
|---|---|---|---|
| Resource conservation | E.g., Shoreline protection | National Environmental Policy Act | Shorefast ice extent and duration |
| Resource harvesting | E.g., Bowhead whales | Convention for the regulation of whaling | Distance, morphology and persistence of leads and polynyas |
| Hazard reduction | E.g., Sea ice as geological agent and coastal hazard | Trajectory of oil spill, encapsulation and biodegradation of oil | Distribution of ice biota |
| Ecological externality-producing | E.g., Platform for industrial activities | Outer Continental Shelf Lands Act | Extent, persistence, thickness, strength and morphology of pack and shorefast ice |

Table 1. Examples of sea ice system service types (Lovecraft, Meek and Eicken, 2013), relevant institutions and suggested monitoring variables.

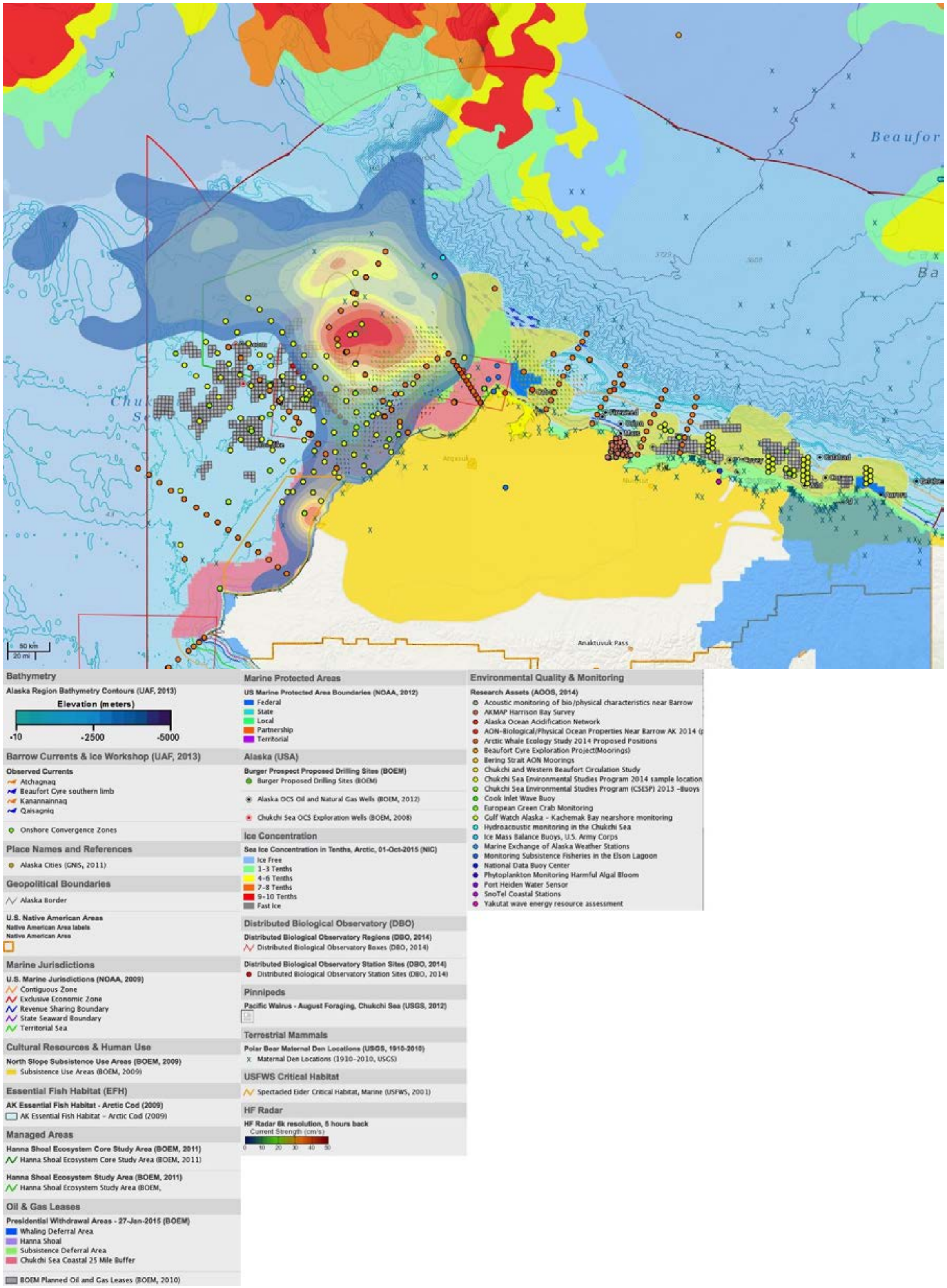


Figure 1: Map of key institutions and other relevant environmental data and sustained observations in the Alaska region, as obtained from Arctic ERMA.

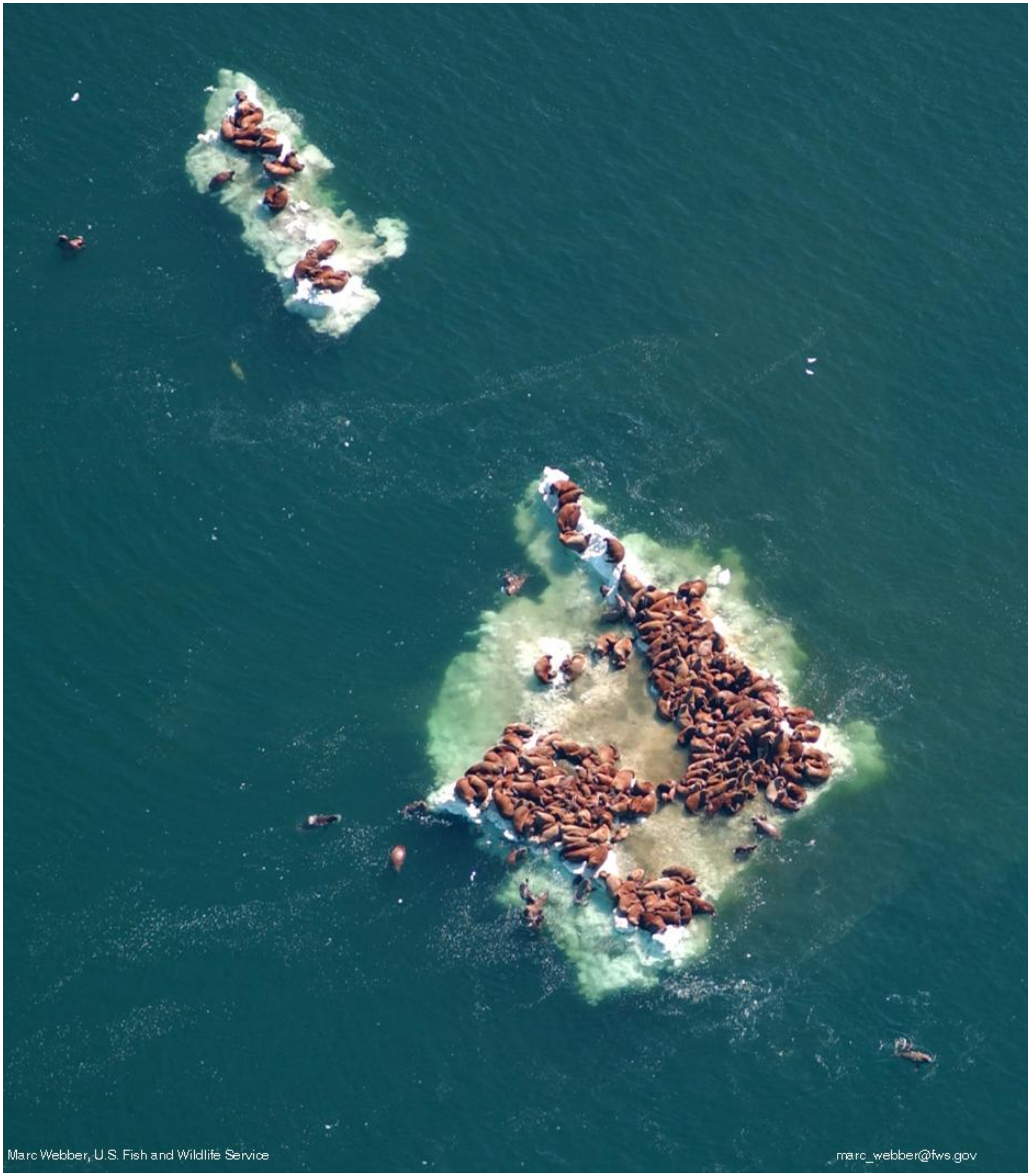


Figure 2: Aerial photograph of walrus congregating on an ice floe in the Chukchi Sea, illustrating ice use and crowding of animals into a limited area in late stages of ice melt (photo taken by Marc Webber, U.S. Fish and Wildlife Service, Anchorage, AK).

