

6-1-2016

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Recommended Citation

Lilian Alessa, Paula Williams, Andrew Kliskey & Grace Beaujean, *Incorporating Community-Based Observing Networks and Systems: Enhancing Community Preparedness and Response to Arctic Critical Events*, 6 WASH. J. ENVTL. L. & POL'Y 1 (2016).

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INCORPORATING COMMUNITY-BASED OBSERVING NETWORKS AND SYSTEMS: ENHANCING COMMUNITY PREPAREDNESS AND RESPONSE TO ARCTIC CRITICAL EVENTS

Lilian Alessa,* Paula Williams,† Andrew Kliskey,* Grace Beaujean†

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I. 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: (1) improving our awareness of activities, conditions, and trends in the Arctic region that may affect our safety, security, environmental, or commercial interests;² (2) protecting the Arctic environment and conserving its resources;³ (3) establishing and

* Center for Resilient Communities, University of Idaho – funding through National Science Foundation grants ARC 1355238 and OIA 1301792 is acknowledged; a partner of the Arctic Domain Awareness Center, University of Alaska – funding through the Department of Homeland Security Center of Excellence program is acknowledged.

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1. THE WHITE HOUSE, NATIONAL STRATEGY FOR THE ARCTIC REGION (2013), https://www.whitehouse.gov/sites/default/files/docs/nat_arctic_strategy.pdf [hereinafter NATIONAL STRATEGY FOR THE ARCTIC REGION].

2. *Id.* at 6.

3. *Id.*

institutionalizing an integrated Arctic management framework;⁴ (4) charting the Arctic region;⁵ and (5) employing scientific research and traditional knowledge to increase understanding of the Arctic.⁶ 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 . . .”⁷ NSAR also calls for improved international cooperation and collaboration in the Arctic,⁸ a call that was echoed by Alaska Senator Lisa Murkowski in a recent forum on Arctic issues held in Washington, D.C. on September 16.⁹

Shortly following the release of the NSAR, the United States Coast Guard released its supporting strategy for the Arctic region on 10 May 2013, aligned to its federally designated missions that principally provide for safety and security. USCG followed that strategy with a comprehensive implementation plan in December 2015. Included in these documents are the task to specifically address assistance coordination and environmental response.

Strengthening U.S. efforts in support of the Arctic, U.S. Department of Homeland Security chartered a new university center of excellence, the Arctic Domain Awareness Center (ADAC) in summer 2014. ADAC, which is hosted by the University of Alaska, supports DHS, USCG and U.S. maritime missions in the Arctic region by developing and transitioning technology solutions, innovative products, and educational programs and to improve situational awareness and crisis response capabilities. A unique project within the center’s efforts is research in support of community-based observation for situational awareness. In a complimentary manner, the University of Idaho’s Center for Community Resilience provides research to strengthen community-based preparedness and response.

Similarly, the United Nations’ Hyogo Framework (HFA) has three strategic goals: to integrate disaster risk reduction into

4. *Id.* at 9, 11.

5. *Id.* at 2.

6. *Id.* at 8.

7. *Id.* at 3.

8. *Id.* at i.

9. Senator Lisa Murkowski, Address at the Forum on Arctic Issues (Sept. 16, 2015).

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.¹⁰ To achieve these goals, the HFA outlined five specific priorities for action: (1) making disaster risk reduction a priority;¹¹ (2) improving risk information and early warning;¹² (3) building a culture of safety and resilience;¹³ (4) reducing the risks in key sectors;¹⁴ and (5) strengthening preparedness for response.¹⁵

There are multiple levels of efforts in the Arctic that can contribute toward these policies. They include: (1) 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;¹⁶ (2) the politics of Alaska (i.e., state and national), perhaps one of the most visible, yet least pragmatic, components;¹⁷ and (3) the adaptation actions which comprise the pragmatic responses on the ground.¹⁸ 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

10. World Conference on Disaster Reduction, *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters*, ¶ 12, U.N. DOC. A/CONF.206/6 (Mar. 16, 2005).

11. *Id.* at 6.

12. *Id.* at 7.

13. *Id.* at 9.

14. *Id.* at 10.

15. *Id.* at 12.

16. See NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1; U.S. DEPT OF DEF., 2014 CLIMATE CHANGE ADAPTATION ROADMAP (2014), <http://ppec.asme.org/wp-content/uploads/2014/10/CCARprint.pdf> [hereinafter CLIMATE CHANGE ADAPTATION ROADMAP].

