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ARCTIC OPTIONS

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WORKSHOP ON INTEGRATED POLICY OPTIONS FOR THE BERING STRAIT REGION

National Center for Ecological Analysis and Synthesis (NCEAS)
University of California Santa Barbara
735 State Street, Santa Barbara, CA 93101

20-24 October 2014

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1. BACKGROUND ON *ARCTIC OPTIONS* PROJECT

a. Introduction

Recent environmental changes along with global economic changes and accessibility of commodities have opened up the prospect of marked increases in human activities across the Arctic Ocean, most prominently commercial shipping and offshore energy development but also harvesting of living resources and ship-based tourism. Figure 1 illustrates these biophysical and socio-economic changes with particular reference to the decline in sea ice and the rise in commercial shipping.

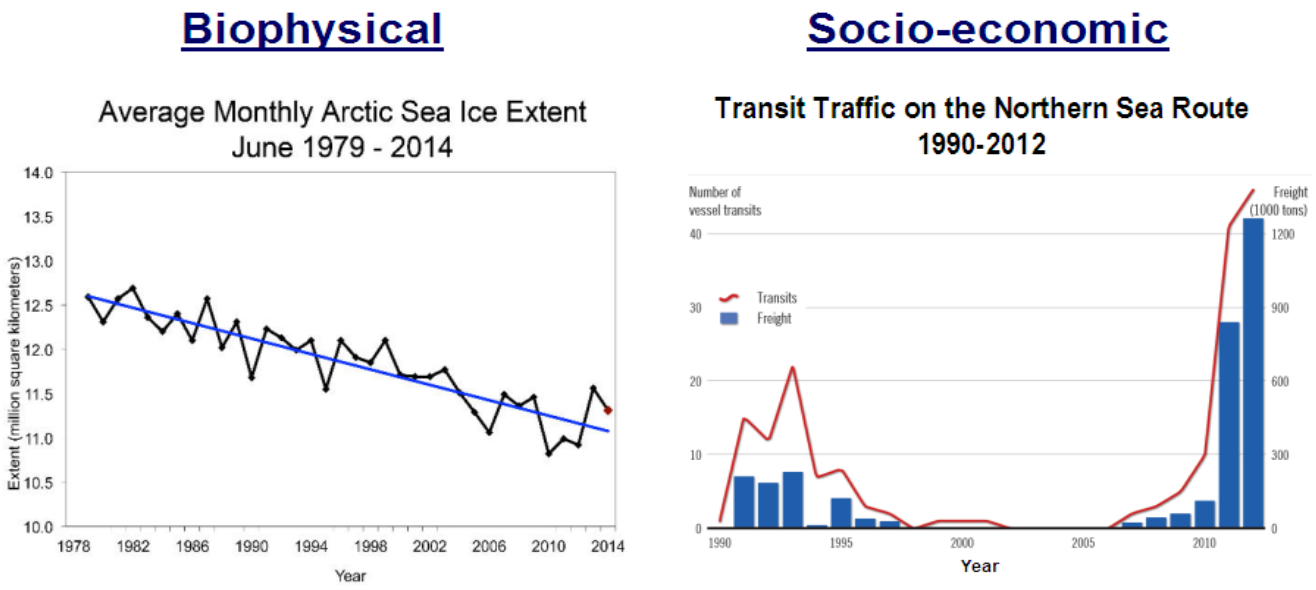

Figure 1: Challenge of sustainable infrastructure development in the Arctic Ocean across diverse time and spaces scales, responding to: (**Biophysical**) changes in the marine ecosystem, as reflected by diminishing sea ice across the region[1]; and (**Socio-economic**) changes associated with increasing commercial activities, as reflected by increased shipping along the Northern Sea Route[2].

[1] NSIDC. 2014. *Arctic Sea Ice News and Outlook.* 17 July 2014. Boulder: National Snow and Ice Data Center.

[2] Arctic Council. 2013. Arctic Resilience Interim Report 2013. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm.

Under law of the sea framework, the human activities extend from the surrounding coastlines across sovereign jurisdictions into international spaces. Accordingly, with involvement of indigenous peoples, Arctic and non-Arctic states have begun to develop national and international policies to address emerging issues, impacts and resources in the Arctic Ocean. The challenge is to align the necessary policy and built infrastructure elements to promote sustainable development from the land seaward around the entire Arctic Ocean.

Oceanography and meteorology of the Arctic Ocean directly influence natural ecosystems and adjacent human populations of indigenous peoples and surrounding coastal states of Norway, Denmark/Greenland, Canada, United States, Russian Federation, and Iceland as well as the non-coastal Arctic states of Sweden and Finland (Fig. 2). Iceland is considered to be a coastal state because it has a coastal zone north of the Arctic Circle, even though the other Arctic states' jurisdictions surround the Central Arctic Ocean. Moreover, there are various boundary configurations of the Arctic Ocean system (Fig. 3), reflecting the interplay of institutions, governments and interests in this region.

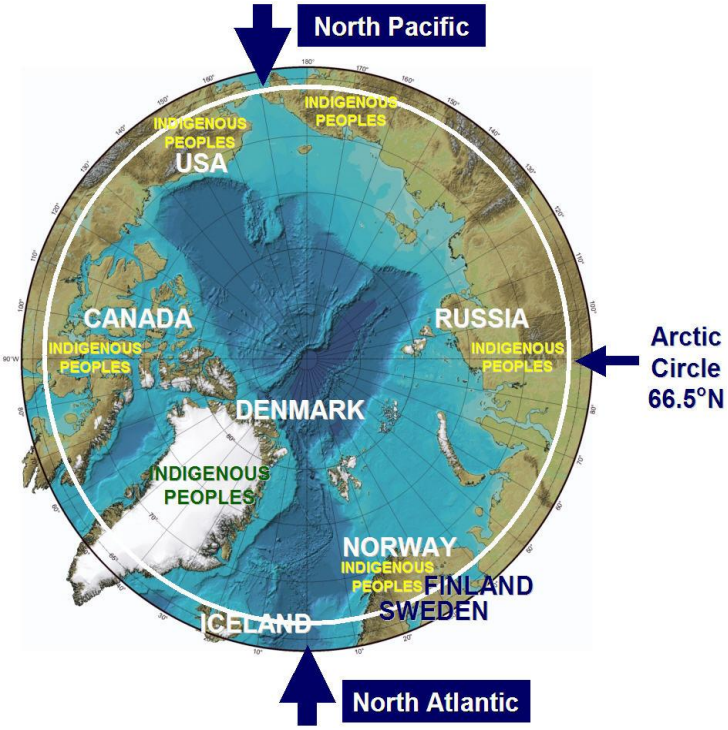

Figure 2: Generalized view of the Arctic Ocean system north of the Arctic Circle at 66.5 degrees North latitude (white circle), which is an unambiguous natural boundary that is constant over human time scales based on tilt of the Earth's axis. Other system boundaries are the sea floor[3] surrounding continents and sea ice (see Fig. 4). Seasonal solar radiation as well as inflow and outflow from the North Pacific and North Atlantic directly impact Arctic marine ecosystems as well as adjacent Arctic coastal states (white), Arctic non-coastal states (blue), circumpolar indigenous peoples (yellow), and mostly indigenous Greenland Self-Government (green).

[3] Jakobsson, M., Macnab, R., Mayer, L., Anderson, R., Edwards, M., Hatzky, J., Schenke, H-W., and Johnson, P. 2008. An improved bathymetric portrayal of the Arctic Ocean: Implications for ocean modeling and geological, geophysical and oceanographic analyses. *Geophysical Research Letters* 35: L07602. doi:10.1029/2008GL033520

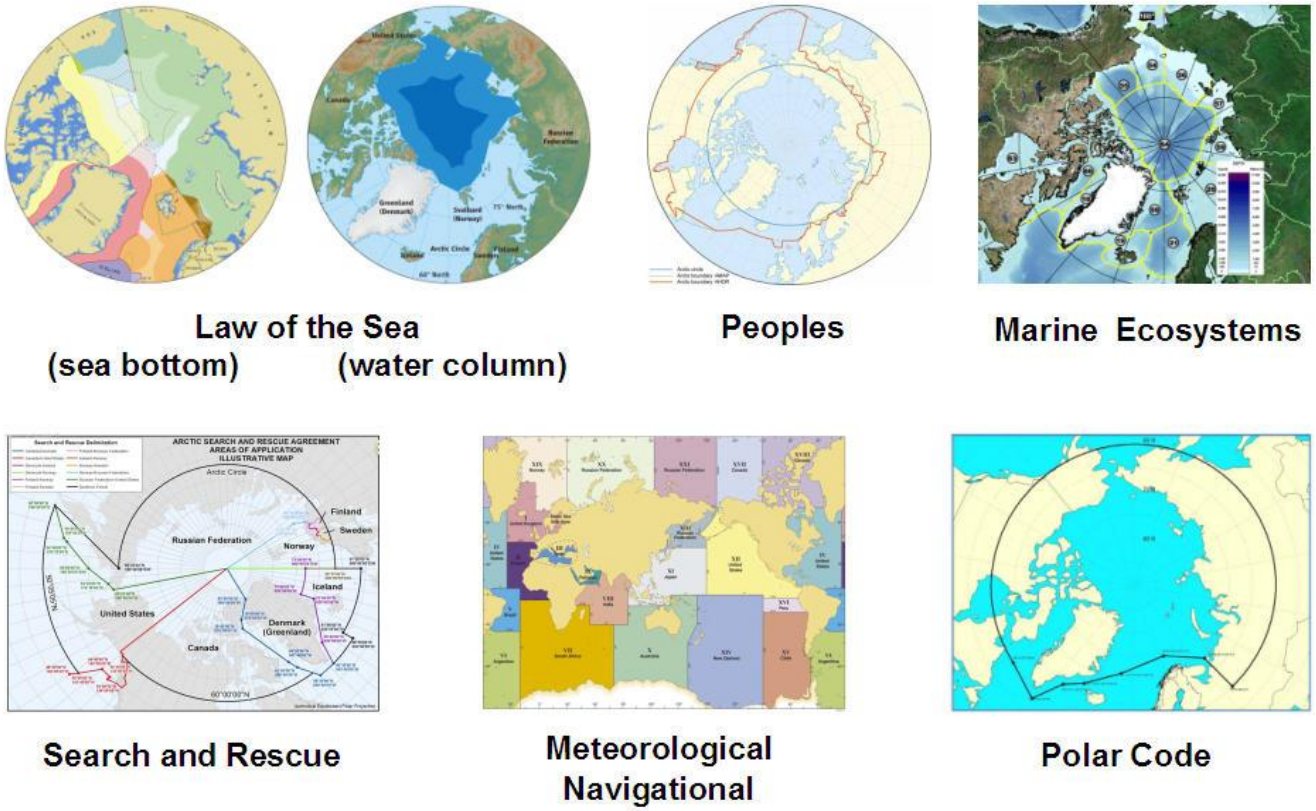

Figure 3: In contrast to the natural boundary (Fig. 2) – subjective boundary configurations in the Arctic Ocean based on: law of the sea[4]; surrounding peoples[5]**;** marine ecosystems[6]; Arctic search and rescue[7] and pollution response[8] agreements; marine navigational[9] and meteorological[10] areas; and pending polar code[11].

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[4] UNCLOS. 1982. *United Nations Convention on the Law of the Sea*. 10 December 1982, Montego Bay, Jamaica.

[5] AHDR. 2004. Arctic Human Development Report. Akureyri: Sustainable Development Working Group.

[6] AMSA. 2009. Arctic Marine Shipping Assessment. Akureyri: Protecting the Arctic Marine Environment.

[7] ASAR. 2011. *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic*. 12 May 2011, Nuuk: Canada, Denmark, Finland, Iceland, Norway, Sweden, Russian Federation and United States.

[8] MOPPRA. 2013. Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response in the Arctic. Kiruna. 15 May 2013, Canada, Denmark, Finland, Iceland, Norway, Sweden, Russian Federation and United States.

[9] NAVAREAS. 2014. Worldwide Navigational Warnings Service - Guidance Document. Publication S53. Monaco, International Hydrographic Office.

[10] METAREAS. 2014 The Global Maritime Distress and Safety System (GMDSS) Services. Geneva. International Meteorological Organization.

[11] IMO. 2014. *Development of an international code of safety for ships operating in polar waters (Polar Code)*, International Maritime Organization, London. (http://www.imo.org/MediaCentre/HotTopics/polar/Pages/default.aspx)

In a practical manner, integrating such diverse perspectives is necessary for informed decision-making about responses to issues, impacts and resources within, across and beyond sovereign jurisdictions in the Arctic Ocean.

b. Environmental State-Change in the Arctic Ocean

With urgency, it is important to recognize that the Arctic Ocean system (Figs. 2-3) is undergoing an environmental state-change, where the boundary conditions of the system are being fundamentally altered. In fact, with the Arctic warming twice as fast as anywhere[12-13], the Arctic Ocean is undergoing the largest environmental state-change on Earth.

The Arctic Ocean system has featured multi-year sea ice, persisting year-round, for as long as 800,000 years[14] and possibly even over millions of years[15]. However, the surface of this maritime region surrounding the North Pole is being transformed from a persistent sea-ice cap to a system with sea ice retreating and advancing seasonally. Rather than projecting out to the mid-21st century, the Arctic Ocean already has crossed a threshold with open water during the summer and first-year sea ice during the winter covering more than 50 percent of its area (Fig. 4). Of greater significance, the volume of Arctic sea ice is in a "death spiral"[16], decreasing more than 70 percent since the late 1970s[17].

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12 Graversen, R.G., Mauritsen, T., Tjernström, M., Källén, E. and Svensson, G. 2008. Vertical structure of recent Arctic warming. *Nature* 451, 53-56.

13 Screen, J.A. and Simmonds, I. 2010. The central role of diminishing sea ice in recent Arctic temperature amplification. *Nature* 464:1334-1337.

14 Overpeck, J.T., Sturm, M., Francis, J.A., Perovich, D.K., Serreze, M.C., Benner, R., Carmack, E.C., Chapin III, F.S., Gerlach, S.C., Hamilton, L.C., Hinzman, L.D., Holland, M., Huntington, H.P., Key, J.R., Lloyd, A.H., Macdonald, G.M., McFadden, J., Noone, D., Prowse, T.,D., Schlosser, P. and Vörösmarty, C. 2005. "Arctic System on Trajectory to New, Seasonally Ice-Free State." *Transactions of the American Geophysical Union* 86(34):309-316.

15 Stickley, C.E., St John, K., Koc, N., Jordan, R.W., Passchier, S., Pearce, R.B. and Kearns, L.E. 2009. Evidence for middle Eocene Arctic sea ice from diatoms and ice-rafted debris. *Nature* 460376-379.

16 Robinson, A.L. 2013. Arctic Sea Ice Volume Death Spiral from PIOMAS (Pan-Arctic Ice Ocean Modeling and Assimilation System) data.

17 Laxon S.W., K. A. Giles, K.A., Ridout, A.L., Wingham, D.J., Willatt, R., Cullen, Kwok, R., Schweiger, A., Zhang, J., Haas, C., Hendricks, S., Krishfield, R., Kurtz, N., Farrell, S., and Davidson, M., 2013. CryoSat-2 estimates of Arctic sea ice thickness and volume. *Geophysical Research Letters* 40:1-6.

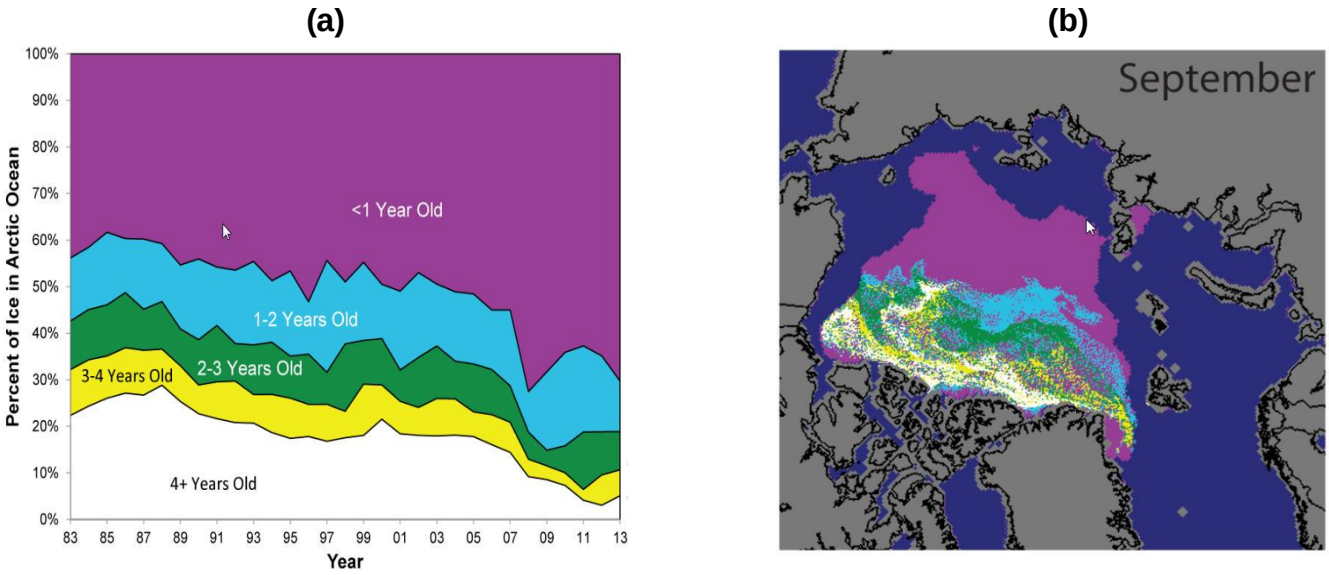

Figure 4: Environmental state-change in the Arctic Ocean[18]. **(a)** Arctic sea-ice composition changes in March (when sea ice extent is maximal) from 1983 to 2013, revealing that multi-year sea ice has been replaced by first-year sea, which now dominates in the Arctic Ocean. **(b)** September 2013 distribution of sea-ice age classes (colours shown in Fig. 4a), revealing that most older sea ice remains next to North America with open water extending from the Bering Strait to the Barents Sea along the Northern Sea Route adjacent to Russia.

It is not a matter of waiting decades or even years for the Arctic Ocean to be completely ice-free during the summer. There is now a new Arctic Ocean, one that lacks a permanent sea-ice cap over most of its area. Like removing the ceiling to a room, the fundamental shift in the surface boundary of the Arctic Ocean has created a new natural system with different dynamics than anything previously experienced by humans in the region.

c. Development in the Arctic Ocean

With increasing accessibility in the Arctic Ocean (Figs. 1 and 4), countries, along with multinational corporations such as ExxonMobil and Royal Dutch Shell, are preparing to exploit the region's enormous energy reserves, estimated to contain 30 percent of the world's undiscovered gas and 13 percent of its undiscovered oil[19]. Commercial harvesting of fish and

[18] Figures courtesy of: NSIDC. 2013. *Arctic Sea Ice News and Outlook.* 2 April and October 2013. Boulder: National Snow and Ice Data Center.

[19] Gautier, D.L., Bird, K.J., Charpentier, R.R., Houseknecht, D.W., Klett, T.R., Moore, T.E, Pitman, J.K., Schenk, C.J., Schunemeyer, J.H., Sørensen, K., Tennyson, M.E., Valin, Z.C., and Wandrey, C.J. 2009. Assessment of Undiscovered Oil and Gas in the Arctic. *Science* 324: 1175-1179.

other living resources may develop without regulation, especially in areas of the Arctic high seas lacking any regional fisheries management organization[20]. Arctic shipping routes are being established to supplement trade through the Panama and Suez Canals[21].

Already, public authorities are taking steps to address policy needs to manage human activities in the Arctic Ocean (Fig. 5). In 2011, representatives of the eight Arctic states signed the *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic* (Ref. 7) at the biennial Arctic Council Ministerial Meeting. Two years later, the Arctic states signed the *Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response in the Arctic* (Ref. 8). The Arctic states are now working on an oil-spill prevention agreement and are also seeking to strengthen their science-policy interface.

Agreements and policy relating to Arctic Ocean also are emerging in other venues (Fig. 5). A legally-binding Polar Code covering the design, construction, and operation of commercial vessels in Arctic waters is being developed through the International Maritime Organization (Ref. 11). The Association of Arctic Expedition Cruise Operators is taking steps to develop a management regime dealing with Arctic ship-based tourism. Various Arctic policies are being developed through the European Parliament, Commission and Council. National security policies relating to the Arctic have been developed by each of the eight Arctic states and are now emerging from non-Arctic states.

All of these measures (Fig. 5) represent important adaptation and mitigation responses to the biophysical and socio-economic impacts associated with expanding human activities in the Arctic Ocean (Figs 1 and 4). A prominent concern, however, relates to the implementation – the transition from *'paper to practice'* – of these policies. It is one thing to sign a document like the Arctic search and rescue agreement; it is another to implement such an agreement in a manner that allows it to operate effectively and adapt to changing conditions.

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[20] Nuuk Statement. 2014. *Chairman's Statement. Meeting on Arctic Fisheries*. Nuuk, Greenland, 24-26 February 2014. Canada, Denmark, Norway, Russian Federation and United States.

[21] Østreng, W., Eger, K.M., Fløistad, B., Jørgensen-Dahl, A., Lothe, L., Mejlænder-Larsen, M. and Wergeland, T. 2013. Shipping in Arctic Waters: A comparison of the Northeast, Northwest and Trans Polar Passages, Dordrecth, Springer.