## Arctic Observing Summit (AOS)

**Statement:** Actions for Biodiversity 2013-2021: implementing the recommendations of the Arctic Biodiversity Assessment
*Relevant to themes: 1-6*

By: Tom Barry, CAFF Executive Secretary; Courtney Price, CAFF Communications Manager

The Conservation of Arctic Flora and Fauna[a] (CAFF) is the biodiversity working group of the Arctic Council [b] and has a mandate to address the conservation of Arctic biodiversity, and to communicate its findings to the governments and residents of the Arctic, helping to promote practices which ensure the sustainability of the Arctic's living resources. It does so through various monitoring, assessment [c] and expert group [d] activities. CAFF's projects provide data for informed decision making to resolve challenges arising from trying to conserve the natural environment and permit regional growth. This work is based upon cooperation between all Arctic countries, Indigenous Organizations, international conventions and organizations.

CAFF released the Arctic Biodiversity Assessment [e] (ABA) at the Kiruna Ministerial Meeting in May 2013, a project containing the best available science informed by traditional ecological knowledge on the status and trends of Arctic biodiversity and accompanying policy recommendations for biodiversity conservation. The ABA consists of five components:

- Arctic Biodiversity Trends 2010: selected indicators of change[f];
- Arctic Biodiversity Assessment: status and trends in Arctic biodiversity;[g]
- Arctic Biodiversity Assessment: synthesis [h];
- Arctic Biodiversity Assessment: report for policy makers[i]; and
- Life Linked to Ice: a guide to sea-ice-associated biodiversity in this time of rapid change[j].

In 2013, Arctic Council Ministers agreed to implement the 17 recommendations [k] articulated in the ABA: Report for Policy Makers [l].

The Actions for Biodiversity 2013-2021: implementing the recommendations of the Arctic Biodiversity Assessment [m] (ABA) is the implementation plan for the ABA's 17 recommendations and was approved at the Arctic Council Ministerial in 2015. This eight-year implementation plan, informed by the results of the Arctic Biodiversity Congress [n] and discussions with Arctic Council countries, Permanent Participants, Working Groups, Task Forces, and Observers, will be key in guiding Arctic Council biodiversity related activities over the coming years.

The ABA recommendations are directed to the Arctic Council as a whole and while some activities are to be implemented through CAFF, others are intended to be led in full, or in part, by other Arctic Council working groups and other subsidiary bodies. Some recommendations will require action by national authorities, stakeholders, and international organizations.

The "Actions for Biodiversity" is a living document that will be reviewed and updated every two years. The plan is not meant to be exhaustive or to replace working group work plans; rather it is complementary, emphasizing specific actions that address the ABA recommendations. Successful implementation of the Arctic Biodiversity Assessment (ABA) recommendations requires a combination of building on existing efforts and embarking in new directions.

For more information please visit: www.caff.is or contact caff@caff.is.

**Contact**: Tom Barry, CAFF Executive Secretary or Courtney Price, CAFF Secretariat (http://www.caff.is/caff-secretariat)

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[a] http://www.caff.is/
[b] http://www.caff.is/arcticcouncil
[c] http://www.caff.is/assessments
[d] http://www.caff.is/expert-group
[e] http://www.caff.is/administrative-series/24-all-administrative-documents/293-actions-for-arctic-biodiversity-2013-2021-implementing-the-recommendations-of-th
[f] http://www.caff.is/assessment-series/10-arctic-biodiversity-assessment/162-arctic-biodiversity-trends-2010-selected-indicators-of-change
[g] http://www.caff.is/assessment-series/10-arctic-biodiversity-assessment/233-arctic-biodiversity-assessment-2013
[h] http://www.caff.is/assessment-series/10-arctic-biodiversity-assessment/232-arctic-biodiversity-assessment-2013-synthesis
[i] http://www.caff.is/assessment-series/10-arctic-biodiversity-assessment/229-arctic-biodiversity-assessment-2013-report-for-policy-makers-english
[j] http://www.caff.is/sea-ice-associated-biodiversity/sea-ice-publications/254-life-linked-to-ice-a-guide-to-sea-ice-associated-biodiversity-in-this-time-of-ra
[k] http://arcticbiodiversity.is/policy
[l] http://arcticbiodiversity.is/the-report/report-for-policy-makers
[m] http://www.caff.is/administrative-series/24-all-administrative-documents/293-actions-for-arctic-biodiversity-2013-2021-implementing-the-recommendations-of-th
[n] http://arcticbiodiversity.is/congress

Alessa, Lilian; Williams, Paula; Kliskey, Andrew; Beaujean, Grace; Ward, Heather; Ingott, Joni and Ingott, Eddie

# INCORPORATING COMMUNITY-BASED OBSERVING NETWORKS FOR ENHANCED PREPAREDNESS AND RESPONSES TO MARINE ARCTIC CRITICAL EVENTS



## INTRODUCTION

On May 10, 2013 President Barack Obama announced the *National Strategy for the Arctic Region* (NSAR)[1]. The document describes foci of the policy, which include: improving our awareness of activities, conditions, and trends in the Arctic region that may affect our safety, security, environmental, or commercial interests[2], protecting the Arctic environment and conserving its resources[3]; establishing and institutionalizing an integrated Arctic management framework; charting the Arctic region[4]; and employing scientific research and traditional knowledge to increase understanding of the Arctic[5]. Two of the guiding principles in accomplishing the strategy are: "*decisions … based on the most current science and traditional knowledge*" and engagement "*in a consultation process with Alaska Natives* . . .[6]" The National Strategy also calls for improved international cooperation and collaboration in the Arctic[7], a call that was echoed by Alaska Senator Lisa Murkowski in a recent forum on Arctic issues held in Washington DC on September 16.[8]

Similarly, the United Nations' Hyogo Framework (HFA)[9] has three strategic goals: to integrate disaster risk reduction into sustainable development policies and planning; to develop and strengthen institutions, mechanisms and capacities to build resilience to hazards; and to systematically incorporate risk reduction approaches into the implementation of emergency preparedness, response and recovery programs. To achieve these goals, the HFA outlined five specific priorities for action: 1. Making disaster risk reduction

[1] UNITED STATES, *National strategy for the Arctic region* (2013), *available at* http://purl.fdlp.gov/GPO/gpo36790.
[2] *Id*. at 6.
[3] *Id*. at 2, 7.
[4] *Id*. at 2.
[5] *Id*. at 8.
[6] *Id*. at 3.
[7] *Id*. at i.
[8] Senator Lisa Murkowski, Address at the Forum on Arctic Issues (September 16, 2015).
[9] United Nations Specialised Conferences, United Nations, *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters*, A/CONF.206/6, (January 22, 2005) at 3, 4 *available at*: http://www.refworld.org/docid/42b98a704.html.

a priority[10], 2. Improving risk information and early warning[11], 3. Building a culture of safety and resilience[12], 4. Reducing the risks in key sectors[13], and 5. Strengthening preparedness for response[14].

There are multiple levels of efforts in the Arctic that can contribute toward these policies. They include: a) basic science to understand the dynamics of Arctic change including its dynamics within the circumpolar North, its connectivities to other global regions, and the consequences to regional and global livelihoods and well-being[15]; b) the politics of Alaska, perhaps one of the most visible, yet redundant, components[16]; and c) the adaptation actions which comprise the pragmatic responses on the ground[17]. Adaptation actions bring together both science and politics but despite the many research papers, databases and roundtables focusing on the Arctic, this area has received little attention.

