The Arctic Domain Awareness Center (ADAC) is a U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Center of Excellence in Maritime Research, hosted by the University of Alaska.

The following is the Literature Review for An ADAC planned and conducted Table-Top Exercise, resourced by HQ U.S. Coast Guard Senior Arctic Policy Advisor and organized in accordance with ADAC’s Arctic Related Medium-and-Long Term Environment (Arctic MaLTE) processes.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>Planned Exercise Moves</td>
<td>4</td>
</tr>
<tr>
<td>Literature Review</td>
<td>6</td>
</tr>
<tr>
<td>Arctic Maritime Transportation System</td>
<td>6</td>
</tr>
<tr>
<td>Risk Considerations within the Arctic MTS</td>
<td>11</td>
</tr>
<tr>
<td>Seasonal ice and Weather Considerations</td>
<td>15</td>
</tr>
<tr>
<td>Sea Ice Navigation and Related Considerations</td>
<td>18</td>
</tr>
<tr>
<td>Governance and Regulation of the Arctic MTS</td>
<td>21</td>
</tr>
<tr>
<td>Circumpolar and Arctic Ocean Considerations</td>
<td>21</td>
</tr>
<tr>
<td>Governance within the U.S. Arctic Maritime EEZ</td>
<td>24</td>
</tr>
<tr>
<td>Options and Opportunities for Advancing the U.S. Arctic MTS</td>
<td>25</td>
</tr>
<tr>
<td>Economic and Resource Development Considerations</td>
<td>31</td>
</tr>
<tr>
<td>Fisheries within the U.S. Arctic EEZ</td>
<td>32</td>
</tr>
<tr>
<td>Community Security: Indigenous Peoples and Rural Communities</td>
<td>33</td>
</tr>
<tr>
<td>Local Indigenous Concerns and Input</td>
<td>33</td>
</tr>
<tr>
<td>Subsistence and Regional Food Security Concerns</td>
<td>35</td>
</tr>
<tr>
<td>Local Vessel Traffic Concerns</td>
<td>37</td>
</tr>
<tr>
<td>National Security and Geopolitical Considerations</td>
<td>38</td>
</tr>
<tr>
<td>People’s Republic of China Strategic Considerations</td>
<td>41</td>
</tr>
<tr>
<td>Russian Federation Strategic Considerations</td>
<td>41</td>
</tr>
<tr>
<td>Canadian Strategic Considerations</td>
<td>43</td>
</tr>
<tr>
<td>Incident Response, Logistics, and Command and Control</td>
<td>45</td>
</tr>
<tr>
<td>Oil Spill and Spill Response Concerns</td>
<td>46</td>
</tr>
<tr>
<td>Maritime and Arctic Domain Context Decision Making</td>
<td>52</td>
</tr>
<tr>
<td>Bibliography</td>
<td>55</td>
</tr>
</tbody>
</table>
**Introduction**

The following is the literature review in support of ADAC’s “Arctic Maritime Horizons” Tabletop Exercise organized in accordance with ADAC’s Arctic Related Medium-and-Long Term Environment (Arctic MaLTE) processes. The exercise will be conducted, in partnership with HQ USCG Director of Maritime Transportation Systems and Senior Arctic Policy Advisor, are creating a table top exercise planned as an in-event for 5-6 May 2021 in Anchorage Alaska focused organized to address policy, plans and initiatives to support HQ USCG and the Coast Guard Enterprise in addressing the 2019 USCG Arctic Strategic Outlook (ArcSO) task to “Advance and Modernize the Arctic Marine Transportation System.” Arctic Maritime Horizons Exercise will provide an orienting and deliberative plenary forum to prepare participants followed by a 4-move exercise to challenge assumptions, gain insights and organize follow-on items of consideration to guide USCG Arctic and Maritime Commerce Strategic Outlook implementation tasks.

ADAC and the aforementioned planning team have devised the following series of exercise moves:

**Planned Exercise Moves**

The following are the summary outlines of the four exercise scenarios. Note, each scenario is fictitious and generated to create challenges for exercise participants to understand the specific response dynamics, create solutions and identify shortfalls in policy and capability. Each scenario has some facet of action that may result to impacts for subsistence activities.

**Move One: disabled oil tanker Bering Straits blown onto known obstacles.** Making a transit during through the Bering Straits during a rough and difficult fall storm, a fuel oil tanker with petroleum products needed for heating homes in remote villages along the Beaufort Sea coast is disabled southeast of Little Diomede Island in the Bering Strait, and is quickly driven from the sea lanes to Fairway rocks blocking movement of maritime commerce in the U.S. Arctic MTS and creating a significant response challenge. The storm results in the vessel to be driven hard on the rocks and causing a rupture of the tank necessitate the need for closing shipping lanes, in order to affect spill response and potentially impacting subsistence activities (based on safety & hazard concerns). Regrettably, the grounding occurs just as annual fall subsistence harvests commence. Complicating response is the remote and austereness of location and an unusually persistent season of low clouds, winds, and precipitation that complicates the response.
Move two: Congested waterways impact subsistence hunting. Due to unpredictable weather patterns, which resulted in a number of significant fall and early weather storms across the Bering and Chukchi Sea regions, shipments from a new, very large and economically significant mine on the Alaska’s Northwest coast (modelled on the Graphite Creek mine near Teller Alaska) are well behind in delivering ore shipments as Spring arrives, and shareholders are insistent that every effort should be made to expedite movement of ore. Unfortunately, as shipping traffic gets underway in relieving the backlog, subsistence hunters, relying on the Spring subsistence Bowhead harvest find the congested traffic as critically disruptive to the hunt and are seeking redress to prioritize their subsistence activities over the movement of ore barges through the region. Complicating factors are an early warming spell coupled with heavy rains resulted in spoiled food stored root cellars due to unexpected thawing conditions and rain that caused heavy snow melt. Accordingly, regional resident food resilience is greatly compromised.

Move three: Chukchi Sea & Bering Straits Economic Boom and associated Security Concerns in U.S. and Russia. MTS activity in the Bering and Chukchi rapidly rises as a result renewed pressure for Petroleum due to the of a decision by the Organization of the Petroleum Exporting Countries (OPEC) to curtail global production in order to drive higher prices per barrel. Demand for oil rises rapidly, resulting in oil sector to quickly assess and initiate drilling activities in the Chukchi Sea. Meanwhile, rising temperatures across the Arctic reach the threshold in which maritime transit of the Northern Sea Route, Northwest Passage and even limited seasons of Transpolar routes are feasible. Sensing economic advantage, Lloyd’s of London and other insurance companies approve bulk carriers and container vessels for Arctic transit through the Bering Straits. Complicating matters, a new discovery of on and near shore gold deposits (similar to the gold sands found near Nome in the 1900-1901 strikes) is made on St Lawrence Island Alaska that creates a new rush for wealth in the Bering Straits region. A number of hastily arranged mining enterprises arrive with little notice to Gambell village on St Lawrence Island eager to strike out and make their mining claims. Some of these enterprises are marginally legal and create a web of concerns to law enforcement, which was totally ill prepared to cope with the economic opportunists, who seem impervious to Tribal and local government concerns. Air and marine traffic rise dramatically, all in a haphazard fashion, which concerns and causes the Russian Federation to commence a series of reactionary/protective measures to include military exercises that restrict transit through Russian waters, forcing yet more traffic into the U.S. EEZ.
Arctic Maritime Traffic and Shipping Routes

2015 Vessel Activity in the Arctic

Description: The marine environment in the Arctic is changing rapidly. Continued expansion of the duration and extent of seasonal ice-free waters is projected to occur over the coming decades, resulting in new opportunities for the utilization of marine resources and increased availability of technically navigable waters. This, in turn, is projected to bring increased levels of maritime activity to the region. It is believed that this increased vessel activity will lead to the degradation of Arctic marine ecosystems, adversely impacting fish and marine mammal populations, as well as the region's indigenous people. While many studies have advanced the idea of increased Arctic vessel activity and the potential impacts, little to no effort has been undertaken to provide a comprehensive baseline of vessel operations in the region to monitor trends.


A Quantitative Assessment of Arctic Shipping in 2010-2014

Abstract: Rapid loss of sea ice is opening up the Arctic Ocean to shipping, a practice that is forecasted to increase rapidly by 2050 when many models predict that the Arctic Ocean will largely be free of ice toward the end of summer. These forecasts carry considerable uncertainty because Arctic shipping was previously considered too sparse to allow for adequate validation. Here, we provide quantitative evidence that the extent of Arctic shipping in the period 2011–2014 is already significant and that it is concentrated (i) in the Norwegian and Barents Seas, and (ii) predominantly accessed via the Northeast and Northwest Passages. Thick ice along the forecasted direct trans-Arctic route was still present in 2014, preventing transit. Although Arctic shipping remains constrained by the extent of ice coverage, during every September, this coverage is at a minimum, allowing the highest levels of shipping activity. Access to Arctic resources, particularly fisheries, is the most important driver of Arctic shipping thus far.


A Ten-Year Projection of Maritime Activity for the U.S. Arctic Region, 2020-2030

Summary: This report, This Report by the U.S. Committee on the Marine Transportation System (CMTS) is an update to the 2015 CMTS report of the same name (2015 Report). It provides a detailed account of past and present vessel activity patterns in the northern U.S. Arctic and surrounding waters around the Bering Strait. The 2019 report also projects how many additional vessels might be expected in the region over the next decade, out to 2030 through four scenarios.

The four scenarios included in this study are the Reduced Activity Scenario, Most Plausible Scenario, Optimized Growth Scenario, and Accelerated, but Unlikely Scenario. Each provides a different possibility for vessel activity in the northern U.S. Arctic and surrounding waters.
over the next decade, ranging from annual growth rates of 0.3% to 4.9% and total annual vessel counts of 284 ships to 535 vessels. Of the four scenarios generated, the Most Plausible Scenario best agrees with mathematical projections from available historic data for the region. The Most Plausible Scenario, based on conservative assumptions, indicates that the number of vessels operating in the U.S. Arctic in 2030 is likely to be more than triple the number of vessels in 2008, while the highest estimates included in the Accelerated, but Unlikely Scenario reflect growth more than four times the 2008 numbers and twice the number we see today. The total transits and movements into, out of, and within the U.S. Arctic will likely more than double the vessel numbers, underscoring the urgency to take on planning and evaluation exercises to be prepared for a changing Arctic maritime environment.


The Complexities of Arctic Maritime Traffic

Summary: In late August 2017, the Russian icebreaking liquefied natural gas (LNG) carrier Christophe de Margerie made headlines in maritime traffic news for a record-setting transit of the Northern Sea Route (NSR). The ship transited the 2,193 nautical mile NSR in just six days, twelve hours, and fifteen minutes. It completed the entire journey from Hammerfest, Norway, to Boryeong, South Korea, in nineteen days—nearly thirty percent faster than the traditional Suez Canal route. During the transit, the vessel averaged just over fourteen knots, remarkable given that part of the transit was through ice fields that were 1.2 meters thick.1) Such an accomplishment has fueled optimism, particularly by Russia and China, on the potential for the Arctic to become a viable alternative to normal maritime routes through the Suez Canal.2) Yet the impressive nature of this achievement must also give rise to serious discussions on both viability and governance in the High North. The transit, which benefited from optimal weather and ice conditions that permitted an expeditious journey for the ice-hardened vessel, highlights potential areas of concern for future maritime activity in the region and could establish a dangerous precedent if improvements to regional governance are not made. This paper examines the nuances of Arctic shipping, including construction and operational requirements, and assesses concerns which will result from increased maritime activity in the region. Specifically, the paper highlights operational challenges and further explores issues with governance, crisis response, and the impact of increased traffic on the fragile Arctic region. It further identifies solutions to these challenges through cooperation between nations and organizations with interests in the Arctic.


Arctic Marine Shipping Assessment 2009 Report

Executive Summary: The Arctic is undergoing extraordinary transformations early in the 21st century. Natural resource development, governance challenges, climate change and marine infrastructure issues are influencing current and future marine uses of the Arctic. The Arctic Council, recognizing these critical changes and issues, at the November 2004 Ministerial meeting in Reykjavik, Iceland, called for the Council’s Protection of the Arctic Marine Environment (PAME) working group to “conduct a comprehensive Arctic marine shipping assessment as outlined under the Arctic Marine Strategic Plan (AMSP) under the guidance of
Canada, Finland and the United States as lead countries and in collaboration with the Emergency Prevention, Preparedness and Response (EPPR) working group and the Permanent Participants as relevant.” The Arctic Marine Shipping Assessment, or The AMSA 2009 Report, is the product of that Arctic Ministerial decision in Reykjavik and was approved at the 2009 Ministerial meeting in Tromsø.

The decision to conduct the AMSA followed the release in 2004 of two relevant Arctic Council reports. First, the Arctic Climate Impact Assessment (ACIA) was a major study that received global attention and reported on the rapid and severe climate change ongoing in the Arctic. One of the key findings of the ACIA was that “reduced sea ice is very likely to increase marine transport and access to resources.” The second report, the Arctic Marine Strategic Plan (AMSP), presented the council’s strategic goals for protecting the Arctic marine environment. The AMSP called for future application of an ecosystems approach to the Arctic Ocean and for a comprehensive assessment of Arctic marine shipping.

The AMSA is designed to be circumpolar in breadth and also to consider regional and local perspectives. The assessment’s central focus is on ships: their uses of the Arctic Ocean, their potential impacts on humans and the Arctic marine environment and their marine infrastructure requirements. The AMSA does not place a primary focus on determining the operational and economic viabilities of specific marine routes within and across the Arctic Ocean.

All ship types are considered in the AMSA under the general topic of Arctic shipping: tankers, bulk carriers, offshore supply vessels, passenger ships, tug/barge combinations, fishing vessels, ferries, research vessels and government and commercial icebreakers. The result of the AMSA data survey effort produced a comprehensive estimate of how many ships (less naval vessels) operated in the Arctic for a given year. This survey represents an historic capture of information from the Arctic states that can be used as a long-term database against which to measure future Arctic marine traffic levels. In addition, more than 185 experts participated directly in the work of the AMSA. Thirteen major AMSA workshops were held from July 2006 through October 2008 on a broad range of relevant topics, including scenarios of future Arctic navigation, indigenous marine use, Arctic marine incidents, environmental impacts, marine infrastructure, Arctic marine technology and the future of the Northern Sea Route and adjacent seas. The AMSA workshops provided extensive information for developing the report sections.


Safe Navigation in the U.S. Arctic: Summary of a Conference

Overview: The workshop focused on the U.S. Arctic and issues affecting U.S. interests in its development and in ensuring safety of navigation. Information from and about other nations was introduced when it might affect the United States or when it might provide useful comparisons or illustrations. The planning committee selected four topic areas to be addressed in the workshop: vessel traffic management, emergency response capabilities, information and data needs, and resource needs and models. These were used to structure the workshop and shape the agenda. Questions were then developed within each topic area to serve as a framework to guide breakout session discussions. Appendix B contains the breakout session discussion guidelines, which were designed to focus breakout session discussions and provided to session moderators, speakers, and presenters in advance of the workshop.

