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CANADIAN ARCTIC MARINE TRANSPORTATION ISSUES, OPPORTUNITIES AND CHALLENGES

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FOREWORD

THE CANADIAN NORTHERN CORRIDOR RESEARCH PROGRAM PAPER SERIES

This paper is part of a special series in *The School of Public Policy Publications*, investigating a concept that would connect the nation's southern infrastructure to a new series of corridors across middle and northern Canada. This paper is an output of the Canadian Northern Corridor Research Program.

The Canadian Northern Corridor Research Program at The School of Public Policy, University of Calgary, is the leading platform for information and analysis on the feasibility, desirability, and acceptability of a connected series of infrastructure corridors throughout Canada. Endorsed by the Senate of Canada, this work responds to the Council of the Federation's July 2019 call for informed discussion of pan-Canadian economic corridors as a key input to strengthening growth across Canada and "a strong, sustainable and environmentally responsible economy." This Research Program will benefit all Canadians, providing recommendations to advance the infrastructure planning and development process in Canada.

This paper, "*Canadian Arctic Marine Transportation Issues, Opportunities and Challenges*", falls under theme Geography and Engineering of the program's eight research themes:

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Dr. Jennifer Winter
Program Director, Canadian Northern Corridor Research Program

CANADIAN ARCTIC MARINE TRANSPORTATION ISSUES, OPPORTUNITIES AND CHALLENGES

Frédéric Lasserre

KEY MESSAGES

Melting Sea Ice

Although ice will always be present in the Arctic in winter, global warming induces a steady decline of the extent of sea ice and a rapid decrease in the share of multi-year ice, giving way to younger, thinner sea ice and giving credence to modelled scenarios of ice-free summers during the 21st century. However, ice remains a hazard and an impediment to navigation. Thinner and more fragmented ice moves faster and in patterns that are difficult to predict. It also seems more prone to building compression ridges. In Baffin Bay, accelerated iceberg calving from Greenland is likely to increase the number of growlers, which pose a serious risk for navigation. From this emerges a nuanced picture of shipping conditions in the Canadian Arctic. There are opportunities for sustained expansion but risks remain high and warrant a robust regulatory framework.

Expanding Commercial Shipping

Shipping in the Canadian Arctic is mainly driven by fishing, mining activities and community resupply, while transit shipping remains marginal. Fishing, mostly carried out by vessels based in Newfoundland and still less developed than in Greenland, is gradually moving north to Baffin Bay. As extraction sites open, mining generates heavy traffic, in terms of both voyages and tonnage. Inland mining sites, faced with complex and costly land transportation due to melting permafrost, may further drive marine transportation. However, fluctuating world prices for commodities, not the extent of sea ice, are the main driver — or constraint — of mining activities. Community resupply is expanding as well, but strategies pursued by the four shipping companies involved differ. Coastal Shipping Ltd., Desgagnés and NEAS all expanded westwards and opted for larger, heavier vessels without expanding frequency of service.

Co-ordination of Activities in the Frame of Corridors

Designing corridors can act both as a regulatory tool and as a way to concentrate development assets to promote more effective transportation. Low impact shipping corridors are being designed within the Canadian Arctic archipelago as a tool to regulate ship movements to reduce navigation hazards, and concentrating navigational aids along these corridors is a way to improve safety and efficiency. Land infrastructure may be developed in co-ordination with shipping patterns and economic projects such as mining ventures. Here, too, the geographic concentration of community resupply and mining logistics may both sustain and further develop transportation activities that could support the profitability and viability of corridors in the Canadian Arctic.

Future Shipping Trends

Due to the constraints to shipping, destinational traffic is likely to remain dominant in the foreseeable future. Traffic generated by mining activities is likely to keep expanding, provided no severe collapse of world commodity prices occurs. Community resupply may also experience continued expansion, partly fuelled by mining ventures, provided operators can take advantage of improved port facilities in the Canadian archipelago. Mining projects and community resupply may both benefit from the development of northern corridors, but these would face the challenge of their profitability.

SUMMARY

Climate change is inducing a steady decline of the extent of sea ice and a rapid decrease in the share of multi-year ice, giving way to younger, thinner sea ice and giving credence to modelled scenarios of ice-free summers during the 21st century. However, ice remains a hazard and an impediment to navigation.

Traffic statistics show that the trend of receding sea ice in the Arctic summer enables shipping to expand. Between 2013 and 2019, the number of ships entering the Arctic increased by 25 per cent. The expanding traffic is largely destinational vessels coming to the Arctic to perform an economic activity — fishing, tourism, community resupply or natural resources extraction — and then going back southwards. Transits are a rare occurrence, although the Arctic route shortens the distance between the Atlantic and the Pacific.

Although a moratorium currently prevents the development of oil and gas extraction projects, and is likely to continue to do so in the foreseeable future, mineral extraction is gradually taking off. As mining sites open up, they generate increasingly heavy traffic, in terms of both voyages and tonnage. Inland mining sites, faced with complex and costly land transportation due to melting permafrost, may further drive marine transportation if mining companies opt for the construction of new ports, and railways or roads connecting them to the mining sites. However, fluctuating world prices for commodities, not the extent of sea ice, is the main driver — or constraint — of mining activities. The development of extractive activities in the Arctic may be technically feasible, but uncertain profitability of such ventures may be a limiting factor.

Shipping in the Canadian Arctic is thus mainly driven by fishing, mining activities and community resupply. Fishing, mostly carried out by vessels based in Newfoundland and still less developed than in Greenland, is gradually moving north to Baffin Bay. Community resupply and ore transportation are expanding, but strategies pursued by the four shipping companies involved differ. MTS took over from bankrupt NTCL in 2016 with a more limited service. Coastal Shipping Ltd., Desgagnés and NEAS all expanded westwards and opted for larger, heavier vessels without expanding frequency of service. The lack of port infrastructure in the Canadian Arctic hampers the development of commercial shipping, fishing, cruise tourism and extractive industries.

The four companies dedicated to community resupply are determined to take advantage of business opportunities in the Canadian Arctic, just as shipping companies involved in mining operations are responsible for a fast expansion of their traffic. In these conditions, northern corridors inland could possibly support the development of improved community resupply, as well as mining operations, provided they can service clusters of mines and communities.

The lack of port infrastructure in the Canadian Arctic hampers the development of commercial shipping, fishing, cruise tourism and extractive industries. Community resupply in the region relies on large vessel sealifts, which enable companies to service several communities with few voyages to secure economies of scale. Given the absence

of infrastructure in the communities, goods are unloaded on the beach using tugboats and barges carried by the vessel. In this respect, the Canadian Arctic differs strikingly from the Greenlandic, Norwegian or Russian Arctic, where communities benefit from deep-sea ports that greatly facilitate loading and unloading operations and prove conducive to the development of economic activities. In the Canadian Arctic, companies have adapted to these logistical constraints and may even benefit from the fact that they act as a barrier to entry into the small, specialized market.

Traffic generated by mining activities is likely to keep expanding, provided no severe collapse of world commodity prices occurs. Several mining sites are being actively explored and havens have been built in Hope Bay and Bathurst Inlet. However, these mining projects concern precious metals or gems that require little transport capacity, with traffic mostly generated by the resupply of mining operations. Extraction of industrial metals — generating huge volumes of ore — requires the construction of deep-sea ports and connecting land transport infrastructure.

Community resupply may also experience continued expansion. However, expansion may be contingent on improved port facilities in the Canadian archipelago. The development of deep-water wharves in selected communities, such as Churchill and Iqaluit, could simplify operations and enable improved shipping services, lowering prices of consumer goods and providing the opportunity to ship locally produced goods to southern markets. These ports could develop into regional hubs similar to those that once flourished in Churchill, Moosonee and Cambridge Bay during NTCL's heyday. NEAS and Desgagnés are considering this option for Churchill.

In this context, northern land corridors may support the development of community resupply by facilitating the reloading of ships while already positioned in Arctic waters. They could also help support mining activities but would have to face the test of profitability given the expensive investments they imply.

