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

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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

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\(^{2}\) 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).

a priority\textsuperscript{10}, 2. Improving risk information and early warning\textsuperscript{11}, 3. Building a culture of safety and resilience\textsuperscript{12}, 4. Reducing the risks in key sectors\textsuperscript{13}, and 5. Strengthening preparedness for response\textsuperscript{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\textsuperscript{15}; b) the politics of Alaska, perhaps one of the most visible, yet redundant, components\textsuperscript{16}; and c) the adaptation actions which comprise the pragmatic responses on the ground\textsuperscript{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\textsuperscript{18}. Additionally, reliability and validity of instrumented data in Alaska and Alaskan waters are questionable for a variety of reasons.\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{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

\begin{thebibliography}{99}
\bibitem{10} Id. at 6.
\bibitem{11} Id. at 7.
\bibitem{12} Id. at 9.
\bibitem{13} Id. at 10.
\bibitem{14} Id. at 12.
\bibitem{15} See, UNITED STATES, supra note 1, and DEPARTMENT OF DEFENSE, Climate Change Adaptation Roadmap (2014).
\bibitem{17} See, UNITED STATES, supra, note 1, and DEPARTMENT OF DEFENSE, supra, note 15.
\bibitem{20} Id.
\bibitem{22} See, Arctic Ocean Observing System, supra, note 18.
\end{thebibliography}
(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

\(^{25}\) 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.
\(^{28}\) 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.
\(^{31}\) Id.
operated as a system of observers, first responders, defenders and people to stock caches along flight corridors and coastal routes. 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, 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."

In the context of this paper, we will specifically advance arguments for inclusion of CBONS in the NRF, the USCG Concept of Operations (CONOPS) in order 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. 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. The tangible consequences of these challenges is that our organization for successful response at multiple spatial scales remains poor.

32 Id.
33 Id. at 2, 3.
34 Id. at 3.
36 UNITED STATES, supra, note 1.
The themes of anticipating threats and translating that knowledge into adaptive capacity are pillars of President Obama’s Climate Action Plan and subsequent Executive Order on Preparedness and Resilience. Key goals of the action plan and the executive order include fostering national awareness of the Arctic, bolstering maritime regimes, enhancing public-private relationships through a national concept of operations, identifying necessary authorities, and recognizing future requirements and resources that lend themselves to success. The action plan and executive order also encourage advances in science and technology intended to facilitate successful response in the region. 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.” 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.

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. 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).
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. 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. 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. The National Environmental Protection Act (NEPA) and the State Transportation Improvement Program (STIP) 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. The majority of these observers are indigenous peoples whose intimacy with their landscapes and waterscapes is high. Some observers can describe changes accurately, and place them in an appropriate social context. 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) as well as anthropogenic activities (e.g., ship traffic, human behaviors, and changing infrastructure).

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48 See, infra, notes 49 through 52.
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).
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 Council59. CONAS utilizes distributed human observers as sensors across the Bering Sea in both Alaska and the Russian Federation to systematically observe and document arctic environmental and globalization changes through co-developed surveys and questionnaires60. 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 validated61. 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 environment62. 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 models63. 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 adaptation64. 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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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).
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. Many of the existing observing systems provide significant value and are meeting needs relevant to specific agencies. 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. These challenges fall squarely into the DHS’s purview. In 2008 DHS reorganized to include 23 agencies under its umbrella, including the USCG. Each of these agencies have established extensive and well thought out scopes, mandates, and missions. 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. One such CoE, the Arctic Domain Awareness Center (ADAC), came into being in 2014. 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. It includes CBONS as part of its research, education and outreach portfolio.

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* 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.

The United Nations International Strategy for Disaster Reduction (UNISDR) 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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68 Id.
71 Id.
73 Arctic Domain Awareness Center, available at, http://www.uidaho.edu/caa/programs/research/crc/research/about.
74 Id.
75 Id.
77 Id., at 164.
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.
81 See, Lilian Alessa, et al., supra, note 28.
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\textsuperscript{86}.

\textit{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\textsuperscript{87}. Moreover, other agencies such as the Alaska Division of Homeland Security & Emergency Management\textsuperscript{88}, Alaska National Guard and the Alaska State Defense Force\textsuperscript{89}, and Alaska Department of Environmental Conservation (DEC)\textsuperscript{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\textsuperscript{91}, as does the DEC\textsuperscript{92} and the US Army Corps of Engineers\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{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

\textsuperscript{86} See, United Nations International Strategy for Disaster Reduction, \textit{supra}, note 78.
\textsuperscript{87} See, Merv Fingas, \textit{The Basics of Oil Spill Cleanup}, CRC Press (2013) at 19.
\textsuperscript{89} See, \textit{ALASKA STATE DEFENSE FORCE}, available at http://dmva.alaska.gov/ASDF/ASDF_JOC.
\textsuperscript{92} See, \textit{STATE OF ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION, supra}, note 90.
\textsuperscript{95} See, Catherine Dale et al.; Harold Relyea and Henry Hogue, \textit{supra}, note 70.
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\(^{100}\).

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

\(^{97}\) 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.


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 warned.

**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.


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. 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,’ 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

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104 National Response Framework, supra, note 23.
resources most likely needed during an incident, including describing the responsibilities of primary and support agencies involved (Emergency Support Function Annexes)\textsuperscript{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\textsuperscript{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)\textsuperscript{108}, and the Arctic Adaptation Exchange Portal (AAEP) in particular\textsuperscript{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\textsuperscript{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

\begin{thebibliography}{10}
\bibitem{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.
\end{thebibliography}
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.