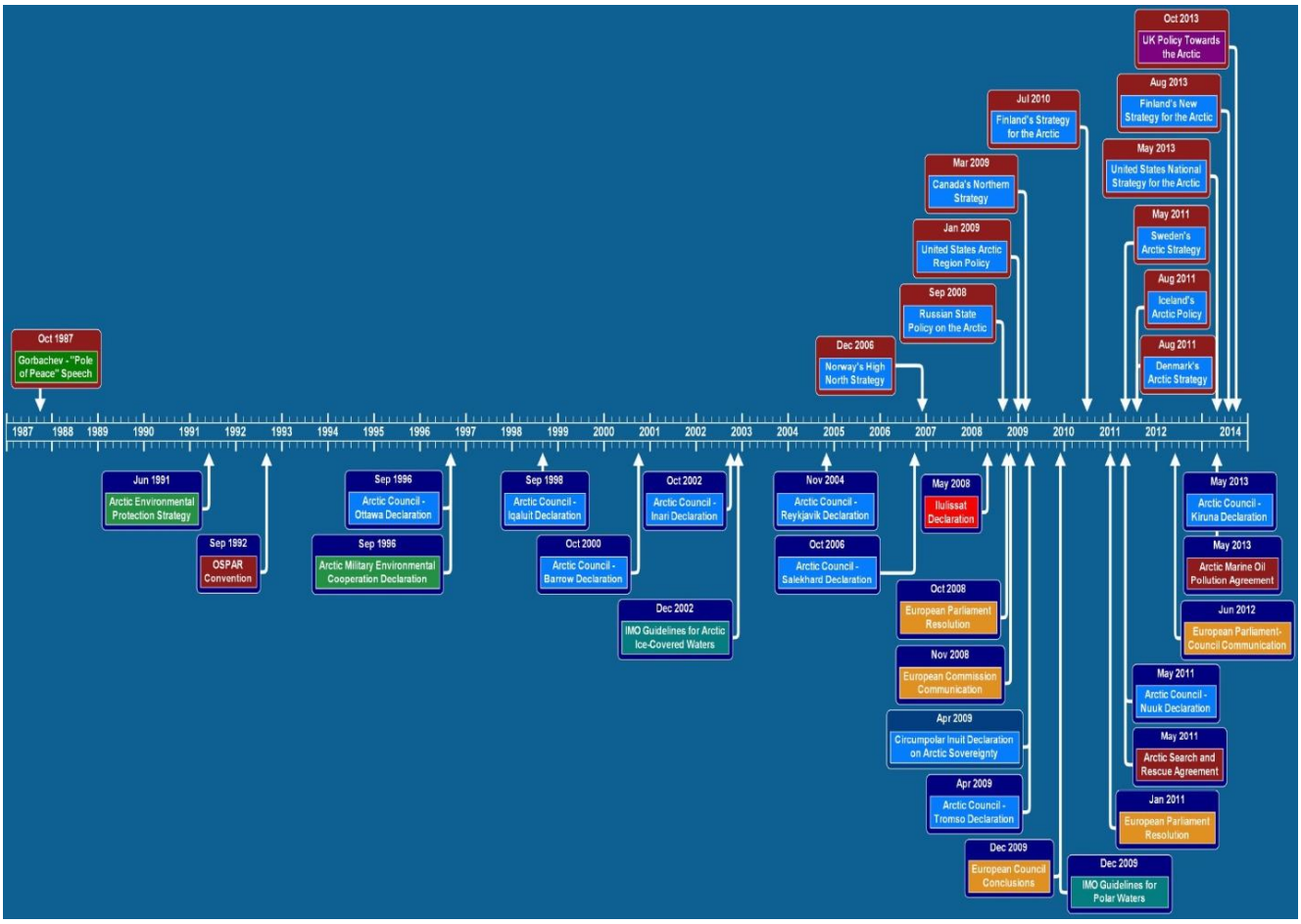

FIGURE 5: Arctic sustainable development phases[22]. Shown is a timeline of Arctic-relevant policy documents that have emerged since the Murmansk speech of Soviet President Mikhail Gorbachev[23]. Colour schemes of international (below the timeline) and national (above the timeline) Arctic policies simply represent documents that are similar in jurisdiction, scope or concept, including: national Arctic strategies; Arctic Council declarations; guidelines from the International Maritime Organization; and European Union policies. Production of policy documents has been accelerating at national and international levels since 2007, much faster than the development of built assets in the Arctic Ocean.

Implementation involves the development of operational measures to ensure that there is an appropriate division of labor among the participants, meshing their individual activities in a

[22] Berkman, P.A. 2015. Institutional Dimensions of Sustaining Arctic Observing Networks (SAON). *Arctic* (in press).

[23] Gorbachev, M. 1987. Speech in Murmansk at the Ceremonial Meeting on the Occasion of the Presentation of the Order of Lenin and the Gold Star to the City of Murmansk, 1 October 1987." (English translation prepared by the Press Office of the USSR Embassy, Ottawa, 1988).

manner that supports their common interests. Equally important, implementation requires the actual construction of built infrastructure. In every case, the challenge will be to devise cost-effective strategies to develop sustainable infrastructure with its policy and built elements, taking into account logistic constraints and stakeholder interests.

d. Holistic Consideration

Arctic Options: Holistic Integration for Arctic-Coastal Marine Sustainability (www.arcticoptions.org) has been designed in an international, interdisciplinary and inclusive manner, involving cost-effective collaboration with currently funded projects to contribute to informed decision-making by policy makers from government and industry (see Box 1, defining terms for *Arctic Options*). In a practical manner, integrating such diverse perspectives is necessary for informed decision-making about responses to issues, impacts and resources within, across and beyond sovereign jurisdictions in the Arctic Ocean.

BOX 1

***ARCTIC OPTIONS* – DEFINITIONS**

Infrastructure: Fixed, mobile and other **built assets** (including observing, communications, research and information systems) as well as regulatory, policy and other **governance mechanisms** (including insurance).

Pan-Arctic: North of the Arctic Circle (Fig. 2).

Options: Practical solutions introduced without advocacy to decision makers from government (local to international) and industry, in contrast to recommendations that involve advocacy and often-polarizing agendas.

Holistic: International, interdisciplinary and inclusive.

Coastal-Marine: From the coastal zone seaward into the central Arctic Ocean.

Sustainability: Involves balance between: (1) environmental protection, economic prosperity and social equity; (2) needs of the present and needs of the future; and (3) national interests and common interests.

The 3-year *Arctic Options* project, which will continue through September 2016, is part of the ArcSEES[24] program that is supported by the National Science Foundation in the United States and Centre national de la recherche scientifique in France. The interlinked goal and objectives of *Arctic Options* (Box 10.2) have been designed to add value across the four ArcSEES themes: (1) The Natural and Living Environment; (2) The Built Environment and Infrastructures; (3) Natural Resource Management and Development; and (4) Governance.

BOX 2

ARCTIC OPTIONS – GOAL AND OBJECTIVES

Project Goal

Implement an holistic process to reveal options that contribute to informed decision-making for sustainable infrastructure development around the Arctic Ocean from the coastal zone seaward (Fig. 1, Box 1).

Holistic Process – Objective 1

Integrate policy documents to reveal their institutional interplay with regard to infrastructure requirements in the Arctic Ocean at diverse jurisdictional levels.

Holistic Process – Objective 2

Integrate Arctic coastal and marine data (from the natural and social sciences) in an efficient, flexible and objective manner for diverse decision-making purposes.

Holistic Process – Objective 3

Integrate stakeholder perspectives about opportunities and risks in Arctic coastal-marine systems to reveal plausible scenarios about infrastructure development across the Arctic Ocean over diverse spatial and temporal scales.

Holistic Process – Objective 4

Distill options for sustainable infrastructure development in a pan-Arctic context (Fig. 1, Box 1), which will be: **(a)** derived from the integrated decision-support process (Objectives 1-3); and **(b)** be shared with decision makers from government (local to international) and industry.

[24] ArcSEES. 2012. Arctic Science and Engineering Education for Sustainability. Program Solicitation: 12533, National Science Foundation, Washington, DC.

Arctic Options involves three 'hot spots' in the Arctic Ocean to design and test a decision-support process that integrates stakeholder perspectives, geospatial information and natural-language documents to address regionally relevant policy issues. The three hot spots are:

- West Greenland;
- Bering Strait Region;
- High Seas in the Arctic Ocean (i.e., beyond the Exclusive Economic Zones in the water column overlying the sea floor) as defined by the law of the sea, most notably the *United Nations Convention on the Law of the Sea* (UNCLOS).[25]

Recognizing the need to consider policy issues across jurisdictions – these three hot spots involve a single State (i.e., Denmark with the autonomous territory of Greenland); two States (United States and Russian Federation); and many States (i.e., more than 160 nations that have ratified UNCLOS), respectively. This *Workshop on Integrated Policy Options for the Bering Strait Region* is the first workshop to apply the decision-support process (see Section 2d) to one of the three hotspots in the *Arctic Options* project.

[25] UNCLOS. 1982. *United Nations Convention on the Law of the Sea*. Signed: Montego Bay, Jamaica, 10 December 1982. Entry into Force: 16 November 1994. (http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm).

2. WORKSHOP FRAMEWORK

a. Bering Strait Region (BSR)

The Bering Strait Region (BSR) has been home for thousands of years to indigenous peoples,[26] who have depended on the natural resources of the region. Subsistence hunting, especially of marine living resources, remains a fundamental feature of the culture and survival of the surrounding native communities in the BSR.[27] To consider the socio-economic and biophysical elements (e.g., Fig. 1) of the BSR, spatial scope of the region was defined for the purposes of this project (Fig. 6), using the following rationale:

- The map is a true polar projection (polar stereographic spheroid) and will include ocean and land (i.e., coastal areas of Alaska in the United States and Chukotka in the Russian Federation) centered on the Bering Strait.

- Eastern and western boundaries are lines of longitude. The western boundary will include the Sea of Anadyr in Chukotka. The eastern boundary will include Norton Sound and Kotzebue Sound in Alaska.

- Southern and northern boundaries are lines of latitude. The southern boundary will be along the latitude projecting from Mys Navirin in Chukotka, which is south of St. Lawrence Island and north of St. Mathew Island to avoid 'industrial fishing' of the Bering Sea proper. The northern boundary will be along the latitude projecting from Point Hope in Alaska.

[26] Hoffecker, J.F., Powers, W.R. and Goebel, T. 1993. The Colonization of Beringia and the Peopling of the New World. *Science* 259:47-53.

[27] Renner, M. and Huntington, H.P. 2014. Connecting subsistence harvest and marine ecology: A cluster analysis of communities by fishing and hunting patterns. *Deep-Seas Research II* 109: 293-299..

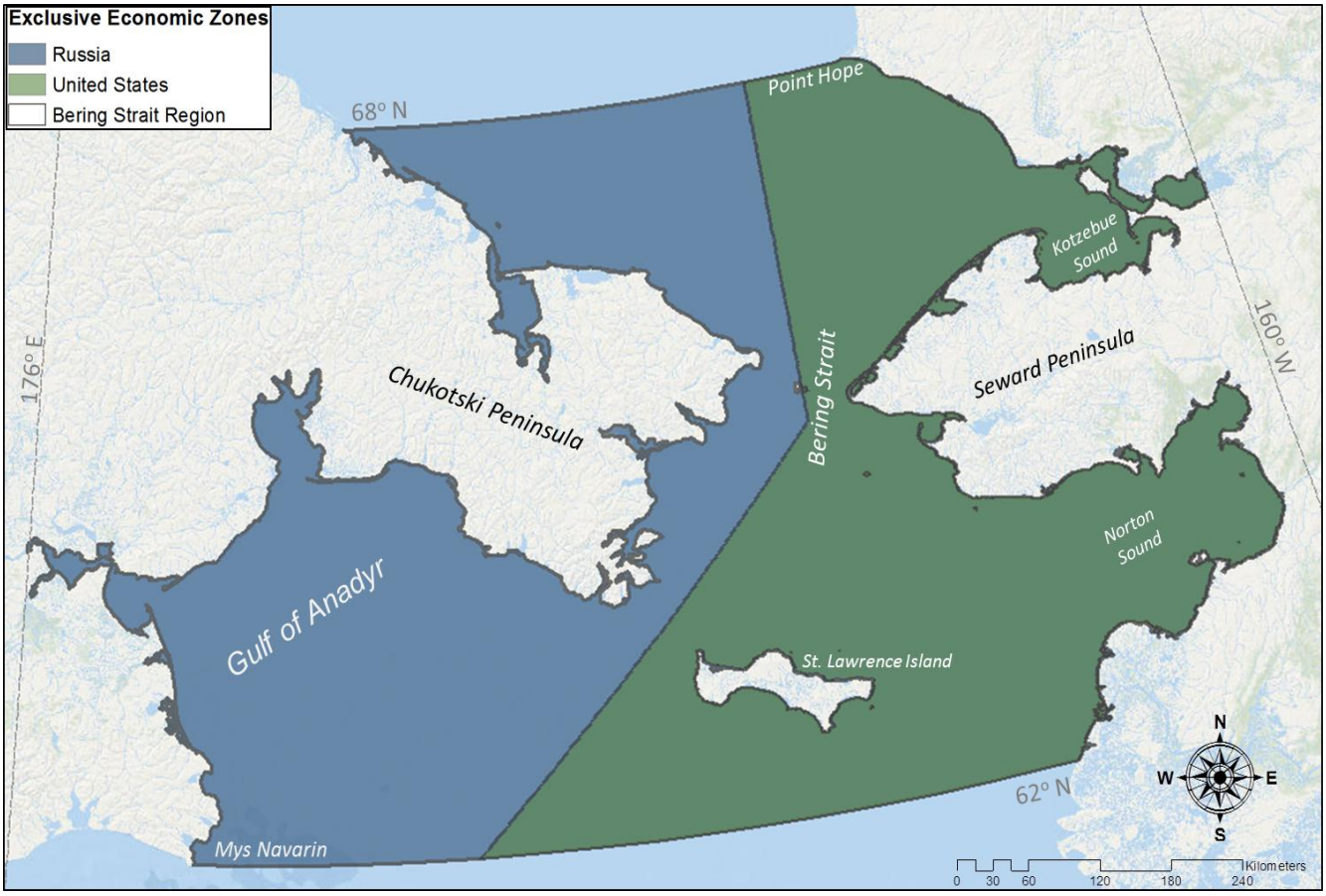

Figure 6: Polygon of the Bering Strait Region (BSR) for the *Arctic Options* project, showing the maritime boundary between the United States and Russian Federation based on their Exclusive Economic Zones, which intersect Little Diomede Island and Big Diomede Island at the center of the Bering Strait. The northern boundary is adjacent to Point Hope (68°N) and southern boundary is adjacent to Mys Navarin (62°N), extending from the 160°W to 176°E and encompassing the coastal-marine systems in between. This map corresponds closely to the proposed transboundary area between the United States and Russian Federation.[28]

Significantly, the BSR is being influenced by climate changes that are altering the dynamics of the associated marine ecosystems and environments. Decreasing sea-ice extent and duration as well as changes in the seasonality of sea-ice coverage alter the water masses, currents and levels of primary production, cascading through the higher trophic levels to the invertebrates, fish and marine mammals in the region.[29,30,31,32] As a consequence, marine

[28] NPS. 2012. Proposed United States / Russian Transboundary Area in the Bering Straits Region. National Parks Service (http://www.nps.gov/akso/beringia/about/pressroom/ProposedTransboundary_EnglishTranslation_Version2.pdf)

[29] Grebmeier, J.M. and others. 2007. A Major Ecosystem Shift in the Northern Bering Sea. *Science* 311:1461-1464.

species' migration patterns have become less predictable, more often resulting in reduced harvests for the dependent human residents of the BSR.[33]

In addition, diminishing sea ice has made the marine environment increasingly accessible for shipping[34,35] through the Bering Strait as well as for fishing[36] and oil-and-gas[37,38] activities in adjacent marine areas. Because the Bering Strait itself is the geographic chokepoint of the Arctic Ocean (only 82 kilometers across at its narrowest), risks of marine ecosystem and environmental impacts from increasing commercial activities are magnified in this particular maritime region.[39]

Moreover, the BSR involves significant governance and geopolitical challenges. As an international strait, all nations have rights and responsibilities for 'innocent passage' as well

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[30] Laidre, K.L. and others. 2008. Quantifying the Sensitivity of Arctic Marine Mammals to Climate-Induced Habitat Change. *Ecological Applications* 18(2): S97–S125.

[31] Huntington, H.P. and Moore, S.E. (eds.) 2008. Arctic Marine Mammals and Climate Change. *Ecological Applications* 18: Special Volume. (http://www.esajournals.org/toc/ecap/18/sp2)

[32] Laidre, K.L. and others. 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. *Conservation Biology* (in press).

[33] Fall, J.A. and others. 2013. Continuity and change in subsistence harvests in five Bering Sea communities: Akutan, Emmonak, Savoonga, St. Paul, and Togiak. *Deep-Seas Research II:* 94:273-291.

[34] Allen, A.S. 2014. The development of ships' 'routeing measures in the Bering Strait: Lessons learned from the North Atlantic right whale to protect local whale populations*. Marine Policy* 50:215-226. -127.

[35] Huntington, H.P. and others. 2014. Vessels, risks, and rules: Planning for safe shipping in Bering Strait. *Marine Policy* 51:119

[36] Huntington, H.P. and others. 2013. Local and traditional knowledge regarding the Bering Sea ecosystem: Selected results from five indigenous communities. *Deep-Sea Research II* 94(2013)323–332.

[37] Hovelsrud, G.K., McKenna, M. and Hutington, H.P. 2008. Marine Mammal Harvests and Other Interactions with Humans. *Ecological Applications*, 18(2):S135–S147.

[38] Schwehr, K.D. and McGillivary, P.A. 2007. Marine Ship Automatic Identification System (AIS) for Enhanced Coastal Security Capabilities: An Oil Spill Tracking Application. IN: Marine Technology Society. Oceans 2007. Pp. 1-9.

[39] Hillmer-Pegram, K. and Robards, M.D. 2015. Relevance of a Particularly Sensitive Sea Area to the Bering Strait Region: a Policy Analysis Using Resilience-Based Governance Principles. *Ecology and Society* 20(1): 26-38.

as 'transit passage'.[40] As the region of closest proximity between the United States and Russian Federation, the Bering Strait involves national decision-making about diverse issues that are resolved separately in the two adjacent exclusive economic zones.[41] While not unique to the BSR, consistency among marine management strategies of adjacent states involves their building common interests.

Within the United States and Russian Federation, there are regional jurisdictions of Alaska and Chukotka, respectively. However, jurisdictional relationships between national and regional authorities differ on either side of the Bering Strait. At the center are the surrounding communities and villages, involving the historic residents of the BSR.

b. Workshop Goal and Objectives

The following goal and objectives of the *Workshop on Integrated Policy Options for the Bering Strait Region* were adapted from the *Arctic Options* project (Box 2), recognizing the unique features and challenges facing the BSR (Fig. 6).

Goal: Identify emerging issues and contribute to informed decision-making about these issues for sustainable development of the BSR.

Objective 1: Integrate stakeholder perspectives about emerging issues, opportunities, risks and uncertainties in the BSR;

Objective 2: Integrate coastal-marine data to identify biophysical and socio-economic impacts, trends and patterns in the BSR;

[40] UNCLOS. 1982. *United Nations Convention on the Law of the Sea*. Signed: Montego Bay, 10 December 1982.

[41] Ebbin, S.A., Hoel, A.H. and Sydnew, A.K. (eds.). 2005. A Sea Change: The Exclusive Economic Zone and Governance Institutions for Living Marine Resources. Springer.

Objective 3: Integrate existing policy documents at diverse jurisdictional levels to reveal their institutional interplay with regard to infrastructure and management requirements in the BSR;

Objective 4: Integrate information and analyses associated with Workshop Objectives 1-3 (above) to derive policy options that will contribute to informed decision-making for the BSR.

Beyond providing the Workshop framework, the above goal and objectives provided the basis to assess Workshop outcomes.

c. Decision-Support Process

Together, the Workshop Objectives underlie a decision-support process (Fig. 7) that integrates stakeholder perspectives, geospatial data and policy documents to reveal options for sustainable infrastructure development (Box 1) in the BSR. As the ultimate outcome of the decision-support process (Fig. 7), options for policies will be generated as a contribution to sustainable infrastructure development for the BSR (Box 1). The "options" can be used or ignored by the decision-makers without the bias, advocacy or interference that generally are associated with "recommendations." The process of generating policy options is designed for contributing to informed decision-making.

The decision-support process (Fig. 7) is effectively initiated by stakeholders, whose insights about risks and uncertainties highlight the priorities for sustainable infrastructure development. Stakeholders include decision-makers from government, industry and civil society, whose participation is necessary throughout the decision-support process. In this way, the decision-makers are helping to define the strategies for sustainable infrastructure development collectively, rather than responding to priorities conceived by others.

The “holistic” approach (Box 1) is intended to be comprehensive with regard to the types of information resources that will be integrated into the decision-support process. Along with stakeholder perspectives, there also are geospatial data that reveal rates, trends, patterns, interactions and other dynamics of biophysical as well as socio-economic systems. In addition, there are policy documents, which reflect previous data syntheses that have been distilled into actions with societal relevance.

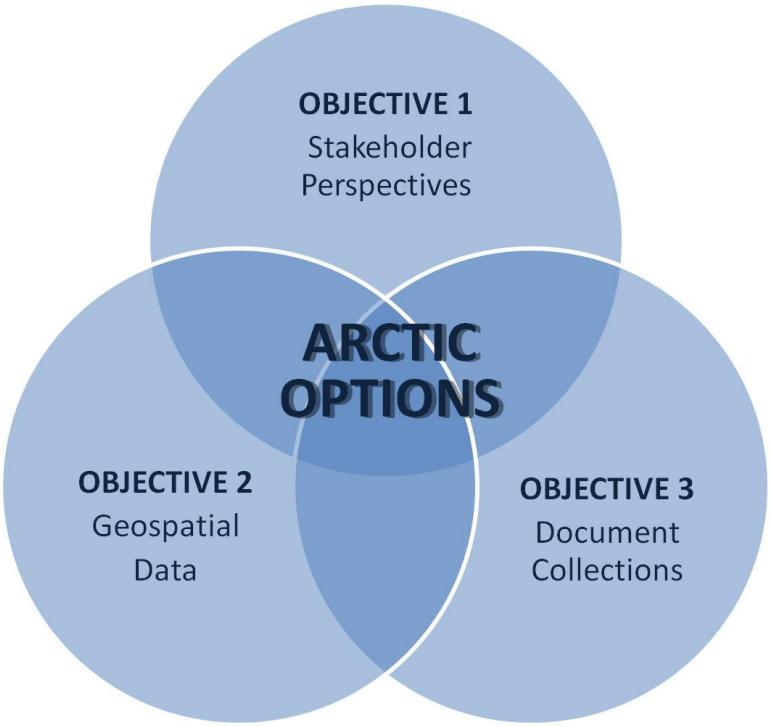

Figure 7: Integrated decision-support process for the Arctic Options project (Box 2),[42] utilizing diverse types of information to synthesize sustainable infrastructure options (see Workshop Objectives) for the Bering Sea Region (Fig. 6).

In a general sense, to be comprehensive, the decision-support process must be:

- International;
- Interdisciplinary; and
- Inclusive.

The biggest challenge is to be inclusive, which is an open-ended approach, emphasizing a dynamic process rather than static outcomes. This process is designed to be iterative and open-ended, responsive to ever-changing circumstances and perspectives.

[42] Arctic Options. 2015. *Arctic Options: Holistic Integration for Arctic Coastal-Marine Sustainability*. Funded by the US National Science Foundation and French Centre national de la recherché scienique (www.arcticoptions.org).

3. INTEGRATION OF STAKEHOLDER PERSPECTIVES

a. Inclusive Consideration of BSR Stakeholders

A necessary element of the decision-support process (Fig. 7) is effective inclusion of stakeholder perspectives. Such inclusion goes beyond just merely distributing outcomes to the stakeholders, but actively working to engage them throughout the process because:

- Stakeholders rely on resources of the region;
- Stakeholders have vested interests in sustainable development of the region; and
- Stakeholders are stewards with policy-making as well as implementation responsibilities for sustainable development of the region.