RECOMMENDATIONS

As shipping in the Canadian Arctic is likely to continue to grow and conditions will remain hazardous, the following recommendations may be made:

- Shipping should be supported by improving infrastructure (such as ports, reliable charting, means of communication, etc.) and by navigation aids and support (such as buoys, ice and weather forecasts, assistance with route selection, ice-breaking services, search and rescue, etc.) to enhance the safety of navigation and reduce shipping's adverse impacts on marine ecosystems and coastal communities.
- Canada's regulatory framework of Arctic shipping should be continuously improved, in particular by incorporating new IMO shipping regulations as they are adopted at the international level and by further developing area-based protection measures, that may include, where relevant, IMO-approved areas to be avoided. Capacity to enforce mandatory laws and regulations should be ensured.
- The low impact shipping corridors project should be pursued, as such corridors may be an efficient means to enhance the safety of navigation and reduce shipping's adverse impacts on marine ecosystems and local communities. This is done by concentrating infrastructure and navigational aids and support in designated zones based on an assessment of safety and environmental and social compatibility.
- Compliance should be a high priority — capacity to enforce mandatory shipping regulations should be ensured. Commitment with non-mandatory corridors should be incentivized.
- A flexible approach should be taken with respect to non-mandatory corridors. Despite the objective of achieving a high compliance rate, ship operations outside designated corridors meant to avoid potentially dangerous, thick and compressed ice should be accommodated. Corridors should be conceived of as dynamic and capable of evolving to accommodate changing physical conditions, advancing both ecological knowledge and emerging economic and social needs and preferences.

INTRODUCTION

Climate change is causing Arctic sea ice to melt at an accelerating pace, gradually making way for longer navigation seasons. Arctic seas may not be ice-free but the ice is thinner and sparser, providing opportunities for longer navigability periods, provided ships are ice-classed. This has led to the advent of scenarios for fast-expanding Arctic shipping, both transit and destinational. The literature largely examines the constraints that affect transit scenarios (Theocaris 2019), but there is a definite expansion of destinational traffic in the region, whether in the Canadian, Scandinavian or Russian Arctic.

This trend towards expanding destinational traffic in the Canadian Arctic, in the context of climate change, provides shipping and mining companies with opportunities to develop activities, new routes and increased frequency of service and to potentially enhance profitability of mining projects given the expanded flexibility of sea logistics. Northern communities also interpret this trend as bearing the potential for improved service for the logistics of consumer goods and community resupply. What are the current trends at work shaping the shipping industry's activities in the Canadian Arctic? What are the current and projected ice environments that condition the opportunities for northern Canadian marine transportation development?

To what extent could expanding shipping in the Canadian Arctic be supported by and support the construction of Arctic corridors? A connection between land and sea transportation, already effective in a few places like Hay River, could possibly sustain economic development in the Arctic, provided these ventures prove to be profitable. Given the remote and extreme conditions of the Canadian Arctic, what are the most realistic scenarios for economic, industrial and other drivers (such as security objectives) for northern marine development in Canada? What are the implications of current Arctic corridor/marine legislation and their impact on potential northern corridor schemes?

Few papers address these issues, as most research about shipping in the Canadian Arctic either draws on models to try to determine probable trends (Somanathan et al. 2007) or analyzes past shipping movements to discuss the development of this crucial transportation activity (Dawson et al. 2017). But they rarely take into account the shipping companies' strategies (except Bourbonnais and Comtois 2010) and their connection with communities and the mining sector. The objective of this report is to examine the evolving navigation conditions in the Arctic, the legal framework regulating shipping in the Canadian Arctic and the trends in the development of Arctic shipping, to draw a picture of their likely future.

This report develops a synthesis of economic trends for shipping in the Canadian Arctic in the context of climate change. It draws on economic reports and traffic data published by shipping companies and government agencies, articles from regional or professional media and interviews conducted with economic and government actors to draw a portrait of trends and developments in Arctic shipping in Canada.

PART 1: THE CONCEPT OF CORRIDORS

There is important literature about corridors (Debrie and Comtois 2010) which reflects varied concepts. However, the general consensus is that a corridor is an axis of communication and transport infrastructures (Alix 2012; Debrie and Comtois 2010; Rodrigue 2017). Corridors are not merely the construction of transport infrastructure; their function is to promote the establishment of new productive activities by improving the accessibility of the territory. They are designed to promote the processing capacities of local productions and the development of peripheral territories, not only to service the main industrial areas (Fau 2019; Lasserre and Mottet 2021). In theory, the corridors are axes of transport, but also tools to sustain connectivity and economic activities.

The concept of corridors is being used in two different projects in Canada. The first, the low impact shipping corridors project, is a regulatory concept designed to organize maritime traffic with the goal of reducing shipping's impact on marine life and the risk of accidents. The government of Canada has initiated a research and consultation project, the Oceans Protection Plan, to develop a network of low impact marine transportation corridors in the Arctic that encourage marine transportation traffic to use routes that pose less risk and minimize the impact on communities and the environment (Pew Trust 2016; Arctic Corridors Research 2021). The other is the Canadian Northern Corridor concept. "The Northern Corridor concept is about establishing a new multi-modal (road, rail, pipeline, electrical transmission and communication) transportation right-of-way through Canada's North and near-North" (Sulzenko and Fellows 2016). Updated in 2020 (Fellows et al. 2020), this project is clearly about building up land infrastructure across northern Canada and bears no regulatory element.

If the maritime Arctic corridors concept is new and similar to a vessel traffic service (VTS),[1] the idea of developing Arctic land corridors to foster transportation and access to resources in the Canadian North is not. It was first aired by former prime minister John Diefenbaker in his 1958 Northern Vision policy (Lasserre 1998; Isard 2010), then advertised again by Richard Rohmer (1969) and Ross (1969) and later by Hopper (2016). Elements of these schemes were eventually built, like the Mackenzie Northern Railway up to Hay River in the NWT in 1964 and, more recently, the Dempster Highway up to Inuvik (1979) and then Tuktoyaktuk (2017). Multi-modal transportation expanded significantly after the completion of the railway. Goods were transshipped onto barges at the Hay River port, fuelling a significant community and mining resupply traffic run by shipping company NTCL before it went bankrupt in 2016. Other schemes, like the development of expanded railway connections in Arctic Quebec, in the context of the Plan Nord promoted by successive Quebec governments since 2011, failed to materialize when iron ore prices collapsed in 2014 and Arctic iron mine projects were

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1 A vessel traffic service (VTS) is a marine traffic monitoring system established by harbour or national authorities. Vessel traffic services range from the provision of simple information messages to ships, such as the position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway. Vessel Traffic Services, International Maritime Organization, https://www.imo.org/en/OurWork/Safety/Pages/VesselTrafficServices.aspx.

either cancelled or shelved (Brun et al. 2017). The construction of a railway between northern Alberta and Alaska is also on the table. The projected connection between the Alaska railway and the Canadian network has been circulating since at least 2000 (Metz and Taylor 2012). Several earlier proposals had been floated, including a 1956 project for a link between British Columbia and the Yukon, eventually extending to Alaska (Taylor 2012). The urgency to find an outlet for oil exploitation in northern Alberta convinced the provincial government to reactivate this project, which was estimated to cost about C$28 billion (US$20.8 billion) (CBC 2016). The corridor concept is also being used in Scandinavia and Russia with infrastructure projects in the Arctic regions. The Russian Federation is trying to develop integrated multi-modal transport corridors to improve access to its Arctic resources and first transformation (Lasserre and Têtu 2020). The concept of an Arctic railway in Finland attracted serious consideration in 2017, with the aim of linking the Finnish railway network to Arctic shipping routes (Gertz 2017), but the project was cancelled when confronted by strong Sami opposition (Nilsen 2021).

Several researchers and organizations are promoting the idea of developing a transportation corridor for northern Canada. C2C2C,[2] suggesting for instance the development of infrastructure projects to link ports and airports to the hinterland, a position shared by the Canadian Vitality Pathway.[3] The Senate of Canada (2017) also published a report framing the development of northern corridors in Canada as the need to develop peripheral regions and to support Canadian sovereignty in the Arctic. Western premiers also published a declaration supporting the idea of national and northern corridors (Western Premiers 2019), a view the other Canadian premiers supported a few weeks later (Canada's Premiers 2019).

Promoters of corridor schemes rely on the volume provided by access to resources such as timber, mineral ore, oil and gas, but they also highlight the potential of multi-modal transportation and the interconnection with ports to increase traffic volume. The interconnection is seen as both a tool to diversify potential benefits of infrastructure construction, with more services provided to communities and more business opportunities for resources exploitation, and as a way to justify the huge investments these Arctic corridors imply.

PART 2. THE PHYSICAL FRAMEWORK: SEA ICE DYNAMICS

This section describes the current and projected ice environment that will set the physical context for the opportunities and constraints for northern Canadian marine transportation development.