Arctic Shipping: A Systematic Literature Review of Comparative Studies

Abstract: Following the gradual decline of Arctic sea ice, shipping using Arctic routes increased from 2010. This led to an upsurge in the number of studies investigating the potential of Arctic maritime routes. A systematic literature review was conducted to assess the extant literature from 1980 to 2017 on comparative studies between Arctic and traditional routes. This review also aimed to provide an initial understanding on route choice decision-making factors and to contribute to the literature by providing suggestions for future research and methodological considerations. The competitiveness of Arctic routes is evaluated from both economic and environmental perspectives. Research themes and methodological characteristics are analysed in order to establish an evidence base in Arctic shipping literature. It is identified that analytical research methods and transport cost models are mainly employed. The results indicate that although Arctic routes can be more cost-effective and energy efficient compared to traditional ones, especially in the long-term, they can mainly serve as seasonal alternatives for bulk and specialised shipping in the short-term.


Sea Ice Decline and 21st Century Trans—Arctic Shipping Routes

Abstract: The observed decline in Arctic sea ice is projected to continue, opening shorter trade routes across the Arctic Ocean, with potentially global economic implications. Here we quantify, using Coupled Model Intercomparison Project Phase 5 global climate model simulations calibrated to remove spatial biases, how projected sea ice loss might increase opportunities for Arctic transit shipping. By midcentury for standard open water vessels, the frequency of navigable periods doubles, with routes across the central Arctic becoming available. A sea ice-ship speed relationship is used to show that European routes to Asia typically become 10 days faster via the Arctic than alternatives by midcentury, and 13 days faster by late century, while North American routes become 4 days faster. Future greenhouse gas emissions have a larger impact by late century; the shipping season reaching 4–8 months in Representative Concentration Pathway (RCP)8.5 double that of RCP2.6, both with substantial interannual variability. Moderately, ice-strengthened vessels likely enable Arctic transits for 10–12 months by late century.


Implications of Climate Change for Shipping: Opening the Arctic Seas

Abstract: This paper assesses the value and environmental feasibility of Arctic shipping by reviewing the relevant scientific and economic peer-reviewed literature. From the physical perspective, this paper examines the impact of climate change on sea ice and marine weather and considers the resultant consequences for Arctic shipping accessibility. From an
economic perspective, it reviews the major research investigating the economic feasibility of diverting ships from conventional shipping routes to Arctic routes, the attitudes of shipping stakeholders, and other major factors affecting the prospect of Arctic shipping. This review also identifies important research gaps. Ultimately, we find that the complex environmental and economic dynamics of the Arctic suggest that an appropriate understanding of Arctic shipping will require close collaboration between natural and social scientists.


**Key Criteria Influencing the choice of Arctic Shipping: A Fuzzy Analytical Hierarchy Process Model**

Abstract: As Arctic sea ice shrinks due to global warming, the Northern Sea Route (NSR) and the Northwest Passage (NWP) offer a substantial reduction in shipping distance between Asia and the European and North American continents, respectively, when compared to conventional routes through the Suez and Panama Canals. However, Arctic shipping routes have many problems associated with their use. The main objective of this paper is to identify the key criteria that influence the decisions of shipping operators with respect to using Arctic shipping routes. A multi-criteria decision-making methodology, the Fuzzy Analytic Hierarchy Process, is applied to rank four potential categories of criteria (‘economic’, ‘technical’, ‘political’ and ‘safety’ factors) and their sub-criteria.

The results of the analysis suggest that, on aggregate, ‘economic’ is the most important category of influential factors, followed by ‘safety’, ‘technical’ and ‘political’ factors. The paper concludes, however, that the most influential specific sub-criteria relate to risks that lie mainly within the ‘safety’ and ‘political’ domains and that, especially in combination, these overwhelm the importance which is attached to ‘economic’ factors such as reduced fuel use. Finally, the implications of these findings for the future development of Arctic shipping are addressed at a strategic level.


**Winter Shipping in the Canadian Arctic: Toward Year-Round Traffic?**

Abstract: With the rapidly melting sea ice in the Arctic, and developing shipping traffic, emerged the idea, popular with the media, that sea ice would soon be completely dominated by first-year ice, and would thus be comparable to ice present in the Gulf of St. Lawrence: this would allow for the setting up of shipping year-round along Arctic passages. In fact, contrary to this idea, even with the vanishing of multi-year ice, ice conditions will remain very different in the Arctic from ice prevailing in the Gulf. Besides, naval technology certainly helps overcoming challenges of ice navigation, but they do not mean it is economically or technically much easier. Year-round shipping in the Arctic remains a difficult challenge to overcome.

Citation: Bourbonnais P., Lasserre, F., (2015) Winter shipping in the Canadian Arctic: toward year-round traffic?, Polar Geography, 38:1, 70-88, DOI:10.1080/1088937X.2015.1006298

**Current Status and Future Operational Models for Transit Shipping Along the Northern Sea Route**
Abstract: The Northern Sea Route (NSR) has received increased international attention during the recent years as an alternative transit corridor for shipping between Europe and East Asia. In 2015, the project “Feasibility and Reliability of Shipping on the Northern Sea Route and Modeling of an Arctic Marine Transportation & Logistics System” was established to perform a comprehensive analysis of the current status and future prospects of NSR transit shipping. The project brought together several partners and numerous participants representing industry, governmental bodies, and research groups from Europe, Asia, and Russia, thus providing a unique and comprehensive overview of the subject. This paper is based on the insights gathered during the project. Firstly, it provides a comprehensive overview of the NSR's current regulations and support services. Secondly, it combines the information on the current status of the route with feedback received from the stakeholders during project discussions for the purpose of establishing several possible future operational models for transit shipping along the NSR. It is concluded that the most probable of the analyzed operational models is a combination of ice-strengthened vessels and independent ice-going cargo vessels. This model requires a decrease in severity of ice conditions to allow for year-round commercial navigation, an increase in bunker prices, further development of maritime infrastructure and icebreaking support, and the development of new maritime insurance models. Additionally, establishing transshipment hubs at each end of the NSR with ice-going cargo vessels sailing between them is also considered to be a viable future option.


Polar Seaways? Maritime Transport in the Arctic: Analysis of Shipowners’ intentions II

Abstract: Climate change in the Arctic is leading to the fast recession of the sea ice extent in the summer. This evolution leads several observers, scientists, media and government officials, to consider the possibility of developing new shipping routes along Arctic routes, as these routes are much shorter between Europe and Asia. The literature displays a strong interest for these potential shipping routes while the media often assume shipping companies nurture a sustained attraction for Arctic routes. This paper tackles with this idea and examines to what extent shipping companies, the ultimate economic agents, are really interested in Arctic shipping routes. The image the research portrayed is that only a minority of shipping companies are indeed interested, and those that are interested stress the destination dimension of Arctic shipping, not transit shipping.


Risk Considerations within the Arctic MTS

Formal Vulnerability Assessment of a Maritime Transportation System

Abstract: World trade increasingly relies on longer, larger and more complex supply chains, where maritime transportation is a vital backbone of such operations. Long and complex supply chain systems are more prone to being vulnerable, though through reviews, no specific methods have been found to assess vulnerabilities of a maritime transportation system. Most existing supply chain risk assessment frameworks require risks to be foreseen to be mitigated, rather than giving transportation systems the ability to cope with unforeseen threats and hazards. In assessing cost-efficiency, societal vulnerability versus industrial cost of measures should be included.
This conceptual paper presents a structured Formal Vulnerability Assessment (FVA) methodology, seeking to transfer the safety-oriented Formal Safety Assessment (FSA) framework into the domain of maritime supply chain vulnerability. To do so, the following two alterations are made: (1) The focus of the assessment is defined to ensure the ability of the transportation to serve as a throughput mechanism of goods, and to survive and recover from disruptive events. (2) To cope with low-frequency high-impact disruptive scenarios that were not necessarily foreseen, two parallel tracks of risk assessments need to be pursued—the cause-focused risk assessment as in the FSA, and a consequence-focused failure mode approach.


Maritime Activity in the High North – The Range of Unwanted Incidents and Risk Patterns

Abstract: Growing commercial activities in the High North increase the possibility of unwanted incidents. The vulnerability related to human safety, environment, and installations or vessels, and a challenging context, call for strengthening of the preparedness system, and cross-boundary and cross-institutional collaboration.

The commercial activity in the High North includes intra- and inter-regional transportation, the search for and exploitation of hydrocarbons and other mineral resources, the fisheries, and cruise tourism. In addition, in the High North we find government activity such as research and naval operations. Activities in the Arctic are challenged by limited infrastructure, low temperatures with ice and icing, polar lows, and a fragile nature. In this paper we look into different stressors and risk factors in the High North related to life and environment. A discussion of risk is important for decisions about operational demands and the development of an adequate preparedness system.

High North is here defined as the circumpolar Arctic, delineated by the Arctic Circle. In the paper and presentation we will focus on the Atlantic Sector of the Arctic.

The main operational risk factors faced include geographical remoteness, climate-change related aspects and weather, electronic communications challenges, sea ice, lack of precise maps or hydrographic and meteorological data. Activity and probability of accidents differs in different parts of the Arctic. An overview of maritime activity and risk assessment are given in the paper. Implications for the preparedness systems are discussed.


Arctic Shipping and Risks: Emergency Categories and Response Capacities

Abstract: The sea ice in the Arctic has shrunk significantly in the last decades. The transport pattern has as a result partly changed with more traffic in remote areas. This change may influence on the risk pattern. The critical factors are harsh weather, ice conditions, remoteness and vulnerability of nature. In this paper, we look into the risk of accidents in
Atlantic Arctic based on previous ship accidents and the changes in maritime activity. The risk has to be assessed to ensure a proper level of emergency response. The consequences of incidents depend on the incident type, scale and location. As accidents are rare, there are limited statistics available for Arctic maritime accidents. Hence, this study offers a qualitative analysis and an expert-based risk assessment. Implications for the emergency preparedness system of the Arctic region are discussed.


A Root Cause Analysis for Arctic Marine Accidents from 1993 to 2011

Abstract: The aim of this paper is to investigate the marine accidents/incidents which are recorded by Marine Accident Investigation Branch (MAIB) as occurring north of 66°33′ in the years from 1993 to 2011 to reveal their causes by using root cause analysis. Due to the global warming, increase of ice melt in North Pole is expected in the future. In the further years, number of vessels and shipping traffic will dramatically increase in the Arctic region. Thus, navigation will become more difficult in the Arctic Region. Consequently, to guide the vessels navigating in this region, an analysis of the previous marine accidents/incidents occurring in the Arctic region is required to improve the safety. Therefore, Root Cause Analysis (RCA) is proposed to clarify the causes and prevent the future incidents from happening. As an empirical study, fault trees of collision and grounding for the Arctic Region is constructed. Fuzzy Fault Tree Analysis (FFTA) is applied to this problem in order to propose a recommendation to reduce the occurrence probabilities. Risk levels of each factors are determined by expert consultations. In this study, Accident to Person is found as the most observed incident. Negligence/careless of injured person has the highest priority for root causes of marine accidents. In order to combat this phenomenon, scientific results of this study can open up a dialog between law makers and shipping companies those aim to decline incidents. Furthermore, it is assumed to contribute representatives developing crew training manuals and competence requirements as well as opening Arctic navigation training centers.

Citation: Kum, S. Sahin, B., A root cause analysis for Arctic Marine accidents from 1993 to 2011. TransNav: The International Journal on Marine Navigation and Safety of Sea Transportation. Volume 12, Number 1. DOI: 10.12716/1001.12.01.12

Mapping and Analysis of the Maritime Accidents in the Russian Arctic through the Lens of the Polar Code and POLARIS System

Abstract: Over the last decade, more than 500 maritime accidents have been reported in the Arctic, and the political will of the Russian government to develop the Northern Sea Route (NSR) for the exportation of raw materials may lead to a rise of such events. However, data on insurance claims in the Russian Arctic are rather sketchy and not up-dated which has hindered accurate analysis so far. Based on empirical data collection throughout the period 2004–2017, the study gathers, classifies and maps certain ‘marine casualties’ and ‘incidents’ that occurred along the NSR until the Polar Code enforcement. Three maritime events are scrutinized through the lens of the Polar Code risk mitigation tools and POLARIS system in order to determine if the joint use of these new prophylactic instruments would have prevented their occurrence. As preliminary results, the research identifies the primary causes of identified maritime accidents that occurred in the Russian Arctic and provides their
categorization in accordance with IMO standards. It appears that serious ‘marine casualties’ represent the greatest number of insurance claims. Shedding light on the type of risk occurrence a ship may face along the NSR, it brings valuable implications for maritime operators who are still awaiting historical data for more realistic risk assessment. Finally, it demonstrates that the combination of the Polar Code and POLARIS system is an appropriate tool for risk mitigation and encourages stakeholders to implement best practices for Arctic shipping in their common interest.


How Vulnerable is Alaska’s Transportation to Climate Change? Managing an Infrastructure Built on Permafrost

Abstract: Climate change is affecting transportation systems across the country, and scientists and policymakers are working to clarify the trends. Alaska’s transportation community, however, has direct experience to verify the impacts of climate change. Geography and extreme climate have made the state a kind of climate-change classroom for the rest of the nation in predicting the effects on transportation infrastructure. The wear and tear of climate change on Alaska’s transportation systems is evident. The state has more than 6,600 miles of coastline, and approximately 80 percent of the land mass has an underlayer of ice-rich permafrost. Alaska has 17 of the nation’s 20 largest mountain ranges and experiences extremes in precipitation, snowfall, and temperature swings that are unique to the arctic and northern latitudes. With warming permafrost, coastal erosion, and increasingly dramatic storms and flood events, Alaska’s highways, runways, and other infrastructure are frequently icing, cracking, and washing away. Although these adversities challenge all of the state’s major transportation systems—maritime, aviation, and surface—the most acute and costly damage occurs within the road system. Climate change in Alaska is forcing engineers and planners to adapt both to warming and to cooling trends. Engineers and planners are addressing knowledge gaps in thermal and hydrological dynamics and are translating the findings into new and more robust designs. (Right:) Differential settlement on an abandoned section of the Richardson Highway, south of Fairbanks, one year after maintenance ceased.

**Seasonal Ice and Weather Considerations**

**Sea Ice: Hazards, Risks, and Implications for Disasters**

Abstract: The role of sea ice as a natural hazard is discussed with a focus on Arctic and sub-Arctic regions where risks associated with human activities and ice processes are the greatest. Hazard assessment and emergency response need to consider a range of controlling factors that can lead to events initiating an accident, failure, or full-scale disaster. These factors include environmental hazards, equipment, procedures and settings, and people. Quantifying risks associated with the presence of sea ice requires the joint consideration of the probability of specific hazards and the magnitude of their impacts. Both of these also depend on the type and level of human activity, such that disaster risks are substantially higher in the Arctic than in the Antarctic. We identify three types of sea-ice hazards: (1) broad, long-term hazards and associated risks associated with a rapid reduction in summer ice extent; (2) near-term hazards resulting from changes in sea-ice extent and dynamics such as increased coastal erosion and threats to coastal infrastructure; and (3) immediate risks and the potential for disasters derived from the combination of sea-ice hazards and human activities such as shipping or offshore resource development. A review of key properties and processes governing the role of sea ice as a hazard focuses on recent rapid changes in ice extent and concentration in the Arctic and resulting threats to coastal systems. Other key factors include the distribution of old perennial ice that has a greater thickness and higher mechanical strength than seasonal ice, patterns of ice movement that determine advection of ice hazards, and the degree of ice deformation that can generate thick, rough ice and represent a hazard in its own right. These factors are examined in the context of a case study for the Beaufort and Chukchi Seas in the North American Arctic. Linking specific environmental hazards to the geospatial distribution of human activities and vulnerable ecosystems allows for an integrated Arctic hazards assessment, currently still in its infancy. The need for coordinated environmental observations in informing hazard assessments and emergency response is discussed in the context of recent increases in maritime activities in the Arctic.