Although considerable scientific monitoring has been conducted in the Arctic, instrumented records of environmental conditions in Alaska and in other Arctic regions present their own set of problems. Ocean surface current sensors, ocean buoy networks, and ocean subsurface glider observations, as well as terrestrial gauges and meteorological stations, are sparse and records often do not extend far back in time, or records are kept for a limited time period and are then discontinued[18]. Additionally, reliability and validity of instrumented data in Alaska and Alaskan waters are questionable for a variety of reasons.[19] Sensors are placed in populated areas and near shore locales because the geographic area of the Arctic is vast and the conditions are harsh, many areas of the Arctic are not populated[20]. The need to deploy sensors lies in the criticality of observing change. High frequency radars are used for monitoring ocean surface currents in the Chukchi Sea, an ocean buoy network provides continuous ocean acidification monitoring in the Chukchi Sea, Bering Sea, and Gulf of Alaska, the distributed biological observatory provides biological, chemical, and physical monitoring for change detection, and glider observations are used to establish a time series of subsurface ocean conditions[21]. The Alaska Ocean Observing System (AOOS) is a regional data steward for all of these observations and data and makes information products available through its online data portal, this includes community-based observing data for the Bering Sea[22]. Such observations are necessary to ensure appropriate responses are mounted to undesired changes, opportunities are utilized and security is sustained for everything from food and water resources to incursions into U.S. territorial waters. Relevant to this, through the Division of Homeland Security's

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[10] *Id*. at 6.
[11] *Id*. at 7.
[12] *Id*. at 9.
[13] *Id*. at 10.
[14] *Id*. at 12.
[15] *See,* UNITED STATES, *supra* note 1, and DEPARTMENT OF DEFENSE, *Climate Change Adaptation Roadmap* (2014).
[16] *See,* Fran Ulmer, *Alaska and the Arctic*, 31 Alaska L. Rev. 161 (2014).
[17] *See,* UNITED STATES, *supra*, note 1, and DEPARTMENT OF DEFENSE, *supra*, note 15.
[18] *See,* National Research Council, *Toward an Integrated Arctic Observing Network* (2006), *at* 85; Alaska Ocean Observing System, *AOOS: A tool for tracking, predicting, managing, and adapting to changes in our marine environment*, (2015), *available at* www.aoos.org.
[19] *See,* Douglas L. Kane & Sveta L. Stuefer, *Reflecting on the status of precipitation data collection in Alaska: a case study*, Hydrology Research, 46.4 (2015), 478; Samuel Bauret & Svetlana L. Stuefer, *Kenai Peninsula Precipitation and Air Temperature Trend Analysis,* 19th International Northern Research Basins Symposium and Workshop Southcentral Alaska, 35 (August 11-17, 2013).
[20] *Id.*
[21] *See*, Arctic Ocean Observing System, *supra*, note 18, *available at* http://portal.aoos.org/real-time-sensors.php#module-search?lg=8c5dd704-59ad-11e1-bb67-0019b9dae22b&p=proj3857&b=google_hybrid&page=1&tagId=&q=chukchi%2Bsea.
[22] *See*, Arctic Ocean Observing System, *supra*, note 18.

(DHS) vast range of agencies focused on ensuring domestic security, is the National Response Framework (NRF)[23]. Under NRF, the Federal Emergency Management Agency (FEMA) sets out five overview areas (prevention, protection, mitigation, response, and recovery) under three key theme areas (engaged partnerships, scalability, flexibility, adaptability in implementation, and integration among the frameworks)[24].

This paper focuses on "engaged partnerships" in the context of the NRF's overview areas; and establishes a means to improve our awareness of activities, conditions, and trends as well as to increase the collection of scientific knowledge and the use of traditional knowledge as set forth in the NSAR[25]. Engaged partnerships can be considered to be working relationships that are sustained by regular communication and active support between response agency leaders and local-level organizations and individuals. This paper also proposes that policies formalizing the incorporation of community based observing networks (CBONS) and the establishment of an integrated response framework (IRF), focusing on the maritime domain, will accomplish many of the goals of both the NSAR and the NRF[26]. Use of such a system will enhance observation networks and preparedness, as well as response entities and actions. These elements will come together to create a whole that respects the enormous diversity in the Arctic and acknowledges that a shared arctic geography requires a different approach, and policies, to collective response. A comprehensive framework requires the use of a socio-environmental and technological systems based approach focusing on key indicators with simple, robust and accessible models for interactions that allow us to forecast Marine Arctic Critical Events (MACE) in the form of a regional, community-centered, early-warning system[27]. In this context we define MACE as any biological, infrastructure, maritime shipping, or other natural or social event that is detrimental to society or the environment and necessitates a timely response in order to ameliorate deleterious effects caused by the event.

Community Based Observing Networks and Systems (CBONS) are used to observe Arctic events and changes, and to record scientific evidence[28]. Broader observing networks are used to prepare for MACE, and an IRF facilitates cooperative, time-critical and successful responses to a range of those events[29]. In addition, an IRF requires federal and state agencies to develop a plan that equips remote communities to assist in response-on-the-ground for a range of MACE. Historical precedent exists for a network of skilled observers and on-the-ground responders in remote areas who are able to put these data into situational context: The Alaska Territorial Guard (ATG)[30]. During World War II the ATG was commissioned to alert the U.S. to enemy activities in the seas and skies of Alaska[31]. All in all, the ATG

[23] FEDERAL EMERGENCY MANAGEMENT AGENCY, *National Response Framework*, (2013) a*vailable at* http://www.fema.gov/national-response-framework.
[24] *Id., available at,* http://www.fema.gov/mission-areas*.*
[25] *See, National Strategy for the Arctic Region, supra*, note 1.
[26] *See, National Strategy for the Arctic Region, and National Response Framework, supra,* notes 1 and 23.
[27] *See,* Francois Fouinat, *A comprehensive framework for human security,* 4 CONFLICT, SEC. & DEV. 3 (Dec. 2004); Noriko Fukita, *et* al. *A comprehensive framework for human resources for health system development in fragile and post-conflict states*,8 PLoS MED 12 (Dec 2011); United Nations Development Programme, http://www.ws.undp.org/content/dam/samoa/docs/prodocs/UNDP_WS_CCSDP_ProDoc.pdf (2008).
[28] *See*, Lilian Alessa, et al., *The role of indigenous science and local knowledge in integrated observing systems: moving toward adaptive capacity indices and early warning systems*. SUST. SC. 1 (2015), *at* 2.
[29] *See,* Christian Huggel, et *al*., *Early warning systems: The "Last Mile" of adaptation.* EOS 93 (2012), at 210.
[30] Ernest Gruening, INTRODUCTION TO MEN OF THE TUNDRA: ALASKA ESKIMOS AT WAR (1969).
[31] *Id.*

operated as a system of observers, first responders, defenders and people to stock caches along flight corridors and coastal routes[32]. The hazards faced in World War II are similar to some of the challenges faced today by responding agencies such as the United States Coast Guard (USCG), particularly in the Bering and Chukchi Seas regions. Alaska was considered too remote and vast to equip with the needed level of equipment and too distant from the contiguous U.S. to be of relevance and to effectively protect[33], an echo of similar challenges faced today. General Malin Craig, US Army Chief of Staff said in November 1937, "*...the mainland of Alaska is so remote from the strategic areas of the Pacific that it is difficult to conceive of circumstances in which air operations therefrom would contribute materially to the national defense*."[34]

In the context of this paper, we will specifically advance arguments for inclusion of CBONS in the NRF, the USCG Concept of Operations (CONOPS)[35], and the Arctic Strategic Plan[36] inorder to create a system to forecast MACE, prepare for their actuality and mount a rapid response. Such a framework could better enable local and regional responses around an “Observe-Prepare-Respond” paradigm (Figure 1). We define observing as quality-assured and quality-controlled documentation of social, physical, and biological data that provides a baseline for detecting changing patterns and subsequently preparation and response. Preparedness is defined as the use of observing system outputs to derive awareness of potential critical events and the forecasting of their emergence, leading to a rapid, yet organized, response. Observing and preparation are consequently the foundations for response, which we describe as any systematic and proactive set of actions to address critical events. The United States assumed the chairmanship of the Arctic Council on April 24, 2015 and will retain the chair until 2017[37]. The opportunity to create such a blueprint, toward arctic national preparedness, response and resilience, hereafter referred to in this paper as the Integrated Response Framework (IRF), will challenge the U.S. and its interests in the Arctic region over the next 18 months. The consequences of failing to produce such a blueprint, while it is chair, may tarnish its legacy.