17. See Fran Ulmer, *Alaska and the Arctic*, 31 ALASKA L. REV. 161, 163–64 (2014).

18. See NATIONAL STRATEGY FOR THE ARCTIC, *supra* note 1; CLIMATE CHANGE ADAPTATION ROADMAP, *supra* note 16.

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.¹⁹ Additionally, the reliability and validity of instrumented data in Alaska and Alaskan waters are questionable for a variety of reasons.²⁰ 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 and therefore no sensors exist.²¹ 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.²² The Alaska Ocean Observing System (AOOS) is a regional data steward for many of these observations and data and makes information products available through its online data portal, including community-based observing data for the Bering Sea.²³ Most recently, the new Arctic Information Fusion Capability (AIFC), which operates out of the Arctic Domain Awareness Center (ADAC), provides a means to organize and integrate diverse data streams with machine learning so as to provide an unprecedented knowledge system for decision support. Such observations and systems are necessary to ensure that appropriate responses are mounted to undesired changes, opportunities are utilized, and security is sustained for everything from food and water resources to incursions into

19. See NATIONAL RESEARCH COUNCIL, TOWARD AN INTEGRATED ARCTIC OBSERVING NETWORK 85 (2006); ALASKA OCEAN OBSERVING SYSTEM, <http://www.aos.org> (last visited Mar. 6, 2016).

20. See Douglas L. Kane & Sveta L. Stuefer, *Reflecting on the Status of Precipitation Data Collection in Alaska: A Case Study*, 46 HYDROLOGY RESEARCH 478 (2015); Samuel Bauret & Svetlana L. Stuefer, *Kenai Peninsula Precipitation and Air Temperature Trend Analysis*, 19TH INT'L NORTHERN RESEARCH BASINS SYMP. & WORKSHOP 35 (2013).

21. Kane & Stuefer, *supra* note 20, at 478.

22. See ALASKA OCEAN OBSERVING SYSTEM, <http://www.aos.org> (follow "Access Data" hyperlink; then follow "Arctic Portal" hyperlink; then in the top left search box, type and search the name "Chukchi").

23. See *id.*

U.S. territorial waters.

Relevant to this, through the Division of Homeland Security's (DHS) vast range of agencies focused on ensuring domestic security, is the National Response Framework (NRF).²⁴ Under NRF, the Federal Emergency Management Agency (FEMA) sets out five overview areas (prevention, protection, mitigation, response, and recovery)²⁵ under three key theme areas (engaged partnerships, scalability, flexibility, adaptability in implementation, and integration among the frameworks).²⁶ Emphasizing the need to focus on these and other aspects of decentralized, community-based observing, preparedness and response, is the recent decision by Shell Oil Corporation and other oil and gas entities to indefinitely suspend operations in the Arctic.²⁷ Since these organizations historically provided much of the critical response support in remote regions we must now address an alternate set of models to ensure safety and security in America's Arctic.

Toward this end, this article 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.²⁸ 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 article 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

24. FED. EMERGENCY MGMT. AGENCY, NATIONAL RESPONSE FRAMEWORK (2013), <http://www.fema.gov/national-response-framework> [hereinafter NATIONAL RESPONSE FRAMEWORK].

25. FED. EMERGENCY MGMT. AGENCY, NATIONAL PREPAREDNESS SYSTEM, <http://www.fema.gov/mission-areas> (last updated Oct. 2, 2015).

26. See FED. EMERGENCY MGMT. AGENCY, NATIONAL RESPONSE FRAMEWORK (NRF) – FACT SHEET, www.fema.gov/pdf/emergency/nrf/NRFOnePageFactSheet.pdf (last visited Oct. 2, 2015).

27. See generally A. Hardee, *Taking Stock of Oil Drilling's Wildlife Impact: Center for Biological Diversity v. Salazar*, 40 Ecology L.Q. 541 (2013); J.D. Unger, *Regulating the Arctic Gold Rush: Recommended Regulatory Reforms to Protect Alaska's Arctic Environment from Offshore Oil Drilling Pollution*, 31 Alaska L. Rev. 263 (2014).

28. See NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1.

accomplish many of the goals of both the NSAR and the NRF.²⁹ 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 Arctic Critical Events (ACE) in the form of a regional, community-centered, early-warning system.³⁰ In this context we define ACE 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.³¹ Broader observing networks are used to prepare for ACE, and an IRF facilitates cooperative, time-critical, and successful responses to a range of those events.³² 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 ACE. Historical precedent exists for a network of skilled observers and on-the-ground responders in remote areas who are able to put these

29. *Id.*; NATIONAL RESPONSE FRAMEWORK, *supra* note 24.

30. See generally Francois Fouinat, *A Comprehensive Framework for Human Security*, 4 CONFLICT, SECURITY & DEV. 289 (2004); Noriko Fujita Fukita et al., *A Comprehensive Framework for Human Resources for Health System Development in Fragile and Post-Conflict States*, 8 PLOS MED. 1 (2011), <http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001146>; U.N. DEV. PROG., JOINT COMMUNITY-CENTERED SUSTAINABLE DEVELOPMENT PROGRAMME, GOVERNMENT OF COOK ISLANDS, NIUE, SAMOA AND TOKELAU/ UN JOINT COMMUNITY-CENTERED SUSTAINABLE DEVELOPMENT PROGRAMME, http://www.ws.undp.org/content/dam/samoa/docs/prodocs/UNDP_WS_CCSDP_ProDoc.pdf (last visited Mar. 8, 2016) (examples of comprehensive frameworks using both socio-environmental and technological systems-based approaches).

