

Overview of marine protected areas in the eastern Canadian Arctic and their ability to mitigate
current and future threats

by

Bryden Bone

Submitted in partial fulfillment of the requirements for the degree
of
Master of Marine Management

at

Dalhousie University
Halifax, Nova Scotia

December 2018

© *Bryden Bone, 2018*

Acknowledgments

I would like to thank my co-supervisors, Dr. Claudio Aporta and Alexandra Vance, for their insights and patience. Jennifer Strang, James Boxall, the Dalhousie GIS Center staff, and Maxime Lapierre for help with GIS-related questions. My internship supervisors, Max Westhead and Dr. Bob Rangeley, for the wonderful experiences with DFO's Ocean and Coastal Management Division and Oceana Canada, respectively. And, most importantly, my family, for their unwavering support.

Table of Contents

LIST OF ACRONYMS AND ABBREVIATIONS	4
INTRODUCTION	5
METHODOLOGY	8
Broad Methodology	8
Relative Risk Assessment	8
Spatial and Temporal Boundary Delineation	8
Threats and their Components	8
Consequence	10
Likelihood	12
Risk determination	13
BROAD CONTEXT	14
The Arctic Ecosystem	14
Arctic Marine Species	16
Available MPA Designations in Canada and Protection Status of the ECA	17
<i>Oceans Act</i> MPAs, <i>Fisheries Act</i> closures, and National Network Coordination	17
Migratory Bird Sanctuaries and National Wildlife Areas	20
National Marine Conservation Areas	20
Governance of Marine Space in the ECA	22
THREATS TO THE ECOLOGICAL, CULTURAL, AND SOCIAL DIMENSIONS OF THE ECA	24
Climate Change	24
Mining	25
Commercial Fishing	26
Hydrocarbon Activities	28
Improper Mechanisms of Inuit Participation	29
Tourism	31
Commercial Shipping	33
Vessel Discharges	34
Vessel Presence	35

RESULTS AND DISCUSSION	36
MPAs' Potential to Mitigate Threats	37
Governance of Future Marine Protection in the ECA	41
Study Limitations	42
RECOMMENDATIONS	43
CONCLUSION	44
REFERENCES	46
APPENDICES	56
Appendix 1. Comparative overview of marine protection tools in Canada	56
Appendix 2. Scoring rubric for C_{exposure}	57
Appendix 3. Scoring rubric for $C_{\text{consequence}}$	58

List of Acronyms and Abbreviations

CBC – Canadian Broadcasting Corporation
DFO – Fisheries and Oceans Canada
ECA – Eastern Canadian Arctic
ECCC – Environment and Climate Change Canada
EEZ – Exclusive Economic Zone
ENGO – Environmental Non-Governmental Organization
FAO – Food and Agriculture Organization of the United Nations
FJMC – Fisheries Joint Management Committee
GoN – Government of Nunavut
IAS – Invasive Aquatic Species
ICE – Indigenous Circle of Experts
IIBA – Inuit Impact and Benefit Agreement
IPA – Indigenous Protected Area
IPCC – Intergovernmental Panel on Climate Change
MARPOL – International Convention for the Prevention of Pollution from Ships
MBS – Migratory Bird Sanctuary
MLA – Members of the Legislative Assembly
MPA – Marine Protected Area
NARW – North Atlantic Right Whale
NEF – Nunavut Economic Forum
NLCA – Nunavut Land Claims Agreement
NMC – Nunavut Marine Council
NMCA – National Marine Conservation Area
NPC - Nunavut Planning Commission
NSIDC – National Snow and Ice Data Center
NSR – Nunavut Settlement Region
NTI – Nunavut Tunngavik Incorporated
NWA – National Wildlife Area
NWMB – Nunavut Wildlife Management Board
OECM – Other Effective Area-Based Conservation Measure
QIA – Qikiqtani Inuit Association
SARA – Species at Risk Act
SOLAS – International Convention for the Safety of Life at Sea
Tcf - Trillion Cubic Feet
UNCBD - United Nations Convention on Biological Diversity
UNDRIP – United Nations Declaration on the Rights of Indigenous Peoples
WWF – World Wildlife Fund

Introduction

The Arctic environment, both marine and terrestrial, is defined by a number of ecological, cultural, and social dimensions. Inuit and their ancestors have inhabited many parts of the Arctic for millennia. Harvesting for subsistence and social purposes, the collection of material for art, and the use of traditional trails and camp sites occurs throughout the Canadian Arctic and these practices are intertwined with and depend on the health of the natural environment (Qikiqtani Inuit Association [QIA], 2018; Nunavut Planning Commission [NPC], 2016). Important environmental features that are unique to the Arctic include polynyas (marine areas that remain ice-free year-round due to high winds and currents [Stirling, 1990]) and the floe-edge (consistent fractures between land-fast ice and pack ice [Stirling, 1990]), which are elements of a sea ice dominated system that creates living conditions for both Inuit and animals (Schimnowski et al., 2018; NPC, 2016). These ice features contribute to the great diversity of endemic organisms and unique ecological communities that reside in the Arctic, such as marine mammals, cold-water biogenic habitat, and globally significant seabird colonies. The Arctic environment is also an important barometer for climate change, as its effects are manifesting at an extent and rate greater in the Arctic than in most other places on the planet (Brown et al., 2018a; Ford et al., 2016; Intergovernmental Panel on Climate Change [IPCC], 2014). The Arctic's complex ecology and how the species and people of the Arctic adapt to this rapidly changing environment have only begun to be researched in great depths within the last two decades (Schimnowski et al., 2018).

Governments and communities alike are utilizing marine protected areas (MPAs) as one of the tools available in coastal and marine environments to help conserve valuable ecosystems, endemic or endangered species, rare oceanographic features, and sites of cultural, spiritual, and social importance (International Union for the Conservation of Nature [IUCN], 2018). MPAs are spatially-bound, legal or otherwise effectively-protected areas that operate to conserve these components of interest by restricting human activities using a holistic and ecosystem-based approach to the greatest extent possible (IUCN, 2018). MPAs are a flexible tool that have proven effective at protecting marine systems around the globe and in a variety of social and ecological contexts (Edgar et al., 2014; Murawski et al., 2005; Gell & Roberts, 2003). There is precedent for MPAs in the Canadian Arctic (Fisheries and Oceans Canada [DFO] & Fisheries Joint Management Committee [FJMC], 2013) and a commitment from the Canadian government to increase their percent cover throughout the national marine estate. The Government of Canada made a public commitment to achieve the United Nation's Convention on Biological Diversity (UNCBD) Aichi Target 11 to protect 5% of Canada's coastal and marine area by 2017, and 10% by 2020 (Environment and Climate Change Canada [ECCC], 2016). However, the extent of MPAs afforded to safeguard the Canadian Arctic from existing and emerging threats is insufficient and is not likely to conserve these important ecological, cultural, and social dimensions for future generations under the *status quo* (Bartlett, 2018; Gies, 2018; McKinnon et al., 2015). Application of appropriate federal and territorial legislation and regulations related to appropriate conservation measures have thus far been insufficient. Therefore, the current extent of MPAs may not be adequate in ensuring the long-term, sustainable use of the Arctic region and its marine resources.

The valuable ecological, cultural, and social dimensions of the Canadian Arctic are threatened by the increasing development of industrial activities and climate change, while improper mechanisms of Inuit participation may also negatively contribute by limiting the effectiveness of MPAs. In order to understand how the ecological, cultural, and social dimensions can be most effectively protected, it is necessary to identify and understand the threats to their integrity and resilience. While some of the ecological, cultural, and social dimensions of the Arctic and potential stressors have been identified, there is a lack of understanding of the level of risk these threats currently present, and how they may develop and change over time. This research will investigate and quantify the risk from these threats in an attempt to elucidate how they may impact marine protection and to what extent MPAs can aid in mitigating such threats.

This paper will focus on the eastern Canadian Arctic (ECA) and follow the bioregional boundary delineated by DFO (Fig. 1 [DFO 2017a]). This area was chosen due to its lack of marine protection measures compared with the western Canadian Arctic and due to its greater exposure to industrial activities compared with the High Arctic. The chosen boundary corresponds to a single land claims agreement (i.e. the Nunavut Land Claims Agreement [NLCA]) facilitating discussion on governance.

This study aims to answer the following questions:

- What level of risk do specific industrial activities, climate change, and improper mechanisms of Inuit participation pose to the ecological, cultural, and social dimensions of the ECA?
- Does the level of risk change among locations within the study area and over time?
- To what extent can MPAs protect the ecological, cultural, and social dimensions against the analyzed threats?

To answer the above questions this paper will introduce the broad methodology undertaken along with the relative risk assessment framework. This will be followed by the environmental and ecological dimensions that provide a strong rationale for further protection in the region, along with how those dimensions intertwine with Inuit culture. The subsequent section will outline available MPA designations in Canada, the context surrounding the implementation of new MPAs, and the current extent of protected marine space in the ECA. The jurisdictional framework of marine governance in the ECA will be also discussed. A description of the threats, their current extent, and factors that may contribute to their evolution in future will follow. A discussion of the results, the management implications, and other factors that may influence the development of marine protection in the ECA will be elaborated upon, followed by management recommendations.



Figure 1. Canada's eastern Arctic and the eastern Arctic bioregional boundary defined by DFO.

Methodology

Broad Methodology

This project will investigate threats to the ecological, cultural, and social dimensions in the ECA. First, an extensive literature review was undertaken to identify threats to be included in analysis and better understand the context within which they operate. The literature review was corroborated by discussions with relevant experts. Industrial activities (i.e. mining, commercial shipping, hydrocarbon activities, commercial fishing, and tourism), climate change, and improper mechanisms of Inuit participation in protected area governance were identified for analysis. The level of risk from these threats was quantified using a relative risk assessment framework (described in detail below). The initial research and scoping were facilitated and supplemented by internships in the summer of 2018 with DFO Maritimes Region Aquatics Ecosystems Division and Oceana Canada. Regulations of Canadian MPAs and other relevant policies were investigated to infer what level of protection could be afforded against specific threats.

Relative Risk Assessment

The relative risk assessment approach for this research assessed the consequences of an interaction between industrial activities and climate change on the integrity of the ecological, cultural, and social dimensions of the ECA. Improper mechanisms of Inuit participation is not a threat to the ecological, cultural, and social dimensions in the same manner as the other threats and was assessed based on its impact on marine protection efforts. The risk assessment framework was adapted from the current methodology being developed by DFO for protected areas planning (Murray et al., 2016; O et al., 2015).

Spatial and Temporal Boundary Delineation

The Eastern Arctic bioregional boundary defined the study area for this research. Three assessment locations (i.e. areas around Cumberland Sound, Clyde River, and Eclipse Sound) were chosen within the bioregion to consider spatial differences and to encompass areas afflicted by all identified threats (Fig. 2).

Risks were evaluated at two different timeframes to elucidate how they might evolve: the current timeframe (i.e. the current state of the threat) and 15 years into the future. A 15-year future scenario was chosen due to the lack of planning strategies (e.g. by organizations and governments) and heightened uncertainty beyond this timeframe. Rationales for assigning risk scores at the different timeframes were created by reviewing federal and territorial government documents, economic forecasts, sector-specific documents, primary and grey literature, and personal communications with relevant experts.

Threats and their Components

Seven threats (Table 1) were selected for inclusion in the risk assessment based upon the literature review and conversations with relevant experts. Each threat may include multiple components and each component was evaluated at each assessment location and at each timeframe separately. An aggregate score of each threat was produced by calculating the mean

risk score of its components. Given that the inclusion of all potential components of climate change was beyond the scope of this paper, it was evaluated as a single component, albeit with several factors being taken into consideration. In evaluation of the 'vessel traffic' component in the threat categories 'commercial fishing', 'tourism', and 'mining', all of the components included in the 'commercial shipping' threat category were taken into consideration.

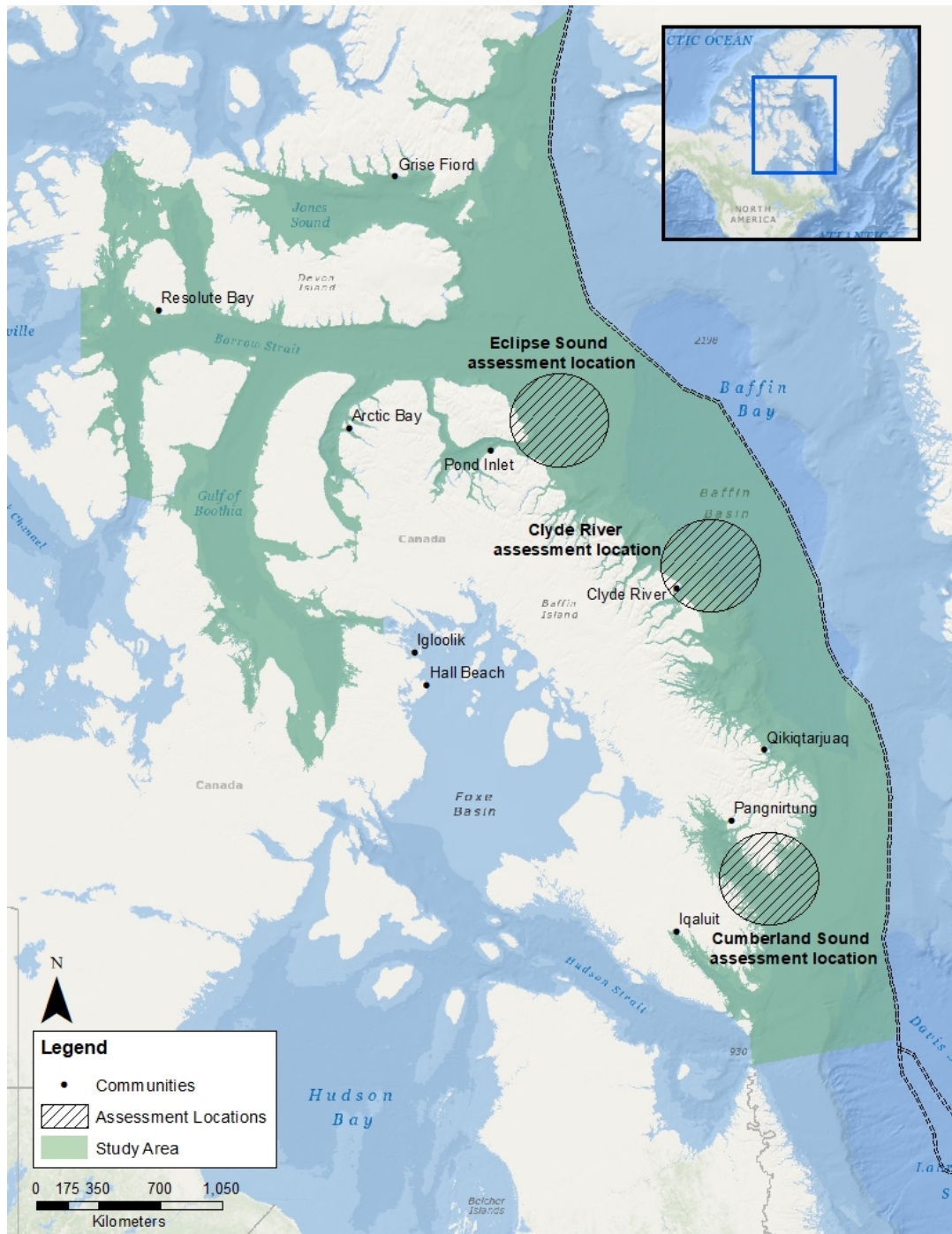


Figure 2. Study area and assessment locations used in the relative risk assessment.

Table 1. List of seven threats and their components used in the relative risk assessment.

Threat	Component
Improper mechanisms of Inuit participation	Lack of financial, technical, and human resources capacity
	Ineffectual co-management arrangement
Commercial fishing	Destructive fishing practices
	Bycatch
	Overexploitation of target species
Commercial shipping	Vessel traffic
	Ship-sourced oil spills
	Vessel strikes
	Noise pollution
	Wastewater discharge
	Icebreaking
	Invasive aquatic species
	Bilge-water discharge
Mining	Vessel traffic
	Contaminants entering marine system
Tourism	Vessel traffic
Climate change	None
Hydrocarbon activities	Seismic testing
	Oil well blow-out

Consequence

Consequence ($C_{\text{consequence}}$) is one of the two values inputted into the risk matrix to determine the final risk score from a threat component. This method defines the potential consequence of a threat on the ecological, cultural, and social dimensions of the ECA by the following equation:

$$C_{\text{exposure}} * C_{\text{impact}} = C_{\text{consequence}}$$

Exposure

Exposure (C_{exposure}) is the magnitude of interaction between the threat and the ecological, cultural, and social dimensions of the ECA defined by the following three factors (Table 2), where low scores indicate low intensity, minimal spatial interaction, or minimal temporal interaction.

Table 2. Three factors included in the calculation of exposure used in the relative risk assessment. Adapted from Murray et al., 2016.

<i>Spatial Scale</i>		
<i>Score</i>	<i>Effect</i>	<i>Definition</i>
1	Few restricted locations	<10% of total assessment location
2	Localized	From 10 - 50% of total assessment location
3	Widespread	>50% of total assessment location
<i>Temporal Frequency Scale</i>		
<i>Score</i>	<i>Effect</i>	<i>Definition</i>
1	Rare	Every several years
2	Relatively Often	Quarterly to Annually
3	Frequent	Weekly to Monthly
4	Continuous	Daily occurrences or continuous
<i>Intensity</i>		
<i>Score</i>	<i>Effect</i>	<i>Definition</i>
1	Low	Low density or low persistence
2	Moderate	Moderate density or persistence
3	High	High density or persistence

The spatial, temporal, and intensity scores are multiplied to derive a raw C_{exposure} score ranging from 1 to 36 and the raw C_{exposure} score is then binned on a scale of 1 to 5 (Appendix 2). Scores were binned to facilitate subsequent calculations. The binned C_{exposure} score is then combined with C_{impact} to derive $C_{\text{consequence}}$.

Impact

Impact is defined here as the potential for long-term harm to the ecological, cultural, and social dimensions of the ECA as a result of the interaction with the threat. Impact was determined by the context surrounding the interaction, relevant peer-reviewed literature, grey literature, and discussions with relevant experts. A score from 1 to 5 was assigned to the descriptive impact criteria to allow for incorporation into the $C_{\text{consequence}}$ calculation (Table 3).

Table 3. Categories describing impact on the ecological, cultural, and social dimensions of the ECA from identified threats. Assigned numeric score for each category is stated in brackets. Adapted from O et al. (2015).

Impact category	Negligible (1)	Low (2)	Moderate (3)	High (4)	Extreme (5)
Description	Insignificant or undetectable change. Unlikely to be detectable against natural variation.	Possible detectable change but minimal impact on species composition, relative abundance, functional group constituents, geographic range, trophic level, size structure, or community dynamics.	Detectable change with some impact on species composition, relative abundance, functional group constituents, geographic range, trophic level/size structure, community dynamics	Major change to ecosystem function as species composition/ relative abundance/ functional group constituents/ geographic range/ trophic level/size structure/ community dynamics is altered measurably. Recovery is months to years.	Total collapse of ecosystem function. Long term recovery period required on the scale of decades to centuries.

To reiterate, calculation of $C_{\text{consequence}}$ was determined by the equation:

$$C_{\text{consequence}} = C_{\text{exposure}} * C_{\text{impact}}$$

The equation above resulted in raw values between 1 and 25, which were then binned into 5 descriptive categories ranging from negligible to very high (Appendix 3). The binned category breaks were determined using quantiles and adjusted so that raw scores with the same value fell into the same category.