With stakeholders, it is useful to draw a clear distinction between actors and institutions. Actors are individual or organizations capable of making (and implementing) decisions; institutions are the rules of the game governing the actions of actors and the forums within which actors interact with one another. The member states are actors, whereas UNCLOS (Ref. 25) is an institutional arrangement. The International Maritime Organization (IMO)[43] is an actor; the Polar Code (Ref. 11) will be an institutional arrangement. The Arctic Council is an unusual case. It is mainly a forum but shows some signs of becoming an actor, as with the search-and-rescue (Ref. 7) and oil-spill (Ref. 8) agreements. Stakeholders are actors. But their options are shaped by the prevailing rules of the game. Some of the issues that concern them have to do with proposed revisions (either formal or informal) in the rules of the game.

[43] IMO. 2015. International Maritime Organization. (http://www.imo.org).

It is useful also to classify actors/stakeholders into a few basic types or categories, including:

- public sector actors;
- private sector actors; and
- civil society actors.

For our purposes, public sector actors include governments and public agencies located within governments. Private sector actors include both domestic and transnational corporations. Civil society actors include environmental non-governmental organizations, indigenous peoples' organizations, scientific bodies, and others (e.g., unions, churches). Some actors are mixed types or hard to classify, such as state-owned enterprises, corporations dominated by states (e.g., Gazprom), or corporations created under various Native claims settlements, suchas the Alaska Native village and regional corporations established under Alaska Native Claims Settlement Act (ANCSA)[44] and organizations whose members include states as well as individuals (e.g., International Union for the Conservation of Nature). More and more, we also have public-private-partnerships (PPPs), such as the Yamal Liquid Natural Gas project.

Of course, actors can operate at different levels of social organizations (e.g. local, regional, national, international); some may be subordinate to others as in the case of lower level governments in federal systems. This gives rise to the phenomenon of multi-level governance in which various levels of government interact with one another on the basis of some more or less clear-cut allocation of authority across levels.

A common phenomenon is ambiguity regarding the division of labor both horizontally and vertically. Many Alaskan communities, for example, have a public government, a tribal

[44] ANCSA. 2015. *United States Code (USC), Title 43, Chapter 33 - Alaska Native Claims Settlement.* (https://www.law.cornell.edu/uscode/text/43/chapter-33).

government, and an ANCSA village corporation. The horizontal division of labor among these bodies is not always clear. Similar issues arise with regard to vertical interactions, especially in federal systems (e.g., the division of authority between the State of Alaska and the Federal government in the United States). In the BSR, these vertical interactions also differ between the United States and Russian Federation. AND all these relationships may be subject to change over time, so that the exact identity and authority of the stakeholders are variables whose values can and do shift over time.

For the BSR, stakeholders can be characterized within the domains of:

- Government (Table 1a);
- Indigenous peoples (Table 1b);
- Business (Table 1c); and
- Non-governmental organizations (Table 1d).

Each of these domains also crosses jurisdictional levels (i.e., international, national, state and region). Consequently, information for each domain (Tables 1a-d) includes jurisdictional contexts and institutional details along with possible contacts who may be willing and able to share perspectives. In the spirit of inclusion, intention is to reach out to these diverse stakeholders and engage them in the decision-support process (Fig. 7) for the BSR. Stakeholder collaborations also will be sought to refine and elaborate Tables 1a-d.

TABLE 1a: Stakeholders in the Bering Strait Region – Governmental					
Jurisdiction	Region	Agency / Institution		Contact	
		Name	Website	Name	Email
International	global	International Maritime Organization	http://www.imo.org	Heike Deggim, Senior Deputy Director	hdeggim@imo.org
International	global	Other institutions to be included			
United States	national	Department of Commerce, Coast and Geodic Survey	http://www.ngs.noaa.gov/	Juliana Blackwell, Director	ngs.infocenter@noaa.gov
United States	national	Department of Commerce, National Marine Fisheries Service	http://www.nmfs.noaa.gov/		
United States	national	Department of Commerce, National Marine Sanctuaries Office	http://sanctuaries.noaa.gov/welcome.html	Daniel Basta, Director	sanctuaries@noaa.gov
United States	national	Department of Defence, Army Corps of Engineers	http://www.usace.army.mil/Home.aspx	Thomas Bostick, Commanding General	hq-publicaffairs@usace.army.mil
United States	national	Department of Defence National Geospatial-Intelligence Agency	https://www.nga.mil/Pages/default.aspx	Robert Cardillo, Director	publicaffairs@nga.mil
United States	national	Department of Defence, NorthCom	http://www.northcom.mil/Home.aspx	William Gortney, Commander	n-nc.peterson.n-ncspecialstaff.mbx.cska-foia-omb@mail.mil
United States	national	Department of Defence, US Navy	http://www.navy.com/navy.html	Ray Mabus, Secretary of the Navy	
United States	national	Department of Homeland Security	http://www.dhs.gov/	Jed Johnson, Secretary	
United States	national	Department of Homeland Security, US Coast Guard	http://www.uscg.mil/	Paul Zukunft, Commandant	
United States	national	Department of Interior, Bureau of Indian Affairs	http://www.bia.gov/	Kevin Washburn, Assistant Secretary	
United States	national	Department of Interior, Bureau of Land Management	http://www.blm.gov/wo/st/en.html	Neil Kornze, Director	director@blm.gov
United States	national	Department of Interior, Bureau of Ocean Energy Management	http://www.boem.gov/	Abigail Ross Hopper, Director	BOEMPublicAffairs@boem.gov
United States	national	Department of Interior, Bureau of Safety and Environmental Enforcement	http://www.bsee.gov/	Brian Salerno, Director	bseewebmaster@bsee.gov
United States	national	Department of Interior, Fish and Wildlife Service	http://www.fws.gov/	Dan Ashe, Director	dan_ashe@fws.gov
United States	national	Department of Interior, National Park Service	http://www.nps.gov/index.htm	Jonathan Jarvis, Director	Jon_Jarvis@nps.gov
United States	national	Department of Interior, Office of Policy Analysis	http://www.doi.gov//ppa/index.cfm	Joel Clement, Director	joel_clement@ios.doi.gov

TABLE 1a: Stakeholders in the Bering Strait Region – Governmental					
Jurisdiction	Region	Agency / Institution		Contact	
		Name	Website	Name	Email
United States	national	Department of Interior, US Geological Survey	http://www.usgs.gov/	Suzette Kimball, Director	suzette_kimball@usgs.gov
United States	national	Department of State, Bureau of Oceans Environmental and Scientific Affairs	http://www.state.gov/e/oes/	David Balton, Chair Senior Arctic Officials to the Arctic Council	
United States	national	Department of Transportation	http://www.dot.gov/	Anthony Foxx, Secretary	
United States	national	Department of Transportation, Maritime Administration	http://www.marad.dot.gov/index.htm	Paul Jaenichen	careersafloat@dot.gov
United States	national	Environmental Protection Agency	http://www.epa.gov/	Gina McCarthy, Administrator	
United States	national	Federal Emergency Management Administration	https://www.fema.gov/	William Craig Fugate, Administrator	
United States	national	Interagency Arctic Research Policy Committee	http://www.iarpccollaborations.org	Simon Stephenson, IARPC Chair	Simon_N_Stephenson@ostp.eop.gov
United States	national	National Aeronautics and Space Administration	http://www.nasa.gov/	Charles Bolden, Administrator	
United States	national	National Science Foundation, Division of Polar Programs	http://www.nsf.gov/div/index.jsp?div=PLR	Kelly Falkner, Director	
United States	national	National Security Council	https://www.whitehouse.gov/administration/eop/nsc		
United States	national	Securities and Exchange Commission, Office of International Affairs	http://www.sec.gov/oia		
United States	national	US Arctic Research Commission	http://www.arctic.gov/	Fran Ulmer, Chair	
United States	national	US Global Change Research Program	http://www.globalchange.gov/	Chris Weaver, Executive Director	
United States	national	Whitehouse, Office of Science Technology Policy (OSTP)	https://www.whitehouse.gov/administration/eop/ostp	John Holdren, Assistant to the President for Science and Technology	
United States	national	Whitehouse, OSTP, National Ocean Council	https://www.whitehouse.gov/administration/eop/oceans	Elizabeth Kerttula, Director	elizabeth_j_kerttula@ostp.eop.gov
United States	Alaska	Alaska Arctic Policy Commission	http://www.akarctic.com/	Nikoosh Carlo, Executive Director	nikoosh.carlo@akleg.gov
United States	Alaska	Alaska Oil and Gas Conservation Commission	http://doa.alaska.gov/ogc/	Dan Seamount, Commissioner	dan.seamount@alaska.gov
United States	Alaska	Arctic Waterway Safety Committee	https://www.institutenorth.org/news/entry/arctic-water-ways-safety-committee-presentations	Willie Goodwin, Chair	
United States	Alaska	Beluga Whale Committee	http://www.north-slope.org/departments/wildlife-management/co-management-organizations/alaska-	Harry Brower, Vice Chair	harry.brower@north-slope.org

TABLE 1a: Stakeholders in the Bering Strait Region – Governmental					
Jurisdiction	**Region**	**Agency / Institution**		**Contact**	
		Name	**Website**	**Name**	**Email**
			beluga-whale-committee#CommMembersDocs		
United States	**Alaska**	Department of Commerce, Community and Economic Development	http://commerce.state.ak.us/commissioner.htm#	Chris Hladick, Commissioner	chris.hladick@alaska.gov
United States	**Alaska**	Department of Environmental Conservation	http://dec.alaska.gov/	Larry Hartig, Commissioner	dec.commissioner@alaska.gov
United States	**Alaska**	Department of Fish and Game	http://www.adfg.alaska.gov/index.cfm?adfg=home.main	Carmen Daggett, Arctic Region Advisory Committee	
United States	**Alaska**	Department of Natural Resources	http://dnr.alaska.gov/commis/pic/dnrdirectory.htm	Mark Myers, Commissioner	mark.myers@alaska.gov
United States	**Alaska**	Department of Revenue	http://dor.alaska.gov/	Randall Hoffbeck, Commissioner	randall.hoffbeck@alaska.gov
United States	**Alaska**	Department of Transportation	http://www.dot.alaska.gov/comm/index.shtml	Mark Luiken, Commissioner	dot.commissioner@alaska.gov
United States	**Alaska**	Ice Seal Committee	http://www.north-slope.org/departments/wildlife-management/co-management-organizations/ice-seal-committee#CommMembersDocs	Mike Pederson, Executive Manager	mike.pederson@north-slope.org
United States	**Alaska**	Limited Entry Commission	http://www.cfec.state.ak.us/	Frank Homan, Chair	dfg.cfec.questions@alaska.gov
United States	**Alaska**	Nanuuq Commission	http://thealaskananuuqcommission.org/	Jack Omelak, Executive Director	
United States	**Alaska**	State Legislature	http://w3.legis.state.ak.us/	John Coghill, Majority Leader	john.coghill@akleg.gov
United States	**Alaska**	Walrus Commission	http://www.kawerak.org/ewc.html	Vera Metcalf, Director	VMetcalf@kawerak.org
United States	**Alaska**	Whaling Commission	http://www.aewc-alaska.com/	Harry Brower, Chair	harry.brower@north-slope.org
Russian Federation	**national**	Agencies to be included			
Russian Federation	**Chukotka**	Anadyrsky District	http://anadyr-mr.ru/		
Russian Federation	**Chukotka**	Chukotsky District	http://www.chukotraion.ru/		
Russian Federation	**Chukotka**	Iultinsky District	http://iultinsky.munrus.ru/in/md/main		
Russian Federation	**Chukotka**	Providensky District	http://www.provadm.ru/		

TABLE 1b: Stakeholders in the Bering Strait Region – Indigenous Peoples					
Region	**Organization**			**Contact**	
	Name	**Locality**	**Website**	**Name**	**Email**
Alaska	Alaska Federation of Natives	Statewide	http://www.nativefederation.org/	Julie Kitka, President	afninfo@NativeFederation.org
Alaska	Alaska Native Claims Settlement Act	Statewide	http://ancsaregional.com/	Michelle Anderson, President	Cindy@ancsaceos.org
Alaska	Bering Sea Alliance	Wales	http://www.beringseaalliance.com	Art Ivanoff, CEO	ivanoffart49@gmail.com
		Saint Michael			
		Stebbins			
		Unalakleet			
		Gambell			
		Golovin			
		Sitnasuak.			
Alaska	Bering Straits Native Cooperation	Brevig Mission	http://beringstraits.com	Nome Headquarters	info@beringstraits.com
		Council			
		Golovin			
		Inalik			
		King Island			
		Koyuk			
		Mary's Igloo			
		Nome			
		Shaktoolik			
		Shishmaref			
		Solomon			
		St. Michael			
		Stebbins			
		Teller			
		Unalaklett			
		Wales			
		White Mtn			
Alaska	Kewark	Brevig Mission	http://www.kawerak.org/	Nome Headquarters	contact@kawerak.org
		Council			
		Diomede			
		Elim			
		Gambell			
		Golovin			
		King Island			
		Koyuk			

TABLE 1b: Stakeholders in the Bering Strait Region – Indigenous Peoples					
Region	**Organization**			**Contact**	
	Name	**Locality**	**Website**	**Name**	**Email**
		Mary's Igloo			
		Nome			
		Savoonga			
		Shaktoolik			
		Shishmaref			
		Solomon			
		St. Michael			
		Stebbins			
		Teller			
Alaska	Maniilaq Association	Point Hope	http://www.maniilaq.org	Timothy Schuerch, President	timothy.schuerch@manillaq.org
		Kivalina			
		Noatak			
		Kozebue			
		Noorvik			
		Kiana			
		Selawik			
		Ambler			
		Shungnak			
		Kobuk			
		Deering			
		Buckland			
Alaska	NANA Regional Corporation	Northwest Alaska	http://nana-dev.com/	Clyde Gooden, Vice President	
Alaska	Northwest Arctic Borough	Ambler	http://www.nwabor.org	Reggie Joule, Borough Mayor	rjoule@nwabor.org
		Buckland			
		Deering			
		Kiana			
		Kivalina			
		Kobuk			
		Kotzebue			
		Noatak			
		Noorvik			
		Selawik			
		Shungnak			

TABLE 1b: Stakeholders in the Bering Strait Region – Indigenous Peoples						
Region		**Organization**			**Contact**	
		Name	**Locality**	**Website**	**Name**	**Email**
Alaska	**Chukotka**	Shared Beringian Heritage Program	Northwest Alaska and Chukota Peninsula	http://www.nps.gov/akso/beringia/index.cfm	Janis Kozlowski, Program Manager	janis_kozlowski@nps.gov
Chukotka		Russian Association of Indigenous Peoples of the North (RAIPON)	Chukotka plus other regions of the Russian Federation	http://www.arctic-council.org/index.php/en/about-us/permanent-participants/russian-association-of-indigenous-peoples-of-the-north-raipon/123-resources/about/permanent-participants	Grigoriy Ledkov, President	raipon@raipon.info
Chukotka		Other organizations to be included				

TABLE 1c: Stakeholders in the Bering Strait Region – Business				
Company			Contact	
Industry	Name	Website	Name	Email
Maritime Construction	Brice	www.briceinc.com/marine	Barry Lindquist, General Manager	barryl@briceinc.com
Maritime Construction	Cruz Marine	www.cruzmarine.com		
Maritime Shipping	ASTRAMAR	www.astramar.net/en/contact_us/main	Alexander Sprishevsky, Director of the Board	astramar@astramar.net
Maritime Shipping	Alaska Logistics	www.alaska-logistics.com	Allyn Long, President	allyn@alaska-logistics.com
Maritime Shipping	Crowley Maritime Corp	www.crowley.com	Greg Pavellas, Director, Marine Operations	greg.pavellas@crowley.com
Maritime Shipping	Nordic Bulk Carriers	www.nordicbulkcarriers.com	Cindy Sam, Manger	cs@nordic-bulk.com
Maritime Shipping	Northern Transport Ltd	www.ntcl.com	William Smith, Vice President	customerservicedesk@ntcl.com
Maritime Shipping	Southport Maritime	www.southportmaritime.com	Michael Corey, President	fix@southportmaritime.com
Oil and Natural Gas	ConocoPhillips	www.conocophillips.com	Ryan Lance, CEO	
Oil and Natural Gas	Mieco	www.mieco.com	Masahiro Yamazaki, President	myamazaki@mieco.com
Oil and Natural Gas	Exxon	www.corporate.exxonmobil.com	Rex W. Tillerson	rex.w.tillerson@exxonmobil.com
Oil and Natural Gas	Shell Alaska	www.shell.us		alaska@shell.com
Oil and Natural Gas	Suncor	www.suncor.com	Steve Williams, President	info@suncor.com
Petroleum Distribution	CPD Alaska LLC	www.cpdalaska.com	Bob Cox, Vice President	formmailer@crowley.com
Petroleum Distribution	Delta Western	www.deltawestern.com	Kirk Payne, President	kirkp@Deltawestern.com
Petroleum Distribution	Vitus Marine	http://vitus-energy.com/vitus-marine	Mark Smith, CEO	info@vitusmarine.com
Seafood	Norton Sound Economic Development Corp	www.nsedc.com	Dan Harrelson, CEO	
Security	Stimson	www.stimson.org	David Michael, Senior Associate	dmichel@stimson.org
Tour Operators & Promoters	Arctic Cruises	www.expeditions.com/destinations/arctic		
Tour Operators & Promoters	Lindblad Expeditions	www.expeditions.com	Sven Lindblad, CEO	
Tour Operators & Promoters	Adventure Canada	www.adventurecanada.com		
Tour Operators & Promoters	Companies du Ponant	www.luxuryonly.com		
Tour Operators & Promoters	Expedition Cruises	www.adventure-life.com/cruises/ships	Brian Morgan, CEO	
Tour Operators & Promoters	Lynden	www.lynden.com/ltia	Jon Burdick, CEO	information@lynden.com
Tour Operators & Promoters	Hapag-Lloyd Cruises	www.hl-cruises.com		
Tour Operators & Promoters	Peregrine Cruises	www.peregrineadventures.com/Arctic	Glenyce Johnson, CEO	
Tour Operators & Promoters	Silver sea Expeditions	www.silversea.com/Official-Site	Enzo Vistone, CEO	
Tour Operators & Promoters	Spitsbergen Cruises	www.arcticodysseys.com	Robin Doberow, CEO	
Vessel Services	Bowhead Transport	www.bowheadtransport.com	James Dwight, Director	
Vessel Services	Boyer	www.boyertowing.com	Tyler Richardson, CEO	hq@boyertowing.com
Vessel Services	Foss Maritime	www.foss.com	Gary Faber, President	info@foss.com
Vessel Services	Northland Services	www.northlandservices.com	Tom Martin, CEO	CustomerService@northlandservices.com

TABLE 1d: Stakeholders in the Bering Strait Region – Non-Governmental Organization				
Organization			Contact	
Type	Name	Website	Name	Email
Environmental	Alaska Community Action on Toxics	http://www.akaction.org	Pamela Miller, Executive Director	pamela@akaction.org
Environmental	Audubon	http://audubon.org	Dave Shaw, Alaska Board	audubon@emailcustomerservice.com
Environmental	Conservation International	http://ci.org	Peter Seligmann, Chairman	media@conservation.org
Environmental	Greenpeace	http://greenpeace.org	Phil Radford, Director	info@wdc.greenpeace.org
Environmental	Mission Blue	http://missionblue.org	Charlotte Vick	
Environmental	Natural Resource Defence Council	http://nrdc.org	Lisa Speer, Director of Oceans Program	ckeeves@nrdc.org
Environmental	North American Marine Environmental Protection Association	http://namepa.org	Carleen Lynden-Kluss, Executive Director	contact@namepa.net
Environmental	Ocean Conservancy	http://oceanconservancy.org	Andrew Hartsig, Arctic Program Director	ahartsig@oceanconservancy.org
Environmental	Oceana	http://oceana.org	Susan Murray, Deputy VP, US Pacific Executive Committee	northpacific@oceana.org
Environmental	Oceanic Preservation Society	http://ops.org	Louie Psihoyos, Executive Director	info@opsociety.org
Environmental	Pacific Environment	http://www.pacificenvironment.org	Kevin Harun, Arctic Program Director	kharun@pacificenvironment.org
Environmental	Pew Charitable Trusts	http://www.pewtrusts.org/en	Marilyn Heiman, Director	mhieman@pewtrusts.org
Environmental	Trustees for Alaska	http://www.trustees.org	Victoria Clark, Executive Director	ECOLAW@TRUSTEES.ORG
Environmental	World Wildlife Fund	http://wwf.org	Miriam Geitz, Senior Project Officer	mgeitz@wwf.no
Industry	Marine Exchange of Alaska	http://www.mxak.org	Ed Page, Executive Director	edpage@mxak.org
Scientific	Arctic Council, Arctic Contaminants and Action Programme (ACAP)	http://www.arctic-council.org/index.php/en/acap-home	Mr. Jaakko Henttonen, ACAP Chair	henttonj@ebrd.com
Scientific	Arctic Council, Arctic Monitoring and Assessment Programme (AMAP)	http://www.amap.no/	Lars-Otto Reiersen, AMAP Chair	lars-otto.reiersen@amap.no
Scientific	Arctic Council, Conservation of Arctic Fauna and Flora (CAFF)	http://www.caff.is/	Risa Smithy, CAFF Chair	risa.smith@ec.gc.ca
Scientific	Arctic Council, Emergency Preparedness and Response (EPPR)	http://www.arctic-council.org/eppr/	Ole Kristian Bjerkemo, EPPR Chair	ole-kristian.bjerkemo@kystverket.no
Scientific	Arctic Council., Protection of the Arctic Marine Environment (PAME)	http://www.pame.is/	Soffia Gudmundsdottir, PAME Executive Secretary	pame@pame.is
Scientific	Arctic Council, Sustainable Development Working Group (SDWG)	http://www.arctic-council.org/index.php/en/about-us/working-groups/sustainable-development-working-group-sdwg	Jutta Wark, SDWG Chair	Jutta.Wark@aadnc-aandc.gc.ca
Scientific	International Arctic Science Committee (IASC)	http://iasc.org	Susan Barr, IASC President	susan.barr@ra.no

b. Initial Analysis of BSR Impact Risks and Uncertainties

Impact drivers or forces of change are fundamental to the design and implementation of sustainable infrastructure development for the BSR. Among the various possible approaches to identify and rank the impact drivers, in every case it is necessary to understand stakeholder perspectives. More importantly, it is essential to integrate stakeholder perspectives into the overall infrastructure planning.