31. 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*, 11 SUSTAINABILITY SCI. 91, 92 (2016).

32. See Christian Huggel et al., *Early Warning Systems: The “Last Mile” of Adaptation*, 93 EOS 209, 210 (2012).

data into situational context: the Alaska Territorial Guard (ATG).³³ During World War II, the ATG was commissioned to alert the U.S. to enemy activities in the seas and skies of Alaska.³⁴ All in all, the ATG operated as a system of observers, first responders, defenders, and people to stock caches along flight corridors and coastal routes.³⁵ 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 outfit 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.³⁶ General Malin Craig, U.S. 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.”³⁷

In the context of this article, we will specifically advance arguments for inclusion of CBONS in the NRF, the USCG Concept of Operations (CONOPS),³⁸ and the Arctic Strategic Plan,³⁹ in order to create a system to forecast ACE, 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

33. Ernest Gruening, *Introduction* to MUKTUK MARSTON, MEN OF THE TUNDRA: ESKIMOS AT WAR 1 (1969).

34. *Id.*

35. *Id.*

36. *Id.* at 2, 3.

37. *Id.* at 3 (emphasis added).

38. U.S. COAST GUARD, NATIONAL RESPONSE FRAMEWORK: CONCEPT OF OPERATIONS (CONOP) (2007),

[http://www.nrt.org/production/NRT/RRTHome.nsf/Resources/RRTDocument1/\\$FILE/NRF_USCG_CONOP.PDF](http://www.nrt.org/production/NRT/RRTHome.nsf/Resources/RRTDocument1/$FILE/NRF_USCG_CONOP.PDF).

39. NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1.

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 2017.⁴⁰ The opportunity to create such a blueprint toward arctic national preparedness, response, and resilience, hereafter referred to as the Integrated Response Framework (IRF), will challenge the United States and its interests in the Arctic region for the remainder of the United States' chairmanship. The consequences of failing to produce such a blueprint, while the United States is chair, may tarnish its legacy.

II. WHY A SYSTEMS-BASED 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.⁴¹ The tangible consequence of these challenges is that our organization for successful response at multiple spatial scales remains poor.

The themes of anticipating threats and translating that knowledge into adaptive capacity are pillars of President Obama's NSAR⁴² and his Executive Order on Preparedness and Resilience.⁴³ Key goals of the strategy 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

40. *Arctic*, U.S. DEPT OF STATE, <http://www.state.gov/e/oes/ocns/opa/arc/> (last visited Mar. 5, 2016).

41. See Nathan L. Engle, *Adaptive Capacity and its Assessment*, 21 GLOBAL ENVTL. CHANGE 647 (2011); Jochen Hinkel, "Indicators of Vulnerability and Adaptive Capacity": *Towards a Clarification of the Science-Policy Interface*, 21 GLOBAL ENVTL. CHANGE 198 (2011).

42. NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1.

43. Exec. Order No. 13653, 70 Fed. Reg. 66819 (Nov. 6, 2013).

requirements and resources that lend themselves to success.⁴⁴ The Arctic strategy and executive order also encourage advances in science and technology intended to facilitate successful response in the region.⁴⁵ In addition, the UN HFA priorities emphasize that there remains a need to develop quantitative indices for “*adaptive capacity*” that aggregates diverse information across time, affected systems and regions, and impact metrics.⁴⁶ Toward this we propose a systems-based approach that consists of: (1) using CBONS to place observations in a situational context; (2) developing a community-centered early warning system capable of forecasting ACE; and (3) 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.⁴⁷

When considering a framework or blueprint for responding to change, it is necessary to incorporate three components: (1) social components, including policies, laws and governance; (2) biogeophysical components, including the inherent types and rates of change in ecosystems; and (3) technological components, including the range of technologies that are both driving socio-environmental change, and the availability to respond to them.⁴⁸ 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 ACE, and then targeting preparedness such that response actions can occur quickly with the best likelihood of success (IRF).