## II. WHY A SYSTEMS APPROACH?

A key challenge for the science of scholarly inquiry and actions responding to changing environments in Alaska is that there are multiple disciplinary effects that remain disconnected. In addition, despite an urgent need to respond, the key variables, mechanisms and processes that can maximize adaptive capacity, and response on the ground by human communities, are neither well-understood, nor effectively operationalized[38]. The tangible consequences of these challenges is that our organization for successful response at multiple spatial scales remains poor.

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[32] *Id*.
[33] *Id. at* 2, 3.
[34] *Id. at* 3.
[35] UNITED STATES COAST GUARD, *National Response Framework: Concept of Operations (CONOP), available at* http://www.nrt.org/production/NRT/RRTHome.nsf/Resources/RRTDocument1/$FILE/NRF_USCG_CONOP.PDF.
[36] UNITED STATES, *supra,* note 1.
[37] U.S. Department of State, *available at:* http://www.state.gov/e/oes/ocns/opa/arc/.
[38] *See,* Nathan L. Engle, *Adaptive capacity and its assessment,* 21 GLOBAL ENV. CHANGE, 647 (2011); Jochen Hinkel, *“Indicators of vulnerability and adaptive capacity”:Towards a clarification of the science-policy interface,* 21 GLOBAL ENV. CHANGE, 198 (2011).

The themes of anticipating threats and translating that knowledge into adaptive capacity are pillars of President Obama's Climate Action Plan[39] and subsequent Executive Order on Preparedness and Resilience[40]. Key goals of the action plan and the executive order include fostering national awareness of the Arctic[41], bolstering maritime regimes[42], enhancing public-private relationships through a national concept of operations, identifying necessary authorities, and recognizing future requirements and resources that lend themselves to success[43]. The action plan and executive order also encourage advances in science and technology intended to facilitate successful response in the region[44]. As well, the UN HFA priorities, emphasize that there remains a need " … *to develop quantitative indices for adaptive capacity that involve the aggregation of diverse information across affected systems and regions, through an analysis of specific metrics.*"[45] Toward this we propose a systems approach that consists of: a) using CBONS to place observations in a situational context, b) developing a community-centered early warning system capable of forecasting MACE, and c) developing new policies and an IRF for partnering with local communities to both train and equip them to be first responders in conjunction with regional, state and federal response agencies as anticipated in the NRF[46].

When considering a framework or blueprint for responding to change it is necessary to incorporate social components, including policies, laws and governance, the biogeophysical components, including the inherent types and rates of change in ecosystems, and the technological components which include the range of technologies that are both driving socio-environmental change as well as available to respond to them[47]. In order to do this, there must be systematic observations of change, placement of these observations of change in both a situational and anticipatory context for MACE and then targeting preparedness such that response actions can occur quickly with the best likelihood of success (IRF).

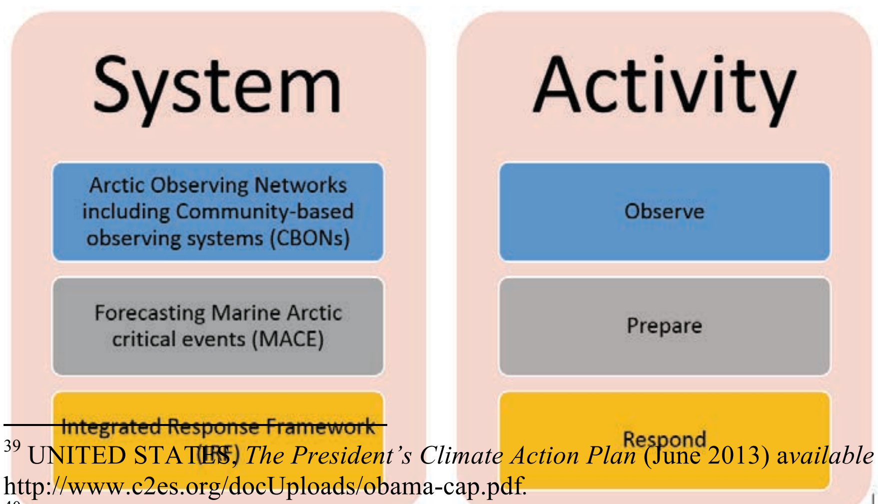


**Figure 1.** The need to adopt a systems approach to develop both MACE and the IRF. CBONS allow observations to be placed in a situational context. The vast array of arctic natural and social sciences can provide input to the forecasting system (MACE), and an integrated response framework (IRF) allows targeted

[39] UNITED STATES, *The President's Climate Action Plan* (June 2013) *available at* http://www.c2es.org/docUploads/obama-cap.pdf.
[40] UNITED STATES, *Executive Order on climate preparedness,* (Nov. 2013) *available at* https://www.whitehouse.gov/the-press-office/2013/11/01/fact-sheet-executive-order-climate-preparedness.
[41] UNITED STATES, *supra,* note 39, *at* 12.
[42] *Id.* at 16.
[43] *Id.*; UNITED STATES, *supra,* note 40.
[44] UNITED STATES, *supra*, note 39; UNITED STATES, *supra*, note 40.
[45] See, Hans-Martin Füssel. *Review and Quantitative Analysis of Indices of Climate Change Exposure Adaptive Capacity, Sensitivity and Impacts* (2009). Background note to the World Development Report 2010. *Development and climate change*.
[46] FEDERAL EMERGENCY MANAGEMENT AGENCY, *supra,* note 23.
[47] *See,* NATIONAL SCIENCE FOUNDATION, ArcticSEES, *available at* http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503604.

preparedness, training and equipment to be mobilized in partnership with responding agencies.

*Using Community Based Observing Networks to Better Enable Local Responses to Marine Arctic Critical Events*

Expansion of the federal government policies of outreach and inclusion of indigenous communities in decision-making will benefit the United States in accomplishing its policies of protecting the Arctic environment and conserving its resources; establishing an integrated arctic management framework; and employing scientific research and traditional knowledge to increase understanding of the Arctic[48]. This can be accomplished through CBONS, which use a set of human observers to provide comprehensive data, through observations of a range of environmental variables and events.

Partnering with Indigenous communities to inform policy is not new in the United States. The Marine Mammal Protection Act of 1972 permits traditional harvest and involvement of local people in the management system[49]. Federal agencies, including the National Marine Fisheries Service, the United States Fish and Wildlife Service, the National Park Service, the United States Environmental Protection Agency, are required by regulation to consult with tribal entities[50]. The National Environmental Protection Act (NEPA)[51] and the State Transportation Improvement Program (STIP)[52] also require outreach and consultation. CBONS are a logical extension of these regulatory requirements.

The human observers who comprise CBONS are connected via a network through which they systematically input observations and collaborate to create a knowledge network that constructs broader, regional-scale changes and dynamics from discrete sets of quality-controlled information[53]. The majority of these observers are indigenous peoples whose intimacy with their landscapes and waterscapes is high[54]. Some observers can describe changes accurately, and place them in an appropriate social context[55]. Each observer is akin to a sensor and, linked together, they form a robust and adaptive sensor array that constitutes CBONS. CBONS are able to monitor changing ecological conditions (e.g., weather, sea state, sea ice, flora, and fauna)[56] as well as anthropogenic activities (e.g., ship traffic, human behaviors, and changing infrastructure)[57].