Citation: Eicken, H., Mahoney, A. R. (2015) Sea Ice: Hazards, Risks, and Implications for Disasters. Coastal and Marine Hazards, Risks, and Disasters, Chapter 13, pg 381-401. https://doi.org/10.1016/B978-0-12-396483-0.00013-3

**Mid-Winter Breakout of Landfast Sea Ice and Major Storm Leads to Significant Ice Push Event Along Chukchi Sea Coastline**

Abstract: During the winter of 2016, anomalous sea ice conditions and a powerful storm culminated in a destructive erosion event along the Chukchi Sea coastline of Cape Espenberg, Alaska. This event is commonly referred to as an “ice push” or “ivu,” the Inupiat word for an ice ridging event. In this article, we report the process and impact of this event by combining traditional ecological knowledge, news accounts, meteorological data, remote sensing, and ground surveys. The midwinter detachment of shorefast ice was caused by a low-pressure system and wind-driven swell that destabilized shorefast ice, while northerly winds developed an open-water lead offshore to the eventual impact area. These conditions preceded the impact of an extratropical cyclone on December 31, 2016, when powerful southerly winds and the second largest storm surge in Kotzebue Sound since at least 2003 led to the compressional failure of the ice cover under uniaxial loading perpendicular to the southern coastline of the Cape, resulting in the ice push event. Ice-pushed debris was shoved up to 6.2 m above mean high water, with ~3.5 km of coastline experiencing net erosion. The largest accumulation of ice-pushed debris had a volume of 1,000 m³, and rose
3 + m above the surrounding ground surface even after roughly 6 months of melting. On low-lying areas, driftwood and other debris were deposited 130 m landward by the surge 5.0 m above mean high water, indicating the potential threat of such events to property, infrastructure, and, in this case, archeological sites and associated cultural resources. The anomalous environmental and sea ice conditions that preceded the ivu seem to suggest that such events may occur more frequently in a warmer Arctic.


**Landfast Sea Ice Breakouts: Stabilizing Ice Features, Oceanic and Atmospheric Forcing at Barrow Alaska**

Abstract: Landfast sea ice is an important seasonal feature along most Arctic coastlines, such as that of the Chukchi Sea near Barrow, Alaska. Its stability throughout the ice season is determined by many factors but grounded pressure ridges are the primary stabilizing component. Landfast ice breakouts occur when these grounded ridges fail or unground, and previously stationary ice detaches from the coast and drifts away. Using ground-based radar imagery from a coastal ice and ocean observatory at Barrow, we have developed a method to estimate the extent of grounded ridges by tracking ice motion and deformation over the course of winter and have derived ice keel depth and potential for grounding from cumulative convergent ice motion. Estimates of landfast ice grounding strength have been compared to the atmospheric and oceanic stresses acting on the landfast ice before and during breakout events to determine prevailing causes for the failure of stabilizing features. Applying this approach to two case studies in 2008 and 2010, we conclude that a combination of atmospheric and oceanic stresses may have caused the breakouts analyzed in this study, with the latter as the dominant force. Preconditioning (as weakening) of grounded ridges by sea level variations may facilitate failure of the ice sheet leading to breakout events.


**Applications of Sea Ice and Weather Modeling Data in Search and Rescue (SAR) Operations in the Arctic: A Case Study in Utqiaġvik, Alaska**

Executive Summary: This research investigated the potential use and application of radar, satellite, and other tracking data for sea ice and weather conditions in maritime-related Search and Research (SAR) operations in the Arctic. Specifically, this study analyzed a SAR event for a missing small vessel due into Utqiaġvik (formerly, Barrow), Alaska in July 2017. This study feeds into the Arctic Domain Awareness Center (ADAC) funded project - Developing sea ice and weather forecasting tools to improve situational awareness and crisis response in the Arctic - which seeks to create a prototype sea ice and weather forecasting module for hazard planning in Utqiaġvik. An archival analysis of email communications regarding the SAR event and the U.S. Coast Guard (USCG) case file) was conducted, in addition to semi-structured interviews (n=17) with relevant stakeholders to understand how this SAR event unfolded, the different types of information that were used during the SAR event, and challenges to data accessibility and availability in the Arctic. This research found that data availability and accessibility, particularly in low bandwidth and further offshore areas, are challenges to data uptake during a SAR event. Nonetheless, this specific SAR incident helped
to illuminate there is a breadth of tools that can be applied and used in a SAR context - traditional and knowledge, modeling data, and USCG operational data. Specifically, modeling data from tools developed by the Arctic Domain Awareness Center (ADAC), the University of Alaska Fairbanks (UAF) and other research institutions was generated during this event to help support the local SAR effort. However, a level of pre- or post-processing was necessary in many cases, which can be a challenge for when data is needed immediately. This research holds implications for future use and uptake of modeling data in local SAR operations in Utqiagvik specifically and potentially across Arctic Alaska. Given that local SAR operators are predominantly the first line of response to maritime emergencies in the North Slope, the ability to share and provide a set of resources to support SAR operators can be beneficial, particularly in a rapidly changing Arctic. A more targeted and systematic way to utilize and draw upon scientific research for SAR operations can potentially support the local SAR community, especially when immediate information is necessary. In particular, leveraging different products to validate, interpolate, and extrapolate information against one another, can help create more comprehensive situational awareness, especially for further offshore SAR events. Further research is therefore necessary to see how such information can be adapted to be SAR-ready, to help maximize time. Lastly, further research to understand different SAR contexts can be of use to help identify which information resources could be useful and for what purpose. A review of other SAR events is one potential way to expand understanding of SAR information needs, helping to support the development and refinement of SAR-relevant information products.


The Impact of Climate Change and Weather on Transport: An Overview of Empirical Findings

Discussion: Although predictions of sea level rise differ widely, it is clear that even for moderate levels substantial transport damages may arise in many coastal areas around the globe. These damages not only consist of damages to infrastructure, also costs related network effects (travel delay and rerouting) may be substantial. In general, the studies that have been done in this area estimate the direct effects of sea level rise and the indirect effects of sea level rise through storm surges on flooding incidences. Effects of climate change on the frequency and intensity of storm surges are left out of the equation. Given the damages related to Hurricanes such as Rita and Katrina, additional research on this particular issue is necessary. Also, most studies are done for the US East Coast; insights for the US West Coast and Europe are largely missing. Finally, a rather substantial drawback of all studies considered is that they are done for aggregated areas only and that flood-defenses that are already in place are not included in the analyses. Although current defenses in most developing countries are limited in scale and scope, defenses in developing countries, and especially those in Europe, are generally well-developed. Therefore, the insights provided here may have limited value for assessing future flood-risk and exposure for specific locations (and likely also overestimate exposure and damages due to climate change). They may, however, give a good approximation of future exposure to and damages from flooding incidences when flood-defenses fail.

A Novel Approach in Probabilistic Quantification of Risks within the Context of Maritime Supply Chain: The Case of Extreme Weather Events in the Arctic

Abstract: Extreme Weather Events (EWEs) are currently not well understood by the maritime community, even though the shipping industry is not immune to their potential disastrous consequences. This is critical for the Arctic supply chains, considering the serious lack of experience, data, communication facilities, and that rules and regulations governing the region are at the embryonic stage. Understanding such, the study develops an effective risk assessment model in the context of the maritime supply chain and quantifies the risks associated with EWEs in the Arctic. The model is developed based on a Bayesian Belief Network (BBN) that reflects a probabilistic risk priority index based on Failure Mode, Effects and Criticality Analysis (FMEA). Here, we introduce a new index, based on a weighted combination of the likelihood, visibility, and consequence of risk factors. The model is quantified by 51 respondents based on their sailing experience with cargo carriers along the Northwest Passage. Our findings suggest that dense fog and ice accretion are distinctly critical risk factors followed by thunderstorm, hail and/or waterspouts, extreme coldness, and blizzard. The study offers useful insight to all right- and stakeholders in the Arctic. Moreover, it presents an effective tool to develop high-resolution maps for maritime routes considering important shipping elements.


Sea Ice Navigation and Related Considerations

A Method for Ice-Aware Maritime Route Optimization

Abstract: We present a method for ice-aware maritime route optimization. Our aim is to increase the safety and efficiency of maritime transport under icy conditions. The proposed method is based on the A* algorithm, developed by Hart et al. It uses a model of maritime navigation, consisting of (1) a sea spatial model, (2) ship maneuverability model, (3) sea ice model, and (4) ship performance model. The sea ice model, which provides a snapshot of the sea ice conditions, is based on previous work by the Finnish Meteorological Institute. The ship performance model, based on previous work by Kotovirta et al., estimates ship transit speed as a function of ice conditions and ship design parameters. The main novelties in this paper are the application of the A* algorithm to maritime route optimization and development of an associated cost function that takes into account ice conditions and available icebreaker assistance. We present preliminary results based on the method, using the Baltic Sea as a case study. Generated routes are compared with historical routes under the same ice conditions. Areas of future work and needed enhancements are briefly discussed.

Challenges of Sea-Ice Prediction for Arctic Marine Policy and Planning

Abstract: Sea ice presents an important challenge for trans-border coordination of Arctic maritime infrastructure. Widespread summer sea-ice melt and anticipated expansion of shipping and offshore oil and gas drilling have highlighted a need for seasonal forecasts and decadal projections of sea ice for strategic planning efforts. While the long-term trend in sea-ice extent is expected to remain negative, ice conditions exhibit large spatial and temporal variability, raising uncertainty and operational risks of navigation in seasonally ice-covered areas. Given the potential trans-border impacts of a maritime accident on the marine and coastal environment, predicting ice conditions is of critical interest to government, industry, and community stakeholders. Seasonal ice forecasts have shown promise for short-term operational decision-making, while decadal projections from general circulation models are increasingly being used for long-term planning of energy, security, and environmental policy. However, numerous issues complicate the application of sea-ice prediction methods for policy and planning. This paper examines the potential of sea-ice prediction as a tool to support strategic planning, with a focus on the trans-border marine space of the US and Canadian Arctic. The utility and limitations of seasonal and decadal sea-ice prediction are reviewed, followed by a discussion of the infrastructure and policy context within which sea-ice forecasts may be used to enhance safety and mitigate risk in the Arctic.


A Risk Analysis of Winter Navigation in Finnish Sea Areas

Abstract: Winter navigation is a complex but common operation in north-European sea areas. In Finnish waters, the smooth flow of maritime traffic and safety of vessel navigation during the winter period are managed through the Finnish–Swedish winter navigation system (FSWNS). This article focuses on accident risks in winter navigation operations, beginning with a brief outline of the FSWNS. The study analyses a hazard identification model of winter navigation and reviews accident data extracted from four winter periods. These are adopted as a basis for visualizing the risks in winter navigation operations. The results reveal that experts consider ship independent navigation in ice conditions the most complex navigational operation, which is confirmed by accident data analysis showing that the operation constitutes the type of navigation with the highest number of accidents reported. The severity of the accidents during winter navigation is mainly categorized as less serious. Collision is the most typical accident in ice navigation and general cargo the type of vessel most frequently involved in these accidents. Consolidated ice, ice ridges and ice thickness between 15 and 40 cm represent the most common ice conditions in which accidents occur. Thus, the analysis presented in this article establishes the key elements for identifying the operation types which would benefit most from further safety engineering and safety or risk management development.


Estimated Risks of Navigation of LNG Vessels Through the Ob River Bay and Kara Sea

Abstract: The project of LNG exploitation in the area of the Yamal peninsula and the Ob Bay in the Russian Federation combines all the elements of the LNG Value/Supply Chain of LNG...
exploitation and transport by sea. LNG ARC7 Ice Class vessels, that in many ways surpass common standards in construction and exploitation of LNG vessels, have been designed and constructed specifically for the purposes of this project. Carriage of LNG by ARC7 Ice Class LNG vessels is very demanding, especially in the conditions of polar night and permanent ice of various thickness, and very low atmospheric temperatures. The complexity of the endeavour is particularly emphasized while manoeuvring in the port, transiting narrow approach channels, and while navigating through the area of Northern Sea Route or just part of it, between the Arctic and Russian Continent. Successful and profitable projects of LNG exploitation depend on planned and uninterrupted ex-port of LNG as well as its safe and reliable delivery to the buyers. Therefore, the emphasis of the paper will be the identification of risks for the vessel and the environment as well as measures taken to mitigate the risks to the acceptable minimum.


Increasing Mobility of High Arctic Sea Ice Increases Marine Hazards Off the East Coast of Newfoundland

Abstract: Heavy ice conditions along Canada's east coast during spring 2017 presented hazardous conditions for the maritime industry and required the Canadian Coast Guard to pull its research icebreaker, CCGS Amundsen, off its scientific cruise to provide ice escort services and conduct search and rescue operations along Newfoundland's northeast coast. Greater ice concentrations and a thicker ice pack than are typical of this area created the anomalous ice cover. Within this paper we present in situ observations of the ice cover, confirming that pieces of multiyear sea ice from the high Arctic were present within the ice cover, and subsequently examine the transport pathway that connects the export of thick multiyear sea ice from the Lincoln Sea and Canadian Arctic Archipelago to coastal communities in Newfoundland. We conclude with a discussion on how an increasingly mobile Arctic sea ice cover may increase these ice hazards in the south.


Changing Sea Ice Conditions and Marine Transportation Activity in Canadian Arctic Waters Between 1990 and 2012

Abstract: Declining sea ice area in the Canadian Arctic has gained significant attention with respect to the prospect of increased shipping activities. To investigate relationships between recent declines in sea ice area with Arctic maritime activity, trend and correlation analysis was performed on sea ice area data for total, first-year ice (FYI), and multi-year ice (MYI), and on a comprehensive shipping dataset of observed vessel transits through the Vessel Traffic Reporting Arctic Canada Traffic Zone (NORDREG zone) from 1990 to 2012. Links to surface air temperature (SAT) and the satellite derived melt season length were also investigated. Between 1990 and 2012, statistically significant increases in vessel traffic were observed within the NORDREG zone on monthly and annual time-scales coincident with declines in sea ice area (FYI, MYI, and total ice) during the shipping season and on a monthly basis.
Similarly, the NORDREG zone is experiencing increased shoulder season shipping activity, alongside an increasing melt season length and warming surface air temperatures (SAT). Despite these trends, only weak correlations between the variables were identified, although a step increase in shipping activity is apparent following the former summer sea ice extent minimum in 2007. Other non-environmental factors have also likely contributed to the observed increase in Arctic shipping activity within the Canadian Arctic, such as tourism demand, community re-supply needs, and resource exploration trends.


**Governance and Regulation of the Arctic MTS**

**Circumpolar and Arctic Ocean Considerations**

**Implementing Marine Management in the Arctic Ocean**

Summary: The Arctic region today faces serious geopolitical, socioeconomic, and environmental challenges. While one may hope for a decrease in geopolitical tensions, the socioeconomic and environmental problems are likely to grow more acute. The dramatic reduction in Arctic sea ice and the other profound changes brought on by a warming climate have already changed the Arctic Ocean in ways that we are only beginning to understand. While these changes are making the Arctic Ocean more accessible for a range of human activities, they are also disrupting marine ecosystems and threatening the well-being of Arctic residents whose lives and livelihoods depend on a healthy Arctic Ocean.