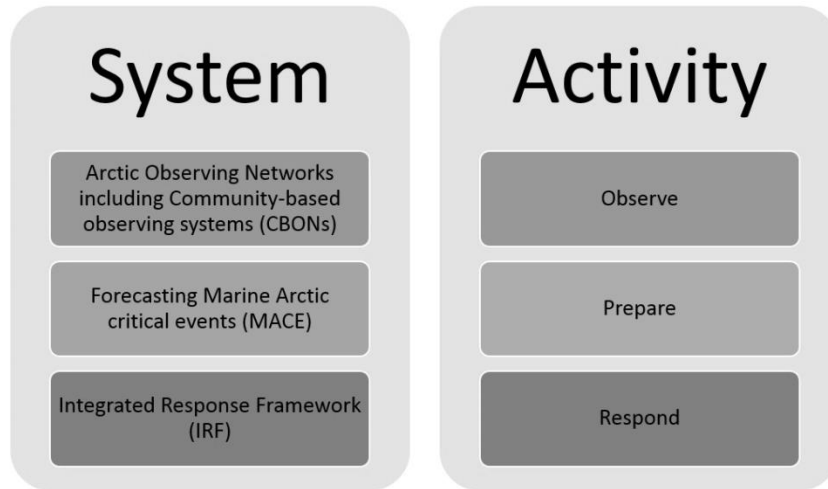
44. NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1, at 6.

45. NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1; Exec. Order No. 13653, *supra* note 43.

46. See generally HANS-MARTIN FÜSSEL, REVIEW AND QUANTITATIVE ANALYSIS OF INDICES OF CLIMATE CHANGE EXPOSURE, ADAPTIVE CAPACITY, SENSITIVITY, AND IMPACTS 8, 8–8 (2009); Rosina M. Bierbaum & Marianne Fey, *World Development Report 2010: Development and Climate Change*, 1 WORLD DEV. REP. 53077 (2009), <http://documents.worldbank.org/curated/en/2010/01/11831971/world-development-report-2010-development-climate-change>.

47. NATIONAL RESPONSE FRAMEWORK, *supra* note 24.

48. Lilian Alessa et al., BEST PRACTICES FOR INTEGRATING SOCIAL SCIENCES INTO SOCIAL ECOLOGICAL SYSTEMS SCIENCE: FUTURE DIRECTIONS FOR BUILDING A MORE RESILIENT AMERICA 2 (2015).

Figure 1. The need to adopt a systems-based

approach to develop both ACE 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 (ACE), and an integrated response framework (IRF) allows targeted preparedness, training and equipment to be mobilized in partnership with responding agencies.

Using Community Based Observing Networks to Better Enable Local Responses to 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 goals 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.⁴⁹ 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 Alaskan Native organizations and the Alaska Nanuuq

49. See NATIONAL STRATEGY FOR THE ARCTIC REGION, *supra* note 1.

Commission in the management system.⁵⁰ Federal agencies, including the National Marine Fisheries Service, the United States Fish and Wildlife Service, the National Park Service, and the United States Environmental Protection Agency, are required by regulation to consult with tribal entities.⁵¹ The National Environmental Protection Act (NEPA),⁵² and the State Transportation Improvement Program (STIP),⁵³ also require outreach and consultation. CBONS are a logical extension of these regulatory requirements.

The human observers who comprise CBONS 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.⁵⁴ The majority of these observers are indigenous peoples whose intimacy with their landscapes and waterscapes is high.⁵⁵ Observers can describe changes accurately and place them in an appropriate social context.⁵⁶ 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)⁵⁷ as well as anthropogenic

50. 16 U.S.C. §§ 1423(c), 1388 (2012).

51. 18 C.F.R. § 16.8 (2015).

52. National Environmental Policy Act, 49 U.S.C. 5304(g) (2012); National Environmental Policy, 42 U.S.C. §§4321–4370(h) (2011)

53. State Transportation Improvement, 25 C.F.R. § 170.106 (2015).

54. See Lilian Alessa et al., *supra* note 31; 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. ENVTL. L. & POL’Y 69 (2015).

55. See Fikret Berkes & Mina Kislalioglu Berkes, *Ecological Complexity, Fuzzy Logic, and Holism in Indigenous Knowledge*, 41 FUTURES 6 (2009); Sandra Grant & Fikret Berkes, *Fisher Knowledge as Expert System: A Case from the Longline Fishery of Grenada, the Eastern Caribbean*, 84 FISHERIES RES. 162 (2007).

56. 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 ARCTIC 265 (2008); Andy Mahoney et al., *Sea-Ice Thickness Measurements from a Community-Based Observing Network*, 90 BULLETIN OF THE AMERICAN METEOROLOGICAL SOC. 370 (2009).