Likelihood

Likelihood was calculated as the probability of an interaction between a threat and the ecological, cultural, and social dimensions of the ECA given the worst-case scenario of the threat occurring (e.g. if a large oil spill occurs what is the likelihood of it interacting with the health of the marine ecosystem?). This was done to offer a precautionary calculation of risk in the context that this research is being undertaken with marine protection in mind (i.e. management of an area included in a marine protection measure is more risk averse than an area that is not protected). The likelihood of the interaction occurring was determined based on the literature review and discussions with relevant experts. Likelihood was classified according to five definitions (Table 4). The time frame for considering likelihood was one year.

Table 4. Likelihood classifications and definitions used in the relative risk assessment.

Likelihood	% Probability	Experience/Observed Frequency
Almost Certain	> 95%	Interaction is occurring or will occur
Likely	76 - 94%	Interaction will occur in most scenarios
Moderate	26 - 75%	Interaction may occur in some but not all scenarios
Unlikely	6 - 25%	Interaction is unlikely
Rare	< 5%	Interaction may occur only in exceptional circumstances or almost never happens

Risk determination

Once the likelihood and consequence scores were produced, risk was calculated using a risk matrix (Fig. 3). Numeric values were assigned depending on placement within the risk matrix with corresponding color-coding; that is, low risk (green), moderate risk (yellow), moderate-high risk (orange), and very high risk (red). Descriptions are provided for the four risk levels in Table 5 below.

Consequence	Extreme	4	5	6	7	8
	High	3	4	5	6	7
	Moderate	2	3	4	5	6
	Low	1	2	3	4	5
	Negligible	1	1	2	3	4
		Rare	Unlikely	Moderate	Likely	Almost Certain
		Likelihood				

Figure 3. Risk matrix used in the relative risk assessment of threats to the ecological, cultural, and social dimensions of the ECA. Risk was calculated as the product of likelihood and consequence and values were assigned based on a literature review and consultation with relevant experts. Adapted from Pelot (2017). Risk level: green = low, yellow = moderate, orange = moderate-high, red = very high.

Table 5. A risk assessment framework used to categorize the degree of risk to the social, ecological, and cultural features from identified threats.

Risk Level	Description
Very high	There is potential for a severe long-term impact on marine ecosystem health, or it is likely that a significant impact will occur.
Moderate-High	There is potential for a moderate impact on marine ecosystem health to occur. A significant or severe long-term impact could occur, but it's unlikely or rare.
Moderate	There is potential for a detectable but low impact to marine ecosystem health. A detectable moderate impact could occur, but it's rare.
Low	Impacts to marine ecosystem health are negligible or non-detectable.

Broad Context

The Arctic Ecosystem

The characteristics of the Arctic ecosystem are unique. The Canadian Arctic, including the eastern bioregion (Fig. 1), is defined by severe seasonality and the dominating influence of sea ice and polynyas. It is also defined by regional differences, which support an assemblage of highly adapted organisms and Inuit communities.

There are several definitions of Canada's Arctic. Two of the most commonly cited correspond to the area above the Arctic circle (i.e. approximately 66° north latitude) and the area located farther north than the tree line (National Snow & Ice Data Center [NSIDC], 2018). Another definition corresponds to Inuit Nunangat, the ancestral territory in Canada occupied by the Inuit (Inuit Tapariit Kanatami [ITK], 2018), which was recently adopted by DFO as their new Arctic regional boundary (CBC News, 2018a) and includes areas north and south of the boundaries described in the previous two definitions. Ford et al. (2016) define the Canadian Arctic as stretching approximately 3,500 km from east to west, and encompassing a massive archipelago which constitutes a significant portion (176,000 km, or >70%) of Canada's coastline.

Regional differences are significant, and the entirety of the Canadian Arctic cannot be described uniformly. For example, the eastern Arctic sees an average of 1,000 mm of precipitation annually, while the western and northern Arctic receive <300 mm, predominantly in the summer months (Ford et al., 2016). Temperature also varies considerably within the Canadian Arctic with mean July temperatures differing by at least 12°C between certain locations (Ford et al., 2016). Wind and ocean-current patterns cause numerous differences on a local scale including modification of sea-ice behaviour.

Seasonality is a defining characteristic of Canadian Arctic ecosystems as polar regions amplify the seasonal processes that are otherwise dampened at lower latitudes. Defining

environmental conditions (e.g. daylight, weather) fluctuate widely among the seasons, with Arctic winters marked by nearly total darkness and summers drenched in nearly perpetual sunlight. The increasing daylight in the spring catalyzes the perennial biological processes of germination, breeding, migration, growth, and overall increased activity; these cycles tend to be completed more quickly than at lower latitudes given the short summer season (Mckinnon et al., 2012).

Temperature is also influenced by the seasons, resulting in large deviations between the cold winters and cool summers (Ford et al., 2016). The seasons heavily influence the presence of sea ice throughout the year, which is one of the most dominating characteristics of the Arctic (Brown et al., 2018a). Vast areas of the Arctic ocean freeze solid during the winter and may not begin to break up until July, while some regions remain ice-covered year-round. Sea ice conditions, including thickness, formation, break-up, and amount of multi-year ice, differ markedly among locations, depending on currents, winds, temperature, and coastal features. The sea ice is integral to the life-history of many marine and terrestrial organisms by determining movement, migrations, and feeding patterns (Brown et al., 2018a; Ford et al., 2016). It also influences movement and hunting patterns for the Inuit communities of the Arctic (Aporta, 2002).

Polynyas are an important occurrence that help define activities and processes in the Arctic (Pikialasorsuaq Commission, 2017; Fisheries and Sealing Division, 2014; Stirling, 1990; Aporta, 2002). There are 23 polynyas throughout the Canadian Arctic, including large polynyas in northern Baffin Bay between Greenland and Ellesmere Island, and in Tallurutiup Imanga (or Lancaster Sound), in the eastern entrance of the Northwest Passage (Canadian Geographic, n.d.). These ice-free areas are crucial for marine mammals and human activities in the Arctic (Fisheries and Sealing Division, 2014). Polynyas (and shore leads) allow living conditions in areas that would otherwise be inaccessible during winter months. These ice-free areas have higher productivity compared to ice-covered areas, increasing the presence of plankton and providing a food source for fish. The fish in turn provide ample feeding opportunities for several organisms, including seabirds, marine mammals, and also for humans (Pikialasorsuaq Commissions, 2017). Thin ice around polynyas and other open water features additionally provide year-round breathing areas (including breathing holes) for numerous marine mammal species. This leads to large aggregations of all types of wildlife in these areas, which are also important for Inuit communities (Aporta, 2002). Harvesting activities of Inuit are often centered on polynyas, as Inuit depend on country food for subsistence and for social and cultural wellbeing (QIA, 2018).

Arctic conditions are changing rapidly, at an unprecedented pace that exceeds most other locations around the world. Temperature in the Mackenzie Delta of the Northwest Territories has warmed by 2.6°C since the middle of the last century, and projections are for that trend to continue across the region (Ford et al., 2016; IPCC, 2014). Autumn sea ice extent has decreased by over 10% per decade since the late 1970s, while variability in sea ice formation and extent has increased (Ford et al., 2016; IPCC, 2014). These and other changes have affected the life-history traits and behaviours of regional species, both fauna and flora. For example, the barnacle goose (*Branta leucopsis*) has modified the timing of its migration in response to an earlier spring, while sea-surface temperature has affected the timing and extent of beluga whale (*Delphinapterus leucas*) migration (Lameris et al., 2018; Bailleul et al., 2012).

The narrow ecological tolerance range of Arctic species may lend itself to more documented behavioural changes and impacts both to ecosystems and Inuit communities in the future.

Arctic Marine Species

The Arctic is home to a diversity of terrestrial and marine species including seabirds, marine mammals, and fishes, many of which are endemic. These species are important to maintain ecological functions in the Arctic, and some sentinel species indicate the health of the marine ecosystem. Marine species also play an integral role in Inuit culture and social practices, as well as being significant for subsistence and economic opportunities (NPC, 2016). Due to the social, cultural, and ecological importance of these species, they are often the objects of protection and conservation efforts.

Some of the world's largest bird colonies aggregate in the Arctic to take advantage of the productive summer for breeding and feeding (Schiminowski et al., 2018). Over 30 Important Bird Areas have been designated in the Canadian Arctic (e.g. Scott Inlet and Prince Leopold Island) in recognition of especially large and/or diverse aggregations of seabirds (Bird Studies Canada, n.d.). The thick-billed murre (*Uria lomvia*), black-legged kittiwake (*Rissa tridactyla*), northern fulmar (*Fulmarus glacialis*) and SARA-listed ivory gull (*Pagophila eburnea*) all depend on the ECA for parts of their lifecycle. The high productivity associated with polynyas and floe-edges attract massive flocks of numerous species of seabirds, as can be seen in Tallurutiup Imanga (Schiminowski et al., 2018).

Many fish species inhabit Arctic waters; the high summer primary productivity supports 11 families in the High Arctic Archipelago with a greater diversity found where the Arctic and Atlantic Ocean waters mix (Schiminowski et al., 2018). Little is known about lifecycle characteristics for many of these species, as conditions (both environmental and economic) have not been conducive to extensive research programs. For instance, research is lacking on the Greenland shark (*Somniosus microcephalus*), one of the most northern-ranging sharks in the world and the largest fish in Arctic waters (Devine et al., 2018). Conversely, Arctic char (*Salvelinus alpinus*) and Greenland halibut (also called turbot [*Reinhardtius hippoglossoides*]) have had a greater research focus due to their economic importance given existing commercial fisheries and char's significance in Inuit diet and culture.

Marine mammals are another assemblage that dominate in the Arctic and include both transient and year-round residents. The iconic and endemic narwhal (*Monodon monoceros*) migrate and overwinter in the ECA, and are especially important to Inuit for cultural and subsistence harvests (Schiminowski et al., 2018; NPC, 2016). Beluga whales, bowhead whales (*Balaena mysticetus*), walrus (*Odobenus rosmarus*) and numerous pinniped species are present (Schiminowski et al., 2018), while orcas (*Orcinus orca*) have been increasingly observed in Foxe Basin and along the coast of Baffin Island in recent years (Fisheries and Sealing Division, 2013). Marine mammals are among the most well-studied assemblages in the Canadian Arctic, and are a primary focus of protection for Inuit communities due to their importance for subsistence, their role in maintaining and fostering cultural identity, and social integrity (DFO & FJMC, 2013). They are also important to conservation organizations given that some are sentinel species, indicating the broader health of the marine ecosystem. They are also noted for their charismatic nature and often used in outreach materials by environmental non-governmental organizations (ENGOS) as flagship species.

The benthic invertebrate community, including biogenic habitat species (e.g. cold-water corals, sea pens, and sponges) are an understudied assemblage of high ecological and biological importance. Although the Arctic marine ecosystem is characterized by low species richness overall, benthic communities are relatively more diverse (Tremblay & Sejr, 2016). Much of the organic matter produced or transported into the Arctic Ocean will inevitably settle on the seafloor, making benthic invertebrates a vital link in the food web. These species have appeared as bycatch in fisheries' bottom trawling operations for years, yet it is only recently that their extent and distribution has been characterized (Oceans North et al., 2018; Kenchington et al., 2011). The extent to which demersal fish species, including those of commercial interest, rely on these habitat-forming invertebrates is assumed to be of great importance, as is seen in other parts of Canada (DFO, 2010a). The immobile and sensitive nature of benthic invertebrate communities makes them vulnerable to both anthropogenic and climatic stressors.

These marine organisms play an integral role in healthy Arctic ecosystems and the cultural and social practices of Inuit communities; however, several research gaps persist, meaning that many habitats, species, and communities remain under-studied and under-protected.

Available MPA Designations in Canada and Protection Status of the ECA

The unique ecological conditions of the Arctic, and its significance to Inuit communities warrant meaningful and effective protection measures in the ECA. Both Inuit and ENGOs have been calling for such protection measures, and there is renewed interest from government to do so in recent years. Currently, there are multiple regulatory tools and methods that are available to designate an MPA in Canada, and various federal departments that have the legislative authority and frameworks to do so. The current state of marine protection in the eastern Arctic bioregion is underdeveloped when compared to other Canadian bioregions, although there are promising developments for the near future (i.e. the Tallurutiup Imanga National Marine Conservation Area [NMCA]). This section will introduce the current MPA context in Canada, different types of MPAs (a brief overview is available in Appendix 1), and the protection catalogue of MPAs in the ECA. A complete list of marine protected areas in the ECA is provided below (Table 6).

Oceans Act MPAs, *Fisheries Act* closures, and National Network Coordination

In 2010 the Government of Canada made public commitments to achieve UNCBD Aichi Target 11 marine protection targets (ECCC, 2016). Achieving these targets has required a significant increase in the rate of designation of MPAs; Canada reported less than 1% of its marine space protected in 2015 and has since surpassed the interim target with a total of approximately 7.75% protection in 2017.

Table 6. Current marine protection measures within the eastern Arctic bioregion. National Parks may include a small marine/coastal portion but are not included in this list. 'Size' indicates total size; extent of marine area is listed in brackets. As of writing, the Tallurutiup Imanga NMCA has not yet been designated. ACC = Area Co-management Committee.

Name	Designation	Managing authority	Location	Size (marine component)	Year enacted
Akpait	National Wildlife Area	Co-managed by ECCC + Sululiit ACC	East coast of Baffin Island near Qikiqtarjuaq	791 km ² (mostly marine)	2010
Ninginganiq	National Wildlife Area	Co-managed by ECCC + Clyde River ACC	East coast of Baffin Island near Clyde River	3364 km ² (mostly marine, some islands)	2010
Nirjutiqavvik (Coburg Island)	National Wildlife Area	Co-managed by ECCC + Grise Fjord ACC	Northern Baffin Bay, between Ellesmere and Devon Islands	1783 km ² (approx. ½ marine)	1995
Qaulluit	National Wildlife Area	Co-managed by ECCC + Sululiit ACC	Off the eastern shore of Baffin Island near Cape Dyer	398 km ² (mostly marine)	2010
Prince Leopold Island	Migratory Bird Sanctuary	Co-managed by Canadian Wildlife Service + Resolute ACC	Western end of Lancaster Sound	304 km ² (>240 km ² marine)	1992
Bylot Island	Migratory Bird Sanctuary	Co-managed by Canadian Wildlife Service + Asungasungaaq ACC of Pond Inlet	North of Baffin Island, SE corner of Lancaster Sound	12,827 km ² (1765 km ² marine)	1965
Davis Strait Conservation Area	Fisheries Act closure	DFO	Along the EEZ between Baffin Island & Greenland	17,298 km ² (all marine)	2017
Disko Fan Conservation Area	Fisheries Act Closure	DFO	Between Baffin Island & Greenland	7485 km ² (all marine)	2017
Hatton Basin Conservation Area	Fisheries Act Closure	DFO	Between northern Labrador and Baffin Island	42,459 km ² (all marine)	2017
Tallurutiup Imanga (Lancaster Sound)	National Marine Conservation Area	Co-managed by Parks Canada + ACCs	North of Baffin Island, eastern entrance to the Northwest Passage	109,000 km ² (all marine)	Not yet designated

DFO is mandated to develop, implement, manage, and monitor the array of *Oceans Act* MPAs, with some recent designations and more expected in light of the federal government's commitments. *Oceans Act* MPAs are managed on a case-by-case basis, each reflecting the unique social, economic, and ecological conditions and needs of the area. Additionally, DFO is mandated to lead and coordinate the development of the national network of MPAs regardless of official designation type; DFO has identified 13 aquatic bioregions across Canada (one of which encompasses the Great Lakes). Five bioregions in Canada have had their MPA network plans prioritized (i.e. the Gulf of St. Lawrence, the Scotian Shelf, Newfoundland-Labrador Shelves, the Western Arctic, and the Northern Shelf). There are no *Oceans Act* MPAs in the eastern Arctic bioregion, and the eastern Arctic does not have a publicly released network plan. Furthermore, the eastern Arctic is not one of the five priority bioregions identified by DFO for development of a network plan.

DFO also has the legislative authority to use the *Fisheries Act* to designate another type of protected area called a marine refuge, *Fisheries Act* closure, or other effective area-based conservation measures (OECM). These closures are often designated to protect specific species or features of a marine ecosystem (e.g. specific fish stocks or biogenic habitat) by restricting the spatial and/or temporal use of certain fishing gear(s) within the designated area. *Fisheries Act* closures are relatively new in the eastern Arctic and have predominantly been used to restrict fishing gear to protect sensitive benthic habitats. There are three *Fisheries Act* closures (i.e. Disko Fan Conservation Area, Hatton Basin Conservation Area, and Davis Strait Conservation Area) in the study region which were enacted in late 2017 and cover an approximate area of 67,000 km² (Fig. 4).

However, *Fisheries Act* closures tend to take a narrow approach to protection measures since they only have the regulatory control to mitigate the effects of fishing activities on marine space, while non-fisheries and environmentally-damaging industrial activities (e.g. hydrocarbon developments) are permitted by default. As a result, the level of protection afforded to a *Fisheries Act* closure is less substantive than other MPAs given the lack of regulatory control over these damaging industrial developments. Therefore, *Fisheries Act* closures may not succeed in achieving the conservation targets from a holistic, ecosystem-based approach. Moreover, OECMs do not necessarily meet the IUCN standards for an MPA, and some parties suggest that they should not count towards international conservation targets. For these reasons, independent MPA tracking databases such as the World Database on Protected Areas and the Atlas of Marine Protection do not include them in their calculations.

While Canada is well positioned to achieve the 10% goal, concerns have been expressed over the pace of protection measures enacted and have questioned the legitimacy and efficacy of these protected areas to successfully conserve conservation objectives (Bartlett, 2018; Gies, 2018; McKinnon et al., 2015). These concerns are centered on the issue of 'paper parks' – MPAs that count towards national or international targets but may not be effective in protecting their conservation objectives given the environmentally-damaging activities sometimes permitted within their boundaries (Edgar et al., 2015; Rife et al., 2013). For example, this issue was raised in the Laurentian Channel Area of Interest upon DFO revealing that hydrocarbon activities would be allowed in 80% of its protected area. *Fisheries Act* closures are another source of concern given that they only address fisheries-related threats and do not have the authority to prohibit other damaging industrial activities from the area. For example, the Northeast

Newfoundland Slope Closure was designated to protect high densities of sensitive cold-water corals and sponges, and prohibited the use of bottom-contact fishing gears, yet recent calls for bids for hydrocarbon activities within the closure's boundaries were successful. These topics have triggered discussions amongst government, academia, ENGOs, communities, and industry; as a result, a call for minimum standards of protection was addressed by a special National Advisory Panel on MPA standards (Bujold & Simon, 2018). The federal government has yet to respond to the Panel's recommendations.

Migratory Bird Sanctuaries and National Wildlife Areas

ECCC has an extensive network of Migratory Bird Sanctuaries (MBSs) and National Wildlife Areas (NWAs) across the country, with many of these having been in existence for decades. Enacted through the *Canada Wildlife Act*, these protected areas contain strict access and activity prohibitions within their regulations, and include a provision for the creation of an NWA with a marine focus. Marine NWAs are an underutilized tool; the first such designation was Scott Islands, implemented in June 2018 in British Columbia. The majority of protection measures currently in place throughout the Canadian Arctic are designated as MBSs and NWAs, and within the study area there are four NWAs and two MBSs (Fig. 4; Table 6) with varying degrees of marine coverage.