Despite these challenges—and in some sense because of them—the common interests of governments, Arctic residents, and other stakeholders in the effective management of increasing human activities in the Arctic Ocean remain very real. The time is ripe to imagine and articulate a vision for a stronger architecture for advancing these common interests, in both the short-to-medium and longer terms, in hopes that policymakers will find the necessary political space in which to move forward on these matters.

This article briefly reviews current efforts to improve Arctic marine management and offers several suggestions for building a stronger architecture to implement needed measures.


**Governance of Ice-covered Areas: Rule Construction in the Arctic Ocean**

Summary: This article recounts the negotiations and emergence of Article 234 concerning ice-covered areas in the UN Convention on the Law of the Sea. As Arctic shipping increases, more vessels and flag states may be subject to the provisions of Article 234, which permit coastal states to both prescribe and enforce special measures to protect the marine environment in ice-covered areas. The history of the Article 234, disclosed partially through declassified U.S. government documents, provides context for implementation of the provision by Arctic coastal states and flag states.
Shipping in Polar Waters: Adoption of an International Code of Safety for Ships Operating in Polar Waters (Polar Code)

Summary: The Polar Code is intended to cover the full range of shipping-related matters relevant to navigation in waters surrounding the two poles – ship design, construction and equipment; operational and training concerns; search and rescue; and, equally important, the protection of the unique environment and eco-systems of the polar regions.

The Code will require ships intending to operating in the defined waters of the Antarctic and Arctic to apply for a Polar Ship Certificate, which would classify the vessel as Category A ship - ships designed for operation in polar waters at least in medium first-year ice, which may include old ice inclusions; Category B ship - a ship not included in category A, designed for operation in polar waters in at least thin first-year ice, which may include old ice inclusions; or Category C ship - a ship designed to operate in open water or in ice conditions less severe than those included in Categories A and B.

The issuance of a certificate would require an assessment, taking into account the anticipated range of operating conditions and hazards the ship may encounter in the polar waters. The assessment would include information on identified operational limitations and plans or procedures or additional safety equipment necessary to mitigate incidents with potential safety or environmental consequences.

Ships need to carry a Polar Water Operational Manual, to provide the Owner, Operator, Master and crew with sufficient information regarding the ship’s operational capabilities and limitations in order to support their decision-making process.

The chapters in the Code each set out goals and functional requirements, to include those covering ship structure; stability and subdivision; watertight and weathertight integrity; machinery installations; operational safety; fire safety/protection; life-saving appliances and arrangements; safety of navigation; communications; voyage planning; Manning and training; prevention of oil pollution; prevention of pollution form noxious liquid substances from ships; prevention of pollution by sewage from ships; and prevention of pollution by discharge of garbage from ships.

The IMO Regulatory Framework for Arctic Shipping: Risk Perspectives and Goal-Based Pathways

Abstract: The International Maritime Organization (IMO), in its capacity as a specialized agency of the United Nations, is the global regulator to ensure safety, security, environmental standards, efficiency and sustainability of international shipping. The current regulatory framework of IMO, which is developed and maintained on a continuous basis, includes over 50 international instruments and numerous codes, guidelines and circulars that cover every aspect of international shipping ranging from design, construction, equipment, manning and operation to ship recycling. The safety net of the universally adopted IMO regulations currently covers approximately 1.5 million seafarers and more than 60,000 ships. With declining ice cover leading to an increasing spiral of traffic despite the many hazards, safety of shipping in polar waters and, in particular, the Arctic and its fragile environment is a current focus area of IMO and purported to be addressed by the Organization through a set of goal-based regulatory standards. This chapter provides an overview of the IMO framework and process of shipping regulation and maps the transition from prescriptive to goal-based approach. Risk-based approaches to safety are discussed in the context of the Canadian Arctic. The chapter further reviews the IMO instruments relevant to the Arctic, including the Polar Code, and discusses the approaches to implementation at the flag state, coastal state and regional level, lending new insights and future pathways on tiered implementation of the IMO goal-based framework.


Governmentality of the Arctic as an international region

Summary: Linked to the image of a wild and still-to-be-explored territory, as well as to images of the region as one of new economic opportunities, discourses on the Arctic also tie in with issues of climate change, cooperation and conflict, Arctic governance, international law and the situation and rights of indigenous people, as well as Great Power politics. Taken together, these aspects characterize a region whose formation is different from regionalization processes in other parts of the world. As the regional peculiarity of the Arctic is reflected by a variety and plurality of representations, discourses, perceptions and imaginaries, it can usefully be analyzed as a region of unfolding governmentality. The present article argues that the prospects for the Arctic are strongly intertwined with perceptions and depictions of it as an international region subject to emerging practices of governmentality. By drawing on both Foucault’s texts and governmentality studies in international relations (IR), we discuss how the Arctic is affected by governmental security rationalities, by specific logics of political economy and order-building, as well as becoming a subject for biopolitical rationalizations and imaginaries. The discourses and practices of governmentality that permeate the Arctic contribute to its spatial, figurative and political reframing and are aimed at making it a governable region that can be addressed by, and accessible for, ordering rationalities and measures.

Governance within the U.S. Arctic Maritime EEZ

Port Access Route Study in the Chukchi Sea, Bering Strait, and Bering Sea

Summary: The United States Coast Guard’s (USCG) Seventeenth Coast Guard District conducted a Port Access Route Study (PARS) of the Bering Sea, Bering Strait and Chukchi Sea to evaluate the applicability and the need for creation of new vessel routing measures. The overarching goal of the Port Access Route Study is to determine if ship routing measures can help reduce the risk of marine casualties and their impact on the environment, increase the efficiency and predictability of vessel traffic, and preserve the paramount right of navigation while continuing to allow for other reasonable waterway uses.


Routing Measures and Mandatory Ship Reporting Systems: Establishing of Two-way Routes and Precautionary Areas in the Bering Sea and Bering Strait

Summary: This document is a proposal by the United States and the Russian Federation to establish six two-way routes and six precautionary areas in the Bering Sea and Bering Strait off the coast of Chukotskiy Peninsula and Alaska. These waters are expected to see increased traffic due to rising economic activity in the Arctic. Use of the proposed routes is intended to be voluntary for all ships of 400 gross tonnage and above.


Vessels, risks, and rules: Planning for safe shipping in Bering Strait

Abstract: Commercial vessel traffic through the Bering Strait is increasing. This region has high biological and cultural significance, to which commercial shipping poses several risks. For this environment, these risks include ship strikes of whales, noise disturbance, chronic pollution, and oil spills. Indigenous Chukchi, Iñupiaq, St. Lawrence Island Yupik, Siberian Yupik, and Yup’ik peoples may be affected by proximity between small hunting boats and large commercial vessels leading to swamping or collisions, through displacement of animals or impacts to food security from contaminants, and through loss of cultural heritage if archeological sites and other important places are disturbed by wakes or an increase in people spending time on shore. Several measures are available to govern shipping through the region, including shipping lanes, Areas to Be Avoided (ATBAs), speed restrictions, communications measures, reporting systems, emissions controls, oil spill prevention and preparedness and salvage, rescue tug capability, voyage and contingency planning, and improved charting. These measures can be implemented in various ways, unilaterally by the U.S. or Russia, bilaterally, or internationally through the International Maritime Organization (IMO). Regulatory measures can be established as voluntary measures or as mandatory measures. No single measure will address all risks, but the framework presented herein may
serve as a means of identifying what needs to be done and evaluating whether the goal of safe shipping has been achieved.

https://doi.org/10.1038/srep30682

Options and Opportunities for Advancing the U.S. Arctic MTS

United States Coast Guard Maritime Commerce Strategic Outlook

Executive Summary: The Coast Guard’s enduring responsibility to safeguard the MTS and enable the uninterrupted flow of maritime commerce is becoming more challenging. Emerging technologies, including the increased complexity in vessel designs, propulsion systems and operations; automation, interconnectivity, robotics and networked systems; and new methods for off shore natural resource exploration, production and transportation pose challenges and can be risk aggravators for the Service. These factors produce a system highly susceptible to disruption. Any man-made or natural disruption, even of brief duration, has the potential for lasting damaging effect on the Nation’s economy and national security.

The Coast Guard’s long-term outlook for maritime commerce emphasizes three lines of effort: Facilitating Lawful Trade and Travel on Secure Waterways, Modernizing Aids to Navigation and Mariner Information Systems, and Transforming Workforce Capacity and Partnerships. This outlook emphasizes the critical need to build a Ready, Relevant, and Responsive Coast Guard that maximizes America’s economic prosperity across the maritime domain. To ensure the Service’s enduring roles of safety, security, and stewardship, the Coast Guard must look to the future and anticipate rapid innovation in the maritime industry and the resulting complexity in the marine environment. To that end, the Coast Guard will pursue three lines of effort:

Facilitating Lawful Trade and Travel on Secure Waterways. The ease of moving people and cargo on America’s waterways is a competitive advantage and wellspring for economic prosperity and national security. The Coast Guard’s enduring role of enabling the uninterrupted flow of maritime commerce requires a multi-faceted approach that includes managing risks to critical infrastructure, ensuring the efficient delivery of Coast Guard services, supporting uniform/consistent vessel and facility standards, and promoting resiliency and unity of effort among all MTS stakeholders.

Modernizing Aids to Navigation and Mariner Information Systems. The Nation must invest in the waterways of the future to sustain global economic competitive advantage. The Coast Guard must build the information, digital, and physical infrastructure to manage emerging sources of risk within America’s waterways brought about by the introduction of new technologies and operating constructs. Leveraging technological advancements such as artificial intelligence, mobile and cloud-based computing, and data analytics will help keep the Service in step with emerging trends in the maritime industry. This includes modernizing information technology (IT) networks and applications that enable the Coast Guard to assess, monitor, and manage risk. Given the competing uses and growing demands for commerce, energy, food, resources, and recreation in U.S. waters, the Coast Guard must optimize maritime planning. The Service must also balance sustaining traditional navigation systems while building next generation waterway management systems, modernizing Inland and Coastal Aids to Navigation cutters, and applying emerging technologies. Regulatory frameworks, applications, and standards will be adapted to accurately incorporate the
implementation of emerging technologies that will transform maritime operations such as autonomous systems and new logistics platforms.

Transforming Workforce Capacity and Partnerships. Given the increased demand on America’s waterways, the Coast Guard must have a transforming workforce capacity and strengthen linkages/partnerships to facilitate, safeguard, and advance maritime commerce. The Service must develop an adaptive force that is proficient operating in a highly complex environment amid rapid evolution of technology. It needs to strengthen its nimble workforce with the digital competencies to respond to changes in commercial markets and the maritime industry. With an ever expanding MTS, the Coast Guard will leverage robust auditing capabilities of Third Party Organizations (TPOs) to improve vessel plans, surveys, and certain required certificates, while strengthening an extensive audit regime that ensures the highest standards of compliance oversight are being maintained. It is imperative to transform the workforce and roles of other enabling organizations to have the capability, experience, and expertise to address the broad spectrum of threats to our national interests.


United States Coast Guard Arctic Strategy

Executive Summary (Abbreviated): This document outlines three strategic objectives in the Arctic for the U.S. Coast Guard over the next 10 years:

Improving Awareness: Coast Guard operations require precise and ongoing awareness of activities in the maritime domain. Maritime awareness in the Arctic is currently restricted due to limited surveillance, monitoring, and information system capabilities. Persistent awareness enables identification of threats, information-sharing with front-line partners, and improved risk management. Improving awareness requires close collaboration within DHS, as well as with the Departments of State, Defense, Interior, the National Science Foundation and other stakeholders to enhance integration, innovation, and fielding of emerging technologies. The Intelligence Community and non-federal partners are also vital stakeholders.

Modernizing Governance: The concept of governance involves institutions, structures of authority, and capabilities necessary to oversee maritime activities while safeguarding national interests. Limited awareness and oversight challenge maritime sovereignty, including the protection of natural resources and control of maritime borders. The Coast Guard will work within its authorities to foster collective efforts, both domestically and internationally, to improve Arctic governance. In so doing, the Coast Guard will review its own institutions and regimes of governance to prepare for future missions throughout the Arctic.

Broadening Partnerships: Success in the Arctic requires a collective effort across both the public and private sectors. Such a collective effort must be inclusive of domestic regulatory regimes; international collaborative forums such as the Arctic Council, International Maritime Organization (IMO), and Inuit Circumpolar Council; domestic and international partnerships; and local engagements in Arctic communities focusing on training and volunteer service. Success in the Arctic also depends upon close intergovernmental cooperation to support national interests, including working closely within DHS, as well as with the Department of
State, Department of Interior and other Federal partners as the U.S. prepares to assume Chairmanship of the Arctic Council in 2015.

Beyond these three strategic objectives, there are a number of additional factors that will position the Coast Guard for long-term success. These factors include building national awareness of the Arctic and its opportunities, strengthening maritime regimes, improving public-private relationships through a national concept of operations, seeking necessary authorities, and identifying future requirements and resources to shape trends favorably. This strategy outlines a number of priorities, ranging from capabilities and requirements to advances in science and technology that will facilitate our Nation’s success in the region. Specifically, the strategy advocates to leverage the entire DHS enterprise and component capabilities to secure our borders, prevent terrorism, adapt to changing environmental conditions, enable community resilience and inform future policy. Operating in the Arctic is not a new venture for the Coast Guard. However, adapting to changing conditions will require foresight, focus, and clear priorities. This strategy will ensure we attain the aim of safe, secure, and environmentally responsible maritime activity in the Arctic by improving awareness, modernizing governance, and broadening partnerships to ensure long-term success.


A Strategic Approach and Interagency Leadership Could Improve Federal Efforts in the U.S. Arctic.

Summary: Maritime shipping activity, as indicated by the number of vessels in the U.S. Arctic, generally increased from 2009 through 2019. Domestic maritime activity declined after the discontinuation of offshore oil and gas exploration activities in Alaska’s Chukchi Sea in 2015. However, since 2015, international activities related to natural gas development, particularly in the Russian Arctic, have increased, according to stakeholders. Factors affecting decisions of ship operators about whether to operate in the U.S. Arctic include increased operating costs of Arctic-capable ships, environmental changes that have caused more volatile weather and ice conditions, and concerns over environmental impacts.

Agencies have taken some steps to address Arctic maritime infrastructure gaps identified by federal agencies, such as a lack of nautical charting, but federal efforts lack a current strategy and interagency leadership. Examples of agency actions include the U.S. Coast Guard developing recommended shipping routes and the National Oceanic and Atmospheric Administration continuing to chart Arctic waters. To guide federal efforts, the White House developed a National Strategy for the Arctic Region in 2013 and established an interagency Arctic Executive Steering Committee (AESC) in 2015. However, agency officials and stakeholders noted the strategy is now outdated due to changing conditions in the Arctic. As a result, federal efforts lack a current government-wide strategy that aligns with key management practices such as identifying goals, objectives, and establishing performance measures. Moreover, U.S. Arctic interagency groups do not reflect leading collaboration practices, such as sustained leadership and inclusion of all relevant stakeholders, and the White House has not designated which entity is to lead U.S. Arctic maritime infrastructure efforts. For example, the AESC is now dormant according to agency officials and staff at the White House Office of Science and Technology Policy (OSTP), which chairs the AESC. Without a current strategy and a designated interagency entity with these collaboration practices in place, agencies may miss opportunities to leverage resources and target infrastructure improvements in areas that would best mitigate risks.