2 C2C2C, "Connecting Canada," https://www.c2c2cunitycorridor.ca/.

3 Canadian Vitality Pathway, Canada's Low Carbon Corridor, https://www.vitalitypathway.ca/.

1. AT THE SCALE OF THE ARCTIC REGION

The impacts of climate change are most evident in the Arctic region (Kim et al. 2016; NSIDC 2021). Over the past 30 years, the Arctic has warmed at about twice the global average rate, due to a phenomenon known as Arctic amplification, which leads to snow and sea ice melting earlier and freezing later. As temperatures increase, the melting sea ice and snow expose dark areas of open water (and land), reducing the region's albedo. As it absorbs more heat from the sun, the heating and melting processes accelerate even more. The loss of sea ice is known to be one of the drivers of Arctic amplification. On land, the thawing permafrost is also involved in feedback loops. Organic material begins to decompose, releasing carbon dioxide and methane back into the atmosphere, further contributing to warming (NSIDC 2021).

This Arctic amplification is both fed by and translates into the melting of sea ice. Since 1979, the yearly minimum extent of sea ice in the Arctic has decreased by about 55 per cent, from 7.2 million square kilometres to fewer than four million square kilometres in 2012 and again in 2020 (see Figure 1 in Appendices).

Several conclusions can be inferred from Figure 1. First, the extent of Arctic sea ice at its minimum is decreasing, and this trend is accelerating since the slope of the regression lines is more pronounced for more recent periods. Second, a significant year-to-year variation remains. Despite the general declining trend, there are years with more ice than the previous years, which makes the year-on-year change unpredictable (see Figure 2).

The spatial distribution of minimal sea ice reveals two facts: first, the Siberian coast is much more ice-free than the Canadian archipelago and second, despite the general trend towards a shrinking sea ice cover, significant inter-annual variability in sea ice distribution remains, with some areas being ice-free some years, but not others.

Multi-year sea ice (ice resisting at least one summer) constitutes a major hazard for navigation. It is thicker — averaging three metres but reaching seven metres, as opposed to up to 1.7 metres for first-year ice — and much harder than first-year ice (Lasserre 2010a). Extended packs of multi-year sea ice can block ice-strengthened commercial vessels, while chunks of multi-year sea ice mixed with first-year ice floes can cause damage to the hull if hit at a sufficient speed. Due to Arctic amplification, the share of multi-year ice has decreased quickly. As Figure 3 shows, the share of ice aged two years and older declined from about 48 per cent in 1984 to about 17 per cent in 2019. The remaining multi-year ice is pushed by the Beaufort gyre to the west of the Canadian Arctic archipelago (Figure 4) where land-fast ice and thick sea ice prevented it, until recently, from entering the straits and channels within the archipelago.

Sea ice is now younger, thinner and less hard (Rothrock et al. 1999, 2008; Giles et al. 2008; Julien 2009; Lasserre 2010a; Kwok and Cunningham 2015), making navigation feasible with suitable vessels. According to modelling studies, the Arctic could experience ice-free summers of a still unknown duration within the current century (Notz and Stroeve 2018; Jahn et al. 2016; Wang and Overland 2009; Stroeve et al.

2007). This would be a tremendous environmental transformation as sea ice has been present in the Arctic for the past 13 million years (Lasserre 2010a). It would also facilitate commercial shipping, not only along the Northwest Passage and the Northern Sea Route, but also across the central Arctic Ocean along the Trans-Arctic Route (Stephenson et al. 2013, 2018).

The likelihood of ice-free summers has given rise in the media to the idea of year-long ice-free Arctic seas (Bourbonnais and Lasserre 2015). However, scientific views converge on this point: ice-free winters are very unlikely, and a pronounced seasonality is likely to remain prevalent in the Arctic. Climate scenarios all predict the presence of winter sea ice as Arctic winters will remain very cold and prone to blizzard conditions due to the polar night (Aksenov et al. 2017; Petty et al. 2018; Onarheim et al. 2018; Stroeve and Notz 2018; EEA 2020).

However, developing ice dynamics are complex. Thinner and less concentrated ice is more mobile and more susceptible to the effects of winds and currents, increasing mobility-induced variability. Straits ice-free on a certain day can be completely ice-clogged a week later (Julien 2009; Blacquière 2018; Paquin 2018). In the shoulder seasons (spring and fall), when a complete ice cover has not formed yet, ice sheets moving in conflicting directions can form compact ice pressure ridges that may reach up to 10 metres high, most of it submerged. Pressure ridges are accumulations of ice forced up by the pressure of moving sea ice (Leppäranta 2011; Strub-Klein and Sudom 2012). As ice sheets thin, the size of such pressure ridges is reduced substantially. (Wilkinson et al. 2006; Wadhams 2012). However, scientists point out that pressure ridges are likely to occur more often in the Arctic because of increased mobility of thinner sea ice, especially in the Beaufort Sea, Hudson Strait, Bering Strait, north of Novaya Zemlya and in the area of the Transpolar Drift across the Arctic Ocean northwest of the Canadian archipelago (Rampal et al. 2009; Stern and Lindsay 2009; Spreen, Kwok and Menemenlis 2011; Kwok, Spreen and Pang 2013). As pressure ridges are of great concern to mariners in the area, their increased frequency will present new challenges for navigation. Ridges resulting from ice deformation are major barriers and barely passable, even with very strong icebreakers (Bourbonnais and Lasserre 2015).

2. AT THE REGIONAL SCALE – IN THE CANADIAN ARCTIC

In the Canadian Arctic archipelago (CAA), the impacts of climate change translate into short-term and longer term effects. There is an ongoing declining trend in sea ice extent, about 4.8 per cent per decade from 1968 to 2016 (Howell and Brady 2019; Zagon 2021). The probability of ice-free summers is increasing. Under a five per cent ice area scenario,[4] there is a greater than 50 per cent probability that all Canadian regions will be ice-free by September 2050 (Mudryk et al. 2018).

4 This scenario evaluates the probability of ice-free areas with the criterion of ice-free being set at ice covering five per cent of the surface.

A counterintuitive effect in the medium term can also be inferred. The weakening ice arches that used to block the transport of multi-year ice from the Arctic Ocean into the northern CAA will break up earlier and reform later, provoking an increased inflow of thick multi-year ice (Barber et al. 2018; Howell and Brady 2019; Kimura et al. 2020; Moore et al. 2021; McGwin 2021). This phenomenon could be problematic for the shipping industry, all the more so as the inflow of multi-year ice blocks could prove difficult to model and forecast. The phenomenon could increase for a few years, then subside as the prevalence of old, thick multi-year ice gradually fades away.

Despite the definite trends toward less ice in the CAA, a significant variability in temporal and spatial distribution of sea ice can be observed. Some summers, 2018 for example, have experienced more ice than others, while some have had lingering ice and yet others have had early melt, all with variations from sub-region to sub-region (Andrews et al. 2018; Dauginis and Brown 2020). In the summer of 2018, several large ships encountered difficult ice conditions and several cruises had to be cancelled (Newswire 2018; CBC News 2018). The rhythm of melting and the movement of the ice is unpredictable — ice can even be found in channels where it would not have been in the past (Bourbonnais 2021). Variability of navigability in CAA channels, especially the Northwest Passage, is typically more pronounced than in the Northern Sea Route (Wagner et al. 2020). This precludes long-term planning despite the downward sea ice trend (Blaquière 2018; Dorais 2021; Paquin 2018; Msadek et al. 2020).

Regarding the formation of pressure ridges, the debate as to whether the phenomenon could occur more frequently and cause navigational difficulties is ongoing. At the scale of the Arctic, past research hinted that ridges could be more modest in height, but also more frequent because of the increased ice mobility. In the CAA, operators or researchers could not identify any trend towards more or less ridges, suggesting a high variability of the phenomenon (Mussells et al. 2017; Dorais 2021). "There remains very limited understanding of the navigational hazards of pressured and ridged ice" (Mussells et al. 2017, 64).

Storms appear to be more frequent in winter. Their impact is diverse — they may destroy forming first-year ice and clear the way, or they may also grind the ice cover and produce a layer of brash ice that proves difficult to navigate (Bourbonnais 2021). In the transition zone between ice-free and ice-covered areas, strong waves can hurl ice blocks onto the decks of ships, thus representing a hazard for the crew and the equipment (Julien 2009).

Unpredictability and greater mobility of sea ice prompts ship officers to determine their path across the pack on an empirical basis by following leads that open up in the ice pack, assisted by navigational aids such as ice maps and embarked drones (Bourbonnais and Lasserre 2015). Tightly delimited shipping corridors may therefore be problematic as optimal progression in the pack may not be linear and may vary over time.