National Marine Conservation Areas

Parks Canada is the third federal department that can designate MPAs, using the *National Marine Conservation Area Act*. Broadly speaking, NMCA's are the marine equivalent of National Parks and are similarly designed. A core protection zone with little to no anthropogenic activity is balanced with space that caters to the visitor experience. All industrial activities are prohibited throughout NMCA's with the exception of marine transportation and commercial fisheries (regulated by Transport Canada and DFO, respectively) which can operate outside of the core protection zone under the condition that their operations remain consistent with the NMCA objectives. Few NMCA's currently exist, although the proposed Tallurutiup Imanga NMCA in the ECA will become the largest protected marine space in Canada once finalized (Lancaster Sound Steering Committee, 2017). Tallurutiup Imanga was developed in a manner consistent with Inuit values, and traditional activities such as harvesting will continue throughout the area (Lancaster Sound Steering Committee, 2017).

Although the Tallurutiup Imanga NMCA is at a mature stage in the designation process, it has not yet been officially designated. The NMCA is a partnership between Parks Canada, the Inuit regional organization (i.e. QIA), and the Government of Nunavut, and will be managed in a way that supports traditional Inuit cultural uses (Lancaster Sound Steering Committee, 2017). The NLCA mandates the completion of an Inuit Impact and Benefit Agreement (IIBA), which is currently underway and will secure benefits for Inuit from the planning, establishment, and management of Tallurutiup Imanga (Lancaster Sound Steering Committee, 2017). Once the IIBA is accepted, this NMCA will encompass approximately 109,000 km² of marine space and will envelop multiple other protected areas (i.e. Coburg Island NWA, Bylot Island MBS, Prince Leopold Island MBS) within its boundaries. Inuit from the communities surrounding the NMCA

will be directly involved in management via co-management boards, which will direct activities to respond to the needs of the local communities (Lancaster Sound Steering Committee, 2017).

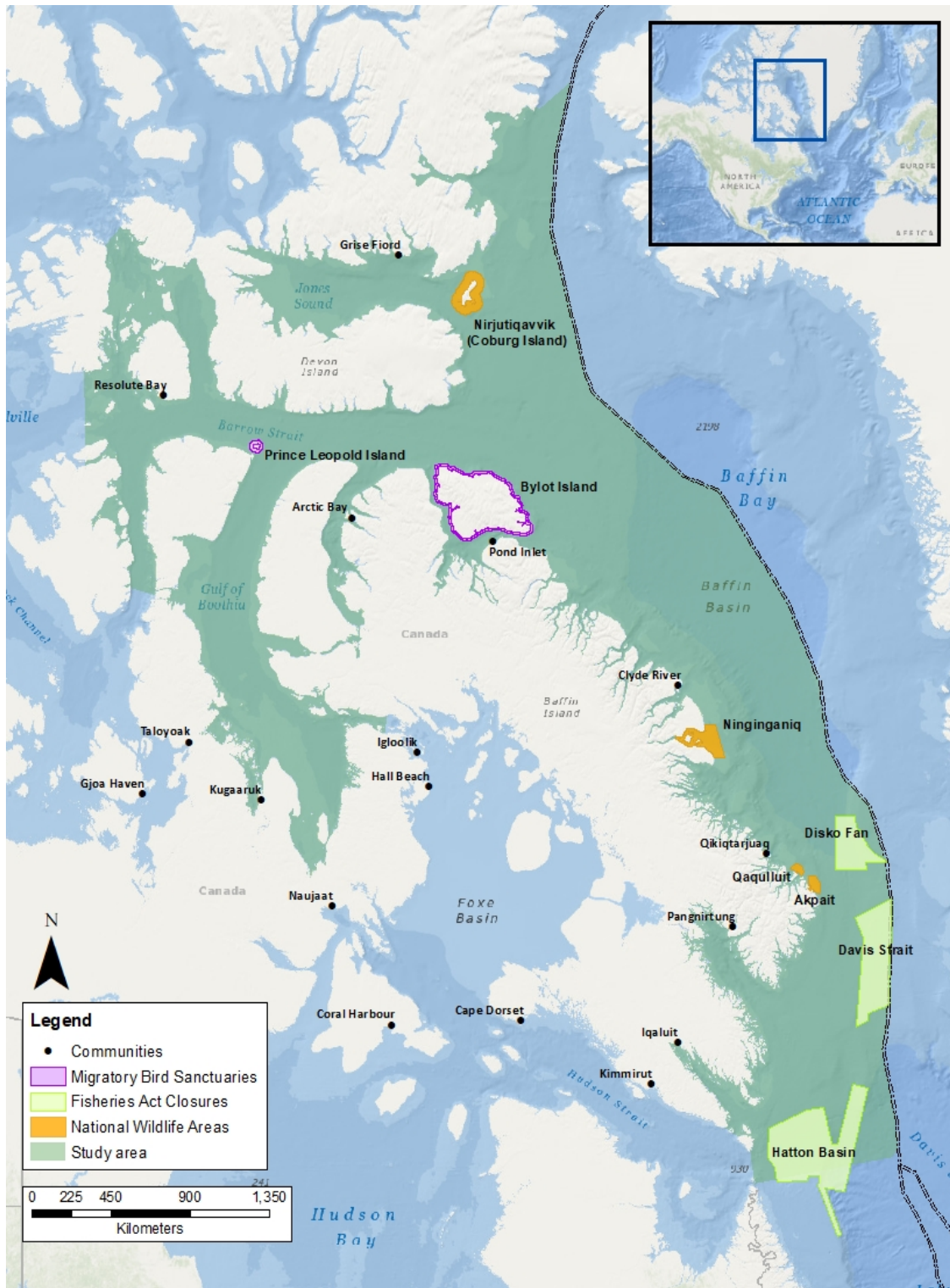


Figure 4. MPAs and Fisheries Act closures in the Eastern Canadian Arctic. The boundary for the Tallurutiup Imanga NMCA is not shown as it had not been designated as of the time of writing. The boundary of the eastern Arctic bioregion as defined by DFO corresponds to the study area considered in this research.

Governance of Marine Space in the ECA

To be effective, marine protection in the ECA needs to be seamlessly incorporated in the broader governance framework that operates on marine space, wildlife management, and Inuit well-being, while respecting the Inuit as rightsholders. This section will discuss the Inuit Organizations and some elements that are influential in the governance of marine space in Nunavut.

The overriding influence on governance in the ECA is the land claims agreement negotiated between Inuit and the Government of Canada which came into effect in 1999. The NLCA is a legally-binding agreement that was negotiated for the redistribution of power and governance authority to Inuit. The purpose of the NLCA was to provide certainty on the use and decision-making authority for lands and resources (including wildlife), to encourage the social and cultural well-being of Inuit, and to provide financial compensation and further economic opportunities to Inuit communities (Minister of Justice, 1993). To accomplish these objectives, the NLCA formally established Nunavut as the third territory of Canada, created its government, and formed numerous Inuit Organizations.

The Government of Nunavut is structurally alike other provincial governments in Canada whereby it employs Members of the Legislative Assembly (MLAs), Ministers, and a Premier; however, there are many operational differences. Although some decisions utilize a majority vote, the territory operates a consensus-based government wherever possible. Every MLA is an independent candidate without any party affiliations, and a secret ballot vote involving every MLA determines the Premier and Ministers. The spirit of the process was designed to be undertaken with traditional Inuit values at the forefront, and many aspects beyond those mentioned above reflect this (GoN, n.d.[a]).

Complementing the Government of Nunavut, while simultaneously acting as independent entities, are the Inuit and Land Claims Organizations which were created with the ratification of the NLCA. As described in the NLCA, Nunavut Tunngavik Inc. (NTI) is the organization that represents all Inuit in the Nunavut Settlement Region (NSR) and its objectives are to foster Inuit economic, social, and cultural well-being by ensuring that federal and territorial government commitments to Inuit are upheld (NTI, n.d.). Regional Inuit Organizations are subsidiary to NTI and advance the rights and interests of Inuit in the three regions (i.e. Kitikmeot, Qikiqtani, and Kivalliq) of Nunavut; the Qikiqtani region in the ECA is overseen by the QIA. Additional Inuit Organizations under the umbrella of NTI take on specific tasks in management of marine space, including Institutions of Public Government, Hunters and Trappers Organizations, and the Nunavut Marine Council (NMC), which recently began to formally operate (NTI, n.d.). The NMC is a collaboration between four Institutions of Public Government (see Table 2) and aims to provide a more holistic approach to managing marine space, offering recommendations on all marine activities to both levels of government and other Inuit Organizations. The NMC has the platform and mandate to shape marine activities going forward once it develops further capacity (Daoust et al., 2010). Descriptions of Inuit organizations relevant to marine governance are provided below (Table 7).

Table 7. Key Nunavut-based organizations in marine governance and planning. * denotes inclusion in the Nunavut Marine Council. Adapted from Daoust et al., 2010.

Actor	Role and relevance to marine planning in Nunavut
Nunavut Tunngavik Inc.	<ul style="list-style-type: none"> • Represents Inuit in the NLCA and ensures its proper implementation • Negotiate IIBAs for proposed MPAs on behalf of the Inuit population in Nunavut
Regional Inuit Associations (the QIA in the ECA)	<ul style="list-style-type: none"> • Hold title for Inuit owned surface lands (NTI owns subsurface rights) • Represent, protect, and improve the rights and benefits of Inuit • Negotiate IIBAs for proposed MPAs on behalf of the Inuit population of that specific region
Hunters and Trappers Organizations	<ul style="list-style-type: none"> • Community-based groups within each Inuit community which manage harvesting • Involved at the community level with the planning of MPAs impacting traditional hunting and trapping territory (involvement could range from consultation to advising government planning agencies) on behalf of the community • Have been involved in IIBA negotiations for proposed MPAs
Community Land and Resource Committees (CLARC)	<ul style="list-style-type: none"> • Community-based groups involved in land-use planning and policy with RIA's (involvement could range from consultation to advising) • Involved in management of certain MPAs through ACCs (see below)
Area Co-management Committees (ACC)	<ul style="list-style-type: none"> • Co-management groups, based in 8 Nunavut communities, made up primarily of CLARC committee members as well as a representative from the Canadian Wildlife Service • Manage NWAs and MBSs (those under the mandate of ECCC) in their area
Nunavut Marine Council	<ul style="list-style-type: none"> • Agency dedicated to providing recommendations on issues involving marine space in Nunavut. Composed of the four Institutions of Public Government listed below
Nunavut Wildlife Management Board*	<ul style="list-style-type: none"> • An Institution of Public Government, which advises governments and other Institutions of Public Government on issues regarding wildlife (including marine planning and management decisions) • Approves establishment or disestablishment of MPAs in Nunavut
Nunavut Planning Commission*	<ul style="list-style-type: none"> • An Institution of Public Government, which prepares land use plans to help guide land/marine and resource development in Nunavut. Draft land use plan published in 2016 • Approves the establishment of new marine conservation areas
Nunavut Water Board*	<ul style="list-style-type: none"> • An Institution of Public Government, which advises governments and other Institutions of Public Government on issues regarding the inland waters of Nunavut
Nunavut Impact Review Board*	<ul style="list-style-type: none"> • An Institution of Public Government, which assesses potential development projects (including those that impact the marine environment) through an impact assessment process

The Government of Nunavut and Inuit Organizations must work collaboratively with the federal government, as the Crown retains jurisdiction over certain aspects of marine space beyond 12 nm (i.e. NSR jurisdiction extends out to 12 nm). As such, much of the decision-making and permitting authority for industrial activities, such as hydrocarbon exploration and extraction and commercial fishing, are regulated at the federal level. Maritime traffic, integral for community re-supply in the Canadian Arctic, is another important activity regulated at the federal level. Most of the MPA planning and implementation processes around the country

have been advanced and underwritten financially by federal departments, namely DFO, ECCC, and Parks Canada. Though these activities are legally under federal jurisdiction, the Crown has committed to making decisions collaboratively with Inuit Organizations and the Government of Nunavut in the spirit of reconciliation and consistent with broader legislation (e.g. the *Oceans Act* and *NLCA*).

There are at least two other notable points regarding the Inuit-Crown relationship. First, as part of the NCLA, the Federal Government was to provide financial and personnel resources for the implementation of the land claims agreement; however, this was not fulfilled to NTI's satisfaction resulting in a civil suit against the Crown in 2006 for \$1 billion. In 2015, the Crown settled with NTI for \$255 million, \$175 million to be spent on education and training and \$80 million to be invested (CBC News, 2015). The added financial influx should increase Inuit Organizations' capacity and independence, with an allotment of effort to marine issues (Mifflin, 2008). Second, Nunavut is the only Canadian territory that does not yet have a devolution agreement with the Crown, which would transfer responsibility and ownership of natural resources to the territory. Once the devolution negotiations are complete, this will give Nunavut greater financial freedom and capacity. This could in theory prove beneficial to marine issues, as development under the ideal of 'environmental stewardship' is cited as a priority of the Nunavummiut (GoN, n.d.[b]).

Threats to the Ecological, Cultural, and Social Dimensions of the ECA

Integrity of the ecological, cultural, and social dimensions of the ECA could be sustained into the future via further development of the MPA network, yet new activities, largely made possible by climate-change, may threaten the long-term sustainable use of the area. Current aspects in the ECA that pose a threat to these features will be examined in this section. Threats to be analyzed were chosen based on literature review and discussions with relevant experts; they include industrial activities (i.e. mining, commercial fishing, tourism, hydrocarbon activities, and commercial shipping), climate change, and improper mechanisms of Inuit participation. The negative effects of increasing vessel traffic are also connected to mining, tourism, and commercial fishing but they will be analyzed solely in the commercial shipping section.

Climate Change

Climate change is a global threat to biodiversity and the environment, which will interact with and may magnify the other identified threats. A comprehensive discussion on the effects of climate change in the Canadian Arctic is beyond the scope of this paper, but this section will introduce current trends and some of its effects on the region's marine ecosystem.

Climate change is manifesting in the Arctic at an unprecedented and unparalleled extent and rate in comparison with other regions on Earth; air and sea-surface temperatures are increasing, historically stable permafrost is melting, and precipitation is increasing (Brown et al., 2018a; Ford et al., 2016; IPCC, 2014). Perhaps most alarmingly, sea ice extent is becoming more variable with an overall decreasing trend. Areas that have historically been ice-covered year-round are increasingly becoming ice-free in the summer and it is projected that the entire Arctic

Ocean may be ice-free in the summer by the middle of the century (IPCC, 2014). Although uncertainty is present, these effects are expected to continue to accelerate into the future under multiple carbon emission scenarios (IPCC, 2014).

Many plants and animals live within a specific range of climate conditions and have a defined habitat range. Changing environmental conditions can affect these species, both positively and negatively, as some species will flourish under these new conditions while others may be forced to vacate their traditional habitats. Habitat modification may affect the integrity of the Arctic food-web, including Inuit harvesting. Given that the extent of sea ice is integral to the Arctic food-web, changes to the sensitive floe-edge and polynyas are likely to impact the survival of many Arctic species, as these features produce great aggregations of marine mammals and seabirds and is therefore where most of the marine mammal harvesting occurs (Schimnowski et al., 2018; Cherry et al., 2013). If the decrease and variability in sea ice extent continues to expand to include more polynyas and floe-edges, they may be affected or disappear. The effects of changing sea-surface temperature or other variables could provide the impetus for additional changes in habitat fidelity (IPCC, 2014).

Climate change can also exacerbate the effects of other identified threats. A well-documented factor leading to increased shipping in the Arctic is connected to diminished summer sea ice extent (Dawson et al., 2017; Lackenbauer & Lajeunesse, 2014). Increased shipping traffic will amplify the probability of negative effects such as the propensity of oil spills and a proliferation of noise pollution and vessel strikes. Similarly, easier access to the Arctic is cited as a major determining factor in the increase in cruise ship tourism (Maher, 2012). A longer shipping season due to diminished sea ice extent has also allowed mining operations to continue their activities longer into the season, resulting in more vessel traffic and an increase in related risk (DFO, 2011).

Other difficult-to-assess aspects of climate change could negatively affect the ECA. Changing conditions will allow opportunistic, temperate species such as Atlantic cod (*Gadus morhua*) and other invasive aquatic species (IAS) to encroach further into the Arctic ecosystem (Chan et al., 2013; Drinkwater, 2005). Invasive species have potentially detrimental effects on current resident organisms such that new species will inevitably compete for access to prey species and the resources on which they rely. Ocean acidification is another stressor on marine systems due to climate change, and its effects are expected to be amplified in the Arctic, impacting cold-water corals, fishes, crustaceans, and echinoderms (IPCC, 2014).

Mining

Mining has a long history in the Canadian Arctic with mineral resources such as diamonds, gold, and zinc being exploited at industrial scale for most of the past century. The mining sector is viewed by the Government of Nunavut as an important component of the economy moving forward and they have produced an official mining strategy which aims to increase the value of mining activities to the territory while acting responsibly towards Inuit, communities, and the environment (GoN, n.d.[c]). While mining operations have previously generated significant financial capital, they have also come under intense scrutiny due to the effects of the activity on the environment, and particularly due to bad practices of some mining companies. This section will provide an outlook of mining activities in Nunavut and the threat associated with mining contaminants entering the marine environment.

The large mineral reserves in the territory offer a tantalizing prospect for potential investment. There are currently three operational mines in Nunavut, one in each region (Buchan, 2018; Nunavut Economic Forum [NEF], 2017). The only operational mine in the ECA is the Baffinland Mary River iron ore mine located in the northwest of Baffin Island (Buchan, 2018). Activities for this mine have been steadily increasing since production began in 2015 and the intention is to construct a dedicated railway line to the port in Milne Bay to accelerate production output (NEF, 2017). This will lead to an increase in marine traffic during the accessible months beyond the current one vessel per day near Pond Inlet (DFO, 2011). The likely increase in bulk carrier traffic in the area has some residents of Pond Inlet concerned about subsistence hunting and marine mammal health (NPC, 2016).

Mining has been an important component of the economy in Nunavut despite the territory's short history, and active mine sites were present until 2009, when activity ceased throughout the territory. Since the hiatus in 2009, activity has expanded quickly, as mining accounted for 22% of gross domestic product of the territory in 2016, at \$700 million, behind only the government sector (Buchan, 2018). This growth is expected to continue. All mines currently operational in Nunavut are expecting to expand production in the coming years, while additional mines are slated to begin operation. The Chidliak Project, a diamond mine located on southeastern Baffin Island near Cumberland Sound, was recently purchased by the mining company De Beers and may begin production as early as 2021 (CBC News, 2018b; NEF, 2017).

Mining activities create waste products that can be mobilized into the environment from either point or non-point sources. Diamonds and gold – two actively extracted minerals in the Canadian Arctic – create large deposits of waste material, which often includes heavy metals such as lead, arsenic, and mercury, and other compounds (Poland et al., 2003). For example, the Giant Mine (which mined gold) in Yellowknife, Northwest Territories produced vast amounts of arsenic and other toxic compounds that have repeatedly contaminated large portions of the surrounding environment, both terrestrial and marine (Indian and Northern Affairs Canada, 2010). Once on the surface, processing and weathering can mobilize compounds into surface water, which make their way into the aquatic environment (Rollo & Jamieson, 2006) where the compounds can bioaccumulate in organisms at multiple trophic levels, such as benthic invertebrates, fish, and marine mammals (Brown et al., 2018b; Doe et al., 2017; Walker & Grant, 2015; Becker, 2000; Lemly, 1994). Even at long inactive sites (decommissioned for >60 years), concentrations of heavy metals from gold mining were above normal in benthic invertebrates and sediment, at levels that suggested a high risk of adverse effects (Doe et al., 2017; Walker & Grant, 2015). Although it is known that heavy metals and other harmful contaminants from mining do bioaccumulate in the tissues of marine organisms, proving a direct causal effect to individual or population-level consequences remains difficult. However, it is plausible (if not likely), that carrying significant concentrations of mine waste products would have detrimental effects on wildlife (Doe et al., 2017; Walker & Grant, 2015).