National Strategy for the Maritime Transportation System: Channeling the Maritime Advantage (2017-2022)

Executive Summary: The 2017 National Strategy on the MTS: Channeling the Maritime Advantage (2017 Strategy) was developed by the CMTS members through interagency engagement and multiple reviews. Members reviewed the five categories from the 2008 Strategy and established or reaffirmed priority areas for the 2017 Strategy:

- Optimize System Performance: Measuring the reliability of physical and operational elements of the MTS to inform and support strategies for targeted improvements as trade and supply chain competitiveness increases.
- Enhance Maritime Safety: Promoting an MTS free from collisions, allisions, groundings and injury, death and damage to property and environment as congestion and maximum vessel size within the MTS increases.
- Support Maritime Security: Evaluating the infrastructure and operations of the MTS, taking into account possible threats and vulnerabilities while continually assessing existing protective measures, procedures and operations, supported by efforts to understand and incorporate maritime domain awareness into shipping activities.
- Advance Energy Innovation and Development: Identifying opportunities to utilize all sources of domestic energy and implement new technologies to ensure energy independence and more efficient fuel use.
- Facilitate Infrastructure Investment: Using all available resources efficiently and effectively for the improvement of the MTS.

This Strategy will be implemented across Federal agencies and within the CMTS partnership, as appropriate. The CMTS will assist in coordinating and tracking the actions and measures through the Executive Secretariat, Integrated Action Teams, Task Teams, or a mechanism to be developed as needed. The CMTS will also align its current and future annual work plans with the approved 2017 Strategy. While the 2017 Strategy is a living document that must also meet emerging issues, the CMTS will make progress on each action within the next five years, with the goal of completing most, if not all, of the actions within those five years, pursuant to agency engagement, resources, and Administration policy.


Sustained Observations of Changing Arctic Coastal and Marine Environments and Their Potential Contribution to Arctic Maritime Domain Awareness: A Case Study in Northern Alaska

Abstract: Increased maritime activities and rapid environmental change pose significant hazards, both natural and technological, to Arctic maritime operators and coastal communities. Currently, U.S. and foreign research activities account for more than half of the sustained hazard-relevant observations in the U.S. maritime Arctic, but hazard assessment and emergency response are hampered by a lack of dedicated hazard monitoring installations in the Arctic. In the present study, we consider a number of different sustained environmental observations associated with research into atmosphere-ice-ocean processes, and discuss how they can help support the toolkit of emergency responders. Building on a
case study at Utqiaġvik (Barrow), Alaska, we investigate potential hazards in the seasonally ice-covered coastal zone. Guided by recent incidents requiring emergency response, we analyze data from coastal radar and other observing assets, such as an ice mass balance site and oceanographic moorings, in order to outline a framework for coastal maritime hazard assessments that builds on diverse observing systems infrastructure. This approach links Arctic system science research to operational information needs in the context of the development of a Common Operational Picture (COP) for Maritime Domain Awareness (MDA) relevant for Arctic coastal and offshore regions. A COP in these regions needs to consider threats not typically part of the classic MDA framework, including sea ice or slow-onset hazards. An environmental security and MDA testbed is proposed for northern Alaska, building on research and community assets to help guide a hybrid research-operational framework that supports effective emergency response in Arctic regions.


Safety at the Helm: A Plan for Smart Shipping Through the Bering Strait

Abstract: The Bering Strait, one of the Arctic's most biologically productive environments and a vital migratory corridor for many iconic Arctic species, is one of the priority areas for WWF work in northern latitudes. The dramatic decline of the summer sea ice and increasing industrialization in the Arctic threaten to significantly impact such important marine areas. In this updated report on the Bering Strait, WWF experts present several measures that will help ensure safe and environmentally sound shipping in the region by addressing increasing threats of growing vessel traffic.


Linking Arctic System Science Research to Decision Maker Needs: Co-producing Sea Ice Decision Support Tools in Utqiaġvik, Alaska

Abstract: Improving situational awareness and crisis response are key priorities in reducing potential risks associated with sea ice and environmental-related hazards in the Arctic. This research explores the opportunities and challenges associated with leveraging arctic system science research to coproduce sea ice decision support tools. The research is based on information derived from a coastal radar operated as part of university research in Utqiaġvik, Alaska as well as decision context analysis from 12 interviews with marine operators and responders, subsistence users, and service providers. Findings revealed a diversity of information preferences and needs, decision thresholds, capacities, and constraints. A sea ice notification framework is presented, which illustrates how near-real time observations can be integrated into existing trusted notification systems. Key challenges to using Arctic system science research to support decision maker needs include the logistics of operating and maintaining near-real time observations. Innovative partnerships and informal networks may be especially important in overcoming these challenges.
Citation: Kettle, N.P., Abdel-Fattah, D., Mahoney A. R., Eicken, H., Brigham, L.W., Jones, J. (2020) Linking Arctic system science research to decision maker needs: co-producing sea ice decision support tools in Utqiaġvik, Alaska, Polar Geography, 43:2-3, 206-222, DOI: 10.1080/1088937X.2019.1707318

Coast Guard Polar Security Cutter (Polar Icebreaker) Program: Background and Issues for Congress

Summary: This report provides background information and issues for Congress on the Polar Security Cutter (PSC) program—the Coast Guard’s program for acquiring new PSCs (i.e., heavy polar icebreakers). The PSC program has received a total of $1,169.6 million (i.e., about $1.2 billion) in procurement funding through FY2020, including $135 million in FY2020, which was $100 million more than the $35 million that the Coast Guard had requested for FY2020. With the funding it has received through FY2020, the first PSC is now fully funded and the second PSC has received initial funding.

The Coast Guard’s proposed FY2021 budget requests $555 million in procurement funding for the PSC program. It also proposes a rescission of $70 million in FY2020 funding that Congress had provided for the procurement of long lead time materials (LLTM) for a 12th National Security Cutter (NSC), with the intent of reprogramming that funding to the PSC program. The Coast Guard states that its proposed FY2021 budget, if approved by Congress, would fully fund the second PSC.

The issue for Congress is whether to approve, reject, or modify the Administration’s FY2021 procurement funding request for the PSC program and the proposed rescission of FY2020 NSC funding, and, more generally, whether to approve, reject, or modify the Coast Guard’s overall plan for procuring new polar icebreakers. Congress’s decisions on this issue could affect Coast Guard funding requirements, the Coast Guard’s ability to perform its polar missions, and the U.S. shipbuilding industrial base.


Vessel Traffic in the Canadian Arctic: Management Solution for Minimizing impacts on whales in a Changing Northern Region

Abstract: Warming weather conditions in the Arctic are already resulting in changes in both sea ice extent and thickness. The resulting extended ‘open water’ season has many implications for vessel traffic and marine life. For example, an increase in vessel traffic due to ice-free waters will most likely lead to an increased risk of impact on cetaceans through increased noise pollution, strike risk for some cetacean species, and the possibility of exposure to chemical pollutants. The objective of this study was to pre-empt a predicted increase in vessels by investigating and exploring possible management scenarios, with the aim of mitigating negative impacts on locally important species such as bowhead and beluga whales. Utilizing insights gained from established vessel management schemes in more southerly regions, this paper evaluates the current suite of tools being implemented and their appropriateness for implementation in a more extreme Arctic environment.

**Economic and Resource Development Considerations**

**A framework for assessing the economic impacts of Arctic change**

Abstract: The scientific literature on physical changes in the Arctic region driven by climate change is extensive. In addition, the emerging understanding of physical feedbacks and teleconnections between the Arctic and the rest of the world suggests that the warming in the Arctic region is likely to cause impacts that extend well beyond the region itself. However, there is only limited research on how Arctic change may affect economies and individual industry sectors around the world. We argue that there is a pressing need for more research on this topic and present a conceptual framework to guide future research for assessing the regional and global economic impacts of Arctic change, including both possible benefits and costs. We stress on the importance of a transdisciplinary approach, which includes an integration of the natural sciences, economics and social sciences, as well as engagement with a wide range of stakeholders to better understand and manage the implications of Arctic change.


**Identification of Development Areas in a Warming Arctic with Respect to Natural Resources, Transportation, Protected Areas, and Geography**

Abstract: The starting point of the analysis in hand is a brief discussion of the so-called ‘Arctic Passages.’ Considering that ice and ice-pacts will remain a concern in the future, the support of icebreakers will still be needed to facilitate the safe passage of ships. Describing the state of these types of vessels currently available is the main aim, with a particular focus on key state players: the Russian Federation (RF), the United States of America (USA) and Canada. Additionally, a critical evaluation of future plans in relation to the introduction of icebreakers into service is taking place. Russia has already built and operates a certain number of vessels that are fully capable to handle current traffic demands, as well as the expected future increase. On the opposite direction, both Canada and USA are facing problems to deal with current demands and the situation during the next couple of years looks rather troublesome. Their obvious lack of icebreaking capabilities is somewhat disconcerting given the expected demand in the Arctic region in coming years coupled with the lengthy acquisition and production process required for a new icebreaking fleet. An acceleration of their acquisition plans and activities to cover the identified gap in icebreakers’ services is clearly a high priority.

Citation: Eliasson, K., Ulfarsson, G. F., Valsson, T., & Gardarsson, S. M. (2017). Identification of development areas in a warming Arctic with respect to natural resources, transportation, protected areas, and geography. Futures, 85, 14–29. https://doi.org/10.1016/j.futures.2016.11.005

**Challenges and Opportunities of Oil and Gas Investment in the Arctic**

Abstract: With a rapidly changing climate, Arctic nations are now adjusting their policies to meet the more navigable and less hostile Arctic. Estimations indicate that the Arctic could hold 30% of the world’s undiscovered gas, 13% of the world’s undiscovered oil, and 44 billion barrels of natural gas liquids.
In this sense, the aim of this Capstone project is to illustrate the opportunities and challenges related to future Arctic oil and gas development. In particular, the group has chosen to focus on offshore oil and gas given that this is the main focus of future exploratory activity. Although Arctic drilling is not commercially viable at this time, and is not expected to be in the near future, a careful analysis of its expected costs and benefits remains relevant, since Shell and other industry leaders have continued their activity in the region. Taking a long-term view, the project outlines the key motivations for oil and gas development, focusing on geopolitical tensions; the interests of the three most important Arctic states, i.e. Russia, the U.S. and Canada; environmental challenges; shipping; technology; infrastructure; and tax regimes and investment activities. We look each of these aspects in turn, using the different Arctic countries as our unit of analysis where appropriate.


A Review of Some Environmental Issues Affecting Marine Mining

Abstract: This article reviews information recently available from existing marine and coastal mining for responses to environmental issues affecting marine mining at different depths. It is particularly but not exclusively concerned with those issues affecting seabed biodiversity impact and recovery. Much information has been gathered in the past 10 years from shallow mining operations for construction aggregate, diamonds, and gold, from coastal mines discharging tailings to shallow and deep water, and from experimental deep mining tests. The responses to issues identified are summarized in a series of eight tables intended to facilitate site-specific consideration. Since impacts can spread widely in the surface mixing layer SML, and can affect the biologically productive euphotic zone, the main issues considered arise from the depth of mining relative to the SML of the sea. Where mining is below the SML, the issue is whether it is environmentally better to bring the extraction products to the surface vessel for processing (and waste discharge), or to process the extraction products as much as possible on the seabed. Responses to the issues need to be site-specific, and dependent on adequate preoperational environmental impact and recovery prediction. For deep tailings disposal from a surface vessel, there are four important environmental unknowns: (1) the possible growth of “marine snow” (bacterial flocs) utilizing the enormous quantities of fine tailings particles (hundreds or thousands of metric tons per day) as nuclei for growth, (2) the possibility that local keystone plankton and nekton species may migrate diurnally down to and beyond the depth of deep discharge and hence be subjected to tailings impact at depth, (3) the burrow-up capability of deep benthos and their ability to survive high rates of tailings deposition, and (4) the pattern and rate of dispersion of a tailings density current through the deep water column from discharge point to seabed. Actions to obtain relevant information in general and site-specifically are suggested.

Citation: Derek V. E. (2001) A Review of Some Environmental Issues Affecting Marine Mining, Marine Georesources & Geotechnology, 19:1, 51-63, DOI: 10.1080/10641190109353804

Fisheries within the U.S. Arctic EEZ

Alaska's Commercial Fisheries
Abstract: Commercial fisheries of Alaska fall under a mix of state and federal management jurisdictions. In general, the state has management authority for all salmon, herring, and shellfish fisheries, whereas the federal government has management authority for the majority of ground fish fisheries, excepting those within 3 nautical miles of shore and a few others. The first major commercial fisheries targeted salmon and herring in the late 1800s when much of the product was salted for storing and shipment. Today, commercial salmon and herring fisheries occur along most of Alaska’s coastline north to the southern Chukchi Sea, with annual harvests averaging 750 million lbs. and 80 million lbs. of salmon and herring, respectively, in the 5-year period 1998–2002. Commercial shellfish fisheries target a diverse assemblage, including 7 crab species, 5 shrimp species, scallops, at least 3 clam species, and several “miscellaneous” invertebrates, including sea urchins and sea cucumbers. Crab harvests have fluctuated widely during their history. Peak years have seen as much as 400 million lbs. harvested, with a recent 5-year average of 137 million lb. Commercial shrimp harvests reached peak levels of over 120 million lbs. in the 1970s and declined following a climate induced regime shift to average harvests of slightly over 2.2 million pounds in the 5-year period 1998–2002. Ground fish fisheries for a variety of species dominate the harvest poundage, with nearly 4.2 billion lbs. harvested on average in the 5-year period 1998–2002. The majority of that total, about 2.9 billion lbs. was walleye Pollock (Theragra chalcogramma), 555 million lbs. were Pacific cod (Gadus macrocephalus), and 483 million lbs. were various flatfish.


Community Security: Indigenous Peoples and Rural Communities

Local Indigenous Concerns and Input

Bering Strait Voices on Arctic Shipping Workshop Report

Summary: This report identifies the conclusions and covers the proceedings of the Bering Strait Voices on Arctic Shipping (BSVAS) workshop held by Kawerak, Inc. in 2014. The workshop involved a round table discussion between tribal leaders and municipal leaders, with participants discussing three topics: protection of natural resources, safety and security, and economic development and infrastructure. These themes were chosen because of their importance to the region and specifically to help Kawerak form a holistic long-term planning process on how to address the impacts of Arctic shipping in the Bering Strait region. Within each of the three focus areas, workshop participants were provided with two questions. The first question centered on the concept of primary concerns about impacts to the region’s residents as a result of increased Arctic shipping. The second question asked participants to start thinking about solutions to address some of their concerns. Solutions could be in the form of policies, advocacy, projects, or programs.


Bering Strait Voices on Arctic Shipping

Summary: This report covers the proceedings of the second Bering Strait Voices on Arctic Shipping workshop held by Kawerak, Inc. on January 25-26, 2016. Like the first BSVAS
workshop, this workshop involved a round table discussion. Both indigenous peoples from multiple villages and USCG representatives participated in the discussion. The first day focused on a variety of local concerns, from changing weather impacts on local indigenous populations to oil spill response concerns to the local Area Contingency Plan. Three presentations were also given on the first day, focusing on the US Coast Guard’s Subarea Contingency Plan, Traditional Knowledge, and Golovin’s Emergency Response Plan. The second day focused on identifying more concerns. These concerns ranged from local oil spill responder training/preparedness, industry/port development and practices, the importance of protecting the ecology and biology of the Bering Strait, ship graywater and blackwater disposal, and sea ice loss.