The accelerated melting of the Greenlandic ice sheet[5] leads to the sustained calving of icebergs along the coasts of Greenland. Although icebergs are no longer a security issue, thanks to effective radar, decaying icebergs produce growlers, smaller pieces of very hard ice, barely floating above sea level and hard to detect (Julien 2009; Bourbonnais and Lasserre 2015). A growler one metre across weighs one metric tonne and can inflict severe damage to vessels (see Figure 5). Currents appear to concentrate icebergs and growlers along the western coast of Baffin Bay at the entrances of the CAA, forcing vessels to reduce speed to avoid serious collision (Julien 2009; Lasserre 2010b; Lasserre and Pelletier 2011).

Bearing in mind the general context of climate change, a few conclusions can be drawn from the observations about ice dynamics in the Canadian Arctic. There is indeed a general trend towards the melting of sea ice taking place earlier in spring and reforming later in fall, with a shrinking minimal extension in September, thus gradually freeing up[6] channels and sea areas in and close to the CAA.

Multi-year ice is declining fast across the Arctic, but remains concentrated west of the CAA, packed by the Beaufort gyre. Weakened ice arches at the northwest entrances of the CAA channels (McClure Strait, straits in the Queen Elizabeth Islands, Nares Strait) also likely facilitate penetration of multi-year ice into the CAA.

Assessing the frequency of pressure ridges in the Canadian Arctic is difficult. Some authors predict higher frequency given the thinning of sea ice, others observe no clear trend. Empirical research and testimonies from shipping companies attest to a high variability of the spatial and temporal distribution of sea ice and pressure ridges, complicating shipping routing and requiring flexibility in ship operation.

PART 3. THE DEVELOPMENT OF SHIPPING IN THE CANADIAN ARCTIC

Traffic has experienced a significant growth in the Arctic, both in general (PAME 2020) and along the Northwest Passage and the Canadian Arctic (PAME 2021). Given the remote and severe conditions of the Canadian Arctic, how is shipping developing in the Canadian Arctic and what does this picture infer regarding realistic scenarios for northern marine development?

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5 Shfaqat et al. (2015) estimated the loss of ice from the Greenlandic ice sheet at seven Gt/year (1992–2002), at 55 Gt/year (1993–1998) and at 237 Gt/year (2003–2008). Estimates suggest even more accelerated melting in the future. See Briner et al. (2020).

6 The Canadian Ice Service considers an area to be ice-free when less than 15 per cent of its surface is ice-covered.

1. SHIPPING IS LARGELY DOMINATED BY DESTINATIONAL TRAFFIC

1.1. Transit Traffic Remains Weak

Contrary to popular belief and widespread expectations, transit traffic remains very limited both in the Canadian Northwest Passage (NWP) and on the Russian Northern Sea Route (NSR),[7] despite declining sea ice. Table 1 below depicts the evolution of transit traffic through the NWP.

Table 1. Transit Traffic Along the Northwest Passage, 2006 – 2020

Vessel Type	2006	2008	2010	2011	2012	2013	2014	2016	2017	2018	2019	2020
Icebreaker	2	1	2	2	2	2	4	3	2	2	1	1
Cruise	2	2	4	2	2	4	2	3	3	0	5	0
Pleasure Boat		7	12	13	22	14	10	15	22	2	13	1
Tug	1		1		2				3	1	1	
Cargo Ship		1		1	1	1	1	1	2		3	5
Research	1	1		1	1	1			1			
Other								1	4			
Total	6	12	19	18	30	22	17	23	33	5	23	7

Source: Figures compiled by the author from data communicated by Nordreg, Iqaluit.

Shipping in the NWP and on the NSR follows a clear trend of expansion, but with a stark difference between the two regions. Transit numbers across the Northwest Passage were low at the beginning of the period, experienced growth until 2012, witnessed a moderate decline, expanded again until 2017, then fell in 2018, only to recover in 2019. As for the NSR, figures show that, both in terms of voyages and tonnage, transit represents a very small share of total traffic, despite increases in tonnage since 2018 (CHNL 2020). Transit traffic was initially very moderate, then expanded to a high of 71 voyages in 2012 before collapsing to 18 in 2014, only to recover gradually to 37 in 2019. This decline, and later stagnation at low levels in transit traffic along the Northern Sea Route, is clearly out of step with media forecasts announcing the advent of heavy traffic along Arctic routes (Balmasov 2016; Doyon et al. 2017; Lasserre et al. 2019).

7 The term transit is interpreted differently by the various administrations that collect and publish figures describing transit along Arctic passages. In Canada, figures are collected by the Canadian Coast Guard section responsible for the enforcement of the Northern Canada Vessel Traffic Services Zone regulations (Nordreg). The definition used by Nordreg for transit is a movement between Baffin Bay and the Beaufort Sea. The Scott Polar Research Institute (SPRI) uses a different definition whereby transits are counted between the Labrador Sea and Bering Strait. This difference does impact figures since a vessel servicing the community of Inuvik from Montreal will be counted as a transit by Nordreg but not by the SPRI. For instance, the SPRI counts 32 transits in 2017 and three in 2018, as opposed to NORDREG, which counts respectively 33 and five. In Russia, figures are collected by the Northern Sea Route Administration (NSRA), but published by the Centre for High North Logistics (CHNL), a private association. CHNL bases its figures on the NSRA definition of transit, which is a voyage between the Bering Strait and the Kara Gate. As a result, a ship from Kamchatka to Murmansk will be counted as a transit by CHNL although the ship never left Russian Arctic waters. Other voyages, like those carried out in 2009 by the heavy-lift vessels Beluga Foresight and Beluga Fraternity, are counted by CHNL as transits from South Korea to Germany, despite the fact that they unloaded their cargo on the way in Yamburg (Siberia), making destinational voyages in a technical sense. On these methodological issues, see Lasserre and Alexeeva (2015) and Lasserre et al. (2019). This paper is based on official Nordreg figures and semi-official CHNL figures.

The composition of traffic in the NWP and on the NSR also differs. Commercial cargo ships represent the largest share of transit traffic on the NSR, whereas transit in the NWP is largely composed of pleasure boats, as opposed to zero to two commercial vessels. This may be about to change: cargo vessels performed three transits in 2019 and five in 2020. Vessels from the Dutch shipping company Royal Wagenborg accounted for two of the transits in 2019 and all five in 2020. The company openly advertises the voyages (Wagenborg 2019, 2020), hinting it may attempt to develop this market in the future.

Among the factors that explain weak interest for transit traffic in the NWP are a higher ice concentration in summer (NSIDC 2019) and the absence of promotion of the NWP, as opposed to a very proactive approach in Russia and a higher level of equipment and infrastructure along the NSR, including ports that can harbour ships in case of damage (Lasserre and Têtu 2020; Lasserre 2021). Icebreaker support also varies greatly, with Canada having only nine Arctic-capable icebreakers, while Russia has five nuclear and 37 diesel icebreakers.

A significant feature of Arctic traffic is the recurrent seasonality. Most traffic takes place from June through October.

Table 2. Share of Voyages Carried Out from June through October, Percentage Share

	2013	2014	2015	2016	2017	2018	2019
NSR				69.8	68.7	64.1	61.2
Canadian Arctic	86.5	88.7	86.7	87.1	88.5	89.2	88.2
Greenland	77.7	77.5	80.7	84.5	71.5	86.6	87.5

Source: Compiled by author from Nordreg, CHNL and Joint Arctic Command (Nuuk) data.

The seasonality is less pronounced and declining on the NSR, in large part because several oil and gas projects included investments in high ice-class vessels for year-round shipments, especially from Varandey oil terminal and Sabetta port. In 2019, 1,245 out of 2,694 transits (46.2 per cent) were carried out by ships with an ice class Arc6 or greater (Polar Class 5), of which 1,032 were carried out by commercial ships and 214 by icebreakers (CHNL 2020). Among these voyages, 866 were carried out by tankers or LNG tankers. This clearly points to a business model resting on year-round shipping developed by the oil and gas industry with regard to Arctic hydrocarbon development. The objective is gradually enforced with the construction of expensive high ice-class LNG carriers (Polar Class 4). However, for now, year-round activity in NSR waters remains to be developed for other segments of the shipping industry, which maintain a seasonal approach, as does the shipping industry operating in Greenlandic and Canadian Arctic waters.

Low numbers of transit traffic are in sharp contrast with figures for destinational traffic (ships going into the Arctic, stopping there to perform an economic task and then sailing back), the driving force of Arctic shipping in all regions. Destinational traffic is fuelled by the servicing of local communities, the exploration of natural resources and their exploitation, including minerals, oil and gas and fisheries.