Commercial Fishing

Subsistence and traditional harvest of many marine fish species has occurred for generations and has been conducted at small scales and in line with Inuit environmental values. However, development of commercial fisheries is a priority of the Government of Nunavut as well as of many individual communities (Department of Environment, 2016). This section will

outline the status of commercial fishing in Nunavut and explore its risk to the ECA, which include overexploitation of target species, bycatch, fishing vessel traffic, and destructive fishing practices. Subsistence and traditional fishing practices will not be assessed here.

The commercial fisheries sector consists predominantly of shrimp (northern [*Pandalus borealis*] and striped [*Pandalus montagui*]) and turbot, with a smaller commercial market for Arctic char. The total harvest of the three fisheries in 2015 was slightly over 13,000 metric tonnes, which is approximately 9,000 tonnes less than the available quota (Department of Environment, 2016). In 2016, the Government of Nunavut released an official strategy and have committed to securing partnerships and providing funding to stimulate the growth of the sector. Obtaining a greater portion of the annual harvest quota for Nunavummiut is a stated objective, as their current portion of the quota is in many cases inconsistent with the adjacency principle (i.e. local fishing communities receiving a greater portion of the quota than distant fleets) demonstrated elsewhere in Canada (Department of Environment, 2016). Infrastructure improvements are a priority as this is currently a major limiting factor for the industry to develop. There are only three established fish processing plants in Nunavut (Rankin Inlet, Cambridge Bay, and Pangnirtung) and one small craft harbor (Pangnirtung), while the industry has an ownership or equity stake in three factory freezer trawlers and four fixed-gear vessels (Department of Environment, 2016). Improvements to infrastructure and receiving a greater portion of the quota are both expected to occur in the short-term; a new small craft harbour is in construction in Pond Inlet while the quota share of Turbot has increased from 60% to 73% from 2004 – 2014 (Department of Environment, 2016).

A major threat from commercial fishing is bycatch, the accidental harvest of non-target, often non-commercial species. Bycatch is ubiquitous in many fisheries due to non-discriminatory fishery gears and practices, leading to high mortality rates that are often unreported or underreported given that the non-targeted species are often discarded back to sea. Most discards do not survive, and globally it is estimated that millions of tonnes of fish are discarded as bycatch at sea every year, although this is likely a vast underestimate (FAO, 2016). Certain gear types are more liable to produce bycatch than others. Regarding the fisheries in Nunavut, the offshore shrimp and turbot fisheries operate using bottom-trawls, a technique that drags a large, weighted net along the seafloor and is notorious for producing very high levels of bycatch (Fuller et al., 2008). For example, in a single year the turbot fishery harvested almost 11% of the total catch as bycatch (Jorgensen & Treble, 2016). In the often low-productivity Arctic marine environment, high bycatch rates may have severe adverse effects on marine ecosystem health by affecting the diversity and abundance of fish species that are crucial to the food web.

The second component of commercial fishing threatens the ECA is the use of destructive fishing practices which cause severe, possibly irreversible, damage to fragile, slow-growing benthic biogenic habitats (Kenchington et al., 2011). Coral and sponge species provide feeding, spawning, and refuge habitats for other benthic and pelagic species (DFO, 2010a), and are considered to be ecologically significant species and ecosystem engineers. Bottom-contact fishing gears are known to be the most environmentally-damaging fishing practice, with bottom-trawls – the gear type used in the offshore turbot and shrimp fisheries – being the most damaging (Fuller et al., 2008). Scientific trawl surveys and bycatch from the shrimp fishery have indicated a widespread occurrence of corals and sponges, yet much of the region suffers from

severe data gaps (Kenchington et al., 2011). Ongoing damage to biogenic habitats has adverse and direct implications on the health and integrity of the marine ecosystem.

The third component of the commercial fisheries' threat is the overexploitation of target species. Commercial fishing in the ECA currently only targets four species. The most recent assessments for all species determined that the stocks were healthy, while it was suggested there are some uncertainties surrounding striped shrimp and Arctic char stock health (DFO, 2017b; Jorgensen & Treble, 2016; DFO, 2010b; DFO, 2005). Furthermore, it should be noted that stock health assessments and supporting information may not account for basic biogeological information (e.g. spawning sites) and some data (e.g. stock estimates) are not considered especially robust.

Expansion in the number of harvested species is currently being explored by the territorial government and individual communities. Eight species are in consideration for an exploratory fishery (e.g. porcupine crab *Neolithodes grimaldii*), as is exploiting current fisheries in other locations within Nunavut (Department of Environment, 2016). Although overexploitation may not currently be an issue, there is the risk that changing environmental conditions combined with overambitious quotas (due to factors such as inexact stock estimates) could negatively affect population health. If fisheries management does not capture these changes, or chooses to ignore them, overexploitation could impact overall ecosystem health as has been seen in numerous fisheries globally (FAO, 2016).

Hydrocarbon Activities

Hydrocarbons continue to be the primary source of energy for much of the world. Petroleum products are the primary fuel source used in transportation and are integral in other sectors such as agriculture. Much of the oil and gas industry in the Canadian Arctic has been developed in the western and High Arctic, with little exploration or extraction in the ECA thus far. This section will discuss the extent of hydrocarbon activities in the ECA and the specific threats from seismic testing and a catastrophic oil well blow-out.

There are no active production licenses in the ECA; however, there is one significant discovery license in the offshore area, east of Frobisher Bay (Landra, 2018). Exploration licenses owned by Shell within the boundary of the proposed Tallurutiup Imanga NMCA were voluntarily relinquished in 2016 as part of the planning process (Lancaster Sound Steering Committee, 2017). Additionally, there are no existing licenses occupying the terrestrial portion of the study region.

Known hydrocarbon reserves in Nunavut are substantial. It is estimated that over 10% of Canadian conventional oil deposits are in the territory, accompanied by an additional 181 Tcf of natural gas (Natural Resources Canada [NrCan], 2017). In the eastern region, the significant discovery license near Frobisher Bay corresponds to the Hekja formation, containing 4 Tcf of natural gas (NrCan, 2017). The only other area of note is a natural hydrocarbon seep near Scott Inlet. No license exists for the area and no plans are underway to exploit it, although the naturally occurring oil slick begets interest in further exploratory operations (NrCan, 2017).

Political and economic conditions are not presently conducive to Arctic hydrocarbon activities. In 2016, the federal government announced the implementation of an offshore oil and gas moratorium (CBC News, 2016) which prohibits any new licenses from being awarded and extends indefinitely; this process will be reviewed every five years by a science-based

review panel. Exploration activities in the region were further impacted when the Supreme Court of Canada recently decided that previously-approved seismic testing in Baffin Bay could not proceed given that Inuit from the community of Clyde River were not properly consulted and that the negative effects on marine mammals were not given proper considerations (Tasker, 2017). The seismic testing which was previously approved by the National Energy Board was cancelled and new proposals will have to begin the process anew.

Economic conditions are also not currently favourable to offshore Arctic hydrocarbon activities. The decrease in value of crude oil from its peak of over \$160/barrel in 2008 to the current price of \$71/barrel for West Texas Intermediate crude (Macrotrends LLC, 2018) has made Arctic projects difficult to justify for hydrocarbon companies. Though summer sea ice extent has diminished in the past decades, the variability from year-to-year is viewed negatively by the industry. Long periods of low or no light, frigid temperatures, and distance to markets are other factors that increase the cost associated with Arctic endeavours (Barnes, 2015). Enhanced regulations and safety concerns regarding Arctic shipping and hydrocarbon activities are yet another barrier to cost-effective operations in the Canadian Arctic.

Seismic testing is used by the hydrocarbon industry to detect oil and gas reserves by blasting arrays of air guns underwater and recording the behaviour of the reflected sound waves. Testing can occur continuously for months at a time, and effects have been noted many kilometers away. One study found that air guns can cause significant mortality in zooplankton up to 1.2 km away, the extent of the testing limit (McCauley et al., 2017). Zooplankton are an integral part of the food web and mass mortality of this food source could have severe trophic cascades and ecosystem-level repercussions. Sound is also a ubiquitous means of communication, foraging, and navigation for many marine organisms, especially marine mammals, and seismic testing could have negative impacts over great distances (NPC, 2012b; Weilgart, 2017).

The event associated with hydrocarbon activities that evokes the greatest concern for marine conservation is a catastrophic oil spill. For example, the *Deepwater Horizon* accident in the Gulf of Mexico released 3.19 million barrels of oil over the span of 87 days (Beyer et al., 2016). It was estimated that over 2,100 km of coastline and a much larger area of deep-sea habitat were negatively affected by the oil, with adverse incidents being catalogued on many of the organisms inhabiting the region. Considering that this incident occurred in an area where accident-response crews and techniques are more easily mobilized and able to mitigate a disaster, a similar event in the remote Arctic could have greater ramifications. Due mainly to freeze-up of the Arctic Ocean and the disappearance of daylight and depending on the timing of an oil-well leak, the oil could flow unabated until the following season (Emergency Prevention Preparedness and Response [EPPR], 2017). Further, oil spill response techniques are underdeveloped for Arctic conditions, with a low degree of success for any of the currently available techniques (EPPR, 2017). A large well leak or blow-out could have wide-ranging and long-lasting negative effects to Arctic ecosystems and Inuit communities.

Improper Mechanisms of Inuit Participation

Given Inuit values that support sustainable resource use and respect for the environment (QIA, 2018), improper mechanisms of Inuit participation will not impact the integrity of the ECA's ecological, cultural, and social dimensions in the same manner as the

other threats. However, it may indirectly impact the features by decreasing the effectiveness of MPAs and the holistic protection that they can provide. Therefore, this threat will be framed as a risk to marine protection efforts, and not as a direct threat to the ecological, cultural, and social dimensions of the ECA. Specific aspects of this threat include the lack of effectual co-management arrangements and a lack of financial, technical, and human resources capacity.

Inuit make up the majority of the population of Nunavut and their cultural practices and values are embedded in policy and legal frameworks in the territory. The importance of these practices and values are outlined as legal rights in the NLCA, which include *inter alia* harvesting, access, and protected area co-management rights (Minister of Justice, 1993). Thus, Inuit engagement is needed during planning, establishing, and implementation of new protected areas or other conservation measures not only as a matter of best practice in light of the spirit of reconciliation and empowerment of Indigenous peoples, but also as a legal requirement within the NSR.

Harvesting and access rights are important to Inuit culture and they are a fundamental part of attaining well-being. These rights are integral to their ability to obtain country foods, which make up a significant portion of the Inuit diet and are important for maintaining food sovereignty and food security, and can provide economic opportunities through guided hunts for polar bears (*Ursus maritimus*) and other animals (QIA, 2018; NPC, 2012c). They are also important for other facets of Inuit culture, including: continued access to traditional campsites and trails; the ability to harvest materials important in Inuit art, such as soapstone, ivory, antlers and bones; and as a way to access areas of personal or social significance (NPC, 2016).

To protect Inuit rights, it is important that the federal government collaboratively discuss with Inuit Organizations and communities any policies or legislations that involve the environments where they live. Co-management, the sharing of responsibility and power between resource-users and the government (Armitage et al., 2007), is codified in the NLCA as the management framework for protected spaces in Nunavut. Effectively using the co-management arrangement to define objectives in line with Inuit values and to maintain Inuit support is integral to the long-term existence of protected areas or management measures.

Examples of effective co-management arrangements in the marine space of the Canadian Arctic exist. The Tarium Niryutait MPA was championed by the local Inuvialuit to act as a reserve for beluga whales, an important species for subsistence; this MPA is co-managed by the Inuvialuit, the FJMC, and DFO (DFO & FJMC, 2013). The Anguniaqvia Niqiyuam MPA is the first that describes conservation objectives based solely on Inuit knowledge and is co-managed by DFO, the FJMC, and the Inuvialuit community of Paulatuk (DFO, 2018a). Ideally these past and current initiatives will illuminate best practices and provide positive examples of co-management that will generate Inuit support for future marine protection elsewhere in the Arctic.

Along with effective co-management, broad support for protection measures will increase the likelihood of protected area implementation. In consultations undertaken within communities corresponding to each assessment location included in this research (i.e. Clyde River, Pangnirtung, and Pond Inlet), two issues were repeatedly raised: the need for increased sustainable economic opportunities, and the protection of wildlife and their habitats for harvesting and tourism (NPC, 2012a, NPC, 2012b; NPC, 2012c). Sentiments appear to support protection from large foreign development projects, such as mining or hydrocarbon activities.

Conversely, protection would not be supported if it infringed upon residents' ability to benefit economically from activities that are an extension of traditional activities (e.g. sustainable commercial fishing or guided hunts). Although Billé (2008) notes that no community will be completely homogenous in their perspectives – regardless of the issue – these consultations have at least provided a sample of concerns and values held within communities in the study region. Thus, the need for a balanced, integrated co-management approach and effective communication of values between parties is necessary for success (Pomeroy, 2007).

Another aspect that may factor into improper mechanisms of Inuit participation relates to a lack of human resources, technical, and financial capacity. The lack of capacity had been foreseen as an issue since the inception of Nunavut and has continued in various government departments (e.g. education [Auditor General of Canada, 2013; Mayer, 2007]) and industrial sectors (e.g. commercial fishing [Department of Environment, 2016]). Nunavut occupies a large geographic area making it difficult to communicate and travel in a timely manner while also raising the cost of acquiring all manner of goods (e.g. building materials, food, and fuel) (GoN, 2012). A small and scattered population resulting in a small work force compounds these issues. Nunavut is composed of 25 communities with a total population of approximately 38,000 people, and a work force of approximately 16,000 (Nunavut Bureau of Statistics, 2018). The NLCA mandates that government employment is representative of the Inuit population, yet there are simply not enough qualified individuals to fill every available position (Mayer, 2007). Finally, Nunavut does not have a strong or diverse economy. The vast majority of the Government of Nunavut's revenue is generated through the territorial formula financing agreement with the federal government which is estimated to account for over 80% of revenue in fiscal year 2018 (GoN, 2017). Most communities are economically depressed and available financial resources are allocated for core needs such as health care, basic education, and housing (GoN, 2017), limiting the available financial capital to improve internal capacity, such as technical training and advanced education.

For Government of Nunavut departments or Inuit Organizations that may have a part to play in enforcement, monitoring, or management of a new protected area, the initiative may demand too many of their already-limited resources. The same could be said for the aforementioned organizations or individuals in engagement for consultation purposes. Given the lack of surplus human, financial, and technical resources, involvement in the designation of a new protected area may not be feasible for certain parties; where that party is integral to the protected area designation process in Nunavut (e.g. Nunavut Wildlife Management Board [NWMB]) this may prove a significant hurdle to effective implementation and management.

Tourism

Specific threats from tourism can predominantly be attributed to the negative effects of vessel traffic, yet also arise from tourists' attraction to wildlife, which can alter animal behaviour and interrupt traditional harvesting. The specific threats associated with vessel traffic will be covered under the commercial shipping section; this section will focus on the reasons Canadian Arctic tourism is increasing and the impacts of wildlife disturbance.

The Canadian Arctic is often seen by the general public as a vast expanse of relatively unspoiled wilderness and has become more popular for tourists in recent years. From 2011-

2015, cruise ship travellers to Nunavut grew by almost 50%; 2015, the most recent year from the report, saw 21 cruise ships that brought in a total of over 2,700 people to the territory (Insignia Marketing Research Inc. [IMRI], 2015). The Government of Nunavut is committed to increasing tourism further as a means of stimulating the economy, and the rise in tourism activities is expected to continue in the coming years (GoN, n.d.[d]). An important logistical reason that Arctic tourism is increasing is the greater access available to Arctic waters as summer sea ice extent continues to decrease. Combined with improvements in vessel technology, regulations (e.g. modifications to Nunavut's *Tourism Act* [Commissioner of Nunavut, 2016]), and navigation, individual tourists and cruise operators are more comfortable undertaking voyages to this historically harsh environment.

The first contributing factor to increasing tourism is the numerous charismatic species that inhabit the Arctic, including polar bears, narwhals, and beluga whales. The inability to view these animals in their natural habitat in any other places on earth make them important to tourists and they are a primary draw for activities such as photography (IMRI, 2015; Maher, 2012). Similarly, the scenic vistas present in the Arctic are also alluring; witnessing fjords, glaciers, and icebergs is another popular tourist pastime (IMRI, 2015).

Another reason the Arctic is becoming more popular as a tourism destination is the growing fascination for different cultures. Indigenous cultures, peoples, and activities are often stereotyped and romanticized, and they are often cited as reasons for visiting an unfamiliar place (IMRI, 2015; Maher, 2012). Indeed, the cultural experiences of Arctic cruise tourism – whether purchasing Inuit art or attending cultural performances – are commonly offered onboard and attended by cruise patrons (IMRI, 2015).

Additionally, the Arctic is considered a 'last chance' tourism opportunity, referring to the draw of visiting a location that is rapidly changing and may not continue to exist in its current state in future (Lemelin et al., 2010). Changing environmental conditions have led to a growing realization and perception that the Arctic and its inhabitants may not persist as they are indefinitely. This is adding to the feeling of urgency in booking an Arctic experience and increasing the number of tourists that visit.

Cruise ship traffic provides two nuances not displayed by other types of vessels. The first is the explicit desire to approach and potentially interact with wildlife. These activities can cause behavioural changes, stress, and increased activity in animals, which may impact the overall health of populations (Carter et al., 2018; Jansen et al., 2010). By modifying behaviour in wildlife, tourism may also disturb traditional harvesting activities, detrimental to Inuit food security and sovereignty, and social aspects (Carter et al., 2018). Reducing tourism's impacts to wildlife is an objective of Nunavut's official tourism strategy (GoN, n.d.[d]).

Second, one of the greatest differences between cruise ships and other vessel types is the amount of wastewater that is produced on board (Vard Marine Inc., 2018). Although regulations prevent the discharge of any waste into Arctic waters it is understood that it still occurs, given the lack of port and wastewater discharge facilities in the Canadian Arctic and the long voyages undertaken by cruise ships (Vard Marine Inc., 2018). Threats from vessel activity in general, including wastewater discharge, are covered in more detail below.

Commercial Shipping

One estimate suggests that 90% of goods traded worldwide are transported by ship at one point in the supply chain (Castonguay, n.d.). Shipping activities are integral to the survival of northern communities as they are the most cost-effective manner to deliver crucial goods. However, shipping activities are a significant source of risk to the ECA's ecological, cultural, and social dimensions and vessel activity is a component of other threats identified in this report (e.g. mining, tourism, and commercial fishing). The current extent and forecast for Arctic shipping will be discussed, as well as specific shipping-based threats loosely categorized as discharges (i.e. wastewater, bilge-water, IAS, and ship-sourced oil spills) or related to vessel presence (e.g. noise pollution, icebreaking, and vessel strikes).

Dawson et. Al. (2017) found that vessel traffic in Nunavut, in terms of total kilometers travelled, doubled in the period from 1990-2015. The two dominant types of vessels over their entire study period were cargo ships (predominantly re-supplying northern communities) and government research and icebreaking vessels. Other vessel types with noticeable activity increases over the study period (Fig. 5) were fishing vessels (concentrated in Baffin Bay) and passenger vessels (trending towards eastern Baffin Island and Tallurutiup Imanga towards the latter portion of the time period).