Community Perspectives on the Environmental Impacts of Arctic Shipping: Case Studies from Russia, Norway, and Canada

Abstract: Communities across the Arctic are experiencing growth in transiting, destination and domestic ship traffic. Environmental impacts resulting from Arctic shipping have been well documented, but little is known about how these impacts affect livelihoods and adaptive capacity of the local communities that are reliant on their natural landscapes. Given the heterogeneity of the Arctic, this study applied a community-based approach to empirically assess the impacts of shipping on the environment. Interviews were conducted in three island communities: Solovetsky in Russia (n = 24), Longyearbyen on Svalbard, Norway (n = 22) and Cambridge Bay, Canadian Arctic (n = 24). Despite differences in the trends of shipping activities that occur in each of the case study communities, there was consensus regarding significant environmental impacts from ship traffic on the natural environment, and that these in turn present a great concern for community livelihoods. The concerns differ greatly among the three communities and depended on the local context and perceptions and use of the natural environment. We conclude that the natural environment represents a salient determinant of adaptive capacity in the context of growing ship traffic across the Arctic. Moreover, this context-dependent determinant varies in the way it is perceived across case communities.


Understanding and Adapting to Observed Changes in the Alaskan Arctic: Actionable Knowledge Co-production with Alaska Native Communities

Abstract: Global changes in climate, connectivity, and commerce are having profound impacts on the Arctic environment and inhabitants. There is widespread recognition of the value of incorporating different worldviews and perspectives when seeking to understand the consequences of these impacts. In turn, attention to local needs, perspectives, and cultures is seen as essential for fostering effective adaptation planning, or more broadly, the resilience of local peoples. The emerging literature on “knowledge co-production” identifies factors that can help incorporate such local needs and information. This field focuses on how different models of what has been termed the “science-policy interface” can incorporate multiple epistemologies. Such an approach goes beyond observing or assessing change from different scales and perspectives, to defining conditions that support the co-production of
actionable knowledge. This approach requires the development of response tools that can accommodate the dynamic relationships among people, wildlife, and habitats that straddle cultures, timescapes, and sometimes, national boundaries. We use lessons from seven Alaskan cases studies to describe a typology of five elements important for the co-production of locally relevant actionable knowledge. Three elements are consistent with earlier work, including 1) evolving communities of practice, 2) iterative processes for defining problems and solutions, and 3) presence of boundary organizations, such as a government agency, university, or co-management council. Our results for the Alaskan Arctic also emphasize the critical need to incorporate 4) the consistent provision of sufficient funds and labor that may transcend any one specific project goal or funding cycle, and 5) long temporal scales (sometimes decades) for achieving the co-production of actionable knowledge. Our results have direct relevance to understanding the mechanisms that might foster greater success in more formalized co-management regimes.


Social impacts of climate change and resource development in the Arctic: Implications for Arctic governance

Abstract: This paper aims to explore the socio-political implications of climate change as the melting ice ignites new debates over territorial sovereignty of Arctic coastal states. Previously ice-jammed waterways are now open, and a number of recent geological surveys have identified new potential sites with vast energy resources. Competition over resources causes states to question each other’s jurisdiction over specific parts of the Arctic. What used to be internal waters of one particular state can now be referred to as international waters by other actors interested in the benefits of resource extraction. Arctic indigenous groups, especially the Inuit, and Sami are directly affected by the current governance patterns that are fragmented across too many different bodies dealing with maritime navigation, tourism, fisheries and administration.


Subsistence and Regional Food Security Concerns

Rebuilding Northern Foodsheds, Sustainable Food Systems, Community Well-Being, and Food Security

Abstract: Multiple climatic, environmental and socio-economic pressures have accumulated to the point where they interfere with the ability of remote rural Alaska Native communities to achieve food security with locally harvestable food resources. The harvest of wild foods has been the historical norm, but most Alaska Native villages are transitioning to a cash economy, with increasing reliance on industrially produced, store-bought foods, and with less reliable access to and reliance on wild, country foods. While commercially available market foods provide one measure of food security, the availability and quality of market foods are subject to the vagaries and vulnerabilities of the global food system; access is dependent on
The Legal Protection of Subsistence: A Prerequisite of Food Security for the Inuit of Alaska

Abstract: For the last twenty-five years, the legal protection of subsistence in Alaska has given rise to legal and political controversies. Subsistence is closely related to the concept of “food security,” as defined by the World Food Summit. The purpose of this Article is to highlight the need to recognize and critically examine the link between food security and the efficient legal protection of the traditional hunting, fishing, and gathering activities of the Inuit people of Alaska. The Article first describes the genesis and evolution of the subsistence debate in Alaska. It then attempts to demonstrate that the legal protection of subsistence is a prerequisite to Inuit food security for nutritional, cultural, and economic reasons. Finally, the Article identifies specific features of the Alaskan legal regime that threaten Inuit subsistence and food security.


“My Fear is Losing Everything”: The Climate Crisis and First Nations’ Right to Food in Canada

Joseph Koostachin, 58, remembers when he and his wife Helen, 56, went out on the land to hunt and berry pick with their young children. In the summer, the forests and meadows were lush and the water in the rivers plentiful. The winters were cold, with ice and snow cover allowing them to travel by dog sled from November through April. They would hunt caribou, a large type of deer, in the winter, while snow geese predictably arrived in April, and fish were bountiful in summer. The varied, seasonal harvest helped Joseph feed his family healthy food year-round.

The Koostachins live in Peawanuck, a remote community on Hudson Bay in the Canadian province of Ontario. Joseph and Helen’s sons are now grown and have taken over the responsibility of securing food from the land for the family. Going out on the land means more than just finding food, however, it is also a reflection of their deep ties to the land of their ancestors and its importance to their cultural identity and traditions.
Yet as global temperatures have risen as a result of climate change, the Koostachins’ way of life, and livelihood, have become increasingly difficult to maintain, and the realization of their rights to food, health, and culture are at risk. There are fewer caribou and geese migrating to the area. And it is harder—at times impossible—to hunt them because the ice and permafrost they must travel over is no longer stable throughout the winter, while the waters they traverse in summer are unpredictably low. As the climate continues to warm, these changes to their lands and environment will intensify, and their traditional sources of sustenance could entirely disappear.


Local Vessel Traffic Concerns

Risk of Ship Strike and Noise Pollution to Cetaceans in the Bering Strait

Abstract: As the Arctic sea ice extent decreases due to global climate change, new commercial shipping routes are opening through the Arctic. All of these routes connect the Arctic Ocean to the Pacific Ocean through the Bering Strait, a bottleneck region between Alaska and Russia. This same Strait is important habitat for cetaceans, including cetaceans migrating to northern feeding grounds, and cetaceans that remain in the Arctic region year-round. The overlap between shipping routes and cetacean habitat indicates an increased probability of a ship striking a cetacean and an increase in underwater noise pollution from the ships. A risk analysis was conducted for cetacean species, analyzing the risk posed by ship strike and ship noise as a function of exposure and vulnerability, with vulnerability being assessed as a combination of the resilience of the cetacean populations, and the potential threat posed by the ships. The analysis found the highest levels of risk to be among the humpback whale and North Pacific right whale populations in the Bering Strait region, although there remain high levels of uncertainty regarding both the rates of future ship traffic and the knowledge of the cetacean abundance and distribution in the region. The results were used to evaluate potential solutions to mitigate future ship strike rates and vessel noise in the region, including marine spatial planning, vessel actions, new technologies, and increased monitoring capabilities. Given the remoteness of the Bering Strait region and the successes and failures of these solutions in other parts of the world, the most effective solution are likely a combination of several solutions, requiring cooperation to implement from the United States, Russia, and the international community.


National Transportation Safety Board Safety Recommendation Report - Shared Waterways: Safety of Recreational and Commercial Vessels in the Marine Transportation System

Summary/Introduction: In the late afternoon on August 30, 2016, a group of eight kayakers set off from the dock at West 44th Street in New York City for a guided tour along the Hudson River. The intended route was south along the waterfront of midtown Manhattan, then
southwest down the river. As the tour passed the New York Waterways ferry piers at West 39th Street, a commercial passenger ferry backed out of its berth, then turned west to head toward New Jersey. The kayak tour guide attempted to signal the ferry captain by waiving his arms, but the captain later told investigators that because of the glare of the setting sun he did not see the paddlers in time to avoid colliding with them. Three kayakers, including the guide, were injured in the collision—two of them seriously. The ferry captain alerted authorities and used his vessel and crew to help rescue the kayakers. New York Waterways did not learn until several hours later that all kayakers had been rescued and accounted for.

The New York City accident illustrates the dangers of recreational and commercial vessels operating on shared waterways, and several stakeholders had previously discussed with the National Transportation Safety Board (NTSB) their concerns rising from an increase in encounters between these types of vessels. Given the number of encounters currently observed between commercial and recreational vessels, the predicted increase in the number of such encounters, and feedback from marine industry representatives, the NTSB sought to better understand the scope of the issue and determine the extent to which the safety of our nation’s waterways is impacted. This report provides the NTSB’s findings as well as recommendations to improve shared waterway safety.


Coastal Waterway Planning and Management for Small Craft

Abstract: With a rapid growth in pleasure boating in recent years and with increased development in commercial fishing likely to follow from the declaration of new sea resource boundaries, it has become apparent that facilities for many of these craft are now inadequate. Conflicts have also arisen in places between different interest groups vying for limited waterways, particularly in metropolitan areas where recreational demands are high. This paper examines planning and management considerations pertinent to the provision of facilities such as launching ramps, moorings and marinas for both pleasure and commercial small craft as well as the resolution of waterway usage conflicts. This is achieved through a number of case studies made by the authors at coastal and estuarine locations in New South Wales. An overall approach to planning and management is developed, and techniques such as opinion surveys, aerial observations and operations research are blended with traditional engineering procedures to formulate solutions to waterway usage problems.


National Security and Geopolitical Considerations

Changes in the Arctic: Background and Issues for Congress

Summary (abbreviated): The diminishment of Arctic sea ice has led to increased human activities in the Arctic, and has heightened interest in, and concerns about, the region’s
future. The United States, by virtue of Alaska, is an Arctic country and has substantial interests in the region. The seven other Arctic states are Canada, Iceland, Norway, Sweden, Finland, Denmark (by virtue of Greenland), and Russia.

The Arctic Council, created in 1996, is the leading international forum for addressing issues relating to the Arctic. The United Nations Convention on the Law of the Sea (UNCLOS) sets forth a comprehensive regime of law and order in the world’s oceans, including the Arctic Ocean. The United States is not a party to UNCLOS.

Record low extents of Arctic sea ice over the past decade have focused scientific and policy attention on links to global climate change and projected ice-free seasons in the Arctic within decades. These changes have potential consequences for weather in the United States, access to mineral and biological resources in the Arctic, the economies and cultures of peoples in the region, and national security.

The geopolitical environment for the Arctic has been substantially affected by the renewal of great power competition. Although there continues to be significant international cooperation on Arctic issues, the Arctic is increasingly viewed as an arena for geopolitical competition among the United States, Russia, and China. Russia in recent years has enhanced its military presence and operations in the Arctic, and the United States, Canada, and the Nordic countries have responded with their own increased presence and operations. China’s growing diplomatic, economic, and scientific activities in the Arctic have become a matter of increasing curiosity or concern among the Arctic states and other observers.


The Good, the Bad and the Ugly: Three Levels of Arctic Geopolitics

Abstract: Statements about conflict surrounding the Arctic is quite common. In May 2019, in a speech in conjunction with a meeting at the Arctic Council — the Arctic’s foremost cooperative mechanism — US Secretary of State Mike Pompeo lambasted both Russia and China for their “provocative actions” that are “part of a pattern of aggressive behavior”. That October, France’s Minister of the Armed Forces even compared the Arctic to the Middle East. Yet both the United States (as a member of the Arctic Council) and France (as an observer) are strong supporters of Arctic cooperative mechanisms, and repeatedly stress their desire to ensure that the circumpolar region remains insulated from troubles elsewhere.

Ideas of the Arctic as an arena for political competition and rivalry are therefore often juxtaposed with the view of the Arctic as a region of harmony and shared interests. Such regional approaches have led to Arctic security debates being dominated by ideas of “exceptionalism” — the notion that the Arctic is unique and separate from the (geo)political rivalries elsewhere in the world.

There seems to be a confusing multitude of actors and layers of engagement in Arctic geopolitics. Numerous questions are left concerning the geopolitical characteristics of the
Arctic, contradictory statements by Arctic states about the region, and how regional relations might evolve in the near future.

This article unpacks the notion of Arctic geopolitics by exploring the different, at times contradictory, political dynamics at play in the North. It explores three levels of inter-state relations: the regional (Arctic) level, the international system, and the level of bilateral relations. Labelling these levels as “good,” “bad” and “ugly” — an unabashed borrowing from Sergio Leone’s epic 1966 film — helps shed light on the distinctiveness of each and on how they interact.


Maritime Militarization in the Arctic: Identifying Civil-Military Dependencies

Abstract: This paper reconsiders extant discourses on Arctic security within the wider body of militarization literature and suggests that the enduring peacetime roles of Arctic maritime forces has resulted in a limited, but recognizable, militarism. However, this militarism is not to be confused with alarmist interpretations of potential interstate conflict or a predilection towards violence. Rather, in focusing on the blurred responsibilities between regional naval, coast guard, and civilian organizations, I highlight the social-economic and material dependencies between Arctic civil societies and their governments’ security providers. Specifically, this paper compares Norwegian, Danish, and Canadian approaches to their respective regional maritime security interests, emphasizing how the process of militarization has developed in the relationships between their Arctic civil societies and those countries’ Arctic maritime security infrastructures. It argues that Arctic literature would do well to move beyond binary debates over whether the Arctic is or is not militarized, and instead recognize that certain sectors of regional societies have long been dependent on the continued sustainment and modernization of maritime and, occasionally, naval power, which continuously provides support for peacetime civilian ways of life. Only with this understanding can the material developments of Arctic military and paramilitary power be properly contextualized.


Geopolitics of Arctic Shipping: The State of Icebreakers and Future Needs

Abstract: The starting point of the analysis in hand is a brief discussion of the so-called ‘Arctic Passages.’ Considering that ice and ice-pacts will remain a concern in the future, the support of icebreakers will still be needed to facilitate the safe passage of ships. Describing the state of these types of vessels currently available is the main aim, with a particular focus on key state players: the Russian Federation (RF), the United States of America (USA) and Canada. Additionally, a critical evaluation of future plans in relation to the introduction of icebreakers into service is taking place. Russia has already built and operates a certain number of
vessels that are fully capable to handle current traffic demands, as well as the expected future increase. On the opposite direction, both Canada and USA are facing problems to deal with current demands and the situation during the next couple of years looks rather troublesome. Their obvious lack of icebreaking capabilities is somewhat disconcerting given the expected demand in the Arctic region in coming years coupled with the lengthy acquisition and production process required for a new icebreaking fleet. An acceleration of their acquisition plans and activities to cover the identified gap in icebreakers’ services is clearly a high priority.