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[48] *See, infra,* notes 49 through 52.
[49] 16 U.S.C. 1423c § 504 (2007); 16 U.S.C. 1388 § 119 (1994).
[50] 18 C.F.R. § 16.8 (2003).
[51] 36 C.F.R. § 219.4 (2012).
[52] 25 C.F.R. § 170.106 (2012).
[53] *See*, Lilian Alessa, *supra*, note 28; Sarah Roop et al., *"We didn't cross the border; the border crossed us: Informal social adaptations to formal governance and policies by communities across the Bering Sea region in the Russian Far East and United States*, 5 WASH. J. ENV. L. POL. 1 (2015).
[54] *See,* Fikret Berkes, & Mina Kislalioglu Berkes, *Ecological complexity, fuzzy logic, and holism in indigenous knowledge*. 41(1) FUTURES 6 (2009); Sandra Grant & Fikret Berkes, *Fisher knowledge as expert system: A case from the longline fishery of Grenada, the Eastern Caribbean*. 84 FISH. RES. 162 (2007).
[55] *See,* Eddy Carmack & Robie MacDonald, *Water and ice-related phenomena in the coastal region of the Beaufort Sea: Some parallels between native experience and western science,* 61(3) ARCTIC 265 (Sept. 2008); Andy Mahoney *et* al., *Sea-ice thickness measurements from a community-based observing network,* 90(3) BULL. OF THE AM. MET. SOC. 370 (2009).
[56] *See,* Lilian Alessa, *supra*, note 28; Peter Collings, *Economic strategies, community and food networks in Ulukhaktok, Northwest Territories, Canada*, 64(2) ARCTIC 207 (2011); James D. Ford & Tristan Pearce, *Climate change vulnerability and adaptation research focusing on the Inuit subsistence sector in Canada: Directions for future research*, 56(2) THE CAN. GEOG. 275 (2012); Dyanna Riedlinger, *Responding to climate change in*

An example of a longstanding, quality-assured, and effective CBONS is the Community-based Observation Network for Adaptation and Security (CONAS)[58]. CONAS is the evolution of the Bering Sea Sub-Network that was developed in 2007 in partnership with university scientists (University of Alaska Anchorage), arctic indigenous communities, and an NGO – the Aleut International Association, a permanent participant of the Arctic Council[59]. CONAS utilizes distributed human observers as sensors across the Bering Sea in both Alaska and the Russian Federation to systematically observe and document artic environmental and globalization changes through co-developed surveys and questionnaires[60]. Over 40 factors of environmental and globalization changes are observed within a socioeconomic context, and all observations are quality assured and controlled, meaning they are verified and validated[61]. Changes monitored at the local level hold higher significance in terms of understanding the social processes that relate to biodiversity and the vulnerabilities inherent in a changing environment[62]. These observations based on bottom-up realities are increasing the communities' abilities to plan, adapt and respond to a changing Arctic to ensure a secure and sustainable future.

Just like an instrumented array, CBONS can be tested and calibrated. However, unlike fixed instruments, they consist of intelligent actors who are much more capable of parsing information to better detect patterns (i.e., local knowledge for global understanding). Indeed, one of the most urgent needs that can be filled by CBONS as part of the suite of integrated observatories is to support efficient and effective adaptation to environmental change. In order to better address the environmental questions put forward by society, observations that are placed in a clear set of social contexts must be better integrated into our current observatory models[63]. As part of the White House's string of recent press releases related to the Arctic, CBONS were highlighted as a key priority area for development both within the U.S. Arctic Chairmanship as well as more broadly in the context of adaptation[64]. In September 2015, the National Science Foundation's Advisory Committee for Environmental Research and Education (AC-ERE) released its "Gold Report" in which CBONS are called out as a necessary mechanism to ensure effective response to a range of socio-environmental change:

"*There is enormous opportunity to leverage current observing networks to provide relevant data for adaptation actions at increasingly finer temporal and spatial scales, for example, through investments in community-based observing networks that harness place-based, local, and traditional knowledge.*"[65]

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*Northern communities: Impacts and adaptations* 54(1) ARCTIC 96 (2001); Martin Tremblay, *et* al., *Climate change in North Quebec: Adaptation strategies from community-based research* , 61(Suppl. 1) ARCTIC 27 (2007).

[57] Heinrich Klutschak & William Barr. OVERLAND TO STARVATION COVE: WITH THE INUIT IN SEARCH OF FRANKLIN, 1878-1880, (1987).

[58] *See,* Lilian Alessa et al, *Bering Sea Sub-Network II: Sharing Knowledge, Improving Understanding, Enabling Response – International community-based environmental observation alliance for a changing Arctic*, CAFF Monitoring Series Report No. 2 (2011).

[59] *See,* Victoria Gofman et al*, Bering Sea Sub-Network: Pilot Phase Final Report 2009,* CAFF Monitoring Series Report (2015).

[60] *See,* Lilian Alessa et al., *supra*, note 58.

[61] *See,* Lilian Alessa et al., *supra*, note 28.

[62] *See,* Lilian Alessa et al., *supra*, note 28.

[63] *See,* James D. Ford & Tristan Pearce, *supra*, note56.

[64] THE WHITE HOUSE, Office of the Press Secretary, *FACT SHEET: President Obama Announces New Investments to Enhance Safety and Security in the Changing Arctic*, (September 1, 2015).

[65] *See,* NATIONAL SCIENCE FOUNDATION ADVISORY COMMITTEE FOR ENVIRONMENTAL RESEARCH & EDUCATION, *America's Future: Environmental Research and Education for a Thriving Century*, (2015), *at* 24.

U.S. federal agencies have invested billions of dollars to support observation systems including those in the Arctic; state, local, and private-sector entities also have established significant observing capacities[66]. Many of the existing observing systems provide significant value and are meeting needs relevant to specific agencies[67]. However, because these systems were established under disciplinary and agency boundaries and continue to operate independently, currently the overall suite of observation systems may not be optimum to address the NSAR and NRF goals. We know that there are critical redundancies and/or gaps, and an uneven level of integration and interoperability among observatories, which hampers our ability to use the data for preparing and responding to arctic change[68]. These challenges fall squarely into the DHS's purview[69]. In 2008 DHS reorganized to include 23 agencies under its umbrella, including the USCG[70]. Each of these agencies have established extensive and well thought out scopes, mandates, and missions[71]. Though DHS continues to experience challenges from the monumental tasks of coordinating and communicating with diverse agencies, it has established a network of Centers of Excellence (CoE) that unite diverse and nationally recognized experts as partners around a common issue [72]. One such CoE, the Arctic Domain Awareness Center (ADAC), came into being in 2014[73]. Its mission is to provide a real-time coordinated system of systems for maritime surveillance in the Arctic, with the USCG as its primary client[74]. It includes CBONS as part of its research, education and outreach portfolio[75].

## III. FORECASTING MARINE ARCTIC CRITICAL EVENTS: WHAT IS A REGIONAL EARLY WARNING SYSTEM?

The 2013 National Research Council report *Abrupt Impacts of Climate Change: Anticipating Surprises*[76] identified one overriding need: early warning systems (EWS) that would be essential for anticipating, warning, and planning for future abrupt changes. The report, however, stopped short of describing in detail how to establish an early warning system, citing the need for additional expertise to adequately tackle this task[77].

The United Nations International Strategy for Disaster Reduction (UNISDR)[78] defines an EWS as: "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and

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66 National Research Council, *Abrupt Impacts of Climate Change: Anticipating Surprises* (2013).
67 *See*, Polar Research Board, *Toward an Integrated Arctic Observing Network.* The National Academies Press (2007).
68 *Id*.
69 *See,* Scott Borgerson, *Arctic Meltdown: The Economic and Security Implications of Global Warming*, FOR. AFF. March/April (2008); James Kraska, *Arctic Security in an Age of Climate Change*, *at* 244-260 (2011).
70 *See,* Catherine Dale et al, *Organizing the U.S. Government for National Security: Overview of the Interagency Reform Debates*, Congressional Report ADA481919 (2008); Harold Relyea and Henry Hogue, Department of Homeland Security Reorganization: The 2SR Initiative, Congressional Report ADA480111 (2005).
71 *Id.*
72 *See,* Louise Comfort, *Crisis Management in Hindsight: Cognition, Communication, Coordination, and Control*, 67 PUB. ADMIN. REV. 189-193 (2007).
73 Arctic Domain Awareness Center, *available at*, http://www.uidaho.edu/caa/programs/research/crc/research/about.
74 *Id.*
75 *Id.*
76 *See*, Ronald O'Rourke, *Changes in the Arctic: Background and Issues for Congress,* Congressional Research Service 7-5700 (2013).
77 *Id*., at 164.
78 United Nations International Strategy for Disaster Reduction (2007), *available at* http://www.unisdr.org/we/inform/terminology.

in sufficient time to reduce the possibility of harm or loss." They further qualify that definition as follows: "This definition encompasses the range of factors necessary to achieve effective responses to warnings. A people-centered early warning system necessarily comprises four key elements: knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received."[79]

This definition and comment include the range of factors necessary to integrate both a coupled socio-environmental and technological system (SETS) for effective response. Early warning systems exist for natural geophysical and biological hazards, complex socio-political emergencies, industrial hazards, personal health risks and many other related hazards[80] but few exist that account for the real-world integration of social, ecological and technological systems so as to increase the effectiveness of on-the-ground responses by communities[81]. Effective regional integrated EWS are co-developed by diverse end-users such that the benefits are fully recognized. This requires both that trust be established and that the community/region must accept responsibility for their own futures. The incorporation of local and place-based knowledge, through CBONS, in cataloging early warning signs will increase community-level response, responsibility and action[82].