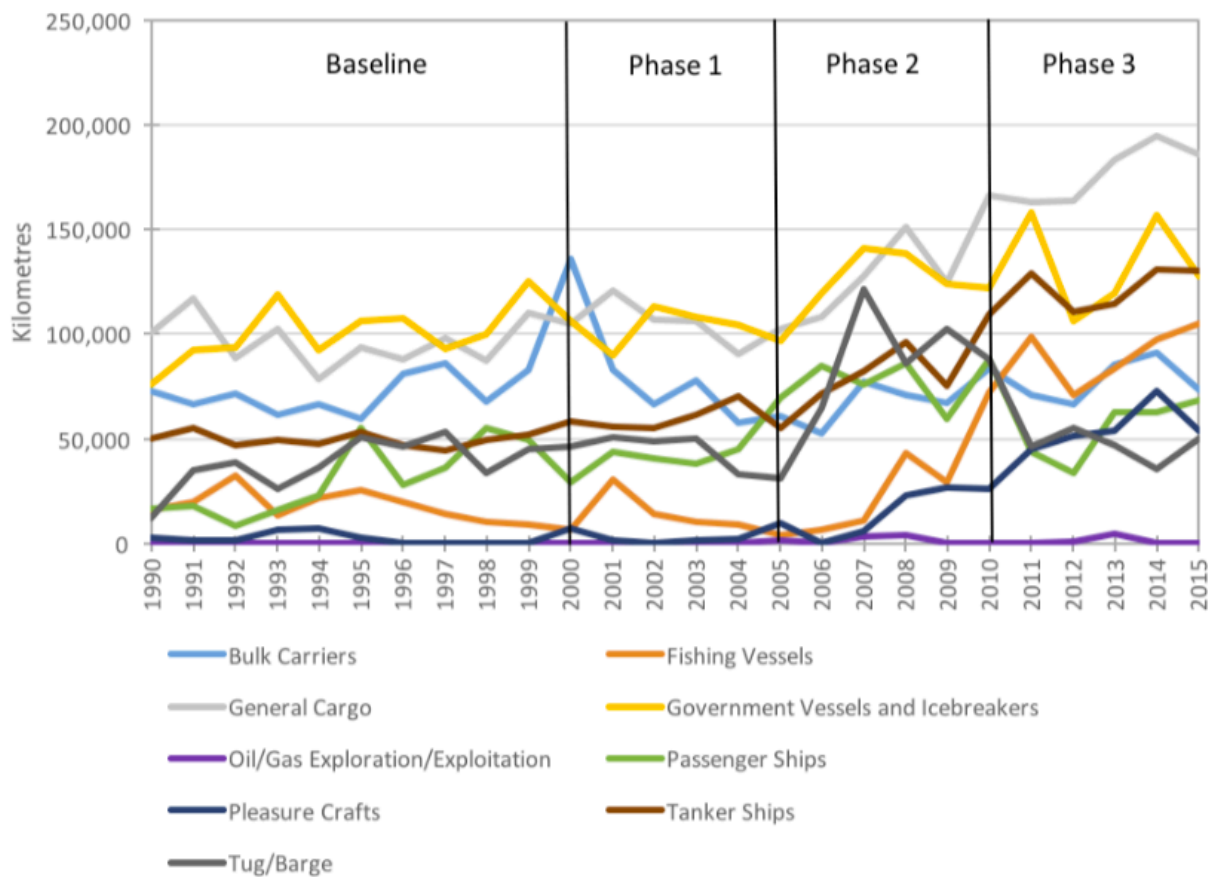


Figure 5. Kilometers travelled per year by vessel type in the Qikiqtani region of Nunavut from 1990 - 2015. Figure from Dawson et al., 2017.

The search for ever-greater efficiency of transport between Europe and Asia has existed since the colonial era and continues to this day (Lackenbauer & Lajeunesse, 2014). The benefits of utilizing routes that cross the Arctic Ocean are related to shorter transit times and distances, leading to the potential for substantial cost savings (Lackenbauer & Lajeunesse, 2014). Two major Arctic seaways exist: the Northeastern Passage, transiting to the north of Russia, and the Northwest Passage, transiting through the Canadian Arctic Archipelago. Although the Northwest Passage has been generating shipping interest for centuries, vessels transiting through the seaway had little impact on the recent increase (Dawson et al., 2017). The Northeastern Passage is currently perceived as a better alternative given that the Russian Federation has invested far more resources in the infrastructure along this route (e.g. ports and icebreaker support) which are attractive amenities for shipping companies. Additionally, the Russian route is shorter and there is less variability in environmental conditions (Lackenbauer & Lajeunesse, 2014).

Nonetheless, there are reasons to believe that shipping traffic will continue to increase in the ECA even without the influence of vessels transiting through the Northwest Passage. A potential factor for increased shipping is the development of the mining sector and its bulk ore carriers. Another potential trigger is the development of commercial fishing activities, a priority economic-growth sector for the Government of Nunavut (Department of Environment, 2016). Moreover, the growing interest in Arctic tourism should expand expedition cruise ship traffic in the coming years (Maher, 2012). The escalation of research interest due to climate change and the political interest of Canada regarding Arctic sovereignty may also contribute to increased vessel activity.

Two initiatives will shape shipping activities in the Canadian Arctic moving forward. The Polar Code came into force in January 2017 and outlines stringent safety and environmental protection regulations for vessels operating in the Arctic (Marine Environmental Protection Committee, 2014) which complements the Canadian *Arctic Waters Pollution Prevention Act*. The Polar Code was implemented by the International Maritime Organization as amendments to the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) which covers all major shipping fleets worldwide. The second initiative is the Low Impact Shipping Corridor project by Transport Canada which aims to concentrate shipping activity along certain routes to facilitate safety and environmental response capabilities in the Canadian Arctic (Carter et al., 2018), which is necessary given the lack of infrastructure and personnel capacity currently in place. The federal government is working with northern communities and organizations to develop shipping routes that minimize the impacts on wildlife and Inuit transportation and harvesting (Carter et al., 2018; Reichert et al., 2016).

Vessel Discharges

Vessels carry and produce numerous substances that can intentionally or accidentally become introduced into the marine environment. Human activity aboard vessels produces wastewater, classified as either greywater (i.e. wastewater from sinks, showers, and galleys) or blackwater (i.e. raw sewage). Wastewater is often held in holding tanks aboard vessels, which, especially during long voyages with limited port and wastewater discharge facilities – such as those in the Arctic – may be dispelled into the marine environment. Though empirical studies in

the Arctic are limited, it is known that this can be detrimental to ecosystems via an increase in nutrient load, which can cause a myriad of effects including algal blooms, modifications to the food web, and a decrease in oxygen concentration (Karydis, 2009). Wastewater can also modify ecological community composition (Tseng et al., 2008) which may cause changes to ecosystem function. A report by Vard Marine Inc. (2018) estimated that greywater discharge rates will increase in future.

Large vessel-sourced oil spills are a common concern with burgeoning Arctic traffic. Negative effects of oil on all manner of organisms have been documented (Nevalainen et al., 2018; Beyer et al., 2016) and the Arctic environment is seen as more susceptible to its effects than other environments (Vergeynst et al., 2018; Blanken et al., 2017). The *Exxon Valdez* incident illuminates the potentially severe consequences of an Arctic oil spill, as it caused acute mortality of many seabirds, otters, fish, and invertebrates, and it was compounded by cascading and long-term effects which are still being felt to this day (Peterson et al., 2003; Peterson, 2001).

Bilge-water – the combination of oil and other compounds that collects in the lower levels of a ship – can also negatively impact marine health. Bilge-water treatment is compulsory before release into the ocean, yet negative effects (e.g. reduced egg production and mortality in the copepod *Acartia tonsa*) have been demonstrated even after treatment (Tiselius & Magnusson, 2017). The chronic release of oil and other compounds directly into the ocean due to standard vessel operation is similar to, yet separate from, bilge-water release; while it is difficult to quantify and assess, it is likely to also negatively impact the marine environment (pers. comm., Hugh Williamson, Oct. 2017).

IAS are species that are non-indigenous and are capable of successfully colonizing an area, and can have enormous negative effects on the ecosystems to which they are introduced. For example, invasive signal crayfish (*Pastifasticus leniusculus*) have been documented preying upon great Arctic char (*Salvelinus umbla*) eggs; egg mortality increased 200% due to the signal crayfish predation, perhaps limiting the population recovery of the endangered fish (Setzer et al., 2011). Simple species-to-species interactions can translate to reduced ecosystem functioning (Preston et al., 2012) and have economic ramifications (Pimentel et al., 2005). The transfer of IAS is facilitated by the global shipping market, with the majority of IAS being introduced via ballast water exchange (Chan et al., 2013). Though ships entering from outside the Canadian Exclusive Economic Zone (EEZ) are required to exchange ballast water, those operating exclusively within Canada's EEZ are not required to do so. Considering that much of the shipping (and therefore the ballast water) to Arctic communities (i.e. community re-supply) originates from within Canada, this could be a significant vector for the introduction of IAS (DFO, 2015; Chan et al., 2013).

Vessel Presence

The presence of vessels in an area generates its own set of threats. Vessel-generated noise pollution produces negative effects in the ecosystem, including reducing the efficiency of communication and diminished situational awareness in both marine mammals and fish (Putland et al., 2018; Halliday et al., 2017). As communication is essential for foraging and mating, a reduction in its efficiency could have significant consequences to fitness. Additionally, vessel-generated noise propagates and can cause effects over long distances. Multiple studies

have found that ambient noise from transiting vessels could modify marine mammal behaviour within a range of 50 km (Halliday et al., 2017; Finlay & Davis, 1984).

Icebreaking is the break-up of sea-ice by vessels (predominantly accomplished by dedicated icebreakers) to facilitate voyages in polar seas. Activities undertaken in other sectors – such as research and resource extraction – may require the support of an icebreaker. Much of the icebreaking research has focused on individual-level response of specific organisms to the disturbance. These species include the Caspian seal (*Pusa capsica*), polar bears, belugas, and narwhals (Wilson et al., 2017; Smultea et al., 2016; Finlay & Davis, 1984). These studies suggest demographic-level consequences, yet empirical evidence is scarce. Inuit observations, however, offer evidence that modification to the structure of polynyas and/or the floe-edge and inhibition of regular movement patterns does negatively impact ecosystem health (NPC, 2016). Overall, icebreaking is contingent on vessel traffic and effects would be exacerbated along a route that undergoes icebreaking repeatedly, which may become more commonplace given the implementation of the Low Impact Shipping Corridor initiative (Carter et al., 2018).

Vessel strikes were a major reason that a sizeable portion of the population of the North Atlantic right whale (*Eubalaena glacialis* [NARW]) was killed in 2017 (DFO, 2018b), and although the NARW does not inhabit the Arctic there are numerous other large whale species that might be susceptible to vessel strikes, including bowhead, beluga, narwhal, orca, sperm (*Physeter macrocephalous*), and minke (*Balaenoptera acutorostrata*). Vessel strikes might have more serious consequences in the Arctic as whale species are often the target of conservation efforts (e.g. Ninginganiq NWA) and an important country food for Inuit. Lethal vessel strikes can be mitigated by implementing speed restrictions within an area of high whale density and enacting closures to vessel traffic (van der Hoop et al., 2012; Vanderlaan & Taggart, 2007).

A final pertinent point is that many MPAs do not restrict vessel traffic entirely. Regulations often request voluntary avoidance, slower speeds, or seasonal closures. Thus, unlike most other commercial threats identified in this report, the effects of shipping may still be felt even in areas that have been designated for protection.

Results and Discussion

The marine environment of the ECA contains many ecological, cultural, and social dimensions that are unique and warrant increased protection measures. Inuit have been the stewards of this region for thousands of years; however, the ECA is increasingly targeted by damaging industrial activities as access and ease of operation are facilitated by changing environmental conditions and other factors. These industrial activities come with their own potential impacts on the sensitive Arctic ecosystem and its ability to support the integrity of these valuable dimensions.

This research aimed to identify threats to the ecological, cultural, and social dimensions of the ECA by quantification of their degree of impact using a relative risk assessment framework. Risks were calculated across two timeframes (current status and 15-year future) and three different locations within the ECA to elucidate how the threats might differ spatially and temporally. By identifying the potential threats before their footprint enlarges, marine protection in the region may be implemented, pre-empting negative impacts. Assessment of

the threats' 19 component parts at three locations and two timeframes resulted in 114 risk score calculations.

This section will discuss the ability of MPAs to mitigate the analyzed threats, propose some factors that may influence governance of marine space in the ECA, and finally review some limitations of the study. Management recommendations will be presented in the subsequent section.

MPAs' Potential to Mitigate Threats

MPAs have demonstrated the ability to mitigate social, cultural, and ecological threats worldwide contingent on factors such as enforcement capacity, stakeholder buy-in, and clear, consistent objectives (Edgar et al., 2014; Rife et al., 2013; Armitage et al., 2007). In the context of the ECA, MPAs have the potential to mitigate some of the harmful effects from the analysed threats, while they could prove ineffectual for others. With the exception of *Fisheries Act* closures, Canadian MPAs have the regulatory means to prohibit industrial activities. However, standards for marine protection vary depending on the type of MPA, the over-arching legislative authority (e.g. DFO, Parks Canada, ECCC), and resulting consultations with rightsholders and stakeholders. Currently, there are underdeveloped industrial activities taking place in the ECA; however, territorial strategies by the Government of Nunavut have outlined mining, tourism, and commercial fishing as priorities for economic growth, while the Northwest Passage will continue to be evaluated for its potential in global shipping (Lackenbauer & Lajeunesse, 2016). These factors likely contributed to the mean risk scores of all industrial threats and climate change increasing over time (Fig. 6)

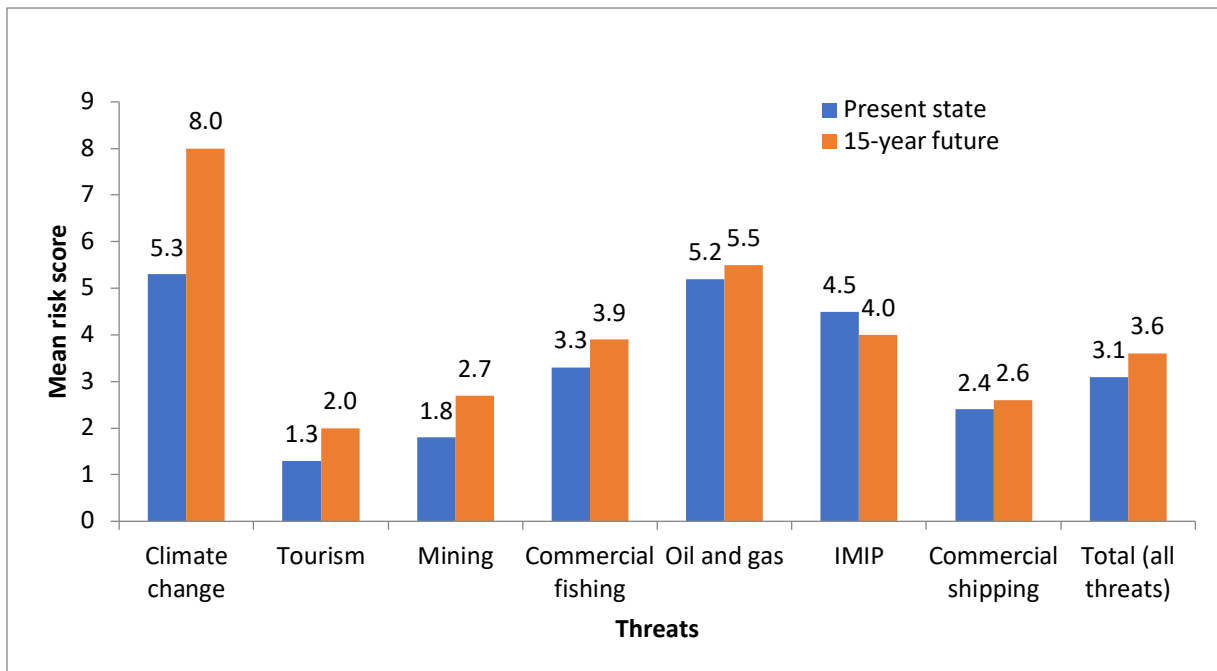


Figure 6. Comparison of risk scores between two timeframes (current state and 15-year future) across all assessment locations. Mean risk was calculated by averaging the risk scores of all components of each threat. IMIP = improper mechanisms of Inuit participation.

Risk scores differed between assessment locations (Fig. 7) due to different levels of industrial activity. Clyde River demonstrated the highest increase in cumulative risk over time, which was likely due to its current lack of industrial activity that may increase by the second timeframe given changing environmental conditions (especially commercial fishing and shipping). Eclipse Sound displayed the lowest increase in cumulative risk score as it was assessed under the assumption that the Tallurutiup Imanga NMCA would protect the area from industrial threats once implemented. Additionally, its location farther north should ensure the integrity of its sea ice to a greater degree than the other locations. The existing commercial fisheries and tourism activity and the projected development of the Chidliak mine contributed to the increase in cumulative risk in Cumberland Sound.

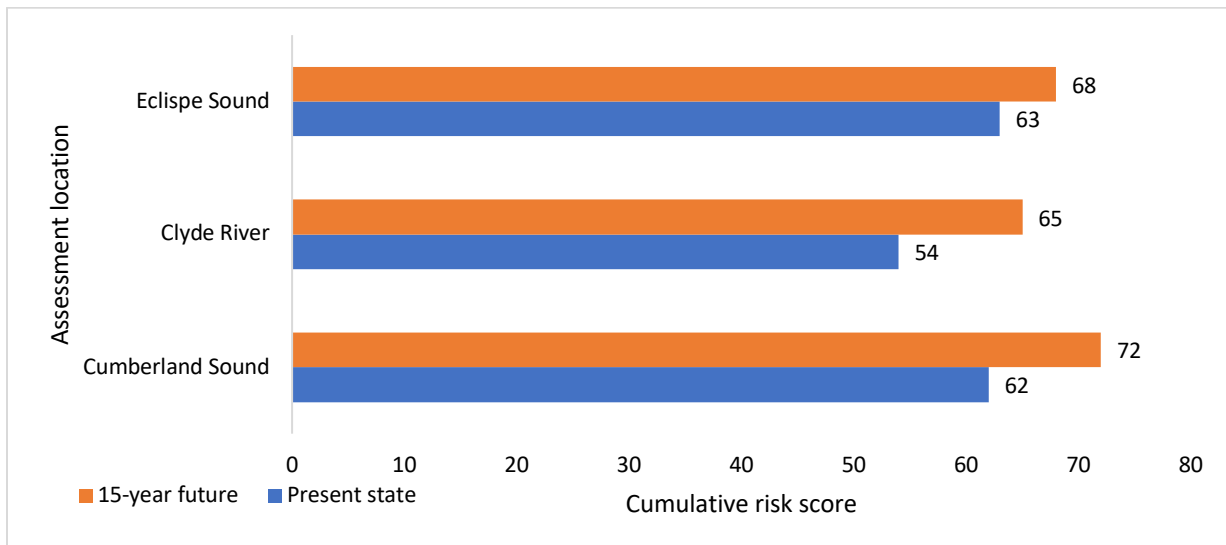


Figure 7. Cumulative risk scores across the seven threats and two time-frames (current state and 15-year future). Cumulative risk was calculated as the sum of risk scores from each component involved in the assessment.