1.2. A Clear Increase in Destinational Traffic

Figures indicate that vessel movements are increasing substantially in the Arctic. From 2009 to 2019, traffic multiplied by 1.92 in the Canadian Arctic (see Table 3 below), by 1.97 in Greenlandic waters and by 1.58 between 2016 and 2019 in waters of the Northern Sea Route (Lasserre 2021a). Traffic in the Canadian Arctic thus follows the general trend of expansion of traffic in the Arctic. The NWP was more used in recent years as ships were more numerous and travelled longer journeys. From 2013 to 2019, the number of ships sailing in Northwest Passage waters increased by 44 per cent, from 112 to 160 vessels. More significant was the increase in total distance travelled in the region, which more than doubled from 2013 to 2019. In aggregate, the ships travelled 2,980 nautical miles in 2013, but that figure jumped to 6,170 nautical miles in 2019 (PAME 2021).

The year 2020 differed because the COVID-19 pandemic affected traffic in various ways: the government banned cruises and pleasure craft visits, while extractive activities were partly hurt by a reduced demand and hobbled by health measures (Vullierme 2021). Health measures also had to be applied for the sealift to communities by shipping companies NEAS, Desgagnés Transarctik and MTS (McCormick 2021).

Table 3. Vessel Movements in the Canadian Arctic, 2009 – 2020 (Number of Voyages, Nordreg Zone)

	2009	2011	2013	2014	2015	2016	2017	2018	2019	2020
Voyages	225	319	348	302	315	347	416	408	431	345
Of which:										
Fishing Boats	65	136	137	119	129	131	138	139	137	132
Cargo or Barges	109	126	127	108	120	147	188	197	223	186
Of which:										
General Cargo	23	38	35	32	34	36	50	48	59	41
Tanker	23	30	28	25	27	23	24	29	28	31
Dry Bulk	27	23	27	33	36	53	72	89	106	94
Tugs and Barges	36	33	36	18	23	35	42	31	30	20
Pleasure Crafts	12	15	32	30	23	22	32	17	19	2
Cruise/Passenger	11	11	17	11	18	20	19	21	24	0
Government Vessels (Icebreakers, Navy)	21	20	17	23	16	20	22	18	20	21
Research vessels	7	11	20	10	9	6	13	13	8	4
Others					3	3	6	4	1	

Source: Figures compiled by the author from data communicated by Nordreg, Iqaluit.

In the Canadian Arctic, growth in traffic, measured by voyages, was mainly driven by fishing vessels (increasing by 106.2 per cent between 2009 and 2019) and cargo ships (increasing by 122 per cent). Of these, dry bulk driven by mining activities (increasing by 288.9 per cent) and general cargo (increasing by 156.5 percent) driven by community resupply and mining activities as a secondary market experienced the fastest expansion.

It is apparent that the main driver for the expansion of shipping in the three areas is the exploitation of natural resources, including minerals, oil and gas and fishing. Community resupply in Canadian waters also experienced sustained growth. Cruise shipping appeared to experience a moderate growth with 24 voyages in 2019, a traffic much more modest than in other Arctic markets like Greenland or the Svalbard archipelago (Têtu et al. 2019). This segment was dealt a severe blow when all cruises were cancelled in 2020 and 2021 due to COVID-19.

2. MINING AND COMMUNITY RESUPPLY: THE MAIN DRIVING FORCES OF SHIPPING

2.1. Mining Activity Fuels Commercial Shipping Expansion

The presence of valuable deposits in the Canadian Arctic has long been documented. Increase in world prices has triggered their exploitation, much more than climate change and melting sea ice, which still had a facilitating effect on the development of mining ventures (Lasserre 2021). A few mines and oil fields, developed when the ice cover was still thick and extensive, were closed down because of depressed global prices, including the Polaris and Nanisivik mines (closed in 2002) and the Bent Horn oil field (closed in 1996).

Bulk traffic has benefited from the exploitation of Arctic and subarctic mines, such as Voisey's Bay (Labrador), Raglan and Canadian Royalties/Jilin Jien (Quebec) and Mary River (Baffin Island, Nunavut). This expanding traffic has largely compensated for dwindling traffic to and from Churchill since the port closed down in 2016, before reopening in 2019 (only four voyages of grain-carrying bulk vessels in 2019 and three in 2020). For instance, Baffinland Iron Mines shipped 920,000 tonnes of ore from its mine in Mary River through its port of Milne Inlet in the first year of activity in 2015, then 4.1 million tonnes in 2017 (Maritime Magazine 2018) and 5.1 million tonnes in 2018 (Debicki 2019). The company intends to eventually reach an annual volume of 12 million tonnes. Other active gold mines north of Rankin Inlet also generate traffic related to the logistics of mining operations (see Figure 6). In the Canadian archipelago, Fednav operates PC4 vessels (Arctic, Umiak, Nunavik) capable of navigating in winter, servicing the Deception Bay mines in northern Quebec. The company may develop a business model in partnership with mining companies for year-round shipping to Deception Bay and Milne Inlet (operational), as well as Steensby Inlet (projected).

The logistics of mining activities are dominant in terms of tonnage in the Canadian Arctic. The capacity of bulk carriers servicing mines (measured in cumulated vessel dwt), at 6.1 Mt, accounted for 77.3 per cent of the tonnage capacity of traffic in the Canadian Arctic in 2020. Large, powerful dry bulk carriers transport ore from the maritime terminal built to service the mine — the construction of deep-water docks is required for base-metal mines that ship large quantities of ore. By contrast, sealift for gold or diamond exploitation is overwhelmingly related to supply of fuel, food and equipment. Consequently, general cargo and tanker companies, such as NTCL/MTS, NEAS, Desgagnés and Coastal Shipping/Woodward, are also tapping into the market created by expanding mining activities for delivery of fuel (Coastal Shipping) and supply (NEAS, Desgagnés, MTS).

For instance, Baker Lake haven (a small terminal built to accommodate large barges and small vessels) saw traffic expand significantly in the past due to the development of gold mining ventures north of the community (see Figure 7).

In the Kitikmeot district of Nunavut, several mining projects are ongoing, mostly gold development ventures. The Chinese company Shandong Gold considered purchasing the TMAC property, but the federal government blocked the transaction in December 2020 (Friedman 2020). TMAC eventually sold to Agnico Eagle, which also develops the mining projects north of Baker Lake. Sabina Gold and Silver Corp. is proceeding with its Black River project, which includes the construction of the Bathurst Inlet haven, now operational and serviced by Desgagnés and MTS on an occasional basis (see Figure 8). Transportation for the mining project will in part depend on shipping and on winter roads to the actual mining site (Sabina Gold and Silver 2021).

Further west, other gold mining projects, held by Blue Star Gold Corp., rely on the construction of a road and a port located on Grays Bay. The Grays Bay road would overlap with a road proposed as part of the mothballed Izok corridor zinc-lead mining project that was promoted by Chinese-owned MMG Ltd., but has been shelved since April 2013 (Bell 2017). The Grays Bay project is experiencing significant logistical challenges (George 2020). This situation sums up the dilemma faced by several inland mining projects. Is it preferable to construct a year-round land road reaching south and connecting to the road and rail network despite high costs or is it more profitable to build a shorter road northwards connecting with a haven, with a navigable season bound to expand in the future but still limited to a few months per year? (Lasserre 2010c; Lasserre and Têtu 2020). It seems noteworthy that most inland projects, either active or under development, are gold or diamond mining projects that require a lighter logistical infrastructure than mining of industrial metals. The Mary River iron mine is a significant exception that can be accounted for by the very high grade of its ore and the sheer size of the deposit (Fontaine 2011; Mining Technology n.d.).

In conclusion, mining is the most significant driver of shipping in the Canadian Arctic, both with respect to the logistics of mining operations and to the shipment of produced ore (iron ore in Mary River, nickel ore in Deception Bay from Raglan and Jilin Jien mines). The ongoing development of gold and diamond ventures in Nunavut and possibly northeastern NWT is also fuelling navigation because of logistical needs for these projects. Most of the traffic generated by mining is concentrated in the eastern part of the Canadian archipelago.