57. See Lilian Alessa, *supra* note 31; Peter Collings, *Economic Strategies, Community and Food Networks in Ulukhaktok, Northwest Territories, Canada*, 64 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 CAN. GEO. 275 (2012); Dyanna Riedlinger, *Responding to Climate Change in Northern Communities: Impacts and Adaptations* 54

activities (e.g., ship traffic, human behaviors, and changing infrastructure).⁵⁸

An example of a longstanding, quality-assured, and effective CBONS is the Community-based Observation Network for Adaptation and Security (CONAS).⁵⁹ CONAS is the evolution of the Bering Sea Sub-Network that was developed in 2007 in partnership with university scientists at University of Alaska Anchorage, arctic indigenous communities, and an NGO—the Aleut International Association, a permanent participant of the Arctic Council.⁶⁰ 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 questionnaires.⁶¹ In CONAS, over forty 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.⁶² 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.⁶³ These observations based on bottom-up realities are increasing 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

ARCTIC 96 (2001); Martin Tremblay, et al., *Climate Change in North Quebec: Adaptation Strategies from Community-Based Research*, 61 ARCTIC 27 (2007).

58. See LILIAN ALESSA ET AL., BEST PRACTICES FOR COMMUNITY-BASED OBSERVING: A NATIONAL WORKSHOP REPORT (2015), https://www.arcus.org/files/news-items/files/cbonreport_03-06-16_final.pdf.

59. See LILIAN ALESSA ET AL., CONSERVATION OF ARCTIC FLORA AND FAUNA MONITORING SERIES REPORT NO.2, BERING SEA SUB-NETWORK II: SHARING KNOWLEDGE, IMPROVING UNDERSTANDING, ENABLING RESPONSE – INTERNATIONAL COMMUNITY-BASED ENVIRONMENTAL OBSERVATION ALLIANCE FOR A CHANGING ARCTIC (2011).

60. See VICTORIA GOFMAN ET AL., CONSERVATION OF ARCTIC FLORA AND FAUNA MONITORING SERIES, BERING SEA SUB-NETWORK: PILOT PHASE FINAL REPORT 2009 (2015).

61. See Lilian Alessa et al., *supra* note 61.

62. See Lilian Alessa et al., *supra* note 31, at 6.

63. *Id.*

information to better detect patterns (i.e., local knowledge for global understanding). Indeed, one of the most urgent needs that can be served 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.⁶⁴ As part of the White House's string of recent press releases related to the Arctic, CBONS were a priority area for development within the U.S. Arctic Chairmanship as well as more broadly in the context of adaptation.⁶⁵ In September 2015, the National Science Foundation's Advisory Committee for Environmental Research and Education 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."⁶⁶

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.⁶⁷ Many of the existing observing systems provide significant value and are meeting needs relevant to specific agencies.⁶⁸ However, because these systems were established under disciplinary and agency

64. See James D. Ford & Tristan Pearce, *supra* note 57, at 277.

65. Press Release, Office of the Press Sec'y, Fact Sheet: President Obama Announces New Investments to Enhance Safety and Security in the Changing Arctic (Sept. 1, 2015), <https://www.whitehouse.gov/the-press-office/2015/09/01/fact-sheet-president-obama-announces-new-investments-enhance-safety-and>.

66. See NAT'L SCIENCE FOUNDATION ADVISORY COMMITTEE FOR ENVTL. RESEARCH & EDUCATION, AMERICA'S FUTURE: ENVTL. RESEARCH AND EDUCATION FOR A THRIVING CENTURY 24 (2015).

67. See NAT'L RESEARCH COUNCIL, ABRUPT IMPACTS OF CLIMATE CHANGE: ANTICIPATING SURPRISES (2013); U.S. GOV'T ACCOUNTABILITY OFF., NOAA'S OBSERVING SYSTEMS: ADDITIONAL STEPS NEEDED TO ACHIEVE AN INTEGRATED, COST-EFFECTIVE, PORTFOLIO 13 (2014).

68. See COMM. ON DESIGNING AN ARCTIC OBSERVING NETWORK, POLAR RESEARCH BOARD, DIV. OF EARTH AND LIFE SCIENCE, NAT'L RESEARCH COUNCIL, TOWARD AN INTEGRATED ARCTIC OBSERVING NETWORK (2007).

boundaries and continue to operate independently, the current overall suite of observation systems may not optimally address the NSAR and NRF goals.⁶⁹ 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.⁷⁰ These challenges fall within the DHS's purview.⁷¹ In 2008 DHS reorganized to include twenty-three agencies under its umbrella, including the USCG.⁷² Each of these agencies has established extensive and well thought out scopes, mandates, and missions.⁷³ 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.⁷⁴ One such CoE, the Arctic Domain Awareness Center (ADAC), came into being in 2014.⁷⁵ Its mission is to provide a real-time coordinated system for maritime monitoring in the Arctic, with the USCG as its primary client.⁷⁶ It includes CBONS as part of its research, education, and outreach portfolio.⁷⁷

69. *Id.* at 25.

70. *Id.* at 11.

71. See generally Scott Borgerson, *Arctic Meltdown: The Economic and Security Implications of Global Warming*, 87 FOREIGN AFF. 63 (2008); FRANKLIN GRIFFITHS, ET AL., ARCTIC SECURITY IN AN AGE OF CLIMATE CHANGE 244–60 (James Kraska ed., 2011).