In order to be economically feasible, a people (or community)-centered EWS should be considered. Such a system necessarily comprises four key elements: i. knowledge of the risks; ii. monitoring, analysis and forecasting of the hazards; iii. communication or dissemination of alerts and warnings; and, iv. local/regional capacities to respond to the warnings received including training, equipment and coordination[83].

The expression "end-to-end warning system" emphasizes that early warning systems need to span all steps from detection of critical changes to community response.[84] Reliable early warning systems developed globally have been instrumental in saving lives and protecting assets and livelihoods[85]. However, they have not yet been implemented in the U.S. as an integrated process for the purpose of anticipating both acute and chronic (threshold) changes that require either intervention, specific preparedness or adaptation through targeted responses.

An essential first step is to develop a shared vision of the desired early warning system, with buy-in and incorporation of local and regional knowledge and capacity. Concerted connection with communities on

[79] *Id.*
[80] Christian Huggel, *et* al., *Is climate change responsible for changing landslide activity in high mountains?* 37(1) EARTH SURF. PROC. AND LAND. 77 (2012).
[81] *See*, Lilian Alessa, et al., *supra*, note 28.
[82] *See*, Lilian Alessa, et al., *supra*, note 28; Kirsty Galloway McLean, *Advance Guard: Climate Change Impacts, Adaptation, Mitigation and Indigenous Peoples – A Compendium of Case Studies*. United Nations University, (2009), *available at* http://www.unutki.org/downloads/File/Publications/UNU_2009_Advance_Reading_Copy_Advance_Guard_Compendium.pdf.
[83] *See*, Lilian Alessa, et al., *supra*, note 28; Kirsty Galloway McLean, *supra*, note 82.
[84] United Nations International Strategy for Disaster Reduction, *supra,* note 78.
[85] *See,* Christian Huggel, et *al*., *supra*, note 29.

the ground allows for the co-prioritization of needs for preparedness/early warning and recovery. Incorporation of local and place based, including indigenous, knowledge can enhance regional EWS[86].

*Forecasting Marine Arctic Critical Events (Mace): An Arctic Early Warning System*

Having articulated a system that establishes an effective means for observation of Arctic critical events, we move to establishing a means for response through preparation. First, we address the need for preparation.

We assert that there are two profound failures in overall policy governing arctic preparedness and response: siloing across agencies and an over-reliance on top-down data inputs. These vulnerabilities are artifacts of the need for different agencies to maintain specializations in key areas. For example, within the USCG, preparedness and response plans for oil spills are separate from the mission area for search and rescue[87]. Moreover, other agencies such as the Alaska Division of Homeland Security & Emergency Management[88], Alaska National Guard and the Alaska State Defense Force[89], and Alaska Department of Environmental Conservation (DEC)[90], as well as a range of private corporations' incident response units each operate under separate scopes and mandates. The State of Alaska has its own Emergency Operations Plan[91], as does the DEC[92] and the US Army Corps of Engineers[93]. There are so many emergency response, operations, or incident plans for Alaska that it is difficult to differentiate responsibilities, overlaps, leverage points, and gaps.

The agency with primary responsibility for maritime response in the Arctic is the U.S. Coast Guard[94]. There is a great deal of uncertainty around the rates and types of geopolitical and environmental changes that may drive the need for a response and hence, the risks that may emerge in the near to midterm future[95]. Risk and uncertainty in Alaska are heightened because of the lack of infrastructure and roads, and a marine geophysical environment setting with extremes of ice and darkness. Given the reductions in funding to the US Coast Guard[96] it is unrealistic to expect the agency to cover all contingencies across a marine area with a combined total greater than that of the continental United States.

We assert that "preparedness and response" will be more effectively implemented through CBONS. These networks can help coordinate responses of the numerous agencies listed above by placing

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[86] *See*, United Nations International Strategy for Disaster Reduction, *supra*, note 78.
[87] *See*, Merv Fingas, *The Basics of Oil Spill Cleanup*, CRC Press (2013) *at* 19.
[88] *See,* STATE OF ALASKA, DIVISION OF HOMELAND SECURITY & EMERGENCY MANAGEMENT, *available at* https://www.ak-prepared.com/.
[89] *See,* ALASKA STATE DEFENSE FORCE, *available at* http://dmva.alaska.gov/ASDF/ASDF_JOC.
[90] *See,* STATE OF ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION, Disaster Response Plan: Departmental Procedures in the Event of a Natural or Man-made Disaster, *available at* https://dec.alaska.gov/spar/ppr/plans/adec_disaster.pdf.
[91] *See,* STATE OF ALASKA, State of Alaska Emergency Operations Plan, available at http://www.poa.usace.army.mil/Portals/34/docs/AKdistrict/StateofAlaskaEmergencyOperationsPlan2011.pdf.
[92] *See,* STATE OF ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION, *supra,* note 90.
[93] UNITED STATES ARMY CORP OF ENGINEERS, Emergency Response Plan (2011), *available at* http://www.poa.usace.army.mil/Portals/34/docs/AKdistrict/StateofAlaskaEmergencyOperationsPlan2011.pdf.
[94] *See*, Lawson Brigham, The Fast-Changing Maritime Arctic, 430 PROC. U.S. NAV. INSTIT. 57 (2011).
[95] *See,* Catherine Dale et al.; Harold Relyea and Henry Hogue, *supra*, note 70.
[96] *See,* U.S. COAST GUARD, Always Ready: 2015 Budget in Brief, *available at* http://www.uscg.mil/budget/docs/2015_Budget_in_Brief.pdf.

communities at the forefront of observation (since they are strategically geographically located) and anticipation of threats or events, and by training community members as first responders. CBONS will concomitantly increase the capacity of the USCG and, in essence, increase its labor force. However, preparedness and response will require efforts beyond incorporating CBONS. Those efforts will include developing a forecasting system for MACE, which could be accomplished through the DHS ADAC.

Developing a forecasting system for MACE can leverage past investments in characterizing the Earth system[97], improve our ability to detect and attribute global and environmental change, inform climate models capable of simulating long-term climate change, and improve research related to environmental health, northern subsistence, natural and man-made disasters, fresh water, and other critical societally-relevant areas. It could also provide a means to identify priorities for repurposing existing observing systems, ranging from satellite-based remote sensing to community based observing networks (CBONS), and/or make new investments. Key to developing this is a more concerted connection with the users of environmental change information, that is, a community-centered early warning system, so as to be able to respond effectively to their needs and partner with them for response operations on the ground. It will be important to connect information on emerging thresholds of change with improved preparedness ranging from equipment to training to planning and response.

A MACE forecasting system can be established by first identifying a list of indicators and sub-indices necessary for integration into an Arctic EWS, using the UNDISR definition[98]. In Table 1, we propose a set of initial indicators that were selected based on a) primary, peer reviewed literature[99], b) agency defined/identified parameters used in operations and c) the Delphi method[100].

| Type of Sensor | Indicator | Sub Indices |
|---|---|---|
| Remote Sensing | Sea ice | Extent, velocity, quality, pattern |
| | Marine debris | Bulk, diffuse, rigid, unknown |
| | Roads, building, and ports | |
| | Shipping patterns (AIS visible) | Baseline, irregular, proximity to habitat |
| | Phytoplankton and marine algae | Variation from baseline, pattern, density, types |
| | Oil / petrochemicals | Location at unfamiliar places, density |
| | Wetland drying / surface drying | Rates |
| | Greening / browning (NDVI) | Rates, types of vegetation, proximity to habitat, cause |
| | Phenology | Increased uncoupling |
| | Ocean temperature | Higher, lower, phenologically disjunct |
| | Coastlines | Erosion (rates & patterns), proximity to habitat, proximity to infrastructure, sedimentation |
| Buoy / Meteorological Station | Ocean temperature | Higher, lower, phenologically disjunct |
| | Salinity | Higher, lower, pattern |
| | Microbes | TBD |
| | Oil / petrochemicals | Location at unfamiliar places, density, proxy indicators through oiling of wildlife. |
| | Precipitation / hydrology | Increase, decrease, rate (e.g., drought/flood), |