The workshop involved experts (see Appendix 2: Workshop Participants) who could share perspectives and information from different key stakeholder groups that relate to the BSR:

- Indigenous peoples from native communities subsisting in the BSR;
- United States agencies managing BSR resources, impacts and activities;
- Russian institutions concerning the productivity of the BSR;
- Commercial enterprises utilizing the BSR and its resources;
- Non-governmental organizations protecting BSR ecosystems and cultures;
- Natural and social scientists researching sustainable development of the BSR; and
- International organizations responding to human activities that involve the BSR.

To understand their perspectives on the BSR, the 23 workshop participants were guided through a day-long interactive process to identify and rank the key BSR drivers (Table 2):

- The first step involved 'brainstorming,' where each participant was asked to identify a possible BSR impact. This step was conducted several times around the room until the identified impacts began to repeat, generating a list of 64 possible impact drivers (Table 2).

- The second step involved individual assessments of the risks and uncertainties among the possible impact drivers (Table 2), characterized in terms of:

- Likelihood of occurrence (Low - Medium - High);
- Spatial scale (Small - Medium - Large);
- Temporal scale (Near-Term - Long-Term); and
- Intensity (Minor - Major).

❖ The third step involved those impact drivers that were considered to have major intensity with long-term consequences, reducing the list to 11 possible impact drivers. In this step, six impact drivers that also were considered to have high likelihood and large footprint within the BSR, were ranked from 1-3 (Table 2).

❖ The fourth step involved classifying the six most significant impacts and determining whether each was a primary driver (D) and/or primary response (R).

The highest ranked BSR impact drivers (Table 2) from these stakeholder analyses are summarized as:

Cultural: Subsistence (R)
Biophysical: Sea-Ice (D) / Marine Ecosystems (R)
Socio-economic: Ship Traffic (R) / Subsistence (R) / Oil and Gas (D/R)
Institutional: Marine governance (D/R)

TABLE 2: Identification and Ranking of BSR Impact Risks and Uncertainties												
Impact		Likelihood of Occurrence			Scale					Intensity		Rank
					Spatial			Temporal				
		Low	Medium	High	Small	Medium	Large	Near-Term	Long-Term	Minor	Major	
1	Changing sea-ice cover			X			X		X		X	1
2	Patterns of ship traffic through the BSR (numbers, types, timing)			X			X		X		X	1
3	Offshore oil-and-gas activity			X			X		X		X	2
4	Marine ecosystem changes in productivity			X			X		X		X	2
5	Marine governance (regional to international)			X			X		X		X	3
6	Loss of subsistence (e.g., contaminants, general change in marine environment)			X			X		X		X	3
7	Sea-level rise			X		X			X		X	
8	Coastal erosion			X		X			X		X	
9	World oil-and-gas market prices			X		X			X		X	
10	Increased or changing commercial or industrial fishing		X		X				X		X	
11	Investment in local marine built and policy infrastructure	X				X			X		X	
12	Terrestrial Mining – support of Arctic marine transport systems (e.g. Pevek to Canada)											
13	Marine mammal population change											
14	Commercial partnerships between stakeholders (owners / stewards) – agreements without regulation and to avoid conflicts											
15	Geopolitical / economic competition between China, US and Russia in the Arctic											
16	Ocean acidification											
17	Increased marine tourism											
18	Corridor of native communities – Bering Strait choke point for a variety of purposes (e.g., currents, migrations, shipping)											
19	Major maritime disaster (tanker, cruise ship, oil platform, vessel grounding)											
20	Legal uniqueness of the Bering Strait											
21	Changing range of wildlife (e.g., fish, birds, marine mammals)											
22	Creation of unique Park – Beringia											
23	Increased nearshore pollution from coastal development											
24	Invasive species (e.g., with ballast, plastics)											

TABLE 2: Identification and Ranking of BSR Impact Risks and Uncertainties												
Impact		Likelihood of Occurrence			Scale					Intensity		Rank
					Spatial			Temporal				
		Low	Medium	High	Small	Medium	Large	Near-Term	Long-Term	Minor	Major	
25	International Maritime Organization conventions (e.g., safety of life at sea, marine pollution, training)											
26	Increased knowledge and technology to understand the environment, region and human activities											
27	Availability and cost of shipping insurance											
28	Noise pollution from marine activities and associated impacts on subsistence											
29	Increased freshwater run-off (e.g., salinity, ice-cover and precipitation changes)											
30	Increased use of renewable resources											
31	Presences or absence of management regimes for the BSR											
32	Increased investment in BSR (public and private) – total dollars / rubles											
33	Bering Strait tunnel / rail linking Russia and US											
34	Flow of oil through BSR – increased tanker traffic											
35	Infrastructure for navigation (e.g., safety, traffic schemes, aids to navigation)											
36	Atmospheric deposition in the Arctic											
37	Overexploitation of fish stocks											
38	Protection of historical and cultural heritage											
39	Aquaculture development global											
40	Marine debris											
41	Migration of species (e.g., birds, mammals, fish)											
42	Escalation of militarization in the Arctic											
43	Increased storms											
44	Emerging persistent organic pollutants in the Arctic (atmospheric)											
45	Communication infrastructure gaps											
46	Agreement with local communities (land owners) around BSR											
47	Disaster from floating nuclear power plants											
48	Disease outbreak (e.g., bird flu)											

TABLE 2: Identification and Ranking of BSR Impact Risks and Uncertainties												
Impact		Likelihood of Occurrence			Scale					Intensity		Rank
					Spatial			Temporal				
		Low	Medium	High	Small	Medium	Large	Near-Term	Long-Term	Minor	Major	
49	Disaster response team development											
50	Scientific Cooperation among US and Russia in the BSR											
51	Extinction of species that may have impact on subsistence											
52	Natural disasters (e.g., earthquakes, tsunami)											
53	Citizen fatigue of small-scale communities from increased participation in discussions											
54	Allocation of scarce resources for Arctic infrastructure – state, national, public funding											
55	Methane hydrates leaks onshore and offshore – (gigaton wild card)											
56	Increased seawater temperatures											
57	Capacity for marine enforcement											
58	Biophysical tipping points (non-linear / unexpected changes)											
59	Increased global concern and awareness about BSR											
60	Marine mammal disease											
61	Road to the West Coast of Alaska											
62	Socio-economic impacts (eg., suicide, alcoholism)											
63	Use of traditional knowledge											
64	Visa-free travel in BSR											

Results and priorities of the stakeholder analyses from this *Workshop on Integrated Policy Options for the Bering Strait Region* (Table 2) are comparable to those from the North Slope Science Initiative (NSSI).[45]

[45] Lee, O., Lassuy, D., Payne, J. and Eicken, H. 2014. *Scenarios to prioritize observing activities on the North Slope, Alaska, in the context of resource development, climate change and socio-economic uncertainties.* International Arctic Research Center Poster (PA51C-4062). American Geophysical Union 2014 Fall Meeting, San Francisco.

4. INTEGRATION OF GEOSPATIAL DATA

a. Methodology for Cumulative Human Impact (CHI) Assessment

The Cumulative Human Impact (CHI) model[46] can be used to synthesize geospatial data and assess the combined impact of stressors on marine habitats around the globe. This framework is well suited for regional application[47,48] and is being adapted for the BSR (Fig. 8) to assess current and projected impacts of human stressors on the marine environment.

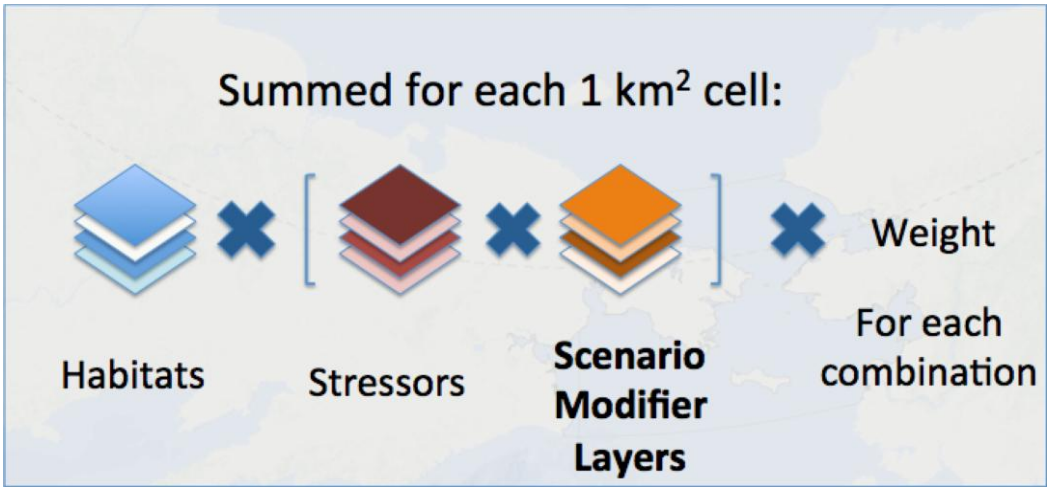

Figure 8: Framework for Cumulative Human Impact (CHI) model that will be applied by the *Arctic Options* project in the Bering Strait Region.

The CHI model will rely on high-resolution geospatial data for stressors and habitats within the BSR. Stressors include factors such as shipping, pollution, changes in sea surface temperature, fishing and land-based pollutants. Importantly, the stressors for the BSR will include those that have been prioritized by its stakeholders (Table 2).

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[46] Halpern, B.S. and others. 2008. A global map of human impact on marine ecosystems. *Science*, *319*:948-952.

[47] Selkoe, K.A., Halpern, B.S. and Toonen, R.J. 2008. Evaluating anthropogenic threats to the Northwestern Hawaiian Islands. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *18:*1149-1165.

[48] Halpern, B.S. and others. 2009. Mapping cumulative human impacts to California Current marine ecosystems. *Conservation Letters*, *2*:138-148.

Each stressor will have a unique impact weight for each habitat it affects, as determined from expert insight or a review of the literature. Each habitat-stressor combination is then summed and the final output is a single data layer for the region at 1-km resolution representing the total cumulative impact of all local stressors on the effected marine environment. In addition, different modifiers will be applied to each stressor layer to model likely future states, calculate their expected impact and compare the results to the present (Fig. 8).

Data to be used in the CHI analysis for the BSR are being stored in an extensive data catalogue by the *Arctic Options* project,[49] which includes more than 500 online datasets that are referenced by region (e.g., BSR, global, pan-Arctic, Russian Arctic) with information about the data: source, type, metadata and online location; impact category; geographic scope; time range and frequency; and spatial and temporal resolution. Impact categories in the data catalogue include:

- Land use;
- Biodiversity;
- Climate;
- Demography;
- Energy;
- Fisheries;
- Habitat;
- Indigenous Populations;
- Infrastructure;
- Jurisdiction;
- Landcover;
- Oceanography;
- Pollution;
- Sea Ice; and
- Shipping.

[49] Arctic Options Data Catalogue. 2015. *Catalogue of Coastal-Marine Biophysical and Socio-Economic Data from the Arctic Ocean*. (http://arcticoptions.org/resources).

Data used in the CHI analyses for the BSR will vary in spatial scale and resolution. Many of the climate stressors are being developed using global data at high resolution while other stressors, such as commercial fishing, are being updated at the scale of the Bering Strait. As an example, we could use estimates of increased shipping intensity in the near future to calculate the expected impacts shipping will have on the local marine environment and use the result to inform policy options regarding shipping in the BSR. Figure 9 illustrates the CHI output from a regional analysis that was completed for the California Current.

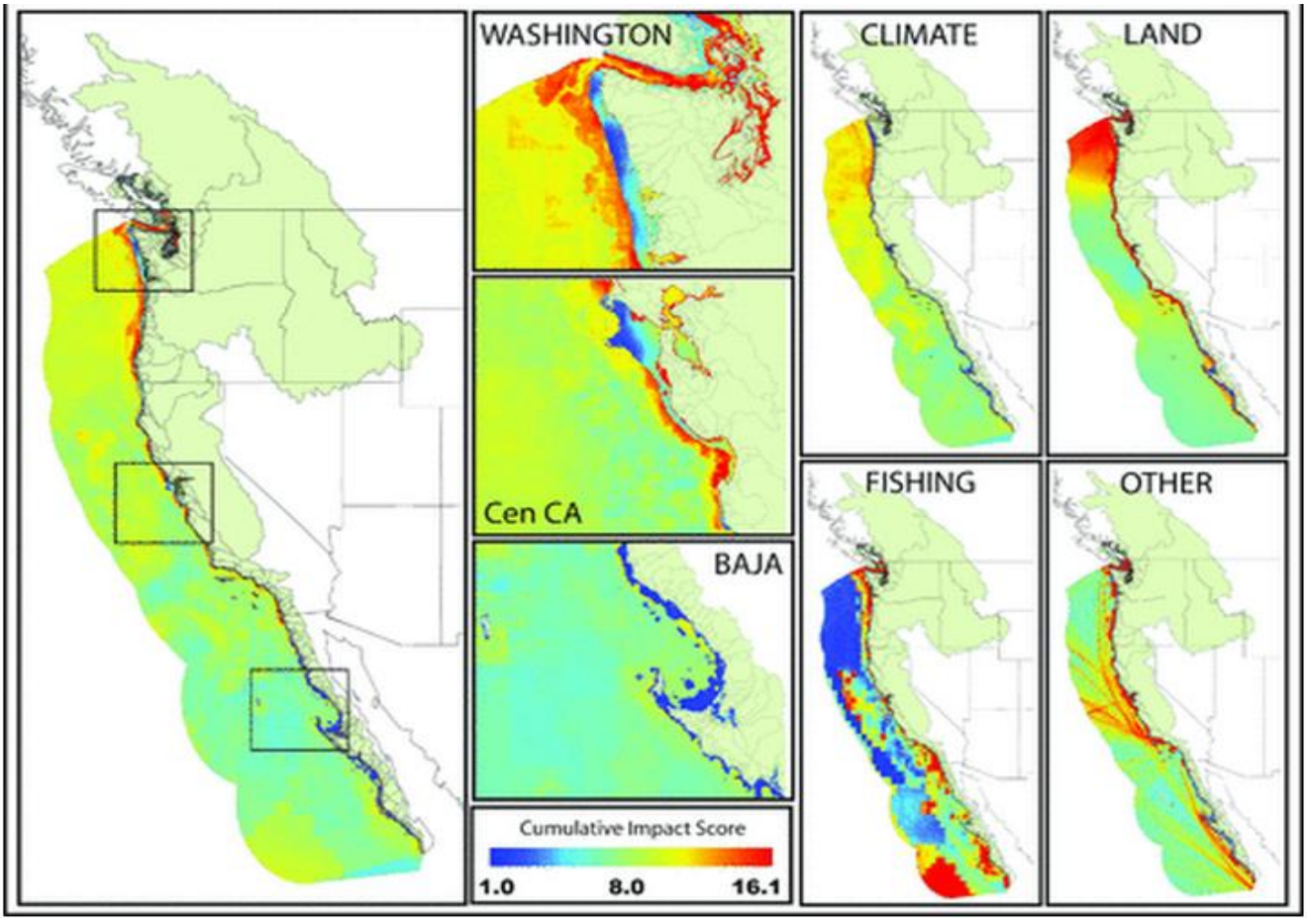


Figure 9: Cumulative Human Impact (CHI) map of 25 different human activities on 19 different marine ecosystems within the California Current with close-up views of three regions (Washington State, central California, and central Baja California), and impact partitioned into four sets of human activities of particular interest: climate change (n=3 layers), land-based sources of stress (n=9 layers), all types of fishing (n=6 layers), and other ocean-based commercial activities (n=7 layers). Puget Sound is the reticulated bay in Washington; San Francisco Bay is the large bay in Central California; and Tijuana is at the Mexican border with California. Figure from Halpern et al. 2009 (see Reference 44).

b. Automatic Identification System (AIS) Visualization

Sea-ice and shipping data are the key drivers identified in the stakeholder analyses (Table 2). Sea-ice data for the Arctic Ocean are publically accessible from the National Snow and Ice Data Center[50] and other national data repositories. However, shipping data are more difficult to obtain. Consequently, a significant feature of the geospatial analyses for the BSR is the unique pan-Arctic dataset of ship traffic from Automatic Identification System (AIS) messages collected from satellites by SpaceQuest Ltd.[51] since 2009. Currently, SpaceQuest Ltd. has four polar-orbiting satellites, each collecting AIS data across a 5000-km swath every 100 minutes, enabling real-time synoptic observations of shipping traffic that can be interpreted in view of sea-ice changes across the entire Arctic Ocean within 24-hour periods (Fig. 10).

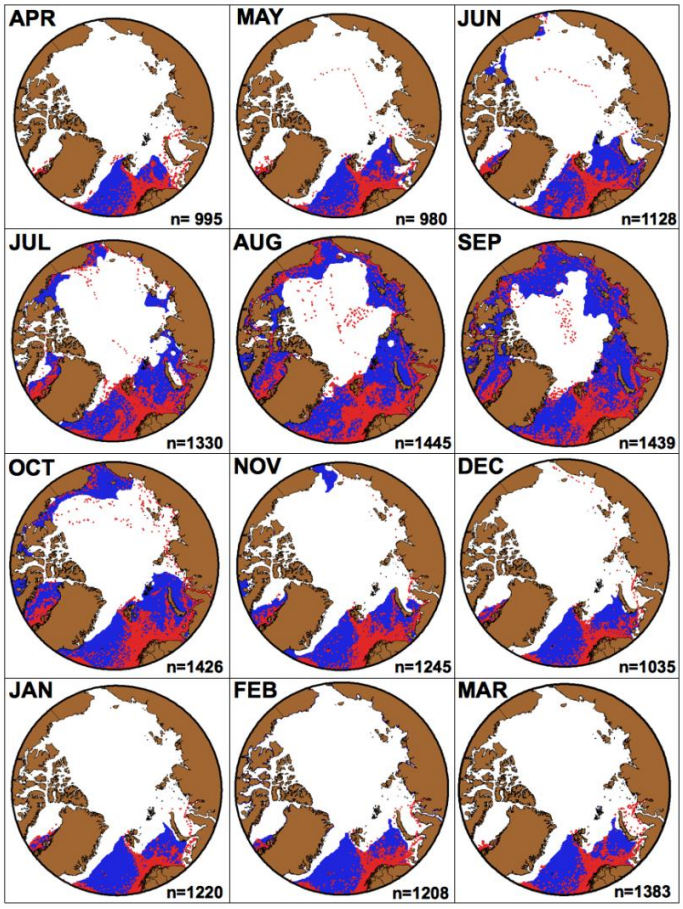


FIGURE 10: Geographic Information System (GIS) analyses of surface vessel positions (red), derived from Automatic Identification System (AIS) messages received by the SpaceQuest-satellite constellation within every 24-hour period from April 2010 through March 2011.[52] Aggregated on a monthly basis north of the Arctic Circle (66.5°N), more than 280,000 time-stamped AIS messages were received. Monthly median extent of sea ice (white) and open water (blue) from passive-microwave satellite measurements are shown with land (brown) and number of ships (n). The ship identifications reveal more than 3200 distinct vessels with the largest densities in perennially ice-free areas as well as year-round operations in ice-covered areas.

[50] NSIDC. 2015. National Snow and Ice Data Center (http://nsidc.org/data/seaice/)

[51] Spacequest Ltd. (http://www.spacequest.com/).

[52] Eucker, W. 2011. *A Geospatial Analysis of Arctic Marine Traffic*. Doctorate Dissertation, University of Cambridge.

Networks of ground stations as well as satellites receive AIS messages that are required from passenger vessels and ships greater than 300 gross tonnage.[53] AIS messages are encoded with each ship's Maritime Mobile Service Identity (MMSI) and International Maritime Organization (IMO) number as well as its dimensions, Global Navigation Satellite System position, speed and other navigational data.[54] In addition, further information about the physical and cargo characteristics for each ship is available on the International Telecommunications Union MMSI database[55] (Table 3).

TABLE 3: List of Attributes Encoded in Automatic Identification System (AIS) Messages

- MMSI unique identification number;
- IMO ship identification number that remains unchanged upon registration transfer;
- Vessel Name;
- Type of ship / cargo (e.g., see Fig. 10);
- Navigation status (at anchor, under way using engine(s) or not under command);
- Rate of turn – right or left, 0 to 720 degrees per minute;
- Speed over ground;
- Position accuracy;
- Longitude and Latitude;
- Course over ground;
- True Heading;
- Time stamp (UTC, time accurate to nearest second when this data was generated);
- International radio call sign, assigned to the vessel by its country of registry;
- Dimensions of ship;
- Type of positioning system (e.g., Global Position System or LORAN-C);
- Location of positioning system's antenna onboard the vessel;
- Draught of ship (0.1 meter to 25.5 meters);
- Destination; and
- Estimated time of arrival at destination.

[53] SOLAS. 2002. *International Convention for the Safety of Life at Sea*, Chapter V (1 July 2002).

[54] Technical characteristics for an automatic identification system using time-division multiple access in the VHF maritime mobile band *(International Telecommunications Union,* ITU R M.1371-4, April 2010).

[55] International Telecommunications Union maritime database: Particulars of Ship Stations (http://www.itu.int/online/mms/mars/ship_search.sh).

Preliminary work has been completed to visualize daily AIS and sea-ice data from the BSR from July through October of 2014 (Fig. 11). The web-based visualization (http://arcticoptions.org/arcticshipping) provides an animated display of ship and sea-ice locations throughout the target period for diverse ship categories (e.g., dredging, enforcement, fishing, icebreaker, research) that can be selected by the user. By applying the SpaceQuest Ltd. Satellite AIS data, this visualization will be extended back to August 2009.