Climate change is a threat unlike the others given that MPAs cannot protect against its consequences in the same manner. Across all locations analysed in this research, it was the only threat to be scored at the highest risk level (Figs. 8-10) given that its effects are known and expected to worsen in the immediate future and over the long-term (Brown et al., 2018a; Ford et al., 2016; IPCC, 2014). Climate change poses a significant threat for many reasons, including: the myriad environmental effects it causes (e.g. decrease in summer sea ice extent, changing sea-surface temperatures); the complex interactions between those effects; its pernicious nature, which can delay management or regulatory action; its ability to enhance the magnitude or occurrence of the other threats assessed here (e.g. by increasing spatial and temporal access for commercial shipping); its global scale and international commitment needed to mitigate it; and, associated socio-economic effects. Furthermore, climate change cannot be mitigated in the same manner as the others. The global scale of inputs into climate change make it very difficult to control, as it would take binding concerted effort from states that are far removed from Canadian jurisdiction to meaningfully reduce its occurrence. Additionally, the timescale over which climate change operates makes it difficult to mitigate. Projections forecast its effects displaying at least into the middle of this century even if global emissions were to be immediately ceased (IPCC, 2014). Regulations and legislation need to take a long-term

perspective, which can be difficult to justify for politicians that are motivated by the short-term political cycle. Although MPAs cannot directly protect against climate change, they may prove effective by reducing the cumulative damage from other stressors, thus increasing ecosystem resilience and ability to adapt to a changing environment. These suppositions are fraught with uncertainty, yet in the global context of climate change, with few alternative tools available, the holistic ecosystem-based approach of MPAs can offer a promising option.

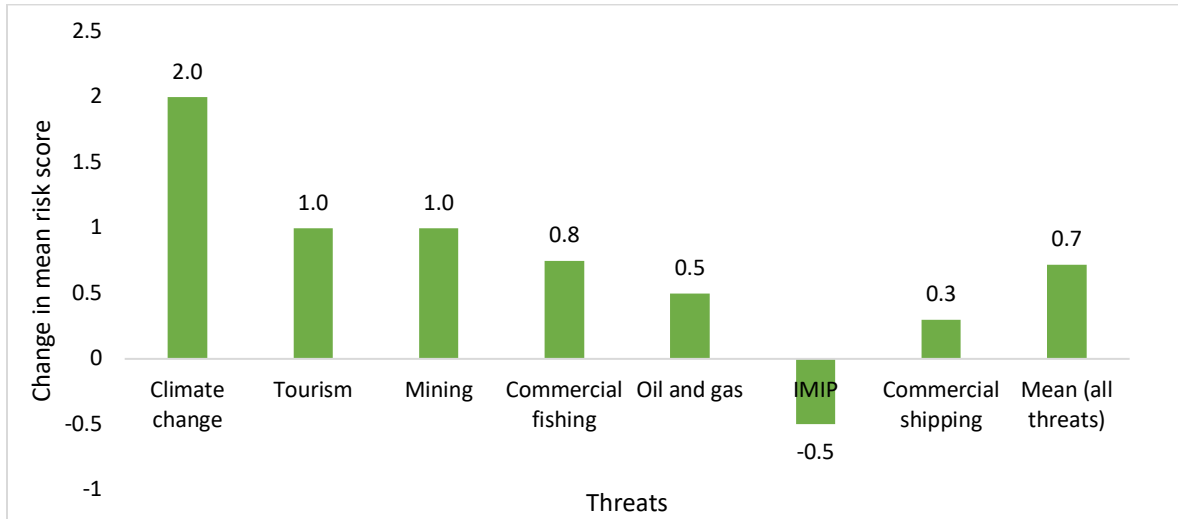


Figure 8. Change in mean risk scores across seven threats and two timeframes (current state and 15-year future) in the Cumberland Sound area. Mean risk was calculated by averaging the risk scores of all components in each threat category. IMIP = improper mechanisms of Inuit participation.

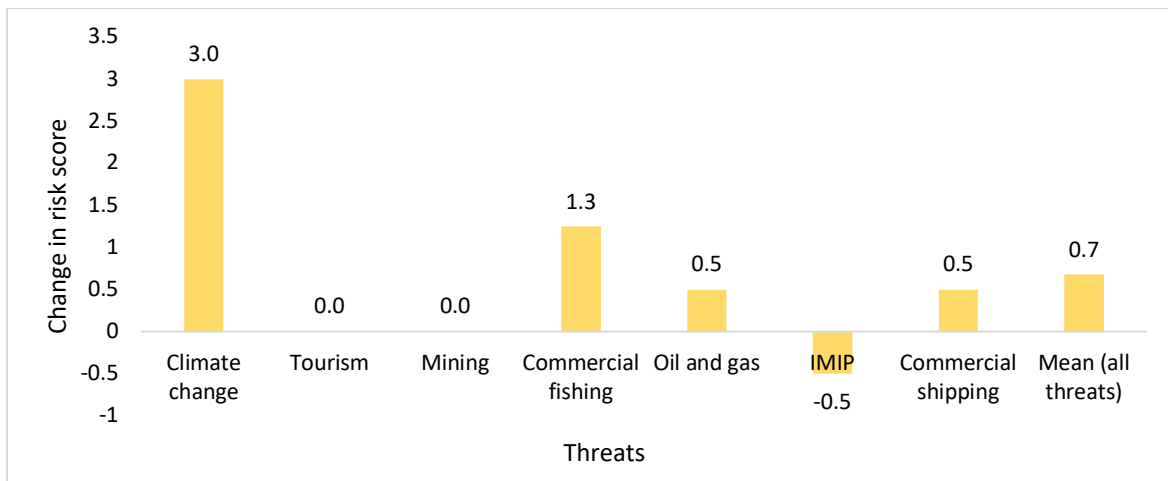


Figure 9. Change in mean risk scores across seven threats and two timeframes (current state and 15-year future) in the Clyde River area. Mean risk was calculated by averaging the risk scores of all components in each threat category. IMIP = improper mechanisms of Inuit participation.

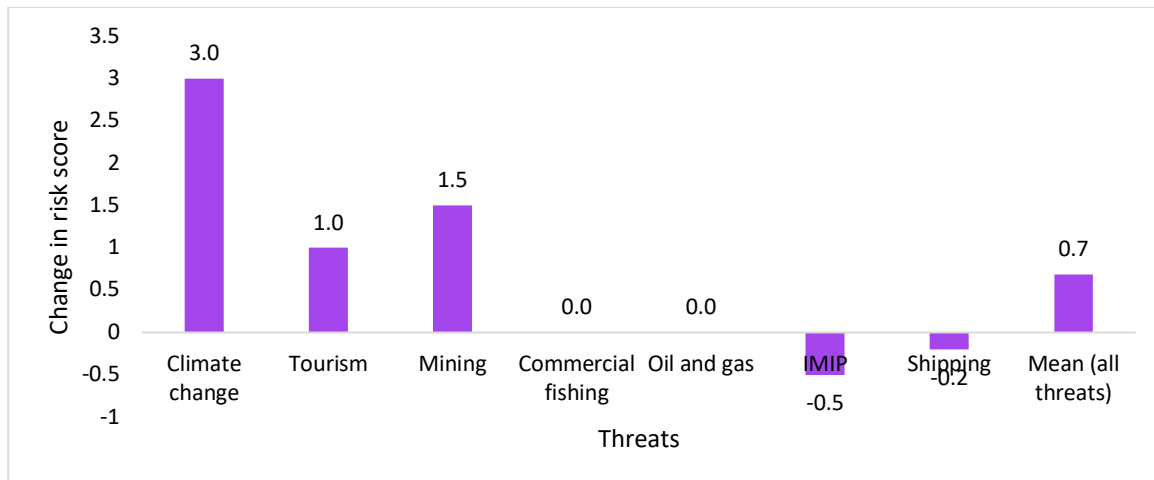


Figure 10. Change in mean risk scores across seven threats and two timeframes (current state and 15-year future) in the Eclipse Sound area. Mean risk was calculated by averaging the risk scores of all components in each threat category. IMIP = improper mechanisms of Inuit participation.

Beyond climate change, threats posed by ships have the most diverse and cumulative effects onto the marine environment, and are a component of some of the other identified threats included in this research. Ships of various classifications range around the ECA and each have slightly nuanced effects. For example, cruise ships are currently infrequent but produce significant amounts of wastewater, which may be discharged illegally, whereas cargo ships and tankers may proliferate IAS via ballast water discharge and pose a greater risk of a large oil spill. To complicate matters further, many of the shipping activities that could prove detrimental to the marine environment are regulated or prohibited yet are assumed to be occurring regardless. The *Arctic Waters Pollution Prevention Act* prohibits the discharge of any waste (e.g. greywater, sewage, bilge-water) into the Arctic ocean yet it is known to occur (Vard Marine Inc., 2018; Frizzell, 2017). Increased enforcement capacity and pursuit of criminal charges against polluters will be necessary to counteract these practices. The Polar Code and Low-Impact Shipping Corridors initiative should also help mitigate negative effects.

Commercial fishing is a threat whose outlook is difficult to predict. It is expected that commercial fishing will continue in the Cumberland Sound area and expand northwards to Clyde River in future due to changing environmental conditions, while protection from the Tallurutiup Imanga NMCA should limit its negative impacts near Eclipse Sound. Bottom-trawling is the primary gear used to catch the major target species in the ECA and is known to be a particularly damaging form of fishing, through habitat destruction and bycatch (Fuller et al., 2008). Fortunately, no current Canadian MPAs or OECMs allow bottom-trawling, which suggests that the ability of marine protection to counter the effects of commercial fishing, as it presently operates, is high. Moreover, the ECA currently encompasses only four commercially-exploited fish species, which is significantly less than other regions that may experience greater ecosystem pressures as a result of having dozens of species targeted by fisheries. The exploration of new target species by the ECA fishing industry and effects of the northern movement of temperate species could introduce a greater degree of risk from commercial fishing, although that is difficult to anticipate and/or model. Overall, the recent increased focus

on seafood sustainability (e.g. initiatives calling for more transparent labelling) and pressure from consumers and other organizations (e.g. FAO and other ENGOs) are expected to drive positive change in the industry through improved fishing technologies and increased monitoring and enforcement (FAO, 2016).

Improper mechanisms of Inuit participation was the only threat that did not increase in risk level over time. This may be explained by the increased commitment from the federal government to undertake meaningful consultation in protected areas planning, as has been seen in Anguniaqvia Niqiqyuam MPA and ongoing negotiations with the Tallurutiup Imanga NMCA (DFO, 2018a; Lancaster Sound Steering Committee, 2017). It is expected that these examples will provide lessons-learned and best practices and facilitate future discussions on governance. More broadly, the Crown's commitment to reconciliation and the adoption of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) provide further credence to the idea of a meaningful Inuit-Crown partnership across all sectors (Prime Minister's Office, 2017). Finally, it is also expected that an increase in human resources, financial, and technical capacity for Inuit Organizations and communities will facilitate marine governance moving forward.

Governance of Future Marine Protection in the ECA

Several initiatives could help shape the future of marine protection measures in the ECA. The continued maturation of the NLCA is an important aspect to consider. Although signed in 1993, there are numerous stipulations within the Act that have yet to be completed; the Nunavut Land Use Plan is one of these aspects. The NPC was mandated to produce a Nunavut-wide land-use plan to inform decision-making on resource use and development, including providing suggestions for future protected areas and a draft plan was published in 2016 (NPC, 2016). Once the final land use plan is implemented, it will have identified areas of biological, cultural, and economic importance based on the needs and wants of Nunavummiut, including marine space 12 nm from shore. This plan will help inform the use of marine space, including the development of future protected areas.

The recent formulation and increase in capacity of the NMC will also shape Arctic marine protection in the future. This is an Inuit organization composed of four institutions of public government (Table 2) whose mandate is to advise other government departments on activities in the marine area of the NSR. Though the NMC was slated for creation as part of the NLCA in 1993, it only recently started to function as an entity in early 2018. As this organization matures and is better able to fulfill its role, issues of marine protection in the ECA may be shaped by its activities and recommendations (Daoust et al., 2010).

The concept of federally-recognized and Indigenous-led protected areas (i.e. IPAs) is relatively new to Canada but gaining momentum across the country. These protected areas would be governed by Indigenous communities, organizations, and governments in accordance with Indigenous values and decentralize protection authority from the federal or provincial government (Indigenous Circle of Experts [ICE], 2018). Recognizing the often deep and longstanding connection between Indigenous communities and space, this is a method of conserving cultural practices and ecological components together, while allowing reconciliation through the recognition of Indigenous cultures and rights. Currently there is no formal legislation at any level of Canadian government for enacting an IPA, though there have been

formal calls to implement enabling policies (Bujold & Simon, 2018; ICE, 2018). Already, multiple efforts to create a marine IPA are underway in the Canadian Arctic and could provide important lessons-learned and best practices for future initiatives. The Nunatsiavut (Northern Labrador) government and the federal government recently signed a Statement of Intent to create an IPA in adjoining coastal waters (Sevunts, 2017). Community consultations began in 2018 to link current terrestrial protection with the marine space of a future IPA. A second IPA initiative has been undertaken further north; Pikialasorsuaq, or the North water polynya, is considered one of the most productive marine spaces in the entire Arctic and important for many species as well as Inuit communities in both Greenland and Canada (Pikialasorsuaq Commission, 2017). The Pikialasorsuaq Commission was created from an Inuit Circumpolar Council meeting and is collaborating with multiple partners including WWF, Oceans North, and DFO with the intent of establishing further protection for this important area while recognizing its importance to Inuit.

The current political climate in Canada will play a role in marine protection moving forward. The Trudeau government has committed to a renewed focus on Inuit-Crown relations and reconciliation (Prime Minister's Office, 2017) and the Canadian government declared in 2016 that it will adopt UNDRIP – an international standard which aims to reverse generations of persecution and neglect suffered by Indigenous Peoples across the globe – without reservation (Fontaine, 2016). The significance of these actions is the reallocation of decision-making authority and empowerment to Inuit. These decisions will either contribute to or detract from future marine conservation efforts, dependent on the principles and values held by individual First Nations, but either way it will likely impact future protection of the natural environment in Canada.

Study Limitations

This study was beset by a few limitations. First, the methodology for the risk assessment was not conducive for direct comparison between threats. Taking a mean of the risk scores from the components of each threat category lowered the risk score (especially from commercial shipping and commercial fishing), due to their higher number of components. Cumulative effects assessment may have been more useful in quantifying the total impact from a threat category, allowing for a more accurate comparison between threats. Additionally, cumulative effects assessment would have offered a more robust suggestion of the absolute amount of risk from all threats combined in a given location or timeframe (United States Environmental Protection Agency, 2003), which was not possible using the current methodology.

Second, much of the Arctic suffers from data limitations. The cost and difficulty of operating in the Arctic has limited the amount of scientific research that is undertaken in the area. The data gaps affect all sectors – everything from oil spill response technology (EPPR, 2017), to fisheries stock assessments (Department of Environment, 2016; DFO, 2010b; DFO, 2008), to the effects of noise, sewage, or mining contaminants on ecosystem health (Amuno et al., 2017). This limited the capability of this research to accurately quantify the impact score of specific components during assessment.

Third, the risk assessment operated under some assumptions, which, if proven incorrect, may impact the validity of the analysis. The risk scores for the 15-year future scenario of commercial fishing, mining, commercial shipping, tourism, and hydrocarbon activities were

all influenced by the assumption that regulations would be more restrictive by this time frame. The stricter regulations could come from the Government of Nunavut, as they continue towards devolution and the implementation of Inuit values into legislation, such as has been suggested in the burgeoning tourism industry (GoN, n.d.[d]). It may also come from the federal government as they re-strengthen some of the environmental protection legislation that was modified during the Stephen Harper administration (e.g. modifications to the *Fisheries Act* and *Environmental Protection Act*) or increase regulations pertaining to harmful fishing practices such as discards-at-sea and destructive techniques (following recommendations from international bodies [FAO, 2016]).

Recommendations

A major first step in Canadian Arctic marine protection efforts will be the official implementation of the Tallurutiup Imanga NMCA. All involved parties should endeavour to work collaboratively and efficiently to finalize designation and create a robust protection measure that has comprehensive support. The size and scope of this protected area is unprecedented in the Arctic (and Canada-wide) and will provide many lessons-learned. Indeed, some Inuit Organizations are waiting to see how the Tallurutiup Imanga IIBA pans out before they begin any new processes towards marine protection (pers. comm., Tracey Loewen, June 22/2018). Additionally, this MPA will make a significant contribution towards the national commitment to Aichi Target 11.

Beyond the Tallurutiup Imanga NMCA, considering the small footprint of current industrial activity in the ECA, and the results of this research that demonstrate a likely increase in all analyzed industrial activities, the implementation of new MPAs in the region should begin as soon as possible. There is an opportunity to provide protection against potentially harmful activities before the footprint of their operations in the region grows. The lack of established industries may provide a less contentious process than a scenario where actors have been operating in the area for a long period of time. Given that the Clyde River location demonstrated the largest increase in cumulative risk score over time, the opportunity to link the marine environment with terrestrial protection (in the form of the proposed Agguttinni Territorial Park [NPC, 2016]), the ability to pre-empt commercial exploration of the natural oil seep nearby, and the presence of a rare Arctic chemolithothallic community (Schimnowski et al., 2018), the exploration of MPA designation in that area should be considered.

In accordance with recommendations from the National Advisory Panel on Marine Protected Area Standards (Bujold & Simon, 2018), A New Shared Arctic Leadership Model (Simon, 2017), and the Indigenous Circle of Experts (ICE, 2018), policies need to be developed to formally provide for the creation of IPAs in Canada. The ability to create these protected spaces would advance multiple objectives simultaneously: reconciliation and support of Indigenous rights; advancement of marine protection targets; and, devolution of federal power to Inuit, by providing a means of creating an MPA outside federal jurisdiction. The principles of sustainable use and respect for the natural environment are present in the Qikiqtani region of Nunavut thus IPAs enacted in collaboration with the QIA would accomplish the same ecological goals as a federally-enacted MPA. They may be more strongly supported by those that use the

space and may provide the added benefit of sharing the human resources and financial commitments that are required of new protection measures beyond only federal government departments.

When it is appropriate to enact a federally- or co-managed MPA (in lieu of an IPA) in the Arctic, they should be upheld to a standard that will ensure the conservation objectives are protected effectively. Thus, the federal government should clarify and enact minimum standards regarding industrial activity in MPAs, as recently suggested by numerous National Advisory Panel intervenors and the final panel report (Bujold & Simon, 2018). Environmentally-damaging industrial activities such as hydrocarbon operations, industrial-scale fishing, mining, and commercial shipping are incompatible with the objectives and principles pursued by Aichi Target 11 and should be prohibited, as is recommended by the IUCN MPA guidelines. Minimum MPA standards provide multiple beneficial aspects: they would expedite the MPA designation process by reducing the amount of effort needed on a case-by-case basis to provide a rationale for excluding harmful activities; reduce uncertainty for industry in what an MPA would mean for them; and, ensure that those activities that may cause the most harm to conservation objectives are prohibited in any MPA.

Along with providing regulatory clarity for harmful activities, improving enforcement capacity would increase the effectiveness of MPAs (Edgar et al., 2014). Although certain threats are prohibited via an MPA designation or other policies, they may be still be occurring due to non-compliance. Enforcement capacity should be improved by providing local peoples the opportunity to become formal guardians. It can also be accomplished informally by fostering a shared vision with local users of the space, who are more likely to take ownership and respect the regulations if involved in the implementation process in a meaningful way (Armitage et al., 2007; Chua et al., 2006). Effective enforcement must involve both education of regulations as well as meaningful penalties for those that disregard them.