[97] The term "Earth system" refers to Earth´s interacting physical, chemical, and biological processes, including the land, oceans, atmosphere and poles. It includes the planet's natural cycles — the carbon, water, nitrogen, phosphorus, sulfur and other cycles — and deep Earth processes. *See*, http://www.igbp.net/globalchange/earthsystemdefinitions.4.d8b4c3c12bf3be638a80001040.html.
[98] United Nations International Strategy for Disaster Reduction, *supra*, note 78.
[99] Alistair Smith, *et* al., *Remote sensing the vulnerability of vegetation in natural terrestrial ecosystems* 154 REM. SENS. ENV. 332 (2014).
[100] Harold A. Linstone and Murray Turoff, THE DELPHI METHOD: TECHNIQUES AND APPLICATIONS (2002), at 10-12.

| | | |
|---|---|---|
| | | proximity to infrastructure |
| | Phenology | Increased uncoupling |
| | Species distributions / biodiversity | TBD |
| Community-based Observing Networks | Marine transit patterns (AIS – dark/unfamiliar) | Increased occurrence |
| | Fauna - familiar | Frequency, body condition (e.g., lesions), behaviors |
| | Fauna – unfamiliar | Occurrence, distribution |
| | Flora – familiar | Frequency, productivity (e.g., berries, rhizomes, roots), condition |
| | Flora –unfamiliar | Occurrence, distribution |
| | Phenology | Increased uncoupling |
| | Human activity – desired<br>Human consequences-anticipated | TBD |
| | Coastlines | Erosion (rates & patterns), proximity to habitat, proximity to infrastructure, sedimentation |

Additional steps to operationalize MACE include:

**Design Based on Current Theory**: MACE will need to be able to detect critical shifts soon enough to intervene. In order to accomplish this, indicators (Table 1) will help guide observations. These indicators are variables for which there are a) easily accessible and reliable observations ranging from remote sensing to CBONS, b) models capable of integrating these data streams and c) outputs on which decisions can be made. Clusters of weighted indicators will constitute warning suites.

**Identify Indicators and Indicator Clusters:** Indicators are derived from currently observed variables for which we can regularly acquire data in near- or real-time. Gaps that are identified in critical indicators will help guide adjustments to existing observing networks and instruments. Weighting will occur through the Delphi Method, using expert input to construct clusters (weighted indicators that are integrated around an Incident of National Significance (ION))[101].

**Identify Warning Suites:** This involves mapping priorities outlined by Pacific Command, Northern Command, the U.S. Coast Guard and the Office of Naval Research to develop indicator clusters and creating attention categories: e.g., watch, adjust, respond[102]. These categories specify what we are warning about and who is being warning.

**Develop Scenarios:** Scenarios based on MACE integration models can help better guide preparedness and response by constructing scenarios of arctic critical events (also see IONS below) that have meaning to communities on the ground.

**Build Capacity:** MACE can guide building preparedness and response capacity among different end users, including management agencies, industries, tribal bodies, NGOs and resident communities, not only through scenario-building, but also by changing culture. Currently, there is a great deal of willingness and desire on behalf of remote communities in the Arctic to be active participants at time zero of a critical event, such as a ship adrift spilling hazardous cargo (potentially requiring not only containment and neutralization but also rescue and housing of survivors and/or recovery of fatalities), because these residents could be severely impacted by the expected delays in a more centralized response[103].

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[101] Incidents of National Significance, as defined in the NRF, are high impact events that require an extensive and well-coordinated multiagency response to save lives, minimize damage, and provide the basis for long-term community and economic recovery. *Available at*, http://www.dhs.gov/xlibrary/assets/NRP_Brochure.pdf.

[102] *See,* U.S. GOVERNMENT ACCOUNTABILITY OFFICE, Arctic Planning: 2015 Budget in Brief, GAO-15-566, *available at* http://www.gao.gov/assets/680/670903.pdf.

[103] *See,* Arctic Council, EPPR: Emergency Prevention and Preparedness Plan, *available at* http://arctic-council.org/eppr/completed-work/oil-and-gas-products/arctic-guide/.

*MACE and Incidents of National Significance (IONS)*

IONS are high-impact events that require an extensive and well-coordinated multiagency response to save lives, minimize damage, and provide the basis for long-term community and economic recovery[104]. However, the realities of response mean that success is variable and dependent on several assumptions and pre-conditions that may not be met. For example, one assumption is that the responding agency is capable of a timely mobilization which has not been compromised such that response-efficacy is reduced. Ideally, emergent responses can help off-set the burden of centralized response but a pre-condition is that a degree of appropriate preparedness must be in place. In order to accomplish this, regional early warning systems (EWS) that are heavily integrated need to be developed against IONS. Our primary concern with IONS arise from both anthropogenic and naturally-derived events to act upon. Examples are as follows:

1. Convergent environmental variables of changing sea ice, coastal erosion and increased ship transits puts coastal communities at risk for not only overt dislocation but also chronic problems associated with rapid changes in food species.
2. Simultaneous malicious and purposeful interference and/or destruction of critical infrastructure and natural resources (e.g., cyber-jamming airport facilities, setting forest fires, disrupting ports, etc.) pre-dispose communities and national security to harm and can critically tax resources of responding agencies, compromising response.

National, regional and local entities possessing integrated early warnings in the form of actionable/trusted information and knowledge of threat precursors are in a much stronger position to anticipate and prevent the incident or, should an incident occur, greatly reduce its impact on the societies they protect.

## IV. TOWARD AN INTEGRATED RESPONSE FRAMEWORK: INCORPORATING CBONS INTO THE NATIONAL RESPONSE FRAMEWORK

The logical framework for a response framework is the NRF. The NRF often uses the phrase ‘engage the whole community’[105] which specifically speaks to policies around: a) Planning, b) Public information and warning and, c) Operational coordination. This phrase seems to anticipate the incorporation of CBONS into the NRF. Incorporating CBONS would add enhance available information by adding a range of data streams, and on-the-ground validation, to supplement existing ones, reduce costs, raise awareness within communities who participate in the observing network, and place observations into a societal context, which further enables the accuracy of MACE. Additional values of CBONS lies in their use these to guide targeted preparedness, planning, workforce and skills development In the Arctic, where data streams are particularly limited and we are often “blind” particularly during certain seasons, CBONS will be of particular utility. This model is readily transferable to other parts of the United States.

As part of an IRF, *not only should key observed/monitored variables and indicators of change, including those obtained through CBONS, be identified but these should also be mapped to the capabilities and*

[104] National Response Framework, *supra,* note 23.
[105] *See,* R. Perkins and R. Bullock, *Indigenous Communities Participation in Environmental Decisions*, (n.d.) *available at* http://www.academia.edu/9410444/Indigenous_Communities_Participation_in_Environmental_Decisions.

*resources most likely needed during an incident*, including describing the responsibilities of primary and support agencies involved (Emergency Support Function Annexes)[106].

Focusing on the relationships between determining the need to respond and effectively doing so requires more concerted connection with communities on the ground in the Arctic. This also serves to build buy-in and trust within these communities because response plans may be compromised by lack of trust in federal agencies[107]. In establishing this connection, communities are asked to prioritize needs (e.g., cultural and resource) so as to develop regional (e.g., state-wide) indicators that can be used to develop a community-based early warning system, leveraging the federal "Climate Resilience Toolkit (CRT)[108], and the Arctic Adaptation Exchange Portal (AAEP) in particular[109]. These indicators can be weighted and represented as a status dashboard (see Figure 2). Using the dashboard, and algorithms for weighting variables over space and time, a regional EWS (i.e., MACE) and an IRF can be meaningfully used on the ground by non-specialized users.

The information derived from observing networks, particularly with those comprised of community observers, forms the basis for continual monitoring of system changes. A community-based early warning system is at the core of the IRF. It is one that is co-developed, managed and maintained by regional response agencies in coordination with the National Response Plan. It is based on a "people-centered" approach that empowers individuals and communities threatened by rapid and/or undesired changes to act in sufficient time and in an appropriate manner to reduce the possibility of injury, mortality, loss of well-being, damage to valued ecosystems, and/or loss of livelihoods (economic viability). It provides communities, practitioners and organizations involved in resource management with advance information of risks that can be readily translated into prevention, preparedness and response actions.

Integrating CBONS into any preparedness and response framework will require particular emphasis and focus on quality assurances, verification and validation. It should be emphasized that, from a policy point of view, CBONS occupy a unique niche in the "citizen science" spectrum. As anticipated in this paper and as utilized in Alaska, CBONS are not as vulnerable to "spoofing" or to misleading or inaccurate data[110].