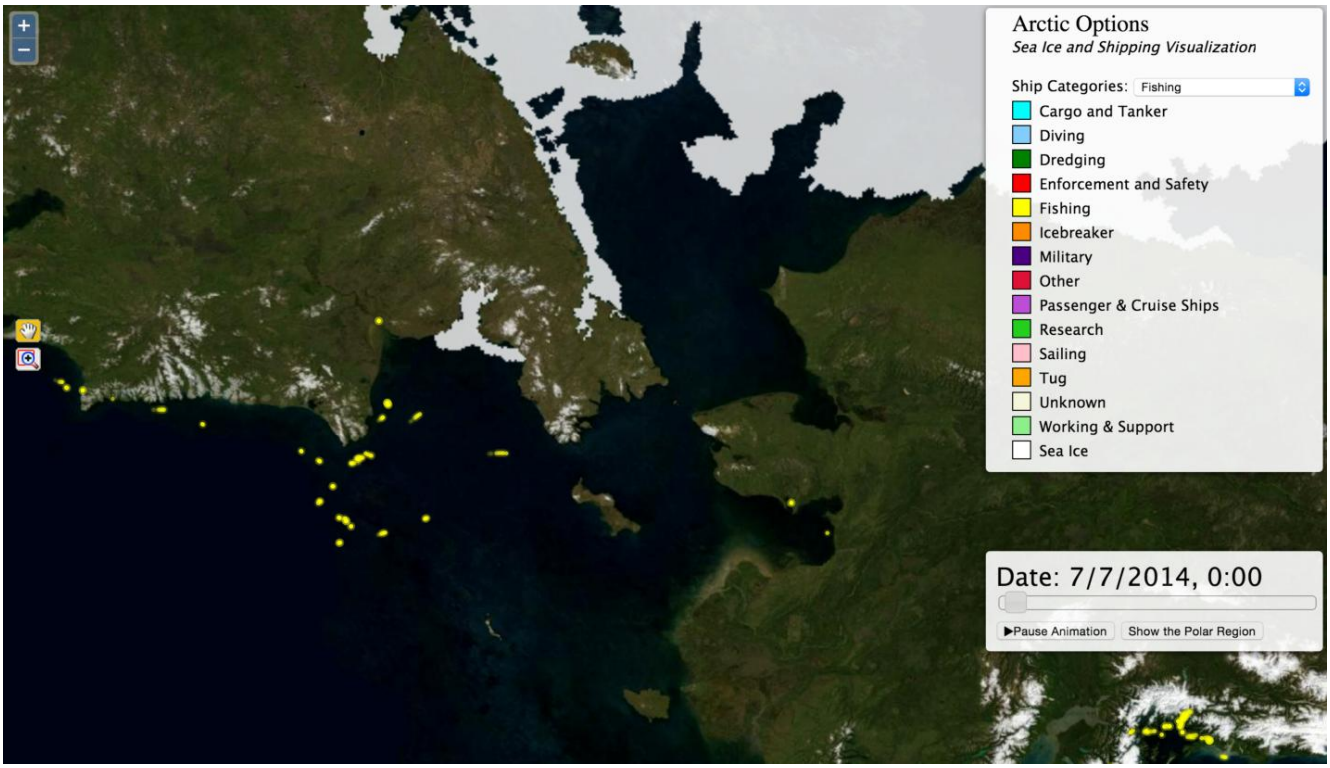


Figure 11: Snapshot of pan-Arctic visualization (http://arcticoptions.org/arcticshipping) with satellite sea-ice data from the National Snow and Ice Data Center and Automatic Identification System data from SpaceQuest Ltd.

In addition to the visualization, the AIS shipping dataset will be further analyzed quantitatively to interpret patterns, trends and relationships in view of other biophysical and socio-economic features in the BSR. For example, Figure 11 clearly shows that fishing activities vary markedly on the Russian and U.S. sides of the BSR, which are exposed to different fishery regulations, even though fish and other ecosystem components don't discriminate between geopolitical boundaries. Understanding such features is important to integrate geospatial information effectively into the policy options (Fig. 6).

To ground truth the AIS data, satellite and land-based messages will be compared, utilizing information collected from the Marine Exchange of Alaska[56] (e.g., Fig. 12).

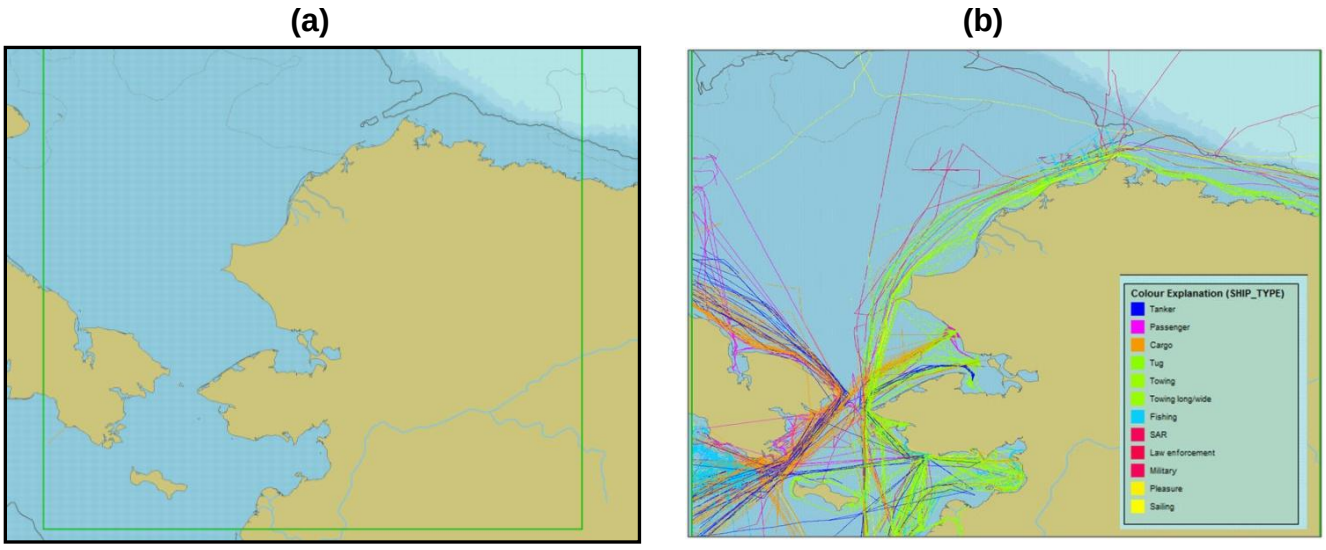
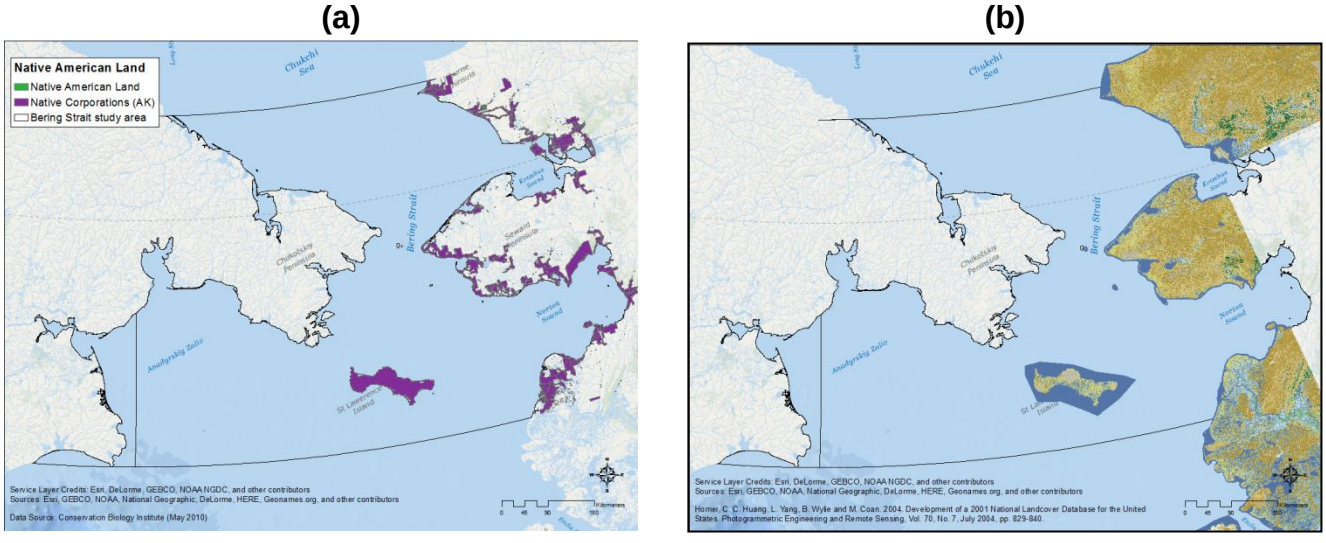


Figure 12: Automatic Identification System (AIS) from ground stations associated with the Marine Exchange of Alaska during the **(a)** winter and **(b)** summer from June through October in 2013.

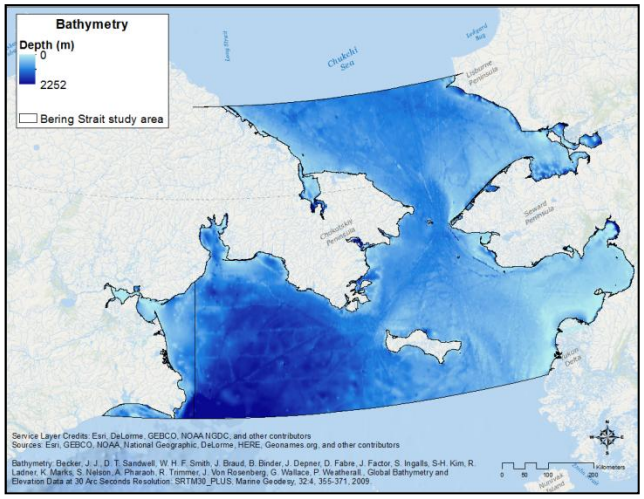
c. Initial BSR Data Maps

The following maps (Figs. 13a-k), constructed as Geographic Information System (GIS) layers, illustrate the geospatial date that will be incorporated into the CHI analyses (Fig. 8).

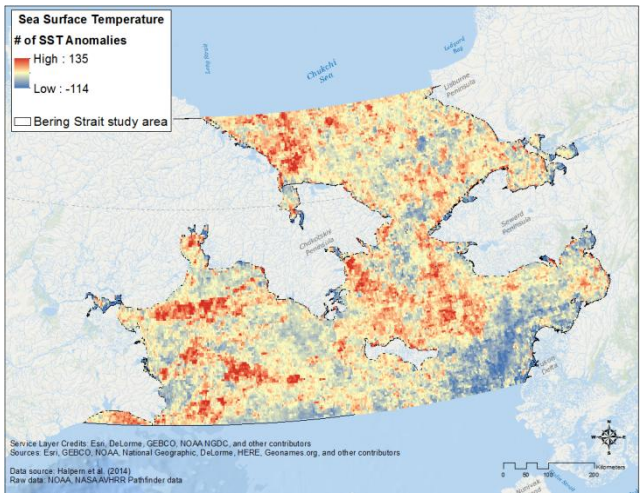


[56] Alaska. 2015. Marine Exchange of Alaska. Automatic Identification System (AIS) Information Links. (http://www.mxak.org/vtrack/ais.html).

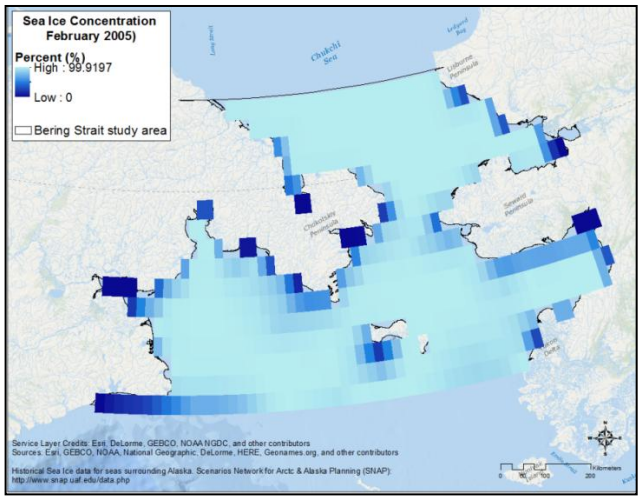
(c)


Bathymetry
Depth (m)
0
2252
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Bathymetry: Becker, J. J., D. T. Sandwell, W. H. F. Smith, J. Braud, B. Binder, J. Depner, D. Fabre, J. Factor, S. Ingalls, S-H. Kim, R. Ladner, K. Marks, S. Nelson, A. Pharaoh, R. Trimmer, J. Von Rosenberg, G. Wallace, P. Weatherall, Global Bathymetry and Elevation Data at 30 Arc Seconds Resolution: SRTM30_PLUS, Marine Geodesy, 32:4, 355-371, 2009.

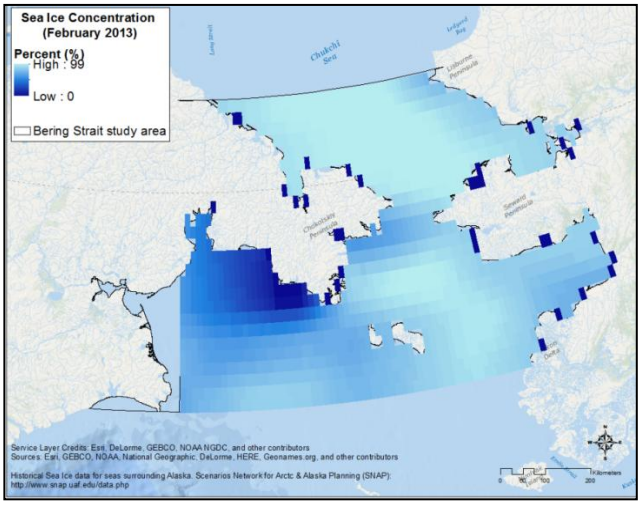
(d)


Sea Surface Temperature
# of SST Anomalies
High : 135
Low : -114
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data source: Halpern et al. (2014)
Raw data: NOAA, NASA AVHRR Pathfinder data

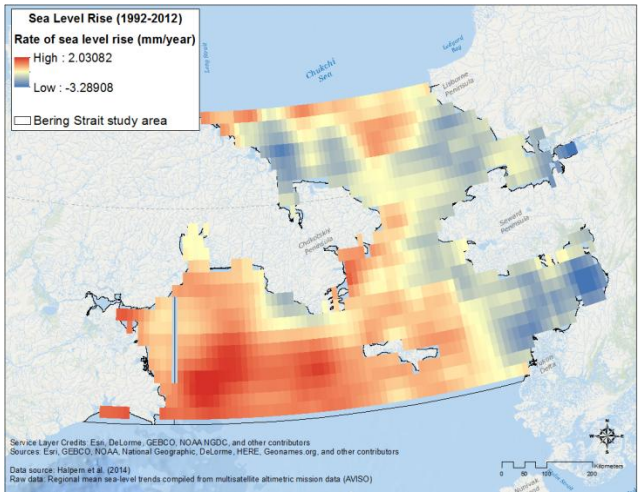
(e)


Sea Ice Concentration
February 2005)
Percent (%)
High : 99.9197
Low : 0
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Historical Sea Ice data for seas surrounding Alaska. Scenarios Network for Arctic & Alaska Planning (SNAP):
http://www.snap.uaf.edu/data.php

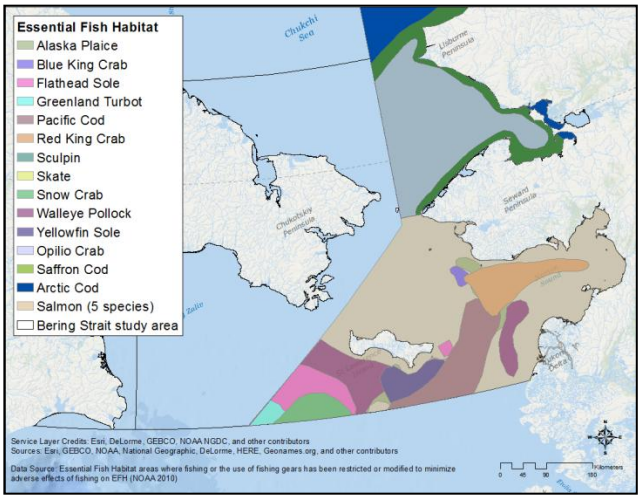
(f)


Sea Ice Concentration
(February 2013)
Percent (%)
High : 99
Low : 0
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Historical Sea Ice data for seas surrounding Alaska. Scenarios Network for Arctic & Alaska Planning (SNAP):
http://www.snap.uaf.edu/data.php

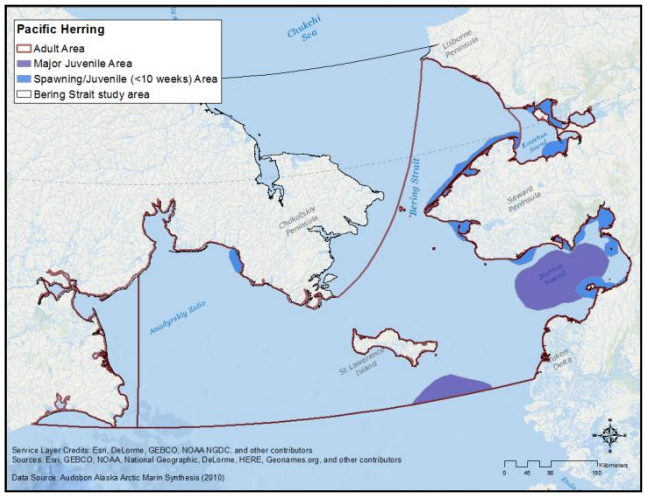
(g)


Sea Level Rise (1992-2012)
Rate of sea level rise (mm/year)
High : 2.03082
Low : -3.28908
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data source: Halpern et al. (2014)
Raw data: Regional mean sea-level trends compiled from multisatellite altimetric mission data (AVISO)

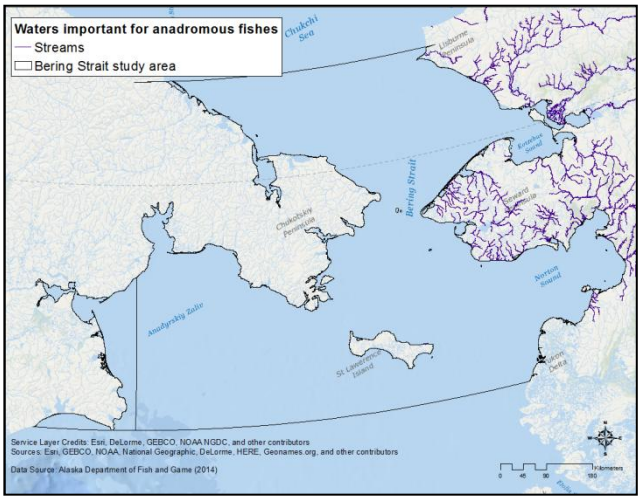
(h)


Essential Fish Habitat
Alaska Plaice
Blue King Crab
Flathead Sole
Greenland Turbot
Pacific Cod
Red King Crab
Sculpin
Skate
Snow Crab
Walleye Pollock
Yellowfin Sole
Opilio Crab
Saffron Cod
Arctic Cod
Salmon (5 species)
Bering Strait study area
Chukchi Sea
Seward Peninsula
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Essential Fish Habitat areas where fishing or the use of fishing gears has been restricted or modified to minimize adverse effects of fishing on EFH (NOAA 2010)

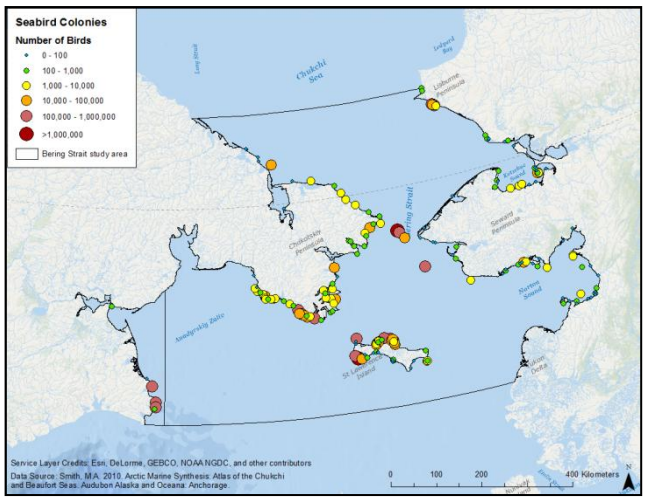
(i)


Pacific Herring
Adult Area
Major Juvenile Area
Spawning/Juvenile (<10 weeks) Area
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Chukotskiy Peninsula
Anadyrskiy Zaliv
Norton Sound
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Audobon Alaska Arctic Marin Synthesis (2010)

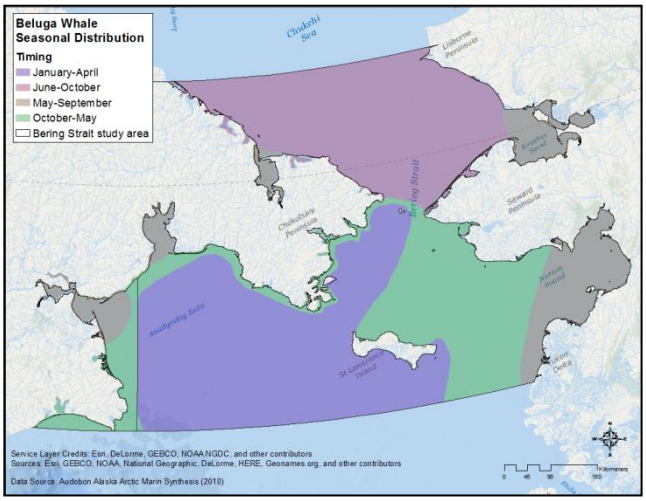
(j)


Waters important for anadromous fishes
Streams
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Chukotskiy Peninsula
Anadyrskiy Zaliv
Norton Sound
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Alaska Department of Fish and Game (2014)

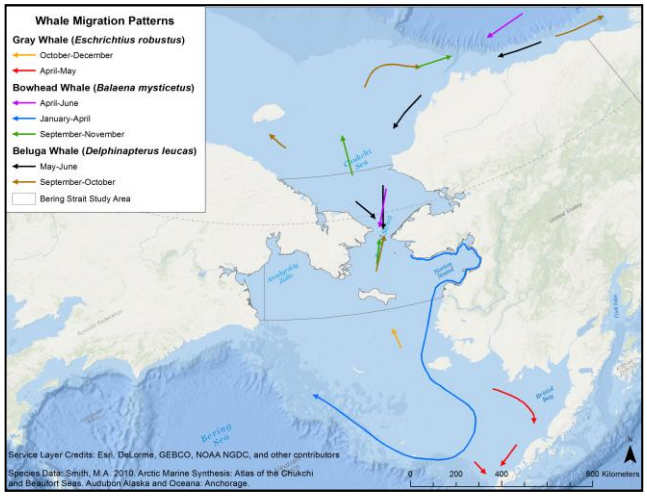
(k)


Seabird Colonies
Number of Birds
0 - 100
100 - 1,000
1,000 - 10,000
10,000 - 100,000
100,000 - 1,000,000
>1,000,000
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Chukotskiy Peninsula
Anadyrskiy Zaliv
Norton Sound
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Data Source: Smith, M.A. 2010. Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas. Audubon Alaska and Oceana: Anchorage.
0 100 200 400 Kilometers