2.2. Community Resupply

2.2.1. Resupply: A Market with Specific Logistical Constraints

Community resupply is the second most important segment of commercial shipping in the Canadian Arctic. It involves the shipment of fuel as well as consumer goods to communities. Fresh food products and high value-added consumer goods are also shipped by air, a situation that accounts for high retail prices experienced in Arctic communities. The reduction of sea ice due to climate change could theoretically present an opportunity for expanded service to communities through increased transportation capacity, either through more voyages (increased frequency of calls) and/or increased capacity of vessels (Stewart 2018; Lasserre and Têtu 2020b). Shipping service to Arctic communities is all the more important as food insecurity is a significant problem, affecting 36 per cent of households in Nunavut in 2012 — a figure reaching 42 per cent in 2014 (Harvey 2020) — as opposed to a national average of 8.3 per cent (De Meulemeester 2018). Food insecurity in Nunavut is largely linked to high food prices that directly stem from transportation of food items (Samson 2019; Harvey 2020).

Community resupply is a complex logistical operation in the Canadian Arctic due to the lack of ports. There are no wharves in Arctic villages, despite a federal program for the construction of small craft harbours. Commercial vessels must therefore anchor offshore and self-unload cargo onto barges that will then be pushed by a tugboat up to the beach where engines will unload goods onto trucks. Unloading beaches being public, including for children, safety issues are a recurrent problem (George 2010; Turmel 2013; Turmel et al. 2013; Rogers 2014; Paquin 2018; Blacquière 2018) (see Figures 9 and 10).

Loading and unloading is much more time-consuming in these conditions than at a dock. For general cargo, Canadian companies NEAS and Desgagnés Transarctik operate large vessels. MTS (formerly NTCL before it went bankrupt in 2016 and was purchased by the NWT government) operated barge convoys pushed by tugs. For fuel products, Desgagnés operates its PetroNav subsidiary, while Woodward Group operates Coastal Shipping Limited. Given the logistical constraints, they all developed a specific expertise that has the indirect benefit of limiting competitors entering the market, as several experts requesting anonymity explained. However, despite extensive experience garnered by shipping companies, efficiency is definitely hampered. The specific unloading procedure has also forced cargo to be handled in the form of pallets rather than containers, in stark contrast with containerization effective in Greenland where small container carriers can dock on wharves in villages (Lasserre 2010b; Brooks and Frost 2012). In that regard, the recent development of small containers by NEAS (10 feet) is both welcomed by customers and a way to streamline unloading (McCormick 2021).

Churchill is currently the only community with a deep-water port and a wharf. Built in 1931 as a maritime outlet for the grain of the Prairies, it is connected to the North American railway network, a theoretical advantage that made Churchill a potential gateway to the heart of the continent. The Arctic bridge sea route, connecting Churchill to the Russian port of Murmansk, never materialized into significant traffic. The port was privatized in 1997 and sold to OmniTrax, who decided to close it down in 2016. Sold to the Arctic Gateway Group, it reopened in 2019, but experiences very little export traffic. It is currently also used as a supply hub by Desgagnés and NEAS, in addition to their Montreal base.

Attesting to the desire to increase service to communities, the project of building a deep-water port in Iqaluit, discussed for decades and relaunched in 2005, has finally come to fruition. Work started in 2018 and should be completed in 2021, with service beginning in 2022 (City of Iqaluit 2005; Lasserre and Têtu 2020b; Patar 2020). Faster and more reliable service could prove particularly useful, not only to meet expanding community needs in resupply, but also to foster the development of local businesses (Stewart 2018). In 2006, the Chamber of Commerce of Baffin Island explored ways to diversify links while improving supply and shipment possibilities. Links considered were between Goose Bay and Iqaluit and between Iqaluit, Nuuk and Reykjavik, with service provided by the Danish company Royal Arctic Lines and the Icelandic company Eimskip (Brooks and Frost 2012). These projects never came to fruition.

2.2.2. Development Strategies of Shipping Companies

Shipping companies that shape the community resupply market experienced major changes in recent years. These changes are depicted in the tables below.

Table 4. The Evolution of NEAS's Fleet

	Year Built	Place	Ice Class[8]	dwt[9]	TEU[10]	Gt[11]
2020						
Qamutik	1994	Netherlands	1A	12 754	730	8 448
Mitiq	1995	Netherlands	1A	12 754	730	8 448
Nunalik	2009	China	1A	12 744	665	9 611
Aujaq	1994	Netherlands	1A	12 754	720	8 448
Sinaa	1994	Netherlands	1A	12 754	720	8 448
2008						
Aivik	1980	France	1A	4 860	280	7 362
Avataq	1989	Japan	1A	9 686	567	6 037
Umiavut	1988	Japan	1A	9 682	567	6 037
Qamutik	1994	Netherlands	1A	12 754	730	8 448

Source: Data compiled by author from NEAS pages and professional websites.

8 The ice class refers to a notation assigned by a classification society or a national authority to denote the level of strengthening as well as other arrangements that enable a ship to navigate through sea ice. Several scales exist, like the International Association of Classification Societies (IACS), which produced a unified scale for the Polar Code, called Polar Classes (PC). The scale ranges from PC7, referring to a vessel able to navigate in autumn in thin first-year ice, to PC1, referring to year-round operations in all Arctic waters. For commercial vessels, a widely used classification is the Baltic or Finnish-Swedish system, with classes stemming from 1D (poorly adapted for navigation in ice-covered seas) to 1C, 1B, 1A and 1AS. 1A is approximately equivalent to PC7 and 1AS to PC6.

9 Deadweight tonnes: the measure of the loaded weight of a ship in metric tonnes.

10 TEU (twenty-foot equivalent unit): Standard measure for containers, which usually come in the form of metal boxes 10, 20 or 40 feet long (0.5, one or two TEUs). Here the value indicates the number of TEUs the vessel can carry.

11 Gross tonnage is a measure of volume, contrary to what the name could imply. It measures the transport capacity of a vessel and is measured in gross tonnes (100 cubic feet).

Table 5. The Evolution of Desgagnés Transarctik's Fleet

	Year Built	Place	Ice Class	dwt	TEU	Gt
2020						
Rosaire	2007	Netherlands/China	1A	12 777	665	9 611
Taïga	2007	China	1A	17 500	958	12 936
Sedna	2009	China	1A	12 612	665	9 611
Zelada	2009	China	1A	12 692	665	9 611
Nordika	2010	China	1A	19 777	958	12 974
Claude	2011	China	1A	12 580	665	9 611
Acadia	2013	China	1D	11 353	164	7 875
Miena	2017	China	1A	12 396	842	11 492
2008						
Camilla	1982	Germany	1AS	6 889	730	10 085
Anna	1986	Germany	1AS	17 850	553	15 893
Rosaire	2007	Netherlands/China	1A	12 777	665	9 611
Beluga Federation	2006	China	1A	12 744	665	9 611
Beluga Enterprise	2005	China	1A	12 744	665	9 611
Dutch Runner	1988	Germany	1D	3056	219	2279

Source: Data compiled by author from Desgagnés' pages and professional websites.

Table 6. Fleet Evolution of Coastal Shipping Limited (Woodward)

	Year built	Place	Ice Class	dwt	Gt
2020					
Kitimeot	2010	Turkey	1A	19 983	13 097
Kivalliq	2004	China	Ice E3 = 1A	13 671	8 882
Qikiqtaaluk	2011	Turkey	1A	19 998	13 097
Tuvaq	2012	China	1A	7 595	5 422
2007					
Nanny	1993			9 176	6 544
Mokami	1989			2 853	3 015
Dorsch	1980			10 556	6 720
Tuvaq	1977		1AS	15 955	11 290

Source: Data compiled by author from CSL's webpages and professional websites.

In the western Canadian Arctic, resupply is performed by the NWT government-owned Marine Transportation Services (MTS), formerly Northern Transportation Company Ltd (NTCL) until its bankruptcy in 2016. Its base port is in Hay River on Great Slave Lake's shore, which is serviced by rail. Churchill was also used to resupply communities in the western Hudson Bay area, with a traffic volume that reached about 35,000 tonnes in 2002 (Integrated Environments 2008; Prolog 2010). From the Hay River terminal, convoys navigate along the Mackenzie River and then visit western Arctic communities; for a while, they also visited Alaska (see Figures 11 and 12). This logistical mode prevented NTCL from operating large vessels, the depth of the Mackenzie River being too shallow. Instead, the company operated tugboats and barges joined in convoys. 1972 was a record year for cargo movement on the Mackenzie River and the Arctic region, with approximately 362,000 metric tonnes transiting through NTCL docks in Hay River. From then on, tonnage from Hay River gradually declined. The reasons include the decline of oil exploration in and around Inuvik and the Arctic offshore and the building of the Dempster Highway across the Yukon to Inuvik (opened in 1979) and then to Tuktoyaktuk (opened in 2017). Another factor was the conversion of NWT Power's power plant in Inuvik from diesel fuel to natural gas, reducing demand for fuel and competition from eastern shipping companies, Woodward for fuel delivery and NEAS and Desgagnés for general cargo (Wright 2020; Prolog 2010).