72. See CATHERINE DALE ET AL., CONG. RESEARCH SERV., RL34455, ORGANIZING THE U.S. GOVERNMENT FOR NATIONAL SECURITY: OVERVIEW OF THE INTERAGENCY REFORM DEBATES (2008); HAROLD RELYEA & HENRY HOGUE, CONG. RESEARCH SERV., RL33042, DEPARTMENT OF HOMELAND SECURITY REORGANIZATION: THE 2SR INITIATIVE (2005).

73. RELYEA & HOGUE, *supra* note 72, at 8.

74. See Louise Comfort, *Crisis Management in Hindsight: Cognition, Communication, Coordination, and Control*, 67 PUB. ADMIN. REV. 189–93, (2007); DEPARTMENT OF HOMELAND SECURITY SCIENCE & TECHNOLOGY CENTERS OF EXCELLENCE (COE), <http://www.dhs.gov/science-and-technology/centers-excellence> (last visited April 4, 2016).

75. ARCTIC DOMAIN AWARENESS CENTER, <http://www.arcticdomainawarenesscenter.org> (last visited April 4, 2016).

76. *Id.*

77. *Id.*

III. FORECASTING 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.⁷⁸ 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.⁷⁹

The United Nations International Strategy for Disaster Reduction (UNISDR) defines an EWS as: “[t]he 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 in sufficient time to reduce the possibility of harm or loss.”⁸⁰ The UN further qualifies that definition as follows: “[t]his 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.”⁸¹

This annotated definition includes 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,⁸² but few EWS exist that account for the real-world

78. See NAT'L RESEARCH COUNCIL, *supra* note 67, at 147.

79. *Id.* at 164.

80. U. N. INT'L STRATEGY FOR DISASTER REDUCTION, 2009 UNISDR TERMINOLOGY ON DISASTER REDUCTION 12 (2009), http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf.

81. *Id.*

82. See, e.g., Christian Huggel, et al., *Is Climate Change Responsible for Changing Landslide Activity in High Mountains?* 37 EARTH SURF. PROCESS LANDFORMS 77 (2012) (discussing early warning systems from a geophysical perspective); Lilian Alessa, et al., *supra* note 31 (discussing early warning systems from a subsistence fishing and hunting perspective).

integration of social, ecological and technological systems so as to increase the effectiveness of on-the-ground responses by communities.⁸³ 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 or region must accept responsibility for its own future. The incorporation of local and place-based knowledge, through CBONS, in cataloging early warning signs will increase community-level response, responsibility and action.⁸⁴

In order to be economically feasible, a community-focused EWS should be considered. Such a system necessarily comprises four key elements: (1) knowledge of the risks; (2) monitoring, analysis and forecasting of the hazards; (3) communication or dissemination of alerts and warnings; and (4) local or regional capacities to respond to the warnings received including training, equipment, and coordination.⁸⁵

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.⁸⁶ Reliable early warning systems developed globally have been instrumental in saving lives and protecting assets and livelihoods.⁸⁷ 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 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 the ground allows for the co-prioritization of needs for preparedness and early warning and recovery. Incorporation of local and place-based, including

83. See Lilian Alessa et al., *supra* note 31.

84. *Id.*; KIRSTY GALLOWAY MCLEAN, ADVANCE GUARD: CLIMATE CHANGE IMPACTS, ADAPTATION, MITIGATION AND INDIGENOUS PEOPLES – A COMPENDIUM OF CASE STUDIES (2009),

http://www.unutki.org/downloads/File/Publications/UNU_2009_Advance_Reading_Copy_Advance_Guard_Compendium.pdf.

85. See Lilian Alessa et al., *supra* note 31, at 10.

86. See, U. N. INT’L STRATEGY FOR DISASTER REDUCTION, *supra* note 80.

87. See Huggel et al., *supra* note 32.

indigenous, knowledge can enhance regional EWS.⁸⁸

Forecasting Arctic Critical Events: 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. 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 a time when there was the need for different agencies to specialize 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.⁸⁹ Moreover, other agencies such as the Alaska Division of Homeland Security & Emergency Management,⁹⁰ Alaska National Guard and the Alaska State Defense Force,⁹¹ and Alaska Department of Environmental Conservation (DEC),⁹² 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,⁹³ as does the DEC⁹⁴ and the U.S. Army Corps of Engineers.⁹⁵ There are so many emergency response, operations, and incident

88. See U.N. OFFICE FOR DISASTER RISK REDUCTION, SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015–2030 23 (2015),

http://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf.

89. See MERV FINGAS, THE BASICS OF OIL SPILL CLEANUP 19 (3d ed. 2012).

90. DIV. OF HOMELAND SECURITY & EMERGENCY MGMT., OUR MISSION, ALASKA DEP'T OF MILITARY AND VETERANS AFF., <https://www.ak-prepared.com> (last visited Mar. 4, 2016).