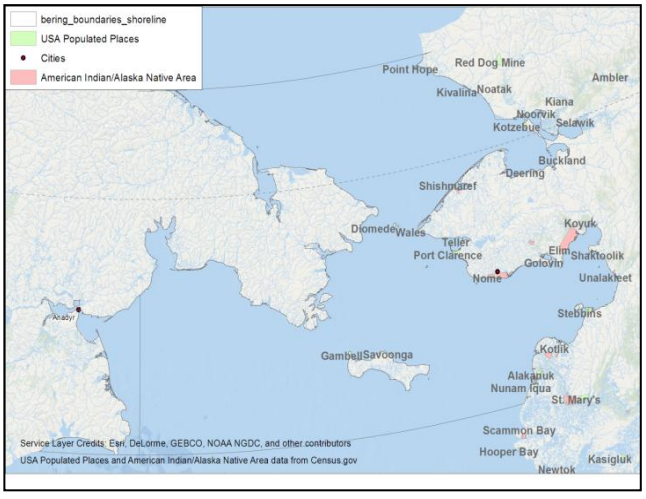
(l)


Beluga Whale Seasonal Distribution
Timing
January-April
June-October
May-September
October-May
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Chukotskiy Peninsula
Anadyrskiy Zaliv
Norton Sound
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Audobon Alaska Arctic Marin Synthesis (2010)

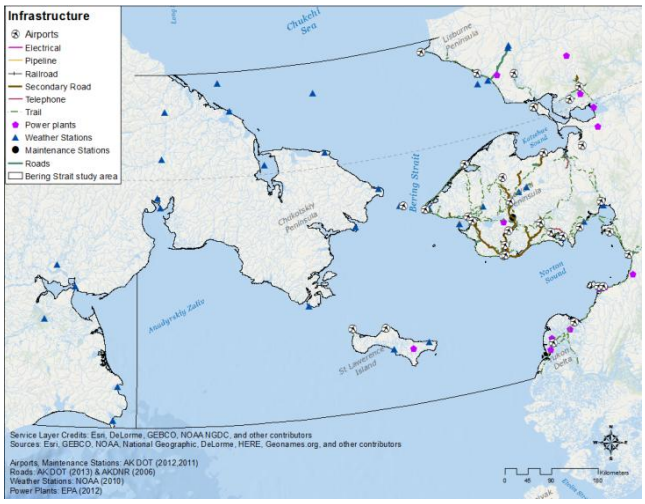
(m)


Whale Migration Patterns
Gray Whale (Eschrichtius robustus)
October-December
April-May
Bowhead Whale (Balaena mysticetus)
April-June
January-April
September-November
Beluga Whale (Delphinapterus leucas)
May-June
September-October
Bering Strait Study Area
Chukchi Sea
Bering Sea
Anadyrskiy Zaliv
Norton Sound
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Species Data: Smith, M.A. 2010. Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas. Audubon Alaska and Oceana: Anchorage.
0 200 400 800 Kilometers

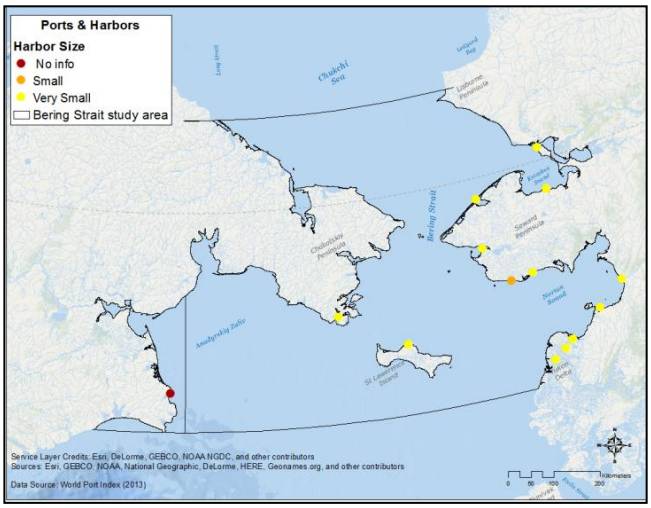
(n)


bering_boundaries_shoreline
USA Populated Places
Cities
American Indian/Alaska Native Area
Point Hope
Red Dog Mine
Ambler
Kivalina
Noatak
Kiana
Noorvik
Kotzebue
Selawik
Buckland
Deering
Shishmaref
Diomede
Wales
Teller
Port Clarence
Koyuk
Elim
Shaktoolik
Golovin
Nome
Unalakleet
Stebbins
Gambell
Savoonga
Kotlik
Alakanuk
Nunam Iqua
St. Mary's
Scammon Bay
Hooper Bay
Kasigluk
Newtok
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
USA Populated Places and American Indian/Alaska Native Area data from Census.gov

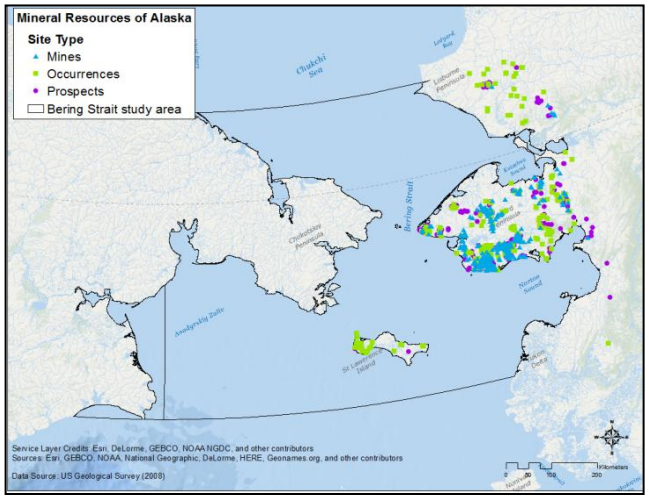
(o)


Infrastructure
Airports
Electrical
Pipeline
Railroad
Secondary Road
Telephone
Trail
Power plants
Weather Stations
Maintenance Stations
Roads
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Airports, Maintenance Stations: AK DOT (2012,2011)
Roads: AK DOT (2013) & AKDNR (2006)
Weather Stations: NOAA (2010)
Power Plants: EPA (2012)

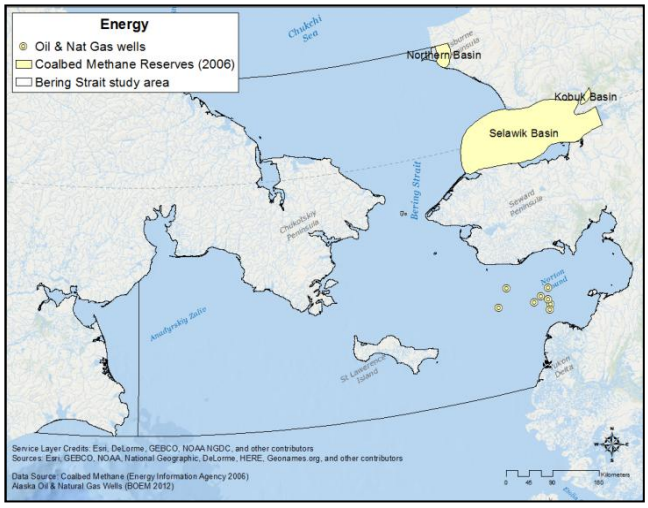
(p)


Ports & Harbors
Harbor Size
No info
Small
Very Small
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: World Port Index (2013)

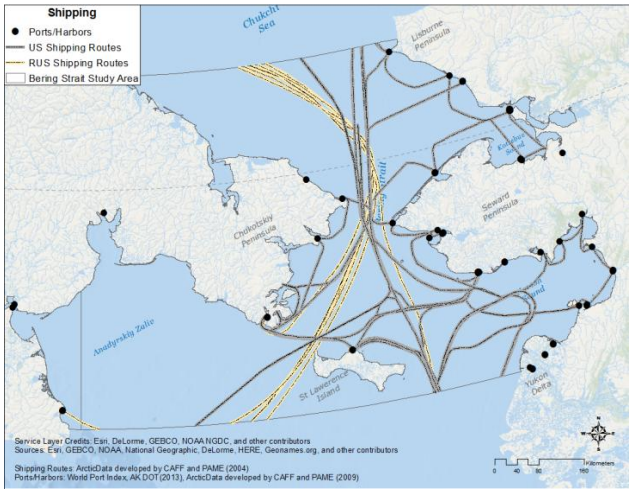
(q)


Mineral Resources of Alaska
Site Type
Mines
Occurrences
Prospects
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: US Geological Survey (2008)

(r)


Energy
Oil & Nat Gas wells
Coalbed Methane Reserves (2006)
Bering Strait study area
Northern Basin
Kobuk Basin
Selawik Basin
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Coalbed Methane (Energy Information Agency 2006)
Alaska Oil & Natural Gas Wells (BOEM 2012)

(s)


Shipping
Ports/Harbors
US Shipping Routes
RUS Shipping Routes
Bering Strait Study Area
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Shipping Routes: ArcticData developed by CAFF and PAME (2004)
Ports/Harbors: World Port Index, AK DOT (2013), ArcticData developed by CAFF and PAME (2009)

(t)

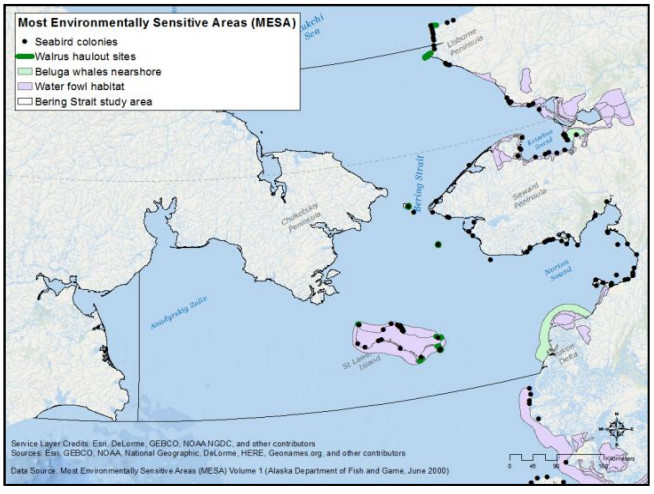

Most Environmentally Sensitive Areas (MESA)
Seabird colonies
Walrus haulout sites
Beluga whales nearshore
Water fowl habitat
Bering Strait study area
Chukchi Sea
Bering Strait
Seward Peninsula
Anadyrskiy Zaliv
St Lawrence Island
Yukon Delta
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors
Data Source: Most Environmentally Sensitive Areas (MESA) Volume 1 (Alaska Department of Fish and Game, June 2000)

FIGURE 13: Initial baps showing various geospatial data that will be incorporated into Cumulative Human Impact (CHI) analyses (Fig. 8) for the Bering Strait Region (Fig. 6). Data sources are elaborated in the *Arctic Options* Data Catalogue (www.arcticoptions.org/resources): **(a)** Native American Lands, United States (owned by the Bureau of Indian Affairs, Native American Tribes and native Alaskan Corporations).[57] **(b)** Land cover types.[58] **(c)** Bering Strait bathymetry.[59] **(d)** Sea surface temperature anomalies in the Bering Strait.[60] **(e)** Historical sea-ice concentration in February 2005.[61] **(f)** Historical sea ice concentration in February 2013.[62] **(g)** Rate of sea level rise in the Bering Strait region from 1992-2012 in millimeters per year. Regional mean sea-level trends compiled from multi-satellite altimetric mission data (AVISO).[63] **(h)** Essential fish habitat for commercially targeted species within Alaskan and US territorial waters as designated by the National Oceanographic and Atmospheric Administration (NOAA).[64] **(i)** Important areas for different life stages of Pacific Herring within the Bering Strait Region.[65] **(j)** Waters important for anadramous fish.[66] **(k)** Location and size of seabird colonies throughout the Bering Strait Region.[67] **(l)** Seasonal distribution of beluga whales throughout the Bering Strait Region.[68] **(m)** Whale migration patterns for gray, bowhead and beluga whales through the Bering Strait Region.[69] **(n)** Communities within the Bering Strait Region according to http://census.gov.[70] **(o)** Infrastructure locations throughout the Bering Strait Region including airports, roads, pipelines, telephone lines,

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[57] Conservation Biology Institute. 2010. (http://databasin.org/protected-center/features/PAD-US-CBI).

[58] Homer, C. and others. 2004. Development of a 2001 National Land Cover Database for the United States. *Photogrammetric Engineering and Remote Sensing.* 70:829-840.

[59] Becker, J.J. and others. 2009. Global Bathymetry and Elevation Data at 30 Arc Seconds Resolution: SRTM30_PLUS. *Marine Geodesy.* 32:355-371.

[60] Halpern, B.S. and others. 2008. A global map of human impact on marine ecosystems. *Science* 319:948-952.

[61] Scenarios Network for Alaska and Arctic Planning, University of Alaska. 2015. Historical Estimates and Projections of Sea Ice Concentration – 0.4 degrees CMIP5/AR5. (https://www.snap.uaf.edu/node/102).

[62] Scenarios Network for Alaska and Arctic Planning, University of Alaska. 2015. Historical Sea Ice Atlas: Observed Estimates of Sea Ice Concentration in Alaska Waters. (https://www.snap.uaf.edu/node/102).

[63] See Reference 56.

[64] NOAA (National Marine Fisheries Service, Office of Habitat Conservation). 2010. (http://marinecadastre.gov/data/).

[65] Smith, M.A. 2010. Arctic Marine Synthesis: Atlas of the Chukchi and Beaufort Seas. Audubon Alaska and Oceana Anchorage.

[66] Alaska Department of Fish and Game. 2014. (http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=data.GIS).

[67] See Reference 61.

[68] See Reference 61.

[69] See Reference 61.

[70] ArcGIS Online. 2014. (http://www.arcgis.com/home/item.html?id=c1ddac2d6a9f47028e2c5ce9c2991ae8).

weather stations, power plants and maintenance stations.[71] [72] [73] [74] [75] [76] **(p)** Ports and harbors of the Bering Strait Region.[77] **(q)** Open mines, previous occurrences and prospective mines in Alaska.[78] **(r)** Locations of energy-related activity including oil and natural gas wells and coal-bed methane reserves.[79] **(s)** Main shipping routes for United States and Russian ships passing through the Bering Strait Region. Black dots indicate ports and harbors.[80] [81] [82] [83] **(t)** Environmentally sensitive areas for seabirds, walrus haulout sites, beluga whales and water fowl.[84]

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[71] Alaska Department of Transportation and Public Facilities. ArcGIS 10.0 Shapefile data: Public Airports in Alaska – May 2013. (http://www.dot.state.ak.us/stwdplng/mapping/shapefiles.shtml#).

[72] Alaska Department of Transportation and Public Facilities. ArcGIS 10.0 Shapefile data: DOT&PF Maintenance Stations in Alaska – January 2012. (http://www.dot.state.ak.us/stwdplng/mapping/shapefiles.shtml#).

[73] Alaska Department of Transportation and Public Facilities. ArcGIS 10.0 Shapefile data: Alaska DOT&PF Route Centerlines. (http://www.dot.state.ak.us/stwdplng/mapping/shapefiles.shtml#)

[74] Alaska Department of Natural Resources. 2006. Roads, Trails, and Railroads. (https://erma.noaa.gov/arctic/erma.html#/x=-158.52172&y=69.38032&z=5&layers=11201+9727).

[75] National Oceanic and Atmospheric Administration. 2010. Weather Stations. (http://databasin.org/datasets/de8f7f71e3334eba863ff6003484364f).

[76] National Oceanic and Atmospheric Administration. National Ocean Service, Office for Coastal Management. 2014. Coastal Energy Facilities. (http://marinecadastre.gov/data/).

[77] World Port Index. 2013. (http://msi.nga.mil/NGAPortal/MSI.portal?_nfpb=true&_pageLabel=msi_portal_page_62&pubCode=0015).

[78] United States Geological Survey (USGS). 2008. Alaska Resource Data File (ARDF). (http://mrdata.usgs.gov/ardf/).

[79] Bureau of Ocean Energy Management. 2012. Alaska OCS Wells. (http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Alaska.aspx#GIStable).

[80] Protection of the Arctic Marine Environment (PAME). 2004. Russian shipping routes. (http://www.arcticdata.is/index.php?option=com_phocadownload&view=category&id=31:russian-federation&Itemid=166#).

[81] Protection of the Arctic Marine Environment (PAME). 2004. United States shipping routes. (http://www.arcticdata.is/index.php?option=com_phocadownload&view=category&id=32:united-states&Itemid=166).

[82] Protection of the Arctic Marine Environment (PAME). 2009. Ports and Communities. (https://erma.noaa.gov/arctic/erma.html#/x=-158.52172&y=69.38032&z=5&layers=11201+9333+10076+9370+10417).

[83] See Reference 73.

[84] Alaska Department of Fish and Game. 2000. (http://www.adfg.alaska.gov/index.cfm?adfg=maps.mesamaps).

5. INTEGRATION OF POLICY DOCUMENTS

a. Aggregation of BSR Policy Documents

This project will integrate previous reports, laws, policies and other written syntheses that relate to Arctic coastal-marine sustainability (see definitions in Box 1) for the BSR. Building on information-technology innovations to comprehensively discover content-in-context relationships within and between digital resources[85], A*rctic Options* is generating a 'knowledge bank' of natural-language documents that enable any user to reveal content-in-context relationships across multiple levels of embedded granularity (e.g., sentences within paragraphs within pages within documents within years in a collection).

The policy documents will deal with arrangements operating at different levels of social organization. The arrangements may interact with one another producing either conflicts (e.g., the conflicts between federal laws and Alaska laws pertaining to wildlife management) or synergistic effects (e.g., national regulatory arrangements designed to implement the provisions of UNCLOS). Policy documents that are relevant to the BSR will be included in the knowledge bank, avoiding peripheral documents just to increase the size of the archive. Nonetheless, because the inclusion of materials into the knowledge bank is a low-cost operation, we will err on the side of inclusiveness.

From local to international jurisdictions, the most important documents to include in the *Bering Strait Governance* knowledge bank are:

- Intergovernmental, multinational and global agreements.
- National, state and local laws;

[85] Berkman, P.A. 2014. "Unstructured Data" Practices in Polar Institutions and Networks: A Case Study with the *Arctic Options* Project. *CODATA Data Science Journal* 13:64-71.

- National, state, and local implementing regulations;
- Executive orders and official government statements;
- Current policies as well as policy planning; and
- Administrative measures.

In addition, courts regularly seek to adjudicate disagreements regarding the meaning of laws, regulations, and so forth as applied to specific cases. Judicial interpretations may change the operational meaning of the provisions of laws, regulations, and so forth, even when there are no changes in the texts of the relevant documents.

With guidance from the stakeholder priorities (Table 2), the following characteristics are being considered for the policy documents to include in the knowledge bank:

- Policy basis (e.g., jurisdiction level, organization);
- Biophysical basis (e.g., sea-ice, ecosystems);
- Socio-economic basis (indigenous communities, commercial development);
- Geographic scope (e.g., regional to pan-Arctic); or
- Language (e.g., English and Russian).

By end of the *Arctic Options* project, an objective is to establish the most comprehensive knowledge-discovery portal for policy documents that relate to BSR governance (in English and Russian). Achieving this objective will help to identify arrangements currently in place or that may need to be revised or supplemented to address emerging issues in the BSR.

b. *Bering Strait Governance – Knowledge Bank*

The documents aggregated into the 'knowledge bank' were defined initially by the *Arctic Options* team and elaborated with input from the workshop participants (Table 3). The

resulting *Bering Strait Governance – Knowledge Bank* is publicly available in the cloud for any user to interrogate:

Bering Strait Governance – Knowledge Bank

http://beringstrait-governance.knohow.co

It is anticipated that this knowledge bank will be elaborated and refined in an iterative manner during the course of the *Arctic Options* project from 2013-2016 with inclusive input from diverse stakeholders (Tables 1a-d).