Lastly, other protection measures should be used in conjunction and integrated with MPAs via bioregional networks to provide flexibility towards environmental protection. IPAs provide one avenue, as do harvesting restrictions outlined by the NWMB, phasing out harmful fishing gears and practices, and broad federal or territorial policies regarding climate change mitigation. Although MPAs are an important tool in the effort to protect ecosystems and cultural dimensions, and national and international commitments should be upheld and even expanded, they are not the only tool available in the effort to reduce anthropogenic impacts on the environment.

Conclusion

The marine environment of the eastern Canadian Arctic contains many ecological, cultural, and social dimensions, such as polynyas, endemic organisms, and Inuit cultural aspects that are unique to the ECA, yet vulnerable to environmentally-damaging industrial activities. One available tool for protection of these components are MPAs; however, their current extent in the Arctic is not sufficient to offer effective protection over the long-term. This research quantified the risk from industrial activities (i.e. mining, tourism, commercial fishing, hydrocarbon activities, and commercial shipping), climate change, and improper mechanisms of

Inuit participation over two timeframes (i.e. current and 15-year future) across three assessment locations in the ECA (i.e. Clyde River, Eclipse Sound, and Cumberland Sound). Six of the threats' risk scores increased in the future, with climate change consistently posing the greatest risk. Recommendations from this research included marine protection for the Clyde River area, taking advantage of the current lack of large-scale industrial activities to enact protection measures pre-emptively, crafting appropriate legislation for the creation of IPAs, and continuing to collaborate with Inuit on any protection measure in the spirit of reconciliation and towards effective MPAs.

References

- Amuno, S., Niyogi, M., Amuno, M. and Attitaaq, J. (2016). Heavy metal bioaccumulation and histopathological alterations in wild Arctic hares (*Lepus arcticus*) inhabiting a former lead-zinc mine in the Canadian high Arctic: A preliminary study. *Science of the Total Environment*, 556, 252-263.
- Aporta, C. (2002). Life on the ice: understanding the codes of a changing environment. *Polar Record*, 38, 341-354.
- Armitage, D., Berkes, F. and Doubleday, N. (2007). Adaptive co-management: Collaboration, learning, and multi-level governance. University of British Columbia Press, Vancouver, British Columbia.
- Auditor General of Canada. (2013). Report of the Auditor General of Canada to the Legislative Assembly of Nunavut – 2013: Education in Nunavut. Office of the Auditor General of Canada. Retrieved from: http://www.oag-bvg.gc.ca/internet/English/nun_201311_e_38772.html
- Bailleul, F., Lesage, V., Power, M., Doidge, D. and Hammill, M. (2012). Migration phenology of beluga whales in a changing Arctic. *Climate Research*, 53, 169-178.
- Barnes, P. (2015). Industry perspectives on offshore oil and gas development and R&D in Canada's Arctic. Canadian Association of Petroleum Producers. Retrieved from: http://www.maritimearcticsecurity.ca/documents/10182/14060/P24_Paul+Barnes_CAP_P.pdf/f26f9019-80c8-4f66-96e1-fc172b4384a1
- Bartlett, L. (2018). MPAs: Are Canada's oceans really protected? Dalhousie University, Sustainability News. Accessed at: <https://blogs.dal.ca/sustainabilitynews/2018/04/10/mpas-are-canadas-oceans-really-protected/>
- Becker, P. (2000). Concentrations of chlorinated hydrocarbons and heavy metals in Alaska Arctic marine mammals. *Marine Pollution Bulletin*, 40(10), 819-829.
- Beyer, J., Trannum, H., Bakke, T., Hodson, P. and Collier, T. (2016). Environmental effects of the Deepwater Horizon oil spill: A review. *Marine Pollution Bulletin*, 110, 28-51.
- Billé, R. (2008). Integrated coastal zone management: Four entrenched illusions. *Survey and Perspective Integrating Environment and Society*, 1, 75-86.
- Bird Studies Canada. (n.d.). Important Bird Areas Canada. Accessed at: <https://www.ibacanada.ca/mapviewer.jsp?lang=en>
- Blanken, H., Tremblay, L., Gaskin, S. and Slavin, A. (2017). Modelling the long-term evolution of worst-case Arctic oil spills. *Marine Pollution Bulletin*, 116, 315-331.
- Brown, T., Boertmann, D., Jacobsen, R. and Barrette, C. (2018a). General description of the BBDS region. In: Adaptation actions for a changing Arctic: Perspectives from the Baffin Bay/Davis Strait region. pp. 7-36. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.
- Brown, T., Macdonald, R., Muir, D. and Letcher, R. (2018b). The distribution and trends of persistent organic pollutants and mercury in marine mammals from Canada's eastern Arctic. *Science of the Total Environment*, 618, 500-517.

- Buchan, A. (2018). Growing the Nunavut mining industry. Presentation at the 2018 Northern Lights Conference. Retrieved from: http://www.miningnorth.com/_rsc/site-content/postings/NorthernLights%20Final.pdf
- Bujold, R. and Simon, M. (2018). Final report of the National Advisory Panel on marine protected area standards. DFO, Ottawa, Ontario.
- Canadian Geographic. (n.d.). Canada's polynyas. Accessed at: <http://maps.canadiangeographic.ca/canadas-polynyas/>
- Carter, N., Dawson, J., Joyce, J., Ogilvie, A. and Weber, M. (2018). Arctic corridors and Northern voices: Governing marine transportation in the Canadian Arctic – Pond Inlet, Nunavut. Department of Geography, Environment and Geomatics, University of Ottawa.
- Castonguay, J. (n.d.). International shipping: Globalization in crisis. Vision Project Inc. Retrieved from: http://www.visionproject.org/images/img_magazine/pdfs/international_shipping.pdf
- CBC News. (2018a). DFO, Canadian Coast Guard create new Arctic region. Accessed at: <https://www.cbc.ca/news/canada/north/dfo-coast-guard-arctic-region-1.4876369>
- CBC News. (2018b). De Beers Canada plans to acquire Peregrine Diamonds, take over Nunavut diamond project. Accessed at: <https://www.cbc.ca/news/canada/north/de-beers-buying-peregrine-chidliak-1.4753277>
- CBC News. (2016). Trudeau announces review of Arctic strategy, joint drilling ban with U.S. CBC News. Accessed at: <https://www.cbc.ca/news/politics/trudeau-obama-arctic-1.3905933>
- CBC News. (2015). Ottawa to pay Nunavut Inuit \$255 million in settlement. CBC News. Accessed at: <https://www.cbc.ca/news/canada/north/ottawa-to-pay-nunavut-inuit-255m-in-settlement-1.3057973>
- Chan, F., Bailey, S., Wiley, C. and MacIsaac, H. (2013). Relative risk assessment for ballast-mediated invasions at Canadian Arctic ports. *Biological Invasions*, 15, 295-308.
- Cherry, S., Derocher, A., Thiemann, G. and Lunn, N. (2013). Migration phenology and seasonal fidelity of an Arctic marine predator in relation to sea ice dynamics. *Journal of Animal Ecology*, 82, 912-921.
- Chua, T., Bonga, D. and Bermas-Atrigenio, N. (2006). Dynamics of integrated coastal management: PEMSEA's experience. *Coastal Management*, 34(3), 303-322.
- Commissioner of Nunavut. (2016). An act to amend the travel and tourism act. Government of Nunavut. Retrieved from: <https://www.nunavutlegislation.ca/en/download/file/fid/11178>
- Conservation Council of New Brunswick. (2018). Tools for marine protection in Canada. Fredericton, New Brunswick, Canada.
- Daoust, T., Haider, W. and Jessen, S. (2010). Institutional arrangements governing marine conservation planning in the Canadian Arctic: The case of Nunavut, Canada. *Environments Journal Volume*, 27(3), 73-93.
- Dawson, J., Copland, L., Mussells, O. and Carter, N. (2017). Shipping trends in Nunavut 1990-2015: A report prepared for the Nunavut general monitoring program. Ottawa, Canada and Iqaluit, Nunavut. Retrieved from: http://www.espg.ca/wp-content/uploads/2013/04/NGMP-Shipping-Report_2017-V1.pdf

- Department of Environment. (2016). Nunavut fisheries strategy 2016-2020. Government of Nunavut. Retrieved from: [http://www.assembly.nu.ca/sites/default/files/TD-277-4\(3\)-EN-Department-of-Environment's-Nunavut-Fisheries-Strategy,-2016-2020.pdf](http://www.assembly.nu.ca/sites/default/files/TD-277-4(3)-EN-Department-of-Environment's-Nunavut-Fisheries-Strategy,-2016-2020.pdf)
- Devine, B. M., Wheeland, L. J. and Fisher, J. A. D. (2018). First estimates of Greenland shark (*Somniosus microcephalus*) local abundances in Arctic waters. *Scientific Reports*, 8(1), 1-11. <https://doi.org/10.1038/s41598-017-19115-x>
- DFO. (2018a). Anguniaqvia Niqiqyuam marine protected area (MPA). Accessed at: <http://www.dfo-mpo.gc.ca/oceans/mpa-zpm/anguniaqvia-niqiqyuam/index-eng.html>
- DFO. (2018b). Confirmed right whale incidents in 2017. Accessed at: <http://dfo-mpo.gc.ca/species-especies/mammals-mammiferes/narightwhale-baleinenoirean/2017/index-eng.html>
- DFO. (2017a). Map of bioregions. Accessed at: <http://www.dfo-mpo.gc.ca/oceans/maps-cartes/bioregions-eng.html>
- DFO. (2017b). Assessment of Northern shrimp, *Pandalus borealis*, and striped shrimp, *Pandalus montagui*, in the eastern and western assessment zones, February 2017. Canadian Science Advisory Secretariat Science Advisory Report 2017/010.
- DFO. (2015). Risk assessment of alternate ballast water exchange zones for vessel traffic to the ECA. Canadian Science Advisory Secretariat Science Advisory Report 2015/019. Retrieved from: <http://waves-vagues.dfo-mpo.gc.ca/Library/364601.pdf>
- DFO. (2011). Technical review of Baffinland Mary River project draft environmental impact statement (EIS). Canadian Science Advisory Secretariat Science Advisory Report. 2011/065.
- DFO. (2010a). A review of the biological characteristics and ecological functions served by corals, sponges, and hydrothermal vents, in the context of applying an ecosystem approach to fisheries. Canadian Science Advisory Secretariat Science Advisory Report 2010/048.
- DFO. (2010b). Stock assessment of Arctic char, *Salvelinus alpinus*, from the Isuituq river system, Nunavut. Canadian Science Advisory Secretariat Science Advisory Report 2010/060.
- DFO. (2008). Cumberland Sound Greenland Halibut (turbot) inshore fishery. Canadian Science Advisory Secretariat Science Advisory Report 2008/040. Retrieved from: http://publications.gc.ca/collections/collection_2011/mpo-dfo/Fs70-6-2008-040-eng.pdf
- DFO. (2005). Stock assessment report on Kipisa Arctic char. Canadian Science Advisory Secretariat Science Advisory Report 2005/028.
- DFO and FJMC. (2013). Tarium Niryutait marine protected areas management plan. The Beaufort Sea Partnership. Retrieved from: http://www.beaufortseapartnership.ca/wp-content/uploads/2015/05/tnmpa-mgmt-plan_final.pdf
- Doe, K., Mroz, R., Tay, K., Burley, J., Teh, S. and Chen, S. (2017). Biological effects of gold mine tailings on the intertidal marine environment in Nova Scotia, Canada. *Marine Pollution Bulletin*, 114, 64-76.
- Drinkwater, K. (2005). The response of Atlantic cod (*Gadus morhua*) to future climate change. *ICES Journal of Marine Sciences*, 62, 1327-1337.

- Frizzell, S. (2017). Baffinland mine ramps up production, ships record amount, minor spills also increase. CBC News. Accessed at: <https://www.cbc.ca/news/canada/north/baffinland-shipping-spills-1.4361174>
- ECCC. (2016). 2020 biodiversity goals & targets for Canada. Retrieved from: http://publications.gc.ca/collections/collection_2016/eccc/CW66-524-2016-eng.pdf
- Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., ... Thomson, R. J. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature*, 506(7487), 216–220. <https://doi.org/10.1038/nature13022>
- Emergency Prevention Preparedness and Response. (2017). Circumpolar oil spill response viability analysis: Technical Report. Arctic Council Secretariat. Retrieved from: <https://oaarchive.arctic-council.org/handle/11374/1928>
- Finlay, K. J. and Davis, R. A. (1984). Reactions of beluga whales and narwhals to ship traffic and ice-breaking along ice edges in the eastern Canadian High Arctic: 1982-1984. An overview. Report by LGL Limited, King City, Ontario, for Canada Department of Indian Affairs and Northern Development, Ottawa. 42 p.
- FAO. (2016). The state of world fisheries and aquaculture 2016: Contributing to food security and nutrition for all. Rome. Retrieved from: <http://www.fao.org/3/a-i5555e.pdf>
- Fisheries and Sealing Division. (2014). Nunavut Coastal Resources Inventory – Clyde River. Nunavut Department of Environment. Retrieved from: https://gov.nu.ca/sites/default/files/ncri_clyde_river_en.pdf
- Fisheries and Sealing Division. (2013). Nunavut Coastal Resource Inventory – Pangnirtung. Nunavut Department of Environment. Retrieved from: https://gov.nu.ca/sites/default/files/ncri_pangnirtung_en_0.pdf
- Fontaine, T. (2016). Canada officially adopts UN declaration on the rights of Indigenous Peoples. CBC News. Accessed at: <http://www.cbc.ca/news/indigenous/canada-adopting-implementing-un-rights-declaration-1.3575272>
- Ford, J. D., Bell, T. and Couture, N. (2016). Perspectives on Canada’s north coast region; *in*: Canada’s marine coasts in a changing climate, (eds.) Lemmen, D. S., Warren, F. J., James, T. S., and Mercer-Clarke, C. S. L. Mercer Clarke, Government of Canada, Ottawa.
- Fuller, S., Picco, C., Ford, J., Tsao, C., Morgan, L., Hangaard, D. and Chuenpagdee, R. (2008). How we fish matters: Addressing the ecological impacts of Canadian fishing gear. Ecology Action Center. Retrieved from: https://mcbi.marine-conservation.org/publications/pub_pdfs/HowWeFish.pdf
- Gell, F. and Roberts, C. (2003). Benefits beyond boundaries: the fishery effects of marine reserves. *Trends in Ecology & Evolution*, 18(9), 448-455.
- Gies, E. (2018). Is Canada taking shortcuts to hit its marine protection targets? Hakai Magazine. Accessed at: <https://www.hakaimagazine.com/news/is-canada-taking-shortcuts-to-hit-its-marine-protection-targets/>
- Government of Nunavut. (n.d.[a]). Consensus government. Accessed at: <https://www.gov.nu.ca/consensus-government>
- Government of Nunavut. (n.d.[b]). Devolution. Accessed at: <https://www.gov.nu.ca/eia/information/devolution>
- Government of Nunavut. (n.d.[c]). Parnautit: A foundation for the future mineral exploration and mining strategy. Department of Economic Development and Transportation.

- Retrieved from:
https://gov.nu.ca/sites/default/files/Parnautit_Mineral_Exploration_and_Mining_Strategy.pdf
- Government of Nunavut. (n.d.[d]). Tunngasaiji: A tourism strategy for Nunavut. Retrieved from:
<https://gov.nu.ca/sites/default/files/tourism-strategy-en-2-aug21-web.pdf>
- Government of Nunavut. (2017). Budget 2017-2018 fiscal and economic indicators. Retrieved from:
https://www.gov.nu.ca/sites/default/files/files/Finance/Taxation/2017-18_fei_-_english.pdf
- Government of Nunavut. (2012). Building our infrastructure. Retrieved from:
[https://www.gov.nu.ca/sites/default/files/files/FINAL%20GN%20Info%20Package%20-%20Building%20Our%20Infrastructure\(1\).pdf](https://www.gov.nu.ca/sites/default/files/files/FINAL%20GN%20Info%20Package%20-%20Building%20Our%20Infrastructure(1).pdf)
- Halliday, W., Insley, S., Hilliard, R., de Jong, T. and Pine, M. (2017). Potential impacts of shipping noise on marine mammals in the western Canadian Arctic. *Marine Pollution Bulletin*, 123, 73-82.
- Indigenous Circle of Experts. (2018). We rise together: Achieving pathway to Canada Target 1 through the creation of Indigenous Protected and Conserved Areas in the spirit and practice of reconciliation. Retrieved from:
https://static1.squarespace.com/static/57e007452e69cf9a7af0a033/t/5ab94aca6d2a7338ecb1d05e/1522092766605/PA234-ICE_Report_2018_Mar_22_web.pdf
- Indian and Northern Affairs Canada and Government of the Northwest Territories. (2010). Giant Mine Remediation Project Developer's Assessment Report. EA 0809-011. Retrieved from:
http://reviewboard.ca/upload/project_document/EA0809-001_Giant_DAR_1288220431.PDF
- Insignia Marketing Research Inc. (2015). Nunavut visitor exit survey 2015 final report. Retrieved from:
https://www.nunavuttourism.com/wp-content/uploads/2018/01/2015_nunavut_visitor_exit_report_english_-_final_0.pdf
- Inuit Tapiriit Kanatami. (2018). Maps of Inuit Nunangat (Inuit regions of Canada). Accessed at:
<https://www.itk.ca/maps-of-inuit-nunangat/>
- IPCC. (2014). Climate change 2014: Synthesis report. Contribution of working groups, I, II, and III to the fifth assessment report of the Intergovernmental Panel on Climate Change [Core writing team, R. K. Pachauri and L. A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- IUCN. (2018). Marine protected areas. Accessed at:
<https://www.iucn.org/theme/marine-and-polar/our-work/marine-protected-areas>
- Jansen, J., Boveng, P., Dahle, S. and Bengston, J. (2010). Reaction of harbor seals to cruise ships. *Journal of Wildlife Management*, 74(6), 1186-1194.
- Jorgensen, O. A. and Treble, M. A. (2016). Assessment of the Greenland halibut stock component in NAFO Subarea 0 + division 1A offshore + divisions 1B-1F. Northwest Atlantic Fisheries Organization. NAFO Science Council Research Document 16/029.
- Karydis, M. (2009). Eutrophication of coastal waters based on indicators: A literature review. *Global NEST Journal*, 11(4), 373-390.
- Kenchington, E., Link, H., Roy, V., Archambault, P., Siferd, T., Treble, M. and Wareham, V. (2011). Identification of mega- and macrobenthic ecologically and biologically significant areas (EBSAs) in the Hudson Bay Complex, the Western and ECA. DFO Canadian Science