People’s Republic of China Strategic Considerations

China’s Arctic Policy & The Polar Silk Road

Abstract: On 26 January 2018, China released the much-anticipated White Paper that sets out its policies and position on the Arctic. China understands the economic opportunities and the territorial challenges in the region as it seeks a greater role in Arctic development. The White Paper outlines China’s ambitious plan to develop a Polar Silk Road across the Arctic. It also summaries China’s policy goals and the principles guiding its conduct. As a non-Arctic state with no territorial sovereignty in the region, China’s ambition would be dependent on its cooperation and the alignment of its interest with Arctic states. In considering China’s Arctic policy, this paper considers three pertinent questions: (1) what are China’s key interests in the Arctic, (2) what are the aims and basis of China’s Arctic policy as outlined in the White Paper and (3) how does China’s Arctic policy complement its Polar Silk Road vision as an extension of its Belt and Road Initiative.

Citation: Lim, K.S. (2020). China's Arctic Policy & The Polar Silk Road. Arctic Yearbook 2018, pp. 420-432. (Akureyri, Northern Research Forum) https://doi.org/10.1080/1088937X.2018.1455756

China’s Arctic Dream

Introduction (abbreviated): China has emerged as an engaged and active Arctic Actor over a relatively short period of time. In 2009 China created its Polar Research Institute. As a mid-latitude country that is impacted by global climate trends, the Chinese government has organized eight Arctic Scientific expeditions and it currently has two research stations in the Arctic – on Svalbard and in Northern Iceland – with ambitions to launch a research station in northern Canada. China’s Scientific agenda focuses on mid-latitude weather, changes in Arctic sea ice, and ocean acidification.


Russian Federation Strategic Considerations

The Ongoing Formation of Russia’s Arctic Policy: A New Stage?
Abstract: This paper provides an overview of Russia’s Arctic policy with a focus on recent changes in the spatial development and legislative/institutional frameworks. It briefly explains the definition of the Arctic Zone of the Russian Federation (AZRF) and examines its basic consolidation mechanism, as well as socio-economic challenges to its development and some legislative gaps. The paper identifies the roles of various actors and institutions in decision-making processes. In doing so, it also investigates how both Western sanctions and oil prices affected the realization of the Arctic policy’s main objectives. It argues that Russia will continue to promote the benefits of using the NSR and to attract all interested parties in the exploitation of the AZRF’s natural resources, but there is a need to revise some strategies in order to do it effectively, considering new circumstances.


The Arctic Policy and Port Development along the Northern Sea Route: Evidence from Russia’s Arctic Strategy

Abstract: As global warming continues, the melting rate of Arctic glaciers is further accelerated, which provides favorable conditions for the development of the Arctic's abundant resources, shipping, and ecological research. Accordingly, Russia, as the country with the longest Arctic coastline, has promulgated a series of policies and guidelines which aimed at the development of the Arctic region and the revitalization of the Northern Sea Route (NSR). By strengthening infrastructure construction, reducing port dues, and improving handling efficiency to promote the development of ports along the NSR and also to gives full play to the transportation potential of NSR, which is an inherent need for the development of Russian Arctic region. However, how Russia's Arctic strategy may affect port development along the NSR and whether the Russian arctic strategy can promote the development of ports along the NSR remain to be investigated. This study, based on the multi-source data, uses the difference-in-difference (DID) method to estimate the impact of Russia's Arctic strategy on the development of ports along the NSR. The results from this study indicate that Russia's Arctic strategy has failed to promote the development of ports along the NSR during 2003–2012, and the growth of port cargo throughput is overly reliant on energy exploitation. All of our preliminary results throw light on the nature of the impact of Russia's Arctic strategy on the development of ports along the NSR.


Telling Domestic and International Policy Stories: The Case of Russian Arctic Policy

Abstract: Based on extensive empirical analysis of policy communication, this chapter investigates the difference between the Arctic narratives presented by the Russian government to the domestic and foreign audiences. We apply narrative policy analysis (Nye 2004; Jones and McBeth 2010) to demonstrate how the Russian government offers two separate, yet intersecting policy stories. For the domestic audience, it highlights the socio-economic significance of natural (hydrocarbon) resources to the development of the Arctic region and Russia as a whole and demonstrates persistence in turning the Arctic into the
primary resource base ‘against all odds’ (such as the Western economic sanctions and low price of oil). For the foreign publics, it presents the narrative of the Arctic as a territory of peace and stability, emphasizing adherence to the norms and principles of the international law.


**Canadian Strategic Considerations**

**Canada's Arctic policy. Striking a balance between national interests and circumpolar cooperation**

Introduction: The Arctic is undergoing rapid changes, both environmentally and politically, and the Arctic states as well as non-Arctic actors are working to establish a presence, secure national interests and natural resources in the High North. Canada is an interesting player in this unpredictable region, with the potential to become an Arctic great power. Canada is the world’s second largest country, over 40% of its landmass is located in the north, it has an extensive Arctic coastline and considerable prospects for northern energy and natural resource development. At the same time, Canada’s northern territories – the Yukon, the Northwest Territories and Nunavut – are severely underdeveloped. Both the federal and the territorial governments face enormous challenges in terms of social and economic development, infrastructure improvements, providing education and job opportunities, improving housing conditions and the health of Aboriginal peoples and northerners in the territories. These challenges notwithstanding, it is crucial for the federal government to facilitate the continued habitation of the Canadian Arctic to assert and maintain its sovereignty claims to the region, which is becoming increasingly vital as international interests in the circumpolar north grows. To deepen the understanding of how Canada works to position itself in the High North, this thesis sets out to answer the problem statement: what are the main priorities for Canada in its Arctic region, and how does Canada pursue its Arctic policy on the domestic and international level? The thesis examines how Canada works domestically and maneuvers on the international arena to respond to challenges in the region while safeguarding domestic interests and protecting its Arctic sovereignty. It focuses on policy issues pursued unilaterally, through bilateral relations with the other Arctic states and through transnational cooperation in multilateral forums, primarily the Arctic Council. It presents Canada’s actions, intentions and motives behind these actions, as well as the outcomes of Canadian Arctic policymaking.

Citation: Steinveg, B. (2014) Canada's Arctic policy. Striking a balance between national interests and circumpolar cooperation. The Arctic University of Norway, Department of Sociology, Political Science and Community Planning, Master Thesis in Political Science. Retrieved From: https://hdl.handle.net/10037/7079

**Canada’s Arctic and Northern Policy Framework: A Roadmap for the Future?**
Introduction: On 10 September 2019, Canada’s Liberal government quietly released its long-awaited Arctic and Northern Policy Framework (ANPF). After four years of development, the document appeared on the Crown-Indigenous Relations and Northern Affairs website. It included no photos, maps, or even a downloadable pdf – just a wave of words, over 17,000 in the main chapter alone. The single infographic that accompanied the framework’s release captured its main “highlights”: that a “whole-of-government, co-development” process that created the framework involved the three territorial governments, over 25 Indigenous organizations, as well as three provincial governments. This collaborative process represents the “profound change of direction” that the Government of Canada highlights in the opening sentence of the ANPF. Iqaluit Mayor Madeleine Redfern noted how “the framework speaks to the fact that we need to be more collaborative, more strategic. It’s not a strategy per se, other than to say we need to actually be working together.”

The government’s emphasis on collaborative governance recognizes that when Ottawa has defined problems facing the North incorrectly or has set the wrong priorities, with little consultation from Northerners, policy responses have been shortsighted and ineffective. While critics have lauded the process involved in co-developing the framework, they have questioned the hasty release of what seems to be a partially-developed document, coming just a day before the federal government announced Canada’s 2019 federal election. The ANPF appeared with no budget, timelines, or clear plan to address the wide array of challenges and issues identified. Critics have labelled the framework a “half-baked” and “chaotic mess” that simply lists well-known issues and gives “lip service to addressing the problems,” while providing no “concrete” plan for action.

The ANPF highlights many well-known issues that Northerners have identified for years, including climate change impacts, food insecurity, poverty, health inequalities, and housing shortages. It is useful in reinforcing common understandings of these problems with those most affected, reiterating the importance of these issues to the general Canadian public, and setting priorities for federal policy. The framework also points out that the government and its Indigenous and territorial partners have already acted on some of the challenges and opportunities identified during the long co-development process – particularly through innovative and unique community based initiatives. The ANPF’s expressed objective, however, is to provide a “roadmap” to achieve the “shared vision” co-developed by the groups involved in the process. If this is a roadmap, it is one with few clear directions – a map that identifies hazards, problems, and opportunities, but does little to illuminate how the federal government will work practically with its partners to navigate the complex terrain around myriad Arctic policy priorities and seemingly intractable political dilemmas.


Geopolitics of Arctic Passages and Continental Shelves

Introduction: Melting summer sea ice in the Arctic is documented and has been making the headlines since 2007. The phenomenon, underlined by scientists and the media since the turning of the century, has triggered speculation on the opening of much shorter sea routes linking Europe via the eastern North American coast to Asia, as well as increased access to the mineral riches of the region. The prospect of growing shipping traffic in Arctic waters, especially through the Northwest Passage in the Canadian Arctic archipelago, or through the Northeast Passage north of Russia, has fuelled rhetoric on the status of these Arctic routes
ARCTIC MARITIME HORIZONS 2021 LITERATURE REVIEW: ARCTIC DOMAIN AWARENESS CENTER

and controversy over the pace of such shipping growth. Similarly, much rhetoric has been voiced regarding the extent of continental shelves in the Arctic.

There are actually two very different issues regarding Arctic sovereignty for Canada at the present time. They are often confused but do not imply the same policy actions, nor the same dimensions of the UN Convention on the Law of the Sea (UNCLOS), which Canada ratified in 2003. These two issues are, first, the extension of the continental shelves beyond the Exclusive Economic Zones (EEZ) of the 5 riparian countries bordering the Arctic Ocean; and, second, the political and legal status of the Arctic passages, namely the Northwest Passage across the Canadian Arctic archipelago, and the Northeast Passage, north of Siberia.


Incident Response, Logistics, and Command and Control

Complex Network Modeling and Evolutionary Game Simulation of the Arctic Environmental Emergency Response and Governance

Abstract: Climate change provides opportunities in the surrounding areas of North Pole to commercial shipping activities, but which also poses risks to ship strikes, oil spills, chronic marine environmental pollution, etc. However, the public product supply of Arctic environmental emergency response and governance is seriously insufficient. As such, a collective and effective system should be established to protect the Arctic environment. In the present paper, a complex network model of Arctic environmental emergency response and governance system is developed. The strategy of each country in the complex network is demonstrated by evolutionary game simulations of this system model. Computational results indicate that the benefit of environmental emergency response and governance affects the cooperation strategy of each country. Moreover, Long-term benefit and return intensity are the key parameters of environmental emergency response and governance benefit. These findings extend theoretical research in the sustainable development Arctic routes and provide reference for the participation of other countries beyond the Arctic Council.

Conclusion: This paper models the countries involving in Arctic environmental emergency response and governance as a complex network. Moreover, we simulate the evolutionary game of the public good of Arctic environmental emergency response and governance. The following conclusions can be drawn from simulation of the complex network.
(1) We prove the complex network shows the characteristics of small world.
(2) Long-term benefit and return intensity parameters are the key factors influencing the strategy of each country in the evolutionary game simulation of supplying the public good of Arctic environmental emergency response and governance.
(3) The long-term benefit promotes cooperation. When the return intensity is high enough to make the environmental benefit larger than the long-term benefit, countries tend to withdraw.
(4) Increasing the proportion of long-term benefit and forming binding agreements concerning Arctic environment governance may be helpful to enhance cooperation between countries.


Abstract: In this paper we focus on managerial roles and structuring mechanisms within the crisis preparedness system. We elaborate on the challenges of crises management in complex and volatile environments. The coordination and control mechanisms are of importance to safeguard operations including joint operations including several preparedness institutions, especially in cross-border cooperation. We include examples from the maritime Arctic. This paper contributes to the crisis management literature emphasizing the relations between context, managerial roles and the organizational structuring mechanisms needed to facilitate the interplay between several emergency response actors.


Oil Spill and Spill Response Concerns

Systemic Risk of Maritime-Related Oil Spills Viewed from Arctic and Insurance Perspective

Abstract: There is a wish for economic development in the Arctic, especially in relation to the region's untapped marine and hydrocarbon resources. However, such developments are inherently risky, entailing the possibility of trade-offs and potentially jeopardizing a fragile and pristine natural environment which provides multiple sources of well-being to the Arctic's four million inhabitants. When the risks of economic development are evaluated, they are usually assessed on a micro (enterprise risk) and/or meso level (portfolio risk, such as an industry). Systemic risk is considered to a much lesser degree. There is also limited discussion about mitigation methods, including the role of insurance in dealing with the consequences of failures, such as oil spills. The aim of this study is, therefore, to explore the systemic risk of maritime-related oil spills in general and place the findings in an Arctic and insurance perspective. The study is based on secondary data relating to major maritime-related oil spills from drilling and shipping. Two analytical frameworks were employed, one explaining the scaling of risks, and another showing the interplay between subsistence and monetized economies in tandem with their institutional, environmental, social and cultural context. The findings suggest, if the worst-case scenario materializes, that maritime-related oil spills may have social/cultural, environmental, and economic impacts, in addition to security/policy implications, as well as affecting businesses involved in the disaster and their partners. This study has academic implications since there are, so far, limited studies carried out on systemic-level risk, but it also has policy relevance, for instance for local and regional authorities and international bodies, such as the Arctic Council, in terms of holistic risk-assessment and its recommended use of appropriate decision-making and evaluative frameworks such as ecosystem-based management.

Weathering of an Arctic Oil Spill

Abstract: A small experimental oil spill was conducted on the northern tip of Baffin Island, Nunavut, Canada (72°310 N, 79°500 W) in August 1981, and the natural weathering of the oil has been followed by periodic visits. This paper reports on the chemical composition of oil collected in August 2001. The vast majority of the initial oil has gone, but small patches remain. Some samples remain essentially unaltered despite their 20 years of exposure to the elements, while others show that biodegradation and photo oxidation can play important roles in removing the majority of the components of the oil. Using 17a(H)21b(H)hopane as a conserved marker within the oil, we show that the most biodegraded sample has lost more than 87% of the hydrocarbons initially present, while another has lost a substantial proportion of its initial chrysene and alkylated congeners. Potential explanations for the different weathering patterns seen in samples collected from this small site are briefly discussed.


Onshore preparedness for hazardous chemical marine vessel accidents: A case study

Abstract: Hazardous and noxious substances (HNS) are widely transported in marine vessels to reach every part of the world. Bulk transportation of hazardous chemicals is carried out in tank container–carrying cargo ships or in designed vessels. Ensuring the safety of HNS containers during maritime transportation is critically important as the accidental release of any substance may be lethal to the on-board crew and marine environment. A general assumption in maritime accidents in open ocean is that it will not create any danger to the coastal population. The case study discussed in this article throws light on the dangers latent in maritime HNS accidents. An accident involving an HNS-carrying marine vessel in the Arabian Sea near the coast of Yemen became a safety issue to the coastal people of Kasargod District of Kerala, India. The ship carried more than 4000 containers, which were lost to the sea in the accident. Six HNS tank containers were carried by the waves and shored at the populated coast of Kasargod, more than 650 nautical miles east from the accident spot. The unanticipated sighting of tank containers in the coast and the response of the administration to the incident, the hurdles faced by the district administration in handling the case, the need for engaging national agencies and lessons learned from the incident are discussed in the article. This case study has proven that accidents in the open ocean have the potential to put the coastal areas at risk if the on-board cargo contains hazardous chemicals. Littoral nations, especially those close to the international waterlines, must include hazardous chemical spills to their oil spill contingency plans.