Hit by competition and adverse economic conditions, NTCL/MTS gradually reduced the scope of their services, both reducing the network and limiting the number of voyages (Wright 2018, 2020). The number of voyages declined from 22 in 2008 to 11 in 2020. Transported volume declined from 154,000 tonnes in 1994 (Wright 2020) to 10,000 tonnes of dry cargo and 37,000 cubic metres of fuel in 2017 (Nunavut News 2018), and then to 6,350 tonnes of dry cargo and 27,900 cubic metres of fuel in 2020 (McCormick 2021).

Examination of the fleets' evolution allows for several observations. First, vessels are much younger. In 2007, the age of CSL's fleet averaged 22.3 years, but only 10.8 years in 2020. In 2008, NEAS's fleet had an average age of 20.3 years, but only 11 years in 2020. In 2008, Desgagnés' fleet age averaged 12.2 years but only 9.6 in 2020 (and 3.2 years for Petro-Nav tankers). This renewal was made possible through the repeal of the import tax for foreign vessels in 2010[12] and was intended as a way to replace an aging fleet, but also to benefit from economies of scale provided by larger vessels.

Second, shipping companies decided to bank on economies of scale for each vessel rather than expanding the fleet with several small units. Fleet expansion was thus real but not major, remaining at four vessels for CSL, going from four to five vessels for NEAS and from six to eight vessels for Desgagnés. However, capacity increased significantly: from 9,635 dwt in 2007 to 15,312 in 2020 for CSL; from 9,246 dwt in 2008 to 12,752 in 2020 for NEAS; and from 11,010 dwt in 2008 to 13,961 in 2020 for Desgagnés. CSL and NEAS clearly bet on increased vessel size, while Desgagnés opted for a mixed strategy of an expanded fleet with modest size increase.

NEAS somewhat expanded the number of voyages (see Table 7), while Desgagnés remained at 21. Given that NEAS operates five vessels (four in 2008) and Desgagnés eight (from six), the average number of voyages per vessel actually decreased. The strategy of these companies is not an expanded frequency from their Montreal/Valleyfield base. CSL performed 14 voyages in 2010 and 19 in 2020 and appears to rely on both increased frequency and larger vessel capacity (see Figure 13).

12 The Ferry Boats, Tankers and Cargo Vessels Remission Order, 2010, published in the Canada Gazette, Part II, on October 13, 2010, allows for the remission of the 25 per cent import duty. This tax removal facilitated the fleet renewal of Canadian shipping companies but did not cause it. (Personal communication with Emmanuel Guy, professor, Université du Québec à Rimouski, January 25, 2021.)

Table 7. Resupply Voyages to Scheduled Destinations (2008 and 2020)

	NTCL/MTS	NEAS	Desgagnés	CSL
2008	22	11	21	14 (2010)
2020	11	13	21	19

Source: Data compiled by author according to published company schedules and Mariport (2012).

The increased vessel carrying capacity was a strategic choice shipping companies made to reduce their costs per transported tonne. This improved capacity and, since 2019, the possibility to resupply in Churchill with the reopening of the port and the railway, made the option of an increased frequency much less attractive. Apparently, the strategy developed by shipping companies is to operate a similar frequency per vessel, given that increased carrying capacity enables vessels to service more communities. This is apparent when examining the network operated by shipping companies in 2008 and in 2020 (see Figures 14–17).

In 2020, CSL's network covered a large area of the Canadian Arctic. MTS remained concentrated in the Mackenzie River Valley and the western Arctic, with fewer destinations serviced than NTCL 20 years ago. From 2008 to 2020, Desgagnés' transported volumes shifted somewhat to communities along the NWP and in western Hudson Bay, at the expense of communities in northern Quebec. Over the same period, NEAS significantly expanded its network westwards, with more destinations and transported volume along the Northwest Passage and in western Hudson Bay.

Shipping development can be illustrated through a traffic density map (see Figure 18). Areas of concentration of ship movements are the entrance of Hudson Strait, Frobisher Bay leading to Iqaluit and the entrance of Navy Board Inlet between Bylot Island and Baffin Island. Secondary commercial routes are the approaches to Rankin Inlet, Lancaster Sound, the coast of the NWT and Amundsen Gulf. The map underlines strong spatial disparities in the Canadian Arctic archipelago, with zones of higher shipping traffic and vast areas with scant traffic, and even no traffic at all, as past research illustrates (Dawson et al. 2017).

3. CORRIDORS AND SHIPPING

3.1. Marine Corridors

It appears maritime traffic in the Canadian Arctic is structured along some regularly plied routes. Shipping companies involved in community resupply have organized their activities along these informal corridors, and formalizing them in the form of low impact shipping corridors will increase security while not significantly impacting general circulation and networks developed by shipping companies.

Canada is in the process of developing low-impact shipping corridors to minimize the negative impact of vessel traffic on the marine environment and coastal communities and to maximize the safety of navigation by concentrating traffic close to infrastructure, navigational support and search and rescue capacity to be developed along these corridors (Transport Canada 2017). Significant data collection and consultation efforts are underway to identify where these shipping routes should be established and what related measures should look like (Dawson et al. 2020). For the time being, corridors are not intended to become mandatory. Shipping may therefore continue to take place outside these corridors; Canadian regulation of shipping activity will, however, remain compulsory. Most ship operators do not see this as an unnecessary burden, but as warranted by hazardous shipping conditions and by a sensitive Arctic environment (Pic et al. 2021). For shipping companies that have not already entered the shipping market but may be considering doing so, international and national regulations, as well as insurance companies' demands regarding equipment, ship architecture, crew training, reporting and navigation within corridors may appear burdensome (Sarrabezoles et al. 2016; Pic et al. 2021). Regulated shipping corridors designed to co-ordinate ship movements may be barriers to entry into the Canadian Arctic shipping market, despite being non-mandatory. It could well be that insurance companies will make them mandatory, as they did in the past with other non-mandatory regulations, like reporting to Nordreg before it became mandatory, or Polar Code provisions before they became enforced (Sarrabezoles et al. 2016).

At the very local scale, shipping companies observed that there may be occasions when ice concentration may force a vessel to temporarily leave a designated corridor. These companies stress that the possible future enforcement of shipping corridors must take into account the need for flexibility as ice is unpredictable and moving faster. So long as the corridors are non-mandatory or there are provisions for occasional navigation outside their scope for safety's sake, shipping companies will not object (Bourbonnais 2021; Paquin 2021).

Questions remain regarding corridor design for the servicing of mining sites. If community resupply implied the development of regular routes, mining sites are exploited for limited periods of time that range in terms of years. If authorities apply due diligence to identify, in co-ordination with local communities, safe corridors for the servicing of new mines or havens, with a degree of flexibility in the enforcement of regulations involved in low impact corridors, then there is a limited likelihood these will negatively impact the development of shipping.

3.2. Land Corridors

Could land corridors, like those proposed in the Canadian Northern Corridor concept, help develop maritime traffic in the Canadian Arctic? In the past, shipping companies have already used resupply hubs like Hay River, Moosonee or Churchill for community resupply. Hay River is still the main hub for service of MTS, and Churchill has been used recently by NEAS (Desgagnés in 2008 as well). An improved land transportation service could promote adding stopovers at these would-be logistical hubs for community resupply and thus facilitate the servicing of Arctic communities, for ships would not have to return to Montreal for reloading at the end of every run.

Land corridors could possibly support the development of international maritime traffic in the Arctic. Churchill was a gateway for Canadian grain only because of the rail connection to the national network. But the existence of the rail connection in itself is not sufficient. There has been a long decline of traffic in Churchill despite the promotion of the Arctic Bridge maritime route between Murmansk and Churchill, including very moderate traffic since the reopening in 2019 (Lasserre 2010b, 2021c).

The development of mining, especially inland, could also support the idea of northern corridors. If operators estimate it costs less to develop a connection southward to join national rail networks, then the logistics of several mining sites could support the construction of a corridor that could also in turn facilitate community resupply. However, as mentioned, and as NTCL experienced in the past, when mining sites close down, traffic may experience sharp drops, eroding their profitability. Uncertainty around world resource prices and the high cost of infrastructure construction challenge the profitability of such large projects. The clusters of mining sites and of community resupply, as could be the case around the Grays Bay Port and Road project, may support a larger transportation volume that could sustain profitability.