Incorporating CBONS into preparedness and response frameworks is necessary because it is unlikely that we, as a nation, will be able to equip and mount a centralized set of responses should arctic activity continue to increase at a moderate rate. Thus, incorporating CBONS into MACE can a) guide purposeful observations, b) facilitate successful responses by Alaskan communities and c) inform more cost-effective planning and partnerships with local communities by state and federal agencies for the following major

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[106] *See*, DEPARTMENT OF HOMELAND SECURITY, *National Response Plan 2004*, *available at* http://fas.org/irp/agency/dhs/nrp.pdf.

[107] See, Ricardo Wray, et al. *Public perceptions about trust in emergency risk communication: Qualitative research findings*, 24(1) INT J OF MASS EM AND DIS 45 (2006).

[108] U.S. Climate Resilience Toolkit, *available at* https://toolkit.climate.gov/.

[109] Arctic Council, Arctic Adaptation Exchange, *available at* http://arcticadaptationexchange.com/.

[110] Of particular concern are "observer blogs" which allow anyone to post observations with little to no systematic data intake protocols. Such blogs are particularly vulnerable to spoofing and purposeful addition of misleading information, potentially introducing both a threat to security as well as an inaccurate picture of changing conditions and events.

reasons: they can a) help manage data on observations of change, b) integrate these data into critical event scenarios which bear realistic meaning to responding communities, and, c) through a combination of engagement, workforce development and better connectivities between communities and agencies, enable responses to occur more quickly and effectively.

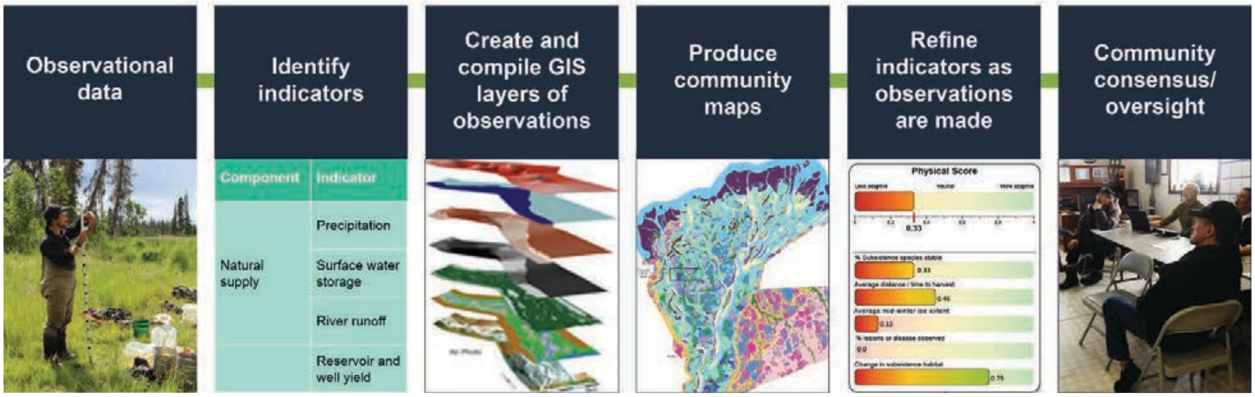


**Figure 2.** The process of co-development of a community-centered, regional ARC-EWS with end-user communities as potential first responders.

Thus, a regional, pilot IRF as a solution-generating system includes the *process* and *framework* that lead to successful on-the-ground responses. It is critical that the framework incorporate an iterative process. Such a framework is illustrated in Figure 2 above and involves:

1. An active stakeholder group that is part of a co-designed framework and co-developed solutions (planners and responders).
2. Identification and assembly of best available data (academic and agency scientists, local, and place-specific, community-based knowledge).
3. Data integration that acknowledges interoperability across diverse data types which can allow more realistic and accurate development of scenarios for planning and training.
4. Suitable representation and visualization of SETS dynamics (e,g, geovisualization).
5. Generation of a range of plausible future scenarios and projection of possible outcomes using geovisualization tools.
6. Development of potential responses to scenarios to guide preparedness, co-develop and refine response plans, such as targeting what kinds of training and equipment need to be provided.

Incorporating CBONS in the National Response Framework

Ultimately, we need to tackle the policies around preparedness and response in the Arctic, a region that presents unusual challenges of distance, extreme environments and limited capacity to mount a centralized response. Several questions that arise regarding our abilities to develop streamlined process of "observe-prepare-respond" range from: Who are we warning? What are we warning about? What is being threatened? What might be emerging opportunities, as the converse of what are the risks?

In this paper, we have proposed a system capable of forecasting Marine Arctic Critical Events that can detect important shifts soon enough to intervene from any one of a series of distributed communities who may be impacted. Most of the pieces currently exist and are functional but will require both a new, adaptive way of thinking by DHS as well as policies which enable greater communication, training, and operationalization on the ground. This will require a careful examination of the kinds of observations, and integrated models, necessary for building response scenarios. The challenges of data, planning and response interoperability also need to be addressed so that any outputs from a forecasting system for MACE can highly accessible to communities on the ground, not just specialized groups within universities or agencies.

By formally incorporating CBONS into the NRF, the challenges of communicating warnings may be met halfway since communities will have greater control of and buy-in to information regarding emerging changes that could potentially impact them, either positively or negatively. Ultimately, a re-consideration of CBONS as part of a range of observation, planning and response frameworks will also elevate the diversity and skills within remote communities in Alaska. Increasing the human capacity to respond across such a vast region could greatly assist responding agencies and build improved trust between the public and government resulting in a more resilient Arctic.

# Ecological and Economic Aspects for the Sustainable Development of the Arctic Regions in Republic of Sakha (Yakutia), Russia

Anisiia Lazareva, Oregon State University, lazareva@oregonstate.edu

Key words: sustainable development, natural resources, northern environment, climate change, economic aspects and calculations, regional economics

Sakha Republic of Yakutia is the biggest and the richest region of Russia. That is why there are a lot of industrial developments connected with oil, gas, coal and other natural resources. Large industrial corporations are developing fields in Yakutia. Such megaprojects as ‘East Siberia – Pacific Ocean’ and ‘Sila Sibiri (Power of Siberia)’ pipelines, which supply Asian countries with gas and oil, got their start with the resources of Yakutia. All that industrial activity, of course, somehow develops the country and brings a lot of profit for the state and private structures, playing their role in terms of national development strategy, but their work keeps a real danger for Russian Arctic.

In this case we can study categories of northern resources’ relevance such as:

- Economic profits and role of the northern resources in global development and economic progress – statistics information with tables and graphics, how much countries are supplied with oil and gas from the Russian North;

- Prospects for Republic of Sakha (Yakutia) from mining – how it can be used, what should be done, which benefits Yakutia can get from extracting northern resources on the sake of the Arctic and people living here;

- Ecological aspects of field’s development and extraction activity for northern environment, its influence on natural balance, about consequences for people, about the level of ecological damage and its economic value and cost; and about how to prevent it and calculate economic advantages from it for the state.

By doing all these we will be able to prove a real importance of the northern resources that are extracted in Yakutia to Russian and world economies. Moreover, it will show importance for the Arctic itself because it provides new opportunities for development. Anyway, the meaning of the northern resources is increasing day by day due to their prospects and the fact that other (not northern) resources run out.

There are three component areas which play an important role in the sustainability in the North. It is economic, social and environmental components. Ignoring or neglecting at least one of them can lead to catastrophic consequences. In the process of research and development of the Arctic it is necessary to work in all these three component areas in the same time. From an economic point of view it is probably still too early to begin extracting of the Arctic shelf resources. But the presence of research centers in the Arctic will have a positive impact on the development of the region. Opening of these centers means that here will be investments which will lead to improvement of life's quality in the Arctic for people.

Finally, we just can make a conclusion that the northern region has a really big development potential. As a natural treasury, Russian Arctic keeps the key to the future development of the country. Industrial development brings more positive consequences for people than negative but only if it is carried out together with the environmental and cultural development. Anyway, we cannot stop globalization and development. We have to learn how to use them correctly for making life better and to use new scientific opportunities to solve old ecological problems, to optimize human intervention in nature. We should love and care for our planet and nature because the Arctic is "the keystone ecosystem for the entire planet", it is the heart of our world.