TABLE 3: Collection of Documents in the 'Knowledge Bank' to Discover Content-in-Context Relationships Within and Between Policies that are Relevant to the Bering Strait Region (http://beringstrait-governance.knohow.co)

Year	Document	Jurisdiction*	Language
1867	*Treaty concerning the Cession of the Russian Possessions in North America by his Majesty the Emperor of all the Russias to the United States of America*	6,8	English, Russian
1965	*International Boundary Study No. 14 (Revised) – October 1, 1965 U.S. – Russia Convention Line of 1867*	6,8	English
1966	Fur Seal Act	8	English
1969	National Environmental Policy Act (NEPA)	8	English
1971	*Alaska Native Claims Settlement Act*	8,10	English
1972	*Coastal Zone Management Act*	8	English
1972	*Convention Concerning the Protection of the World Cultural and Natural Heritage*	16	Russian, English
1972	*International Regulations for Preventing Collisions at Sea*	15	English
1972	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter	16	English
1972	*Agreement on Cooperation in the Field of Environmental Protection Between the United States of America and the Union of Soviet Socialist Republics*	6,8	English
1972	*Marine Mammal Protection Act*	8	English
1973	*Agreement on the Conservation of Polar Bears*	1,2,5,6,8	English
1973	*US Endangered Species Act of 1973*	8	English
1973	*International Convention for the Prevention of Pollution from Ships*	15	English
1974	*International Convention for Safety of Life At Sea (SOLAS)*	15	English
1976	*Fishery and Conservation Management Act of 1976*	8	English
1977	*Convention concerning the Protection of Workers against Occupational Hazards in the Working Environment Due to Air Pollution, Noise, and Vibration*	15	English
1977	*Alaska Coastal Management Program*	10	English
1978	*International Convention on Standards of Training, Certification and Watchkeeping for Seafarers*	15	English
1978	*Protocol of 1978 Relating to the International Convention for the Prevention of Pollution From Ships, 1973 (MARPOL)*	15	English
1980	*Comprehensive Environmental Response, Compensation and Liability Act*	8	English
1982	*United Nations Convention on the Law of the Sea*	16	English
1984	*Alaska Occupational Safety and Health Standards*	10	English

TABLE 3: Collection of Documents in the 'Knowledge Bank' to Discover Content-in-Context Relationships Within and Between Policies that are Relevant to the Bering Strait Region (http://beringstrait-governance.knohow.co)			
Year	**Document**	**Jurisdiction***	**Language**
1984	*Resource Conservation and Liability Act*	8	English
1989	*Agreement Between The Government of the United States of America and the Government of the Union of Soviet Socialist Republics Concerning Cooperation in Combating Pollution in the Bering and Chukchi Seas in Emergency Situations*	6,8	English, Russian
1989	*Convention Concerning Indigenous and Tribal Peoples in Independent Countries*	16	English
1989	*Bering Straits Regional Commission : Agreement Between the United States of America and the Union of Soviet Socialist Republics, signed at Jackson Hole September 23, 1989.*	6,8	
1990	*Oil Pollution Act*	8	English
1990	*The Agreement Between the United States Of America and the Union Of Soviet Socialist Republics on the Maritime Boundary, With Annex, Signed At Washington, June 1, 1990*	6,8	English, Russian
1991	*Convention on Environmental Impact Assessment in a Transboundary Context*	16	English
1992	*Convention on Biological Diversity*	16	English
1994	*The Decree of the Government of the Russian Federation No. 1338 (About the Organization of the National Park "Beringia" of the Ministry of Natural Resources on the Territory of the Chukotka Autonomous District)*	6	Russian (English abstract)
1995	*Russian Federal Law on Environmental Review*	6	Russian
1995	Law on the Continental shelf of the Russian Federation	6	Russian
1995	*Federal Law of the Russian Federation on Wildlife (No. 52-FZ)*	6	English, Russian
1995	*A Protocol Between the United States and Canada Amending the 1916 Convention for the Protection of Migratory Birds in Canada and the United States, With Related Exchange of Notes, Signed At Washington On December 14, 1995*	1,8	English
1996	*International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996*	15 (US and Russia not parties)	English
1996	*Federal Russian Law of the Ministry of Environmental Protection and Natural Resources regarding authorized state institutions in the sphere of protection, control and regulation of wildlife species and their habitats*	6	Russian
1997	*Russian Federal law 'On Industrial Safety of Hazardous Production Facilities*	6	Russian, English
1998	*Environmental Risk Analysis of Arctic Activities*	17	English
1998	*Russian Law on Environmental Review*	6	Russian
1998	*Field Guide for Oil Spill Response in Arctic Waters*	17	English
1998	*Kyoto Protocol to the United Nations Framework Convention on Climate Change*	16	English
1999	*Russian Federal Law No.155-FZ On internal waters, territorial sea and contiguous zone*	6	Russian
2000	*United States-Russian Federation Bilateral Agreement for Polar Bears of the Chukchi Sea Population*	6,8	English, Russian
2000	US National Historic Preservation Act of 1966, As amended through 2000	8	English
2001	Land Code of the Russian Federation	6	English
2002	*IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters*	15	English
2002	*Federal Law on Environmental Protection*	6	English
2002	*Arctic Offshore Oil and Gas Guidelines*	17	English, Russian
2003	Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context	16	English
2003	*United States Arctic Research Commission – Goals and Objectives 2003*	8	English
2003	*Order No. 342 of the Ministry of Natural Resources and Ecology of the Russian Federation (About the Approval of the Main Directions of Development of the System of the State Nature Reserves and the National Parks in the Russian Federation for the Period till 2015)*	6	Russian (English abstract)
2004	Decree of the President of the Russian Federation Issues of the Ministry of	6	English, Russian

TABLE 3: Collection of Documents in the 'Knowledge Bank' to Discover Content-in-Context Relationships Within and Between Policies that are Relevant to the Bering Strait Region (http://beringstrait-governance.knohow.co)			
Year	**Document**	**Jurisdiction***	**Language**
	the Russian Federation For Civil Defense, Emergency Preparedness and Response		
2004	The Regulation On the Federal Supervisory Natural Resources Management Service	6	English
2005	Revised Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas	15	English
2005	*United States Arctic Research Commission – Goals and Objectives 2005*	8	English
2006	*Civil Code of the Russian Federation*	6	English
2006	*Water Code of the Russian Federation*	6	English
2007	*Marine Mammal Protection Act of 1972 as Amended*	8	English
2007	*Kamchatka Regional Protected Areas*	6	Russian
2007	*United States Arctic Research Commission – Goals and Objectives 2007*	8	English
2007	*Alaska Fire and Life Safety Regulations*	10	English
2008	*Guidelines on Voyage Planning for Passenger Ships Operating in Remote Areas*	15	English
2008	Ministerial Decree No. 603 validating the Regulation on setting up protected fishery water areas	6	Russian
2008	Supplement to the 2006 Biological Evaluation of the Potential Effects of Oil and Gas Leasing and Exploration in the Alaska OCS Beaufort Sea and Chukchi Sea Planning Areas on Endangered Bowhead Whales, Fin Whales, and Humpback Whales	8	English
2008	*Basics of the State Policy of the Russian Federation in the Arctic for the Period Till 2020 and for a Further Perspective*	6	Russian, English
2009	*United States Arctic Region Policy (National Security Presidential Directive / NSPD-66 and Homeland Security Presidential Directive / HSPD-25)*	8	English
2009	*State of Alaska Selected Oil and Other Hazardous Substances Pollution Control Statutes And Regulations*	10	English
2009	*United States Arctic Navy Roadmap*	8	English
2009	*Alaska Petroleum Distributors And Transporters Agreement For Compliance*	8,11	English
2009	*Alaskan Tribal Air Program Strategic Plan*	14,10	English
2009	*Guidelines for Ships Operating in Polar Waters*	15	English
2009	*United States Arctic Research Commission – Goals and Objectives 2009-10*	8	English
2010	*Barge Grounding Reporting Requirements*	8	English
2010	*Native Village of Gambell Marine Mammal Ordinance*	14	English
2010	*An Ordinance of the Native Village of Savoonga Regarding Harvesting of Marine Mammals*	14	English
2010	*Characteristic Coastal Habitats: Choosing Spill Response Alternatives*	8	English
2010	*United States Navy Climate Change Roadmap*	8	English
2011	*Joint Statement of the President of the United States of America and the President of the Russian Federation on Cooperation in the Bering Strait Region*	6,8	English, Russian
2011	*Atlas of Marine and Coastal Biodiversity in the Russian Arctic*	6	English, Russian
2011	EPPR: Arctic and Emergencies: Current and Future Risks, Mitigation, and Response Cooperation	1,2,3,4,5,6,7,8	Engish
2011	Planning for Alaska's Regional Ports and Harbors	8,10	English
2011	*Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic*	1,2,3,4,5,6,7,8	English, Russian
2011	*Regulations on the Federal Supervisory Natural Resources Management Service*	6	Russian
2011	*The Challenges of Oil Spill Response in the Arctic*	8	English
2011	*Agreement Between the Government of the United States of America and the Government of the Russian Federation on Cooperation in the Field of Protection of the Environment and Natural Resources (Activities for 2011-2012)*	6,8	English, Russian
2011	*United States Arctic Research Commission – Goals and Objectives 2013-14*	8	English
2013	*Agreement Between the Government of the United States of America and the Government of the Russian Federation on Cooperation in the Field of*	6,8	English

TABLE 3: Collection of Documents in the 'Knowledge Bank' to Discover Content-in-Context Relationships Within and Between Policies that are Relevant to the Bering Strait Region (http://beringstrait-governance.knohow.co)			
Year	**Document**	**Jurisdiction***	**Language**
	Protection of the Environment and Natural Resources (Activities for 2013-2014)		
2013	*Alaska Deep-Draft Port Study*	10,8	English
2013	*US Arctic Research Plan: FY 2013–2017*	8	English
2013	Specially Designated Marine Areas in the Arctic High Seas	17	Engish
2013	*US Draft Arctic Marine Transportation System: Overview and Priorities for Action 2013*	8	English
2013	*PAME: Arctic Ocean Review Final Report*	17	English
2013	*Identification of Arctic marine areas of Heightened Ecological and Cultural Significance: Arctic Marine Shipping Assessment (AMSA) IIc*	17	English
2013	*US-Russian Bilateral Presidental Commission Joint Report*	6,8	English
2013	*Effects of Oil and Gas Activities in the Arctic Ocean Supplemental Draft Environmental Impact Statement*	8	English
2013	*US Coast Guard Arctic Strategy*	8	English
2013	*Arctic Nautical Charting Plan*	8	English
2013	*Agreement on Cooperation on Marine Oil Pollution, Preparedness and Response in the Arctic*	1,2,3,4,5,6,7,8	English, Russian
2013	*Managing for the Future in a Rapidly Changing Arctic: A Report to the President*	8	English
2013	*US Department of Defense Arctic Strategy*	8	English
2013	*United States Arctic Research Commission – Goals and Objectives 2013-14*	8	English
2013	*Memorandum of Understanding between the Government of the United States of America and the Government of the Russian Federation Symbolically Linking National Parks in the Bering Strait Region*	6,8	English
2013	*Order of the Government of the Russian Federation No. 947-p About the Creation of the Federal State-Funded Institution "The National Park - Beringia"*	6	Russian (English abstract)
2013	*Resolution of the Government of the Russian Federation About the Establishment of the National Park "Beringia"*	6	Russian (English abstract)
2013	*United States National Strategy for the Arctic Region*	8	English
2013	*United States Coast Guard Arctic Strategy*	8	English
2014	*Kitgaaryuit Declaration*	9	English
2014	*Decree No. 366 of the Government of the Russian Federation (About the approval of the state program of the Russian Federation - Socio-economic development of the Arctic zone of the Russian Federation for the period till 2020)*	6	Russian (English abstract)
2014	*Departmental List of the Public Services Provided Under the Jurisdiction of the Ministry for the Protection of the Environment and Ministry of Natural Resources of the Russian Federation by the Federal-Funded Institutions as the Basic Kinds of Activity*	6	Russian (English abstract)
2014	*United States Implementation Plan for the National Strategy for the Arctic Region*	8	English
2014	*United States Arctic Navy Roadmap 2014-2030*	8	English
2014	*2014 Open Water Season Programmatic Conflict Avoidance Agreement*	11,12,13	English
2014	*Alaska Safe Families and Villages Act*	14,10	English
2014	*Status of the United Nations Convention on the Law of the Sea, of the Agreement relating to the implementation of Part XI of the Convention and of the Agreement for the implementation of the provisions of the Convention relating to the conservation and management of straddling fish stocks and highly migratory fish stocks*	16	English
2014	*Russian Federal Law No. 361-FZ amending Federal Law No. 33-FZ on protected areas:* The present Federal Law regulates relations in the sphere of organization, protection and use of protected areas for the purpose of conservation of unique and typical environmental complexes and objects, notable natural formations, plant and wildlife species, their genetic fund, study of natural processes in the biosphere and control over its alterations and ecological education of the population.	6	Russian

TABLE 3: Collection of Documents in the 'Knowledge Bank' to Discover Content-in-Context Relationships Within and Between Policies that are Relevant to the Bering Strait Region (http://beringstrait-governance.knohow.co)			
Year	**Document**	**Jurisdiction***	**Language**
2014	*United States Coast Guard Pilot 9*	8	English
2014	*United States Coast Guard, Oil Spill Response Organization (Alaska – Chadux)*	8	English
2014	*KEWARAK Policy-Based Recommendations for Ice Seal and Walrus*	12,14	English
2014	*NOAA Nautical Chart – Bering Strait North*	8	English
2014	*NOAA Nautical Chart – Bering Strait South*	8	English
2014	*Endangered and Threatened Species; Designation of Critical Habitat for the Arctic Ringed Seal (proposed)*	8	English
2014	*NOAA's Arctic Action Plan: Supporting the National Strategy for the Arctic Region*	8	English
2014	*Maritime Infrastructure: Key Issues Related to Commercial Activity in the U.S. Arctic over the Next Decade*	8	English
2014	*Alaska Arctic Policy Commission: Preliminary Report to the Alaska State Legislature*	10	English
2014	*PAME: Systems Safety Management and Safety Culture: Avioding Major Disaster in Arctic Offshore Oil and Gas Operations*	17	English
2014	Fesiability Analysis: Port Clarence Support Base	8, 10,11,14	English
2014	Responding to Oil Spills in the US Arctic Marine Environment: Strategies for Response and Mitigation	8	English
2014	Russian Federal Law on Enviornmental Protection (Law No. 219-FZ) and amendment (Federal Law No. 7-FZ) on Environmental Protection	6	English, Russian
2015	State of Alaska Air Quality Control Standards	10	English
*(1) Canada; (2) Denmark; (3) Finland; (4) Iceland; (5) Norway; (6) Russian Federation; (7) Sweden; (8) United States; (9) Inuit Circumpolar Council; (10) Alaska; (11) Industry; (12) Associations; (13) Commissions; (14) Villages; (15) International Maritime Organization; (16) United Nations; (17) Arctic Council			

The basic idea with the *Bering Strait Governance – Knowledge Bank* is to develop capacity to easily identify and comprehensively assess existing policy arrangements to address emerging issues identified by stakeholders (Tables 1a-d and Table 2) for the BSR. Once an emerging issue is identified and framed as clearly as possible, it becomes important to determine whether:

i. A policy or governance arrangement already exists that offers a way to address the issue;

ii. Two or more relevant policy or governance arrangements exist, but they point in different or even conflicting directions regarding the treatment of the issue;

iii. There is a gap in the sense that no existing policy or governance arrangement appears to be relevant for addressing the issue.

c. Content-in-Context Discovery

The *Bering Strait Governance – Knowledge Bank* provides an opportunity to reveal multi-level perspectives, taking into account policies and governance arrangements articulated on the part of local communities all the way to global environmental regimes (Table 3). This dimensionality provides the framework to ask questions not only about what level may be most appropriate but also about interactions across levels (e.g. local, state, national, international) to address specific issues. In the case of the Bering Strait Region, for example, it would be appropriate to include measures initiated by:

- Local communities (e.g. Gambell, Anadyr);
- Regional bodies (e.g. Kawerak, Arctic Council);
- Regional governments (e.g., State of Alaska, Chukotka Autonomous Okrug);
- National governments and agencies (e.g., National Oceanic and Atmospheric Administration in the United States, Sovcomflot in the Russian Federation);
- Bilateral agreements (e.g., international boundary agreement between the United States and Russian Federation);
- International bodies (e.g. IMO); and
- Global arrangements (e.g. UNCLOS).

The point is not to force issues into boxes provided by existing policies or governance arrangements, but to think in an holistic manner for the purpose of conceiving practical policy solutions across the governance landscape that applies to the BSR. In this sense, the *Bering Strait Governance – Knowledge Bank* provides a powerful tool to consider a menu of policy options that include existing arrangements as well as new arrangements where this seems appropriate.

As an example to interrogate the *Bering Strait Governance – Knowledge Bank*, consider the socio-economic driver of “shipping” that was identified as a top priority of the BSR stakeholders (Fig. 14). Based on the current contents of the knowledge bank (Table 3), the term “shipping” occurs in 53 policy documents in 19 different years, starting in 1976. The *Bering Strait Governance - Knowledge Bank* further reveals “shipping” in 271 sections across 481 pages in 637 paragraphs and 637 sentences. The “digital zoom” interface enables the user to dig into this ‘concept space’ in an expandable-collapsible manner, analogous to zooming in and out across spatial dimensions of a geographic space.

The user also has the freedom to select or exclude specific levels of granularity. In Figure 14, for example, the year 1973 was expanded only to expose the *Endangered Species Act* at the document level whereas in 1976 the *Magnusson-Stevens Fishery Conservation and Management Act* was expanded all the way to the sentence level to highlight (in red) “shipping” in the context of this specific document and the overall collection. These documents apply at the national level of the United States, but it would have been just as easy to discover context of “shipping” at the international level (as with UNCLOS in 1982) or any other level of jurisdiction (as with the KEWARAK document in 2014). Similarly, if the user is interested in shipping impacts on whales, connections can be elaborated by expanding the relevant policy-planning document in 2008.

The unique advantage with the *Bering Strait Governance – Knowledge Bank* (Fig. 14) is for any user to comprehensively, objectively and automatically identify content-in-context relationships across the BSR governance landscape. Insights from these analyses frame the development of policy options to address specific issues in the BSR.

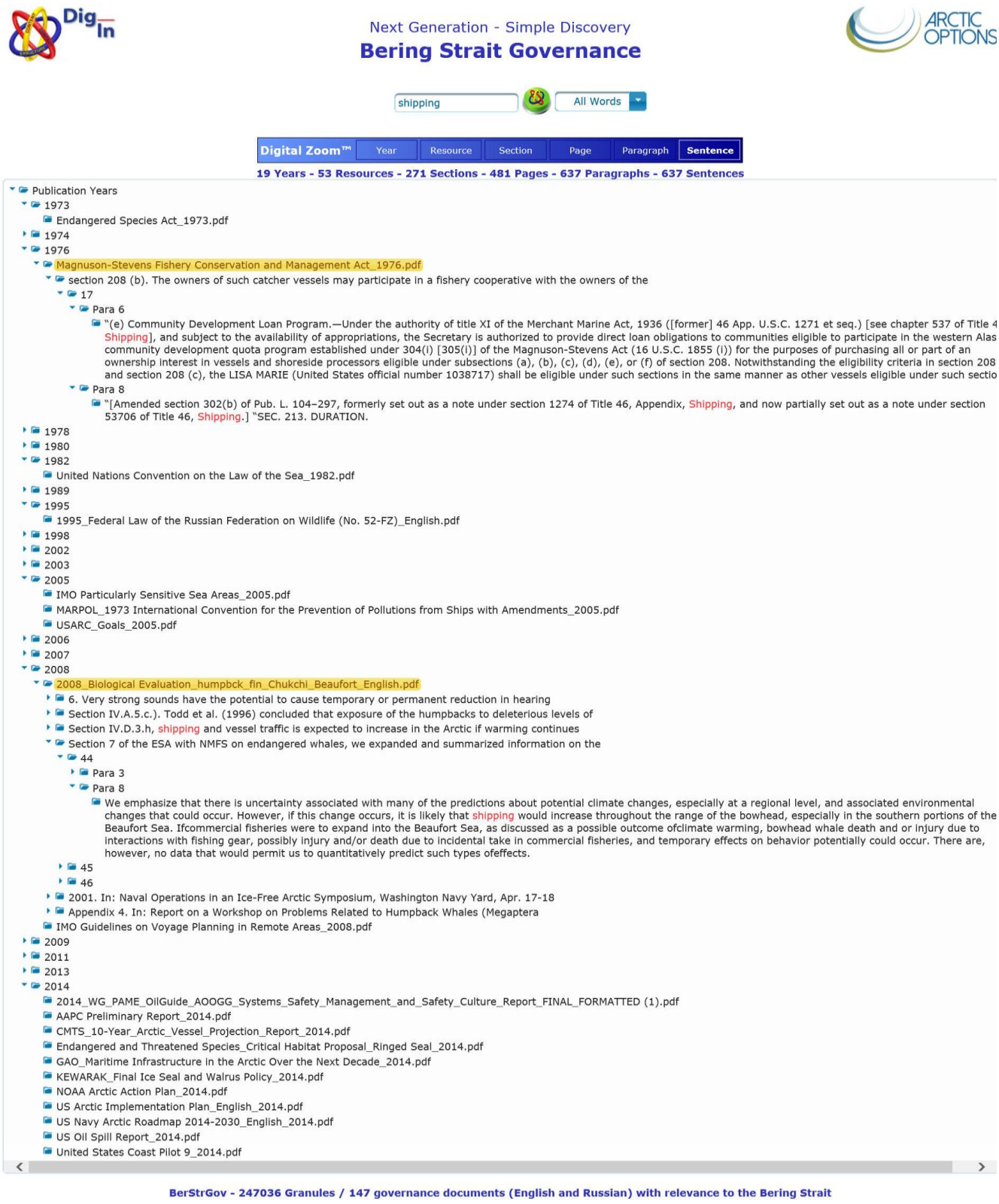

FIGURE 14: *Bering Strait Governance – Knowledge Bank* (http://beringstrait-governance.knohow.co) discovery for "shipping" among 147 documents that are relevant to the BSR (Table 3). Query instances are highlighted (in red) among user-selected documents, using the "digital zoom" (see text for explanation), and quantified at each granularity level among the 247,036 granules in the collection.

Various modes of analysis become feasible with the *Bering Strait Governance – Knowledge Bank* because content-in-context relationships can be turned objectively into statistics for any query, as indicated for "shipping" across the various granularity levels in Figure 14. Consequently, trends can be revealed quantitatively among the policy documents for any combination of queries (Fig. 15). For example, "indigenous" was more frequent in the documents in the *Bering Strait Governance – Knowledge Bank* during the 1970's and 1980's than subsequently. In contrast, "shipping" and "whaling" are more frequent in documents after 2010. Decrease in the frequency of "shipping" in the most recent documents raises questions about the completeness of the document collection (Table 3) and whether the trend is an artefact or not.

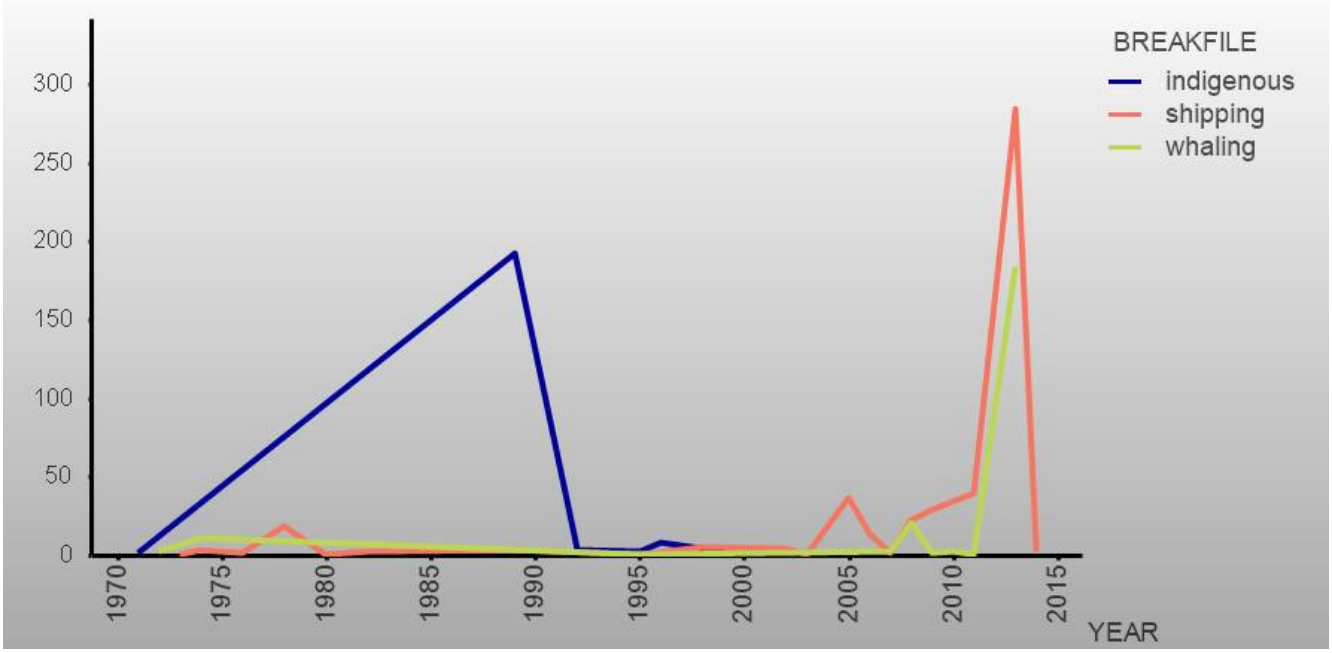

Figure 15: Example of temporal trends based on the frequencies of three queries ("shipping," "whaling" and "indigenous") across all origination years of the relevant documents from the *Bering Strait Governance – Knowledge Bank* (http://beringstrait-governance.knohow.co).