- Advisory Secretariat Research Document 2011/071. vi + 52 p. Retrieved from: <http://waves-vagues.dfo-mpo.gc.ca/Library/344614.pdf>
- Kroodsmas, D., Mayorga, J., Hochberg, T., Miller, T., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T., Block, B., Woods, P., Sullivan, B., Costello, C. and Worm, B. (2018). Tracking the global footprint of fisheries. *Science*, 359, 904-908.
- Lackenbauer, W. and Lajeunesse, A. (2014). On uncertain ice: The future of Arctic shipping and the Northwest Passage. Canadian Defense and Foreign Affairs Institute. Retrieved from: <https://journalhosting.ucalgary.ca/index.php/sppp/article/view/42493/30384>
- Lameris, T., van der Jeugd, H., Eichhorn, G., Dotker, A., Bouten, W., Boom, M., Litvin, K., Ens, B. and Nolet, B. (2018). Arctic geese tune migration to a warming climate but still suffer from a phenological mismatch. *Current Biology*, 28, 2467-2473.
- Lancaster Sound NMCA Feasibility Assessment Steering Committee. (2017). A national marine conservation area proposal for Lancaster Sound. Government of Nunavut, Qikiqtani Inuit Association, Parks Canada. Retrieved from: <https://gia.ca/wp-content/uploads/2017/08/NMCA-Propossal-for-Lancaster-Sound-ENG-April-4.pdf>
- Landra, K. (2018). Oil & gas activity in the Canadian Arctic and Eastern Canada activity. National Energy Board. Retrieved from: <http://www.ptil.no/getfile.php/1348159/PDF/Seminar%202018/Arctic%20Safety%202018/Keith%20Landra%2C%20National%20Energy%20Board%2C%20Canada.pdf>
- Lemelin, H., Dawson, J., Stewart, E., Maher, P. and Lueck, M. (2010). Last-chance tourism: The boom, doom, and gloom of visiting vanishing destinations. *Current Issues in Tourism*, 13(5), 477-493.
- Lemly, A. D. (1994). Mining in northern Canada: Expanding the industry while protecting Arctic fishes – A review. *Ecotoxicology and Environmental Safety*, 29, 229-242.
- Macrotrends LLC. (2018). Crude oil prices – 70 year historical chart. Accessed at: <https://www.macrotrends.net/1369/crude-oil-price-history-chart>
- Maher, P. (2012). Expedition cruise visits to protected areas in the Canadian Arctic: Issues of sustainability and change for an emerging market. *Tourism*, 60(1), 55-70.
- Marine Environmental Protection Committee. (2014). International code for ships operating in polar waters (Polar Code). International Maritime Organization, resolution MSC.385(94).
- Mayer, P. (2007). Mayer report on Nunavut devolution. Fasken Martineau DuMoulin LLP. Retrieved from: http://publications.gc.ca/collections/collection_2008/ainc-inac/R2-478-2007E.pdf
- McCauley, R., Day, R., Swadling, K., Fitzgibbon, Q., Watson, R. and Semmens, J. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology and Evolution*, 1(7), 0195.
- McKinnon, D., Lemieux, C., Beazley, K., Woodley, S., Helie, R., Perron, J., Elliot, J., Haas, C., Langlois, J., Lazaruk, H., Beechey, T. and Gray, P. (2015). Canada and Aichi biodiversity target 11: understanding ‘other effective area-based conservation measures’ in the context of the broader target. *Biodiversity Conservation*, 24, 3559-3581.
- McKinnon, L., Picotin, M., Bolduc, E., Juillet, C. and Bety, J. (2012). Timing of breeding, peak food availability, and effects of mismatch on chick growth in birds nesting in the High Arctic. *Canadian Journal of Zoology*, 90, 961-971.

- Mifflin, M. (2008). Canada's Arctic sovereignty and Nunavut's place in the federation. Policy Options. Accessed at: <http://policyoptions.irpp.org/magazines/quebec-1608-2008/canadas-arctic-sovereignty-and-nunavuts-place-in-the-federation/>
- Minister of Justice. (1993). Agreement between the Inuit of the Nunavut settlement area and her majesty the queen in right of Canada. Retrieved from: https://www.gov.nu.ca/sites/default/files/Nunavut_Land_Claims_Agreement.pdf
- Minister of Justice. (1985). *Arctic Waters Pollution Prevention Act*. Government of Canada. Retrieved from: <http://laws-lois.justice.gc.ca/eng/acts/A-12/page-2.html#docCont>
- Murray, C. C., Mach, M. E. and O, M. (2016). Pilot ecosystem risk assessment to assess cumulative risk to species in the Pacific North Coast Integrated Management Area (PNCIMA). Canadian Science Advisory Secretariat Research Document 2016/049.
- National Snow and Ice Data Center. (2018). What is the Arctic? Accessed at: <https://nsidc.org/cryosphere/arctic-meteorology/arctic.html>
- Natural Resources Canada. (2017). Energy sources and distribution. Accessed at: <http://www.nrcan.gc.ca/energy/energy-sources-distribution>
- Nevalainen, M., Helle, I. and Vanhatalo, J. (2018). Estimating the acute impacts of Arctic marine oil spills using expert elicitation. *Marine Pollution Bulletin*, 131, 782-792.
- Nunavut Bureau of Statistics. (2018). Nunavut bureau of statistics. Accessed at: <http://www.stats.gov.nu.ca/en/home.aspx>
- Nunavut Economic Forum. (2017). Nunavut Economic Strategy Outlook. Retrieved from: <https://nunavuttradeshaw.ca/wp-content/uploads/2017/09/Forth-NEF.pdf>
- Nunavut Planning Commission. (2016). Nunavut land use plan 2016 draft. Retrieved from: http://www.nunavut.ca/files/2016DNLUP/2016_Draft_Nunavut_Land_Use_Plan.pdf
- Nunavut Planning Commission. (2012a). Summary of community meetings on the Draft Nunavut Land Use Plan Pangnirtung November 26-27, 2012. Retrieved from: http://www.nunavut.ca/files/reports/2013-08-28_Pangnirtung_Report.pdf
- Nunavut Planning Commission. (2012b). Summary of community meetings on the Draft Nunavut Land Use Plan Clyde River November 7-8, 2012. Retrieved from: http://www.nunavut.ca/files/reports/2013-08-15_Clyde_River_Report.pdf
- Nunavut Planning Commission. (2012c). Summary of community meetings on the Draft Nunavut Land Use Plan Pond Inlet November 5-6, 2012. Retrieved from: http://www.nunavut.ca/files/reports/2013-08-15_Pond_Inlet_Report.pdf
- Nunavut Tunngavik Inc. (n.d.). NTI organizational chart. Accessed at: <http://www.tunngavik.com/about/nti-organizational-chartnti-timiup-havaktut-naunaitkutaat/>
- O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J. and Patton, S. (2014). An ecological risk assessment framework (ERAF) for ecosystem-based oceans management in the Pacific Region. Canadian Science Advisory Secretariat Research Document 2014/072.
- Oceans North Conservation Society, WWF Canada and Ducks Unlimited Canada. (2018). *Canada's Arctic Marine Atlas*. Ottawa, Ontario. Oceans North Conservation Society.
- Pelot, R. (2017). Marine management skills development – Risk assessment module. Marine Affairs Program, Dalhousie University.
- Peterson, C. (2001). The "Exxon Valdez" oil spill in Alaska: Acute, indirect, and chronic effects on the ecosystem. *Advances in Marine Biology*, 39, 1-103.

- Peterson, C., Rice, S., Short, J., Esler, D., Bodkin, J., Ballachey, B. and Irons, D. (2003). Long-term ecosystem response to the Exxon Valdez oil spill. *Science*, 302, 2082-2086.
- Pikialasorsuaq Commission. (2017). People of the ice bridge: The future of the Pikialasorsuaq. Retrieved from: <http://pikialasorsuaq.org/en/Resources/Reports>
- Pimentel, D., Zuniga, R. and Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*, 52, 273-288.
- Prime Minister's Office. (2017). Inuit Nunangat declaration on Inuit-Crown partnership. Accessed at: <https://pm.gc.ca/eng/news/2017/02/09/inuit-nunangat-declaration-inuit-crown-partnership>
- Poland, J., Riddle, M. and Zeeb, B. (2003). Contaminants in the Arctic and the Antarctic: a comparison of sources, impacts, and remediation options. *Polar Record*, 39, 369-383.
- Pomeroy, R. (2007). Conditions for successful fisheries and coastal resources co-management: Lessons learned in Asia, Africa, and the wider Caribbean. In: Adaptive co-management: Collaboration, learning, and multi-level governance. Armitage, D., Berkes, F., and Doubleday, Nancy (eds.).
- Preston, D., Henderson, J. and Johnson, P. (2012). Community ecology of invasions: direct and indirect effects of multiple invasive species on aquatic communities. *Ecology*, 93(6), 1254-1261.
- Putland, R., Merchant, N., Farcas, A. and Radford, C. (2018). Vessel noise cut down communication space or vocalizing fish and marine mammals. *Global Change Biology*, 24, 1708-1721.
- Qikiqtani Inuit Association. (2018). A new approach to economic development in Nunavut. Retrieved from: <https://qia.ca/wp-content/uploads/2018/02/Asukuluk-QIA-Economic-Development-ENG-2018-02-27-v3-1.pdf>
- Reichert, J., Wathen, T., Highleyman, S., Abou-Abssi, E., Debicki, C., Dewar, M., Joynt, A., Knopp, J., Porta, L., Stewart, G., Taylor, T., Thompson, L. and Westdal, J. (2016). The integrated Arctic corridors framework: Planning for responsible shipping in Canada's Arctic waters. The Pew Charitable Trusts and Oceans North Canada. Retrieved from: <https://www.pewtrusts.org/~media/assets/2016/04/the-integrated-arctic-corridors-framework.pdf>
- Rife, A. N., Erisman, B., Sanchez, A. and Aburto-Oropeza, O. (2013). When good intentions are not enough... Networks of 'paper park' marine protected areas. *Conservation Letters*, 6(3), 200-212.
- Rollo, H. and Jamieson, H. (2006). Interaction of diamond mine waste and surface water in the Canadian Arctic. *Applied Geochemistry*, 21, 1522-1538.
- Schimnowski, O., Paulic, J. E. and Martin, K. A. (2018). Information in support of the evaluation of ecologically and biologically significant areas (EBSAs) in the Eastern Arctic biogeographic region. Canadian Science Advisory Secretariat, DFO. Retrieved from: <http://waves-vagues.dfo-mpo.gc.ca/Library/40656123.pdf>
- Setzer, M., Norrgard, J. and Jonsson, T. (2011). An invasive crayfish affects egg survival and the potential recovery of an endangered population of Arctic charr. *Freshwater Biology*, 56, 2543-2553.

- Sevunts, L. (2017). Inuit traditional knowledge to guide marine management off Labrador coast. Accessed at: <http://www.rcinet.ca/eye-on-the-arctic/2017/09/29/inuit-traditional-knowledge-to-guide-marine-management-plan-off-labrador-coast/>
- Simon, M. (2017). A new shared Arctic leadership model. Retrieved from: http://publications.gc.ca/collections/collection_2017/aanc-inac/R74-38-2017-eng.pdf
- Smultea, M., Brueggeman, J., Robertson, F., Fertl, D., Bacon, C., Rowlett, R. and Green, G. (2016). Polar bear (*Ursus maritimus*) behavior near icebreaker operations in the Chukchi Sea, 1991. *Arctic*, 69(2), 177-184.
- Stirling, I. (1990). The biological importance of polynyas in the Canadian Arctic. *Arctic*, 33(2), 303-315.
- Tasker, P. (2017). Supreme court quashes seismic testing in Nunavut, but gives green light to Enbridge pipeline. CBC News. Accessed at: <https://www.cbc.ca/news/politics/supreme-court-ruling-indigenous-rights-1.4221698>
- Tiselius, P. and Magnusson, K. (2017). Toxicity of treated bilge water: The need for revised regulatory control. *Marine Pollution Bulletin*, 114(2), 860-866.
- Tremblay, J. and Sejr, M. (2018). Marine ecosystems. In: Adaptation actions for a changing Arctic: Perspectives from the Baffin Bay/Davis Strait region. pp. 139-152. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.
- Tseng, L., Kumar, R., Dahms, H.-U., Chen, C.-T., Souissi, S., Chen, Q.-C. and Hwang, J.-S. (2008). Copepod community structure over a marine outfall area in the north-eastern South China Sea. *Journal of the Marine Biological Association of the United Kingdom*, 88(5), 955-966.
- United States Environmental Protection Agency. (2003). Framework for cumulative risk assessment. Risk Assessment Forum, Washington, DC, USA. Accessed at: https://www.epa.gov/sites/production/files/2014-11/documents/frmwrk_cum_risk_assmnt.pdf
- van der Hoop, J. Vanderlaan, A., and Taggart, C. (2012). Absolute probability estimates of lethal vessel strikes to North Atlantic right whales in Roseway Basin, Scotian Shelf. *Ecological Applications*, 22(7), 2021-2033.
- Vanderlaan, J., and Taggart, C. (2007). Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science*, 23(1) 144-156.
- Vard Marine Inc. (2018). Canadian Arctic greywater report: Estimates, forecasts, and treatment technologies. Report #360-000. Retrieved from: http://d2akrl9rvxl3z3.cloudfront.net/downloads/ward_360_000_01_dfr_rev2_29_05_2018.pdf
- Vergeynst, L., Wegeberg, S., Aamand, J., Lassen, P., Gosewinkel, U., Fritt-Rasmussen, Gustavson, K. and Mosbech, A. (2018). Biodegradation of marine oil spills in the Arctic with a Greenland perspective. *Science of the Total Environment*, 626, 1243-1258.
- Walker, T. and Grant, J. (2015). Metal(loids)s in sediment, lobster, and mussel tissues near historical gold mine sites. *Marine Pollution Bulletin*, 101, 404-408.
- Weilgart, L. (2017). Seismic testing for oil extremely harmful to marine life. The Star. Retrieved from: <https://www.thestar.com/opinion/commentary/2017/08/14/seismic-testing-for-oil-extremely-harmful-to-marine-life.html>

Wilson, S., Trukhanova, I., Dmitrieva, L., Dolgova, E., Crawford, I., Baimukanov, M., Baimukanov, T., Ismagambetov, B., Pazylbekov, M., Jussi, M. and Goodman, S. (2017). Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. *Biological Conservation*, 214, 213-222.

WWF Canada. (n.d.). The last ice area. Accessed at: <http://www.wwf.ca/conservation/arctic/lia/>

Appendices

Appendix 1. Comparative overview of marine protection tools in Canada

This table provides an overview of the legislative tools for MPA creation in Canada that count towards international commitments under Aichi target 11 of the UNCBD. Adapted from 'Tools for marine protection in Canada' by the Conservation Council of New Brunswick (2018).

	<i>Oceans Act</i> MPA	NMCA	Marine Refuge (OECM)	National Wildlife Area	Migratory Bird Sanctuary
Primary objective	Conservation and protection of species, habitats, and resources	Conservation and protection, as well as sustainable use, education, and recreation	Conservation or stock management	Preserving habitats for migratory birds and other wildlife species	Providing safe refuge for nesting migratory birds
Enabling laws	<i>Oceans Act</i> , SC 1996 and Regulations	<i>Canada National Marine Conservation Areas Act</i> , SC 2002	<i>Fisheries Act</i> , RSC 1985	<i>Canada Wildlife Act</i> , RSC 1985 and Regulations	<i>Migratory Birds Convention Act</i> , SC 1994 and Regulations
Authority	DFO	Parks Canada	DFO	ECCC	ECCC
Existing sites	11 existing MPAs and 8 Areas of Interest for future designation	3 existing NMCAs, 1 in designation process, and 3 proposed	34 existing marine refuges	54 National Wildlife Areas, some with marine components, and 1 Protected Marine Area	92 sites, some with marine components
ECA sites	None	1 incomplete	3 existing	4 existing	2 existing
Ongoing reviews of laws and policies	Bill C-55 amendments to <i>Oceans Act</i>	None	Bill C-68 amendments to <i>Fisheries Act</i>	None	None
National advisory panel on Marine Protected Area standards					

Appendix 2. Scoring rubric for C_{exposure}

This rubric was used in the calculation of C_{exposure} , a term in the calculation of the consequence score, in the relative risk assessment of threats to the ecological, cultural, and social dimensions of the ECA. (Adapted from O et al., 2014).

<i>Description</i>			<i>Raw Score</i>	<i>Binned Score</i>
<i>Intensity</i>	<i>Temporal Scale</i>	<i>Spatial Scale</i>		
1 (Low)	1 (Rare)	1 (Few restricted locations)	1	1
1 (Low)	1 (Rare)	2 (Localized)	2	1
1 (Low)	2 (Relatively often)	1 (Few restricted locations)	2	1
2 (Moderate)	1 (Rare)	1 (Few restricted locations)	2	1
1 (Low)	1 (Rare)	3 (Widespread)	3	1
1 (Low)	3 (Frequent)	1 (Few restricted locations)	3	1
3 (High)	1 (Rare)	1 (Few restricted locations)	3	1
1 (Low)	2 (Relatively often)	2 (Localized)	4	2
1 (Low)	4 (Continuous)	1 (Few restricted locations)	4	2
2 (Moderate)	1 (Rare)	2 (Localized)	4	2
2 (Moderate)	2 (Relatively often)	1 (Few restricted locations)	4	2
1 (Low)	2 (Relatively often)	3 (Widespread)	6	2
1 (Low)	3 (Frequent)	2 (Localized)	6	2
2 (Moderate)	1 (Rare)	3 (Widespread)	6	2
2 (Moderate)	3 (Frequent)	1 (Few restricted locations)	6	2
3 (High)	1 (Rare)	2 (Localized)	6	2
3 (High)	2 (Relatively often)	1 (Few restricted locations)	6	2
1 (Low)	4 (Continuous)	2 (Localized)	8	3
2 (Moderate)	2 (Relatively often)	2 (Localized)	8	3
2 (Moderate)	4 (Continuous)	1 (Few restricted locations)	8	3
1 (Low)	3 (Frequent)	3 (Widespread)	9	3
3 (High)	1 (Rare)	3 (Widespread)	9	3
3 (High)	3 (Frequent)	1 (Few restricted locations)	9	3
1 (Low)	4 (Continuous)	3 (Widespread)	12	4
2 (Moderate)	2 (Relatively often)	3 (Widespread)	12	4
2 (Moderate)	3 (Frequent)	2 (Localized)	12	4
3 (High)	2 (Relatively often)	2 (Localized)	12	4
3 (High)	4 (Continuous)	1 (Few restricted locations)	12	4
2 (Moderate)	4 (Continuous)	2 (Localized)	16	4
2 (Moderate)	3 (Frequent)	3 (Widespread)	18	5
3 (High)	2 (Relatively often)	3 (Widespread)	18	5
3 (High)	3 (Frequent)	2 (Localized)	18	5
2 (Moderate)	4 (Continuous)	3 (Widespread)	24	5
3 (High)	4 (Continuous)	2 (Localized)	24	5
3 (High)	3 (Frequent)	3 (Widespread)	27	5
3 (High)	4 (Continuous)	3 (Widespread)	36	5

Appendix 3. Scoring rubric for $C_{consequence}$

This rubric was used in the calculation of $C_{consequence}$, a term used to determine the risk score in the relative risk assessment of threats to marine ecosystem health in the ECA.

$C_{exposure}$	C_{impact}	$C_{consequence} = C_{exposure} * C_{impact}$ (Raw Score)	Binned Consequence Category
1	1	1	Negligible
1	2	2	Negligible
2	1	2	Negligible
1	3	3	Low
3	1	3	Low
1	4	4	Low
2	2	4	Low
4	1	4	Low
1	5	5	Moderate
5	1	5	Moderate
2	3	6	Moderate
3	2	6	Moderate
2	4	8	Moderate
4	2	8	Moderate
3	3	9	Moderate
2	5	10	High
5	2	10	High
3	4	12	High
4	3	12	High
3	5	15	High
5	3	15	High
4	4	16	Very high
4	5	20	Very high
5	4	20	Very high
5	5	25	Very high