PART 4. FUTURE OPTIONS AND DRIVERS

Commercial shipping in the Arctic is currently composed of four main sectors, not counting transit shipping, which may be on the verge of developing, as shown by Wagenborg's transits in 2019 and 2020. Fishing remains limited, as few fishing ports and little cold chain infrastructure exist in the Canadian Arctic; catches in Canadian Arctic waters are often unloaded in Newfoundland (Boyer et al. 2014). The cruise industry, less developed than in Greenland and Svalbard, was hard hit by COVID-19 and banned from Canadian waters in 2020 and 2021. It remains to be seen how the market will recover when restrictions are lifted. Mining extraction fuels significant shipping activity near extraction sites or their marine ports/havens. Foreign shipping companies are active besides the Canadian shipping company Fednav in this market, and its expansion will most likely entail the arrival of new players. Sealift for mining sites, performed with large, heavy bulk carriers, could affect marine life if frequency were to increase significantly. General cargo and tanker supply could service communities and, to a lesser extent, mining extraction sites, in particular with fuel for energy production and non-perishable consumer goods. Communities would like the scope of this vital service to be expanded, to bring down prices of consumer goods and enable local economic activities. A number of factors could drive further development of shipping in the Canadian Arctic.

1. DEVELOPMENT OF REGIONAL HUBS

To ease logistics for communities, one or two ports capable of accommodating larger vessels could be developed. From these hubs, cargo could then be distributed by smaller vessels across the region. This option has already been explored. From 2009 until 2011, NTCL ran a link with an ocean-going large barge from Richmond, B.C. to Barrow (for an oil project) as well as to Cambridge Bay (community resupply and mining projects in Hope Bay) (Bourbonnais and Comtois 2010), redistributing cargo from there to western Arctic communities. NTCL also shipped cargo from Churchill and Moosonee (Prolog 2010). The company abandoned this service because of competition and the lack of servicing to mining sites that would have made the service cost-effective (Mariport 2012; Wright 2020). This example illustrates, however, the possibility of organizing community resupply using one or two regional hubs, such as the deep-water port of Iqaluit, from where cargo could be dispatched with smaller vessels. For the moment, the idea does not seem to appear attractive to NEAS or to Desgagnés (Paquin 2018; Blacquière 2018). The cost of building, maintaining and operating deep-water ports must be recovered through fees charged to forwarders and transporters. For the goods to remain competitive, the cost of operations must be spread across a large volume of goods (Government of Nunavut 2008). Thus, building a regional hub can be afforded only if regional operators can reasonably bet on an increase in cargo flows — build it and they will come.

The community of Qikiqtarjuaq tried to develop a regional hub to boost activities. The idea of building a port for the community (Qikiqtaaluk Corporation n.d.) stemmed from the desire to support the fishing industry, but also from the vision of developing a “little Singapore of the Arctic” with the help of “Chinese investors” whose identity remains elusive (Blacquière 2021). This idea first emerged in the 1950s during the construction of the DEW Line, thrived amid burgeoning projects of Arctic hub ports to facilitate the development of transit and destinational shipping (Zerehi 2016; Godbout 2019) and included the promotion of North American ports at St. John’s, Saint-Pierre and Miquelon, or Portland, Maine. However, this project is reportedly stalled, especially as Chinese investors may not be welcome in the context of challenging Sino-Canadian relations. Senator Dennis Patterson recently included the Qikiqtarjuaq port in his budget recommendations for Nunavut’s development (Ritchot 2021), but the government does not seem to have followed suit.

If the strategy of Arctic hubs bears no fruit, another option could be the development of other ports as Arctic gateways. Churchill and Moosonee used to serve as entry ports into the Arctic market, and it appears that Desgagnés and NEAS may consider the option of using Churchill again as a resupply port.

2. PROMOTION OF THE NORTHWEST PASSAGE

Vessels operating in the Arctic are not subject to the two fees levied on commercial vessels operating in Canadian waters — the marine navigation services fees (for aids to navigation) and the icebreaking services fees (Poland 2021). This does not stem from a desire to promote Arctic shipping but rather from an obsolete fee structure, as Sylvie Pelletier (2015) hinted at when she was regional director of the Canadian Coast Guard programs, and as the Coast Guard (2014, 28) acknowledged. A revision was planned but delayed because of “other priorities” (Pelletier 2015; Poland 2021). It is worth noting that there is no policy intended to promote transit shipping across the NWP, contrary to Russia’s active efforts to promote transit and destinational traffic on the Northern Sea Route (Government of Russia 2018; Staalesen 2018; Blakkisrud 2019; Moe 2020).

3. AN EXPANSION OF NATURAL EXTRACTION RESOURCES

Mining activities are expanding in the Canadian Arctic but the pace is slow, as Arctic conditions remain harsh, while climate change causes more complicated logistics and shipping conditions both inland and offshore. Solutions to navigation challenges do exist — the key driver is commodity prices in world markets (Lasserre and Pic 2021). There are probably significant oil and gas deposits in the Beaufort Sea, but Canada signed a five-year moratorium in 2016 on Arctic offshore oil and gas exploration (Canada Gazette 2016). It is unclear if the moratorium will be removed or extended beyond December 31, 2021, although the Nunavut Impact Review Board has recommended the moratorium be extended until 2026 to ensure proper research and consultation on possible impacts of exploration and exploitation (Lasserre and Pic 2021). Furthermore, according to public polling done by Environics Research, over 60 per cent of the population in the territories and 58 per cent of the population in the provinces want the moratorium to be extended until 2026 (Anselmi 2019).

CONCLUSION

Canada's Arctic shipping routes have to be seen in the broader context of attempts to integrate the Northwest Passage into ocean networks and to integrate economic activities with either global markets for resources or southern Canadian markets for consumer goods. As this study demonstrates, developing a Canadian policy on Arctic shipping requires understanding market changes, shipping strategies, evolving regulatory regimes and risk assessments (Giguère et al. 2017; Lasserre 2021). Development of commercial shipping in the Canadian Arctic is ongoing, although it did not take the form that was heralded at the beginning of the 21st century, and despite the fact that it is not actively promoted by the Canadian government. Largely driven by community resupply and natural resource extraction, mostly mining, shipping can be both an economic growth enabler as well as a hazard for the natural environment.

Due to the constraints that ice still imposes on shipping, destinational traffic is likely to remain dominant in the foreseeable future. Unlike Russia, Canada does not pursue a proactive policy that aims to bolster the development of transit shipping through the Northwest Passage. While a few shipping companies may be interested in operating in the niche market this route represents, transit traffic is likely to remain marginal.

Traffic generated by mining activities is likely to keep expanding provided no severe collapse of world commodity prices occurs. Several mining sites are being actively explored and havens have been built in Hope Bay and Bathurst Inlet. However, these mining projects concern precious metals or gems that require little transport capacity, with traffic mostly generated by the resupply of mining operations. Extraction of industrial metals, which generates huge volumes of ore, requires the construction of deep-sea ports and connecting land transport infrastructure.

Community resupply may also experience continued expansion, partly fuelled by mining ventures. However, expansion may be contingent on improved port facilities in the Canadian archipelago. The development of deep-water wharves in selected communities, such as Churchill and Iqaluit, could simplify operations and improve shipping services, lowering prices of consumer goods and providing the opportunity to ship locally produced goods to southern markets. These ports could develop into regional hubs similar to those that once flourished in Churchill, Moosonee and Cambridge Bay during NTCL's heyday. NEAS and Desgagnés are considering this option for Churchill.

The construction of northern corridors could prove very useful for the improvement of community resupply and the servicing of mining activities. This is less probable as demonstrated by the poor performance of the port of Churchill, but it could help develop international traffic to and from Canada through Arctic routes. Corridors remain very costly to build in remote, sparsely populated areas. Their profitability would be better supported if they were oriented towards clusters of communities and several mining projects, with the caveat that mining sites have limited periods of activity.

In this context, northern land corridors may support the development of community resupply by facilitating the reloading of ships already positioned in Arctic waters. They could also help support mining activities but would have to face the test of profitability given the expensive investments they entail.

It is therefore paramount to make sure regulations are appropriate, well-understood and observed by shipping companies. Further research is needed to fine-tune regulations, potential corridors and navigational aids and to better outline the trends in the Canadian shipping market in connection with extractive industries, community economic development, fishing, tourism and possibly the advent of transit traffic.

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