91. *Alaska State Defense Force*, ALASKA DEP'T OF MILITARY AND VETERANS AFF., http://dmva.alaska.gov/ASDF/ASDF_JOC (last visited Mar. 4, 2016).

92. ALASKA DEP'T OF ENVTL. CONSERVATION, DISASTER RESPONSE PLAN: DEPARTMENTAL PROCEDURES IN THE EVENT OF A NATURAL OR MAN-MADE DISASTER https://dec.alaska.gov/spar/ppr/plans/adec_disaster.pdf.

93. STATE OF ALASKA, DIV. OF HOMELAND SECURITY & EMERGENCY MGMT., THE STATE OF ALASKA 2011 EMERGENCY OPERATIONS PLAN,

<http://www.poa.usace.army.mil/Portals/34/docs/AKdistrict/StateofAlaskaEmergencyOperationsPlan2011.pdf>.

94. See DISASTER RESPONSE PLAN, *supra* note 92.

95. U.S. ARMY CORPS OF ENGINEERS, EMERGENCY RESPONSE PLAN (2011), <http://www.poa.usace.army.mil/Portals/34/docs/AKdistrict/StateofAlaskaEmergencyOperationsPlan2011.pdf>.

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.⁹⁶

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.⁹⁷ Risk and uncertainty in Alaska are heightened because of the lack of infrastructure, including roads, and a marine geophysical environment setting with extremes of ice and darkness. Given the reductions in funding to the U.S. Coast Guard,⁹⁸ 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 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 ACE, which could be accomplished through the DHS ADAC.

Developing a forecasting system for ACE can leverage past investments in characterizing the Earth system,⁹⁹ improve our ability to detect and attribute global and environmental change, inform climate models capable of simulating long-term

96. U.S. COAST GUARD, COAST GUARD ARCTIC STRATEGY (2013), http://www.uscg.mil/seniorleadership/docs/cg_arctic_strategy.pdf

97. See DALE ET AL., *supra* note 72; RELYEA & HOGUE, *supra* note 72.

98. See U.S. COAST GUARD, ALWAYS READY: 2013 PERFORMANCE HIGHLIGHTS & 2015 BUDGET IN BRIEF (2015), http://www.uscg.mil/budget/docs/2015_Budget_in_Brief.pdf.

99. The term “Earth system” refers to the interactions of the Earth’s physical, chemical, and biological processes, including the land, oceans, atmosphere, and poles. It includes the planet’s natural cycles—carbon, water, nitrogen, phosphorus, sulfur and other cycles—and deep Earth processes. See *Earth System Definitions*, GLOBAL CHANGE, <http://www.igbp.net/globalchange/earthsystemdefinitions.4.d8b4c3c12bf3be638a80001040.html> (last visited Mar. 4, 2016).

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 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.

An ACE forecasting system can be established by first identifying a list of indicators and sub-indices necessary for integration into an Arctic EWS as defined by UNDISR.¹⁰⁰ In Table 1, we propose a set of initial indicators that were selected based on: (1) primary, peer reviewed literature,¹⁰¹ (2) agency defined and identified parameters used in operations; and (3) the Delphi method.¹⁰²

Table 1.

Type of Sensor	Indicator	Sub-Indices
Remote Sensing	Sea ice	Extent, velocity, quality, pattern
	Marine debris	Bulk, diffuse, rigid, unknown
	Roads, buildings, & 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

100. See U.N. INT'L STRATEGY FOR DISASTER REDUCTION, *supra* note 80, at 12.

101. Alistair Smith et al., *Remote Sensing the Vulnerability of Vegetation in Natural Terrestrial Ecosystems*, 154 REMOTE SENSING OF ENVTL. 332 (2014).

102. HAROLD A. LINSTONE & MURRAY TUROFF, THE DELPHI METHOD: TECHNIQUES AND APPLICATIONS 10–12 (2002).

	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), 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 Human consequences- anticipated	TBD
	Coastlines	Erosion (rates & patterns), proximity to habitat, proximity to infrastructure, sedimentation

Additional steps to operationalize ACE include:

Design Based on Current Theory: ACE 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: (1) easily accessible and reliable observations ranging from remote sensing to CBONS; (2) models capable of integrating these data streams; and (3) 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 Incidents of National Significance (IONS)).¹⁰³

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.¹⁰⁴ These categories specify what we are warning about and who is being warned.

103. Incidents of National Significance, as defined in the NRF, are high impact events that require an extensive and well-coordinated multi-agency response to save lives, minimize damage, and provide the basis for long-term community and economic recovery. See NATIONAL RESPONSE PLAN, DEP'T OF HOMELAND SECURITY, http://www.dhs.gov/xlibrary/assets/NRP_Brochure.pdf.