The Technology Windows-of-Opportunity for Marine Oil Spill Response as Related to Oil Weathering and Operations

Introduction: This paper identifies and estimates time periods as ‘windows-of-opportunity’ where specific response methods, technologies, equipment, or products are more effective in clean-up operations. These windows have been estimated utilizing oil weathering and technology performance data as tools to optimize effectiveness in marine oil spill response
decision-making. The windows will also provide data for action or no-action alternatives. Weathering of oil has a direct bearing on oil recovery operations, influencing the selection of response methods and technologies applicable for clean up, including their effectiveness and capacity, which can influence the time and cost of operations and the effects on natural resources. Generic windows-of-opportunity can be delineated for the general categories of spill response namely: (1) dispersants, (2) in situ burning, (3) booms, (4) skimmers, (5) sorbents, and (6) oil-water separators. To estimate windows-of-opportunity for the above technologies (except booms), the IKU Oil Weathering Model was utilized to predict relationships—with 5 m s⁻¹ wind speed and seawater temperatures of 15 °C.

Dispersant Window-of-Opportunity
The window-of-opportunity for the dispersant (Corexit 9527 ®) with Alaska North Slope (ANS) oil was estimated from laboratory data to be the first 26 h. A period of 'reduced' dispersibility, was estimated to last from 26-120 h. The oil was considered to be no longer dispersible if treated for the first time after 120 h. The window of opportunity for a dispersant may be lengthened if the dispersant contains an emulsion breaking agent or multiple applications of dispersant are utilized. Therefore, a long-term emulsion breaking effect may increase the effectiveness of a dispersant and lengthen the window-of-opportunity.

In-Situ Burning Window-of-Opportunity
The window-of-opportunity of in situ burning (based upon time required for an oil to form an emulsion with 50% water content) was estimated to be approximately 0-36 h for ANS oil after being spilled.

Booms Window-of-Opportunity
The estimation of windows-of-opportunity for offshore booms is constrained by the fact that many booms available on the market undergo submergence at speeds of less than 2 knots. The data suggest that booms with buoyancy to weight ratios less than 8 : 1 may submerge at speeds within the envelope in which they could be expected to operate. This submergence is an indication of poor wave conformance, caused by reduction of freeboard and reserve net buoyancy within the range of operation. No data on boom windows-of-opportunity on ANS available in this paper.

Sorbent Window-of-Opportunity
For sorbents, an upper viscosity limit for an effective and practical use has in studies been found to be approximately 15,000 cP, which is the viscosity range of some Bunker C oils.

Separator Window-of-Opportunity
The windows-of-opportunity for several centrifuged separators based upon the time period to close the density gap between weathered oils and seawater to less than 0.025 g ml⁻¹ (which is expected to be an end-point for effective use of centrifugal separation technology), were estimated to be 0-18 h after the spill for ANS oil.

Oil spill response capabilities and technologies for ice-covered Arctic marine waters: A review of recent developments and established practices

Summary: In low sea ice concentrations (less than 30%) oil behaves as in open water, but with 70-80% concentrations oil drifts with ice, with little known in the 30-70% zone. Oil can also be incorporated into new ice when in open water, making it inaccessible for clean up. If oil is released under the ice oil will slick underneath the ice thickening and spreading out to the ice edge. Oil can also seep into the ice; this ice oil uptake is worsened in the ice growth season. Entrapped oil can then be released later into the environment as ice melts and becomes porous. Ice can also encapsulate oil into an ice-oil sandwich. Floating ice can also negatively impact spill responses such as booms that can be destroyed by ice. However, ice can act as a natural boom making containment and in situ burning easier. Certain concentrations of ice aren’t high enough to act as a boom, but high enough to decrease boomability of the oil. Ice can also hinder dispersant oil mixing making dispersants less effective, but the window for dispersant use is increased with partial ice coverage.


Arctic Sea Ice Extent Forecasting Using Support Vector Regression

Abstract: The summer minimum Arctic sea ice extent has long been used as a measure of climate change, with record lows being reported in recent years. Understanding the dynamics of the Arctic sea ice extent is of utmost importance in understanding the timescales associated with this change. Complex global climate models are typically employed to gain insights about the future of Arctic sea ice, however, these models are typically very computationally expensive to solve and the results are often controversial. Here, we use historical data from remote sensing satellites along with machine learning algorithms in the forecasting of the Arctic sea ice extent. Support Vector Regression is employed in the learning of a dynamic model to represent this system. Validation results demonstrate the ability of the method to successfully forecast both the seasonal and long-term trends in Arctic sea ice coverage.

Citation: Reid, T., Tarantino, P. 2014. Arctic Sea Ice Extent Forecasting Using Support Vector Regression. 2014 13th International Conference on Machine Learning and Applications. https://doi.org/10.1109/ICMLA.2014.7

Review on Burn Residues from In Situ Burning of Oil Spills in Relation to Arctic Waters

Abstract: In situ burning is a method by which oil is burned at a spill site under controlled conditions, and this method is subject to increased interest due to its applicability in the Arctic. This paper reviews the literature regarding the characterization and environmental effects of burn residues in Arctic waters. The results of a systematic literature search indicate that only a very limited number of studies have arctic pertinence. From the review, it is also indicated that the properties and composition of the residues depend on the efficiency of the burning and the oil type. Furthermore, the studies within the frame of the literature search reach consensus that in situ burning may increase the concentrations of large poly-aromatic hydrocarbons (PAHs; high ring number) while reducing small PAHs (low ring number). There are very few toxicity studies of burn residues on aquatic and arctic organisms, and to enhance the knowledge base, more organisms as well as oil types must be studied.
Furthermore, there is a lack of studies investigating the potential effect of sinking burn residues on benthic organism and the smothering effects of the more viscous burn residues on birds and other organisms related to the sea surface. More knowledge regarding environmental fate and effect of residues is crucial to complete a robust net environmental benefit analysis prior to an oil spill response operation in arctic waters.


Seasonal ecology in ice-covered Arctic seas - Considerations for spill response decision making

Abstract: Due to retreating sea ice and predictions of undiscovered oil and gas resources, increased activity in Arctic shelf sea areas associated with shipping and oil and gas exploration is expected. Such activities may accidentally lead to oil spills in partly ice-covered ocean areas, which raises issues related to oil spill response. Net Environmental Benefit Analysis (NEBA) is the process that the response community uses to identify which combination of response strategies minimizes the impact to environment and people. The vulnerability of Valued Ecosystem Components (VEC's) to oil pollution depends on their sensitivity to oil and the likelihood that they will be exposed to oil. As such, NEBA requires a good ecological knowledge base on biodiversity, species' distributions in time and space, and timing of ecological events. Biological resources found at interfaces (e.g., air/water, ice/water or water/coastline) are in general vulnerable because that is where oil can accumulate. Here, we summarize recent information about the seasonal, physical and ecological processes in Arctic waters and evaluate the importance these processes when considering in oil spill response decision making through NEBA. In springtime, many boreal species conduct a lateral migration northwards in response to sea ice retraction and increased production associated with the spring bloom. However, many Arctic species, including fish, seabirds and marine mammals, are present in upper water layers in the Arctic throughout the year, and recent research has demonstrated that bioactivity during the Arctic winter is higher than previously assumed. Information on the seasonal presence/absence of less resilient VEC's such as marine mammals and seabirds in combination with the presence/absence of sea ice seems to be especially crucial to consider in a NEBA. In addition, quantification of the potential impact of different, realistic spill sizes on the energy cascade following the spring bloom at the ice edge would provide important information for assessing ecosystem effects.


Current practices and knowledge supporting oil spill risk assessment in the Arctic

Abstract: Oil spill response (OSR) in the Arctic marine environment conducted as part of operational planning and preparedness supporting exploration and development is most successful when knowledge of the ecosystem is readily available and applicable in an oil spill risk assessment framework. OSR strategies supporting decision-making during the critical period after a spill event should be explicit about the environmental resources potentially at risk and the efficacy of OSR countermeasures that best protect sensitive and valued resources. At present, there are 6 prominent methods for spill impact mitigation assessment (SIMA) in the Arctic aimed at supporting OSR and operational planning and preparedness;
each method examines spill scenarios and identifies response strategies best suited to overcome the unique challenges posed by polar ecosystems and to minimize potential long-term environmental consequences. The different methods are grounded in classical environmental risk assessment and the net environmental benefit analysis (NEBA) approach that emerged in the 1990s after the Exxon Valdez oil spill. The different approaches share 5 primary assessment elements (oil physical and chemical properties, fate and transport, exposure, effects and consequence analysis). This paper highlights how the different Arctic methods reflect this common risk assessment framework and share a common need for oil spill science relevant to Arctic ecosystems. An online literature navigation portal, developed as part of the 5-year Arctic Oil Spill Response Technologies Joint Industry Programme, complements the different approaches currently used in the Arctic by capturing the rapidly expanding body of scientific knowledge useful to evaluating exposure, vulnerability and recovery of the Arctic ecosystem after an oil spill.

Evaluating Educational Needs in Maritime Emergency Management within the Arctic: The Case of Sweden

Abstract: Climate change and diminishing sea ice pave the way towards increased human activities in the wider Arctic region. However, these new opportunities for shipping, tourism, energy exploration and various other sectors also involve risks, with ship accidents and oil spills standing out. The status quo pressing problem concerns habitat degradation, and other negative impacts on the Arctic environment, as well as the implementation of stricter maritime preparedness and environmental regulations. Following the introduction of the International Maritime Organization’s (IMO) International Code for Ships Operating in Polar Waters (Polar Code) and related amendments, it has become crucial for the Arctic States to emphasize on improving the prevention and crisis management regime pertaining to large maritime emergency incidents. The MARPART project on maritime preparedness and international partnership in the High North is an ongoing research project concerning Norway, Sweden, Denmark, Greenland, Iceland, and Russia. The principle objective is to map and highlight the challenges of large-scale emergencies in an Arctic context and recommend improvements in the preparedness and crisis management domains. One part of the project, MARPART-2 MAN, is focused on the development of competence needs coupled with gaps related to the competence of personnel at the on-scene tactical level, mission coordination at the operational level, and staff management at regional and national strategic level. To that end, a comparative study has been conducted among five countries that have operational experiences regarding large-scale incidents in extremely cold climate areas. The World Maritime University (WMU) has been responsible for the review of the Swedish emergency response capacities. The assessment concerns mapping current educational programs and training within Swedish emergency management in academic and professional training institutions with a special focus on the High North. The outcome identified important gaps between the demand side competence needs and the supply side within emergency management education. WMU, with its capacity-building focus, is playing a pivot role in the following areas: a) designing new educational activities, training, and exercises which aims to fill this gap, and b) developing concepts and tools for simulation for improving the crisis management of large maritime emergency actions.


Operational risk issues and time-critical decision-making for sensitive logistics nodes.

In this chapter an approach which supports decision-making processes for time-critical situations in supply chain networks after the occurrence of serious disruptions is described. The focus lies on the development of a concept that enables organizations to maintain business, or at least rapidly recover after a disruption, so that the impact is reduced to a minimum. While most strategies and measures regarding supply chain risks are concerned with the prevention and mitigation of risks, the approach presented concentrates on how to handle the impacts of such risks. Therefore, the primary objective is to assure that business can rapidly be resumed after the occurrence of a potential crisis. For this purpose the approach aims to (1) achieve transparency by developing and applying a reference model for sensitive logistics nodes, (2) identify potential risks and (3) support the decision-making process by proposing pre-planned standard measures in the context of time-critical
Conceptualizing cold disasters: Disaster risk governance at the arctic edge.

Abstract: Present literature on disasters predominantly focuses on warm, accessible and well-populated contexts. However, as human activities in Arctic and Antarctica become more common, cold contexts, and their special characteristics, become more relevant to study. In the present article, we explore in more depth the particular circumstances and characteristics of governing what we call 'cold disasters'. The article is structured in four overall parts. The first part, Cold Context, provides an overview of the specific conditions in a cold context, exemplified by the Arctic, and zooming in on Greenland to provide more specific background for the paper. The second part, Disasters in Cold Contexts, discusses 'cold disasters' in relation to disaster theory, in order to, elucidate how cold disasters challenge existing understandings of disasters, also it provides examples of emergency scenarios, in order to, demonstrate the demanding dynamics of cold contexts. In the third part, Governing Cold Disasters, we discuss the main implications for the governance of 'cold disasters' in the Greenlandic context. Finally, we offer our conclusions.


Scenario analysis and disaster preparedness for port and maritime logistics risk management

Abstract: System Dynamics (SD) modelling is used to investigate the impacts of policy interventions on industry actors’ preparedness to mitigate risks and to recover from disruptions along the maritime logistics and supply chain network. The model suggests a bi-directional relation between regulation and industry actors’ behaviour towards Disaster Preparedness (DP) in maritime logistics networks. The model also showed that the level of DP is highly contingent on forecast accuracy, technology change, attitude to risk prevention, port activities, and port environment.

Highlights: 1. Ports and ship owners have become increasingly exposed (vulnerable) to logistics risks, disruptions, and uncertainties. 2. System Dynamics modelling show effect on the impacts of policy intervention on shippers’ preparedness to mitigate risks. 3. System Dynamics modelling shows the effect on the ability to recover from disruptions along the maritime logistics network. 4. A bi-directional relationship between regulation and shippers’ behaviour towards Disaster Preparedness in logistics networks is revealed. 5. The level of Disaster Preparedness is highly contingent on technology change, attitude to risk prevention, port activities, and port environment.


Arctic and Western Alaska Area Contingency Plan
The Arctic and Western Alaska Area Contingency Plan (or AWA-ACP) is a tactical and operational instruction and guidance manual for responders and planners preparing a coordinated Federal, State, and local exercise and/or response to a discharge, or substantial threat of discharge of oil and/or release of a hazardous substance from a vessel or on/offshore facility operating within the area bounded by the Western Alaska Captain of the Port (COTP) Zone. The Western Alaska COTP boundary includes all Alaskan coastal waters except Prince William Sound and Southeast Alaska.

The AWA-ACP provides everything needed for a coordinated oil or hazardous material response. This includes: instructions on proper spill protocol; designations of the spill response command hierarchy; methods of oil spill response for various environments; proper planning of hazardous material or oil spill responses; required correspondence and documentation; available logistical and material response assets; organizations that may assist with response funding; instructions on evaluating, handling, and transporting hazardous/radiological substances; and a guide to marine firefighting, salvage, and lightering operations.

Additionally, the AWA-ACP contains the necessary forms and documents for large-scale accident response. AWA-ACP has extensive lists of contact information for industrial and governmental actors who may be involved in large-scale response efforts. There is also information on the response capabilities, location and climate, transportation facilities, utilities, housing, and economy for villages, towns, and cities along the Western Alaska COTP Zone.

Bibliography


ARCTIC MARITIME HORIZONS 2021 LITERATURE REVIEW: ARCTIC DOMAIN AWARENESS CENTER


Kettle, N.P., Abdel-Fattah, D., Mahoney A. R., Eicken, H., Brigham, L.W., Jones, J. (2020) Linking Arctic system science research to decision maker needs: co-producing sea ice decision
support tools in Utqiaġvik, Alaska, Polar Geography, 43:2-3, 206-222, DOI: 10.1080/1088937X.2019.1707318


Arctic Maritime Horizons...advancing understanding the future Arctic MTS
Steinveg, B. (2014) Canada’s Arctic policy. Striking a balance between national interests and circumpolar cooperation. The Arctic University of Norway, Department of Sociology, Political Science and Community Planning, Master Thesis in Political Science. Retrieved From: https://hdl.handle.net/10037/7079