In addition, with different granularity levels exposed, it is possible to reveal patterns in the *Bering Strait Governance – Knowledge Bank* for any set of queries (Fig. 16). This three-dimensional "heat map" comprehensively describes which documents as well as where in those documents the queries "Gambell" and "bowhead" exist alone or together. Occurrence

of these terms also demonstrates relevance of the documents in the *Bering Strait Governance – Knowledge Bank.*

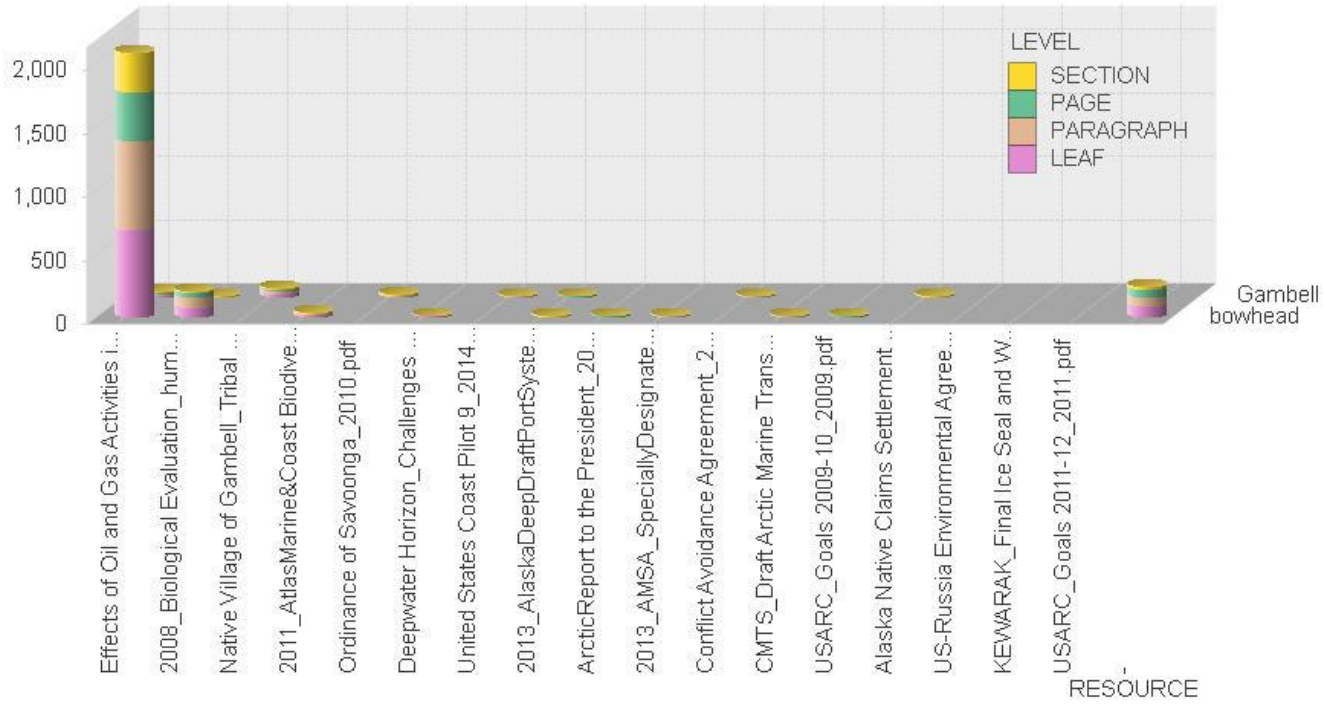

Figure 16: Example of a "heat map" showing the frequencies of two queries ("Gambell" and "bowhead") in relation to each other across all granularity levels in the relevant documents from the *Bering Strait Governance – Knowledge Bank* (http://beringstrait-governance.knohow.co).

Quantitative analyses of terms within and between documents can be used to reveal their trends (Fig. 15) and patterns (Fig. 16). Moreover, these content-in-context relationships can be further interpreted by zooming in and out of the collection across different levels of granularity (Fig. 14). Together, these approaches will reveal overlaps, conflicts and gaps in the BSR governance landscape. As an essential element of the decision-support process (Fig. 7), the *Bering Strait Governance – Knowledge Bank* provides *a* rigorous basis for generating policy options that contribute to informed decision-making by government and industry to effectively address impacts and issues in the Bering Strait Region.

6. SYNTHESIS OF POLICY OPTIONS

Each of the Arctic Options components – geospatial analysis, stakeholder engagement/scenario development, the creation of knowledge banks – is capable of delivering useful results in its own right. But we also want to combine these elements to take full advantage of the project's potential on providing a decision support process. Our goal here is not to develop a tool that can evaluate the relative merits of policy options to arrive at specific recommendations regarding the choices that policymakers are called upon to make. Rather, we aim to devise a process that can spot emerging issues in a timely manner, suggest suitable ways to frame these issues for purposes of policymaking, and identify that policymakers will want to consider as they go through the process of arriving at decisions regarding specific issues. In this process, our objective is simply to introduce options that contribute to informed decision-making about sustainable infrastructure development without the advocacy and bias that are associated with recommendations.

The first step in this process is to spot current or emergent problems likely to develop into policy issues and to identify the policy arenas most suitable for dealing with these issues. In the language of policy analysis, this is the stage of agenda formation.[86] Since agendas are always crowded, we can also make an effort to attach some measure of priority or urgency to each issue in order to provide a sense of where they should stand in the policy queue.

The next step is to consult the knowledge bank of BSR governance documents (Table 3 – http://beringstrait-governance.knohow.co) to determine whether management systems already exist that have the capacity to address a given risk or uncertainty. If the answer is yes, we can take the relevant management systems as a point of departure, building on their capacity individually or collectively to address the issue. If the answer is no, we can proceed

[86] Parsons, W. and Parsons, W.D. 1995. Public Policy: An Introduction to the Theory and Practice of Policy Analysis. Cheltenham: Edward Elgar.

to an examination of the current policy elements that could be integrated into new management systems to address the issue. In either case, we will identify options to resolve the issue in collaboration with diverse stakeholders and policymakers. Consider two concrete examples relating to the Bering Strait Region:

- Managing fish stocks across jurisdictional boundaries; and
- Managing ship traffic transiting the Bering Strait.

Drawing on Automatic Identification System (AIS) data, our geospatial analysis has identified a clear asymmetry in the levels of fishing activity occurring on the Russian side of the BSR in contrast to the American side where there are no fishing vessels (Fig. 11). Explanation of this asymmetry is straightforward. Acting on recommendations from the North Pacific Fisheries Management Council in 2009, the Department of Commerce imposed a moratorium on commercial fishing in the segment of the region under United States jurisdiction, pending the conduct of sufficient research to make a determination whether the fish stocks of this region can support a sustainable fishery.[87] The expectation is that it will be some time before it is possible to make such a determination, especially since uncertainties regarding the impacts of climate change constitute an important complicating factor. In the segment of the region under Russian jurisdiction, on the other hand, no such moratorium is in place.

Jurisdiction over the eastern and western segments of the BSR is based on a legal boundary that reflects an application of the equidistance principle between the coastlines of the two countries; it does not reflect any ecological considerations. It is likely that the fish stocks in question belong to the same marine biophysical or ecological system. To the extent that this is true, there is a misfit or mismatch between the socio-ecological system and the existing management regime. The policy problem, therefore, is how to manage the fisheries of the BSR in the interests of achieving sustainable yields and in a manner that is sensitive to other

[87] National Marine Fisheries Service. 2015. Arctic Fisheries. (https://alaskafisheries.noaa.gov/sustainablefisheries/arctic/).

considerations like the population dynamics of marine mammals or the interests of subsistence users. Under existing international law, the parties are entitled to cling to the jurisdictional boundary in the BSR, applying existing management regimes in their respective sectors of the region. Nonetheless, there may be common interests of the US and Russia to coordinate, if not integrate, management to protect their shared resources.

In this case, we can consult the appropriate knowledge bank of BSR governance documents (Table 3 – http://beringstrait-governance.knohow.co) to determine whether any existing institutional arrangements are capable of providing a platform to resolve this issue. If (as is likely) no existing arrangements are able to address the associated risks and uncertainties, we can proceed to ask what the options are for devising suitable arrangements.

These options will have both horizontal and vertical dimensions. In horizontal terms, the issue is whether to opt for a purely bilateral Russian-American arrangement or to fold this issue into a larger multilateral arrangement, such as the five-nation arrangement currently under consideration for potential commercial fisheries in the central Arctic Ocean.[88] Vertically, the question is how to provide suitable opportunities to integrate the concerns of regional and local stakeholders into an arrangement that is international or transnational in scope.

Turning to the case of managing ship traffic in the BSR, we started by asking a representative group of stakeholders to identify the major drivers of change affecting this region (Table 2). Their responses indicated that the number of commercial ship transits and the condition of sea ice in the region are among the dominant drivers. This allows us to construct a two-dimensional matrix of the sort represented in Figure 15. From a policy perspective, the issue becomes increasingly pressing as we move from left to right across the x-axis with increasing shipping and bottom to top across the y-axis with decreasing sea ice. For example, the

[88] Chairman's Statement. 2014. Meeting on Arctic Fisheries. Nuuk, Greenland, 24-26 February 2014. (http://naalakkersuisut.gl/~/media/Nanoq/Images/Nyheder/250214/Chairmans%20Statement%20from%20Nuuk%20Meeting%20February%202014%202.docx).

management challenges arising from increases in commercial transits when sea ice remains a major hazard are fundamentally different from those arising under conditions involving a substantial decline in sea ice. This suggests the importance of thinking hard about management systems that are appropriate in each quadrant of the matrix (Fig. 15).

Going a step further, we can add a time dimension to this analysis. We can start with empirical measurement regarding past ship transits and sea ice (e.g., Figs. 10-12) and then make projections regarding the likely value of these variables at five-year intervals going forward. We plan to poll representatives of stakeholder groups who participated in the workshop and others who were identified for the purpose of determining whether knowledgeable observers have convergent projections about the slope of the line (Fig. 15), reflecting the relationship between BSR shipping and sea ice into the future. The management issues arising in this connection involve a combination of:

i. Regulations regarding the design, construction, and operation of commercial ships;
ii. Rules dealing with ship tracks like vessel traffic schemes;
iii. Services like hydrographic charts, satellite navigation capabilities, and search and rescue capacity.

The next step is to consult the knowledge bank of BSR governance documents (Table 3 – http://beringstrait-governance.knohow.co) to see whether existing arrangements are adequate to cover these needs. One relevant candidate is the emerging Polar Code now expected to enter into force at the beginning of 2017.[89] The code deals with matters of ship design, construction, and operation. Are provisions of the code adequate to address the conditions regarding ship traffic and sea ice likely to occur in 2020, 2025, and beyond? Key questions further include potential ship strikes on whales, noise pollution, and interference

[89] International Maritime Organization. 2014. IMO adopts mandatory Code for Ships Operating in Polar Waters. Maritime Safety Committee (MSC), 94th session, 17-21 November 2014 (http://www.imo.org/MediaCentre/PressBriefings/Pages/38-nmsc94polar.aspx#.VTq74X5wZU8).

with aboriginal subsistence harvesting activities. This process would lead to the development of options for special regulations that apply to ships transiting the BSR.

If (as is likely), we find no existing arrangements pertaining to vessel traffic schemes and the provision of services, the next step will be to identify options for new arrangements of this sort. Questions in this context concern the feasibility of devising arrangements that safeguard ecological and cultural systems without imposing excessive demands on shippers or impractical burdens on the responsible institutions. Should search and rescue services, for instance, be treated like infrastructure to be supplied at public expense or as normal business expenses to be paid for by users?

On first blush, legal framework for the BSR involves jurisdictional elements within and between the US and Russia as well as rights and responsibilities of the international community under law of the sea. In this regard, any BSR regime covering commercial navigation would involve some form of international agreement. Moreover, it would clearly be important to create arrangements allowing for meaningful participation on the part of legitimate stakeholders including local residents, commercial shippers, classification societies, insurers, and environmental non-governmental organizations (Tables 1a-d). This latter step would require inclusion beyond the limits of intergovernmental organizations, like the International Maritime Organization, that limit participation to members of member-state delegations. An option might bet to engage the Arctic Council or one of its working groups, including the Arctic Monitoring and Assessment Programme (AMAP), Protection of the Arctic Marine Environment (PAME) or the Emergency Prevention, Preparedness, and Response (EPPR) to facilitate the necessary dialogues that relate to the BSR.

These examples are meant only to illustrate the potential of *Arctic Options* as a contributor to the development of a useful decision-support process for the BSR as well as other areas of the Arctic Ocean (Figs. 2-3). Clearly, balanced and responsible decision-making regarding

BSR issues is complex and not quickly completed. Solutions require international, interdisciplinary and inclusive perspectives. In this regard, *Arctic Options* offers an holistic process to integrate relevant stakeholder perspectives, geospatial data and policy documents in a manner that will reveal options that contribute to informed decision-making about urgent issues for the BSR, both through existing and potential management systems.

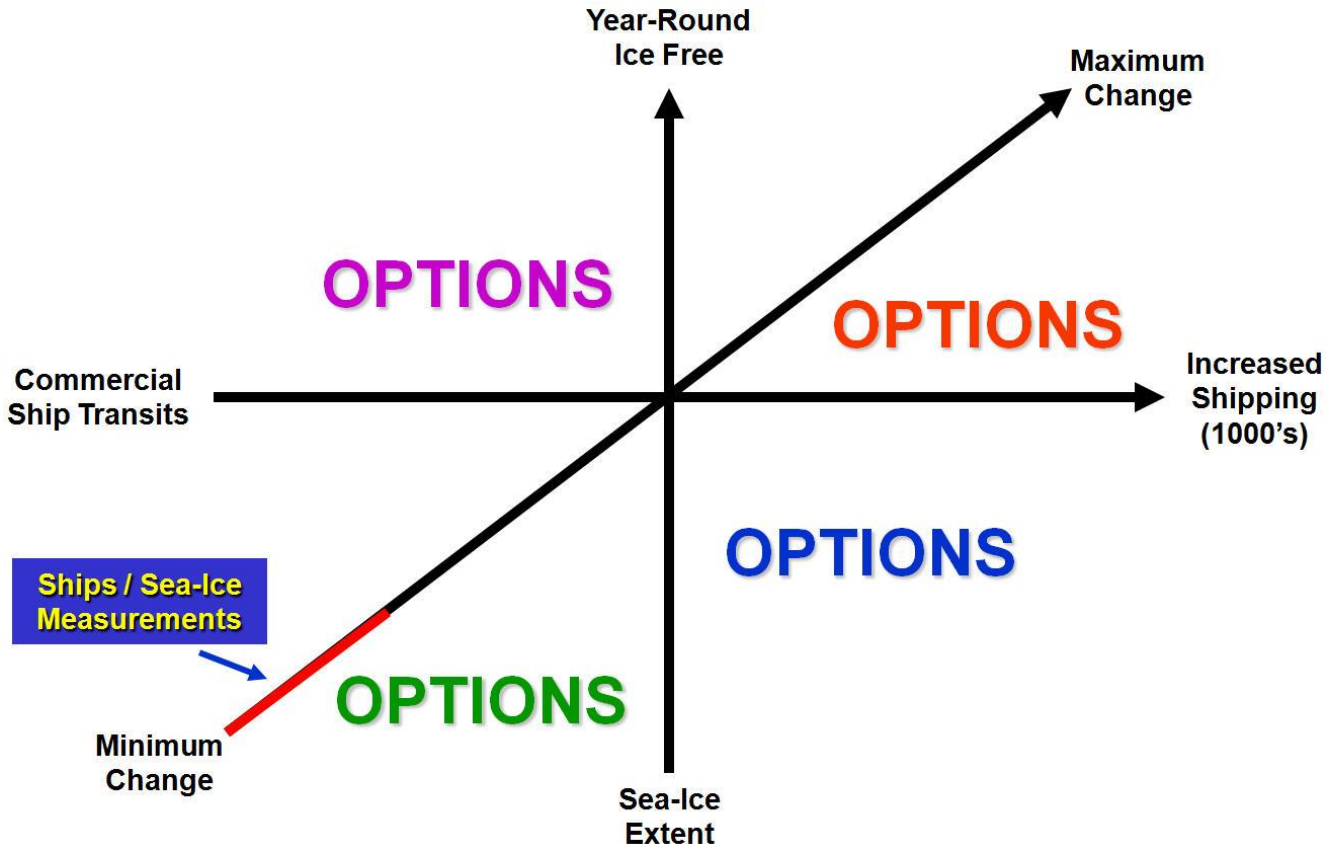

Figure 17: Generalized approach to integrate geospatial data and policy documents with regard to the priority socio-economic and biophysical drivers of shipping and sea ice in the BSR, respectively (Table 1a-d). Relationship between shipping and sea ice will be empirically defined for the BSR using satellite-derived Automatic Identification System (AIS) data (Figs. 10-12). The four quadrants of policy options are intended to aid in the decision-support process (Fig. 7) by distinguishing strategies that will contribute to informed decision making by government and industry to resolve impacts and issues in the Bering Strait Region.

APPENDIX 1: Workshop Agenda

Monday – 20 October 2014 (Informed Decision-Making – Bering Strait)

08:30-09:00 Arrive at NCEAS
09:00-09:10 Welcome – Frank Davis
09:10-09:30 Workshop Introduction (Definitions, Objectives and Process) – Paul Berkman
09:30-10:30 Introductions by Participants
10:30-10:50 Coffee
10:50-11:10 Introductions by Participants (cont'd.)
11:10-11:25 A Perspective on Interagency Arctic Research – Brendan Kelly
11:25-11:40 Adaptation Actions for a Changing Arctic (AACA) – Jon L. Fuglestad
11:40-11:55 Bering Strait Data Overview – Ben Halpern
11:55-12:30 Decision-Making in the Context of Sustainability – Group Discussion
12:30-14:00 Lunch
14:00-15:15 Breakout Groups: Bering Strait Sustainability
15:15-15:30 Coffee
15:30-16:30 Bering Strait Sustainability Framework – Group Discussion
16:30-17:00 Short Documentary on the Bering Strait – David Wright
17:00-18:00 Open
18:00-21:30 Reception – Oreana Winery – Group

Tuesday – 21 October 2014 (Bering Strait Stakeholder Perspectives)

09:00-09:20 Summary and Outcomes from Day 1 – Paul Berkman
09:20-09:40 Integration of Stakeholder Perspectives – Lawson Brigham
09:20-10:30 Scenarios for the Bering Strait: Drivers and Values – Group Brainstorming
10:30-10:50 Coffee
10:50-12:30 Scenarios for the Bering Strait: Risks and Uncertainties – Group Brainstorming
12:30-14:00 Lunch
14:00-15:30 Breakout Groups: Perspectives on Drivers, Values, Risks and Uncertainties
15:30-15:45 Coffee
15:45-17:00 Framing Bering Strait Stakeholder Perspectives – Group Discussion
17:00-18:00 Open
18:30-21:30 Santa Barbara Dinner Feast (Cadiz) – Group

Wednesday – 22 October 2014 (Bering Strait: Geospatial Data Integration)

09:00-09:20 Summary and Outcomes from Day 2 – Paul Berkman
09:20-09:50 Bering Strait Data Catalogue and Mapping – Ben Halpern and Team
09:50-10:20 Bering Strait Cumulative-Impact Analyses – Ben Halpern and Team
10:20-10:40 Coffee
10:40-11:00 Marine Exchange of Alaska Data – Lawson Brigham
11:00-11:20 Satellite Automatic Identification System (AIS) Data – Dino Lorenzini
11:20-11:40 Google WebGL and AIS Data Visualization - Jenifer Austin (remotely)
11:40-12:15 Bering Strait Data Integration, Analysis and Visualization – Group Discussion
12:15-13:40 Lunch
13:40-14:00 'Knowledge Banks' to Integrate Policy Documents – Paul Berkman
14:00-14:20 Russian Legislation and Policies for the Bering Strait – Alexander Vylegzhanin
14:20-15:00 Breakout Group 1: 'Knowledge Bank' Analyses for Risks and Uncertainties
14:20-15:00 Breakout Group 2: 'Knowledge Bank' Analyses for Key Drivers
15:00-15:15 Coffee
15:15-16:00 Breakout Group 1: 'Knowledge Bank' Analyses for Key Drivers
15:15-16:00 Breakout Group 2: 'Knowledge Bank' Analyses for Risks and Uncertainties
16:00-17:00 Bering Strait Policy Gaps – Group Discussion
17:00-Later Open Evening with Santa Barbara Dinner Choices

Thursday – 23 October 2014 (Bering Strait: Policy Document Integration)

09:00-09:20 Summary and Outcomes from Day 3 – Paul Berkman
09:20-09:40 Indigenous Peoples Perspectives: Bering Sea Alliance – Art Ivanoff
09:40-10:30 Breakout Groups: Bering Strait Policy Priorities
10:30-10:50 Coffee
10:50-11:30 Breakout Groups: Bering Strait Institutional Interplay
11:30-12:30 Bering Strait Policy Priorities and Institutional Interplay – Group Discussion
12:30-14:00 Lunch
13:45-14:45 Breakout Group 1: Data Questions to Address Risks and Uncertainties
13:45-14:45 Breakout Group 2: Data Questions to Address Key Drivers and Values
14:45-15:00 Coffee
15:00-16:00 Breakout Group 1: Data Questions to Address Key Drivers and Values
15:00-16:00 Breakout Group 2: Data Questions to Address Risks and Uncertainties
16:00-17:00 Data Integration Strategy for the Bering Strait – Group Discussion
17:00-Later Open Evening with Santa Barbara Dinner Choices

Friday – 24 October 2014 (Bering Strait Policy Options)

09:00-09:20 Summary and Outcomes from Day 4 – Paul Berkman
09:20-09:40 Synthesis of Policy Options – Oran Young
09:40-10:00 Policy-Making Perspectives: Government – Dennis Thurston
10:00-10:20 Policy-Making Perspectives: Industry – Greg Pavellas
10:20-10:40 Coffee
10:40-11:30 Breakout Group 1: Matrix of Policy Options by Sustainability Dimension
10:40-11:30 Breakout Group 2: Matrix of Policy Options by Stakeholder
11:30-12:20 Breakout Group 1: Matrix of Policy Options by Stakeholder
11:30-12:20 Breakout Group 2: Matrix of Policy Options by Sustainability Dimension
12:20-13:50 Lunch
13:50-15:00 Integrated Policy Options for Bering Strait Sustainability – Group Discussion
15:00-15:15 Coffee
15:15-16:00 Assessment of Workshop Outcomes – Group Discussion
16:00-17:00 Next Steps: Collaborations, Deliverables and Timelines – Group Discussion
17:00-Later Open Evening with Santa Barbara Dinner Choices

APPENDIX 2: Workshop Participants

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