104. See U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-15-566, ARCTIC PLANNING: DOD EXPECTS TO PLAY A SUPPORTING ROLE TO OTHER FEDERAL AGENCIES AND HAS EFFORTS UNDER WAY TO ADDRESS CAPABILITY NEEDS AND UPDATE PLANS (2015), <http://www.gao.gov/assets/680/670903.pdf>.

Develop Scenarios: Scenarios based on ACE 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: ACE 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.¹⁰⁵

ACE 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.¹⁰⁶ 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 EWS that are heavily integrated need to be developed against IONS. Our primary concerns with IONS arise from both anthropogenic and naturally-derived events. 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

105. See *EPPR: Emergency Prevention and Preparedness Plan*, ARCTIC COUNCIL, <http://arctic-council.org/eppr/completed-work/oil-and-gas-products/arctic-guide/>.

106. See NATIONAL RESPONSE FRAMEWORK, *supra* note 24.

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 and trusted information and knowledge of threat precursors are in a much stronger position to anticipate and prevent an incident or, should one occur, greatly reduce its impact on the societies they protect.

IV. TOWARD AN INTEGRATED RESPONSE FRAMEWORK.

The logical framework for a response framework is the NRF. The NRF emphasizes community engagement,¹⁰⁷ which specifically speaks to policies around: (1) planning, (2) public information and warning; and (3) operational coordination. This phrase seems to anticipate the incorporation of CBONS into the NRF. Incorporating CBONS would enhance available information by adding a range of data streams, as well as on-the-ground validation, to supplement existing data-streams, reduce costs, raise awareness within communities who participate in the observing network, and place observations into a societal context, which would further enable the accuracy of ACE. Additional values of CBONS lie in their use in guiding targeted preparedness, planning, workforce, and skills development. In the Arctic, where data streams are particularly limited and we are often “blind” 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 be identified, including those obtained through CBONS, but these should also be*

107. See R. Perkins & R. Bullock, *Indigenous Communities Participation in Environmental Decisions* (2014), http://www.academia.edu/9410444/Indigenous_Communities_Participation_in_Environmental_Decisions.

mapped to the capabilities and resources most likely needed during an incident, including describing the responsibilities of primary and support agencies involved (Emergency Support Function Annexes).¹⁰⁸

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, mitigating the possibility of a compromised response plan that could arise if a lack of trust is present.¹⁰⁹ 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),¹¹⁰ and the Arctic Adaptation Exchange Portal (AAEP) in particular.¹¹¹ These indicators can be weighted and represented as a status dashboard (Figure 2). Using the dashboard and algorithms for weighting variables over space and time, a regional EWS (i.e., ACE) 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

108. See DEPT’ OF HOMELAND SECURITY, NATIONAL RESPONSE PLAN 2004, FEDERATION OF AMERICAN SCIENTISTS, at ESF-i, <http://fas.org/irp/agency/dhs/nrp.pdf>.

109. See Ricardo Wray et al., *Public Perceptions About Trust in Emergency Risk Communication: Qualitative Research Findings*, 24 INT. J. MASS EMERGENCIES AND DISASTERS 45 (2006).

110. U.S. *Climate Resilience Toolkit*, NAT’L OCEANIC AND ATMOSPHERIC ADMIN., <https://toolkit.climate.gov/> (last visited April 6, 2016).

111. *Arctic Adaptation Exchange*, ARCTIC COUNCIL SUSTAINABLE DEVELOPMENT WORKING GROUP, <http://arcticadaptationexchange.com/> (last visited April 6, 2016).

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 article and as utilized in Alaska, CBONS are not as vulnerable to “spoofing” or to misleading or inaccurate data.¹¹²

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 ACE can: (1) guide purposeful observations; (2) facilitate successful responses by Alaskan communities; and (3) inform more cost-effective planning and partnerships with local communities by state and federal agencies. This can be accomplished by: (1) helping manage data on observations of change; (2) integrating these data into critical event scenarios which bear realistic meaning to responding communities; and (3) combining engagement, workforce development, and better connections between communities and agencies. These elements enable responses to occur more quickly and effectively.



Figure 2. The process of co-development of a community-centered, regional early warning systems with end-user communities as potential first responders.

112. 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. See Lilian Alessa et al., *supra* note 48.

Thus, a regional, pilot IRF as a solution-generating system includes the *process* and *framework* that lead to successful on-the-ground responses. 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.

V. 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 a streamlined process of “observe-prepare-respond” range from: Who are we warning? What are we warning about? What is being threatened? What emerging opportunities might there be, as the converse of what the risks are?

In this article, we have proposed a system capable of forecasting 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 a new, adaptive way of thinking by DHS and the State of Alaska, as well as agencies such as the Department of Justice and

Defense which can play important roles in support of the NRF, thus enabling greater communication 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 ACE can be 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 because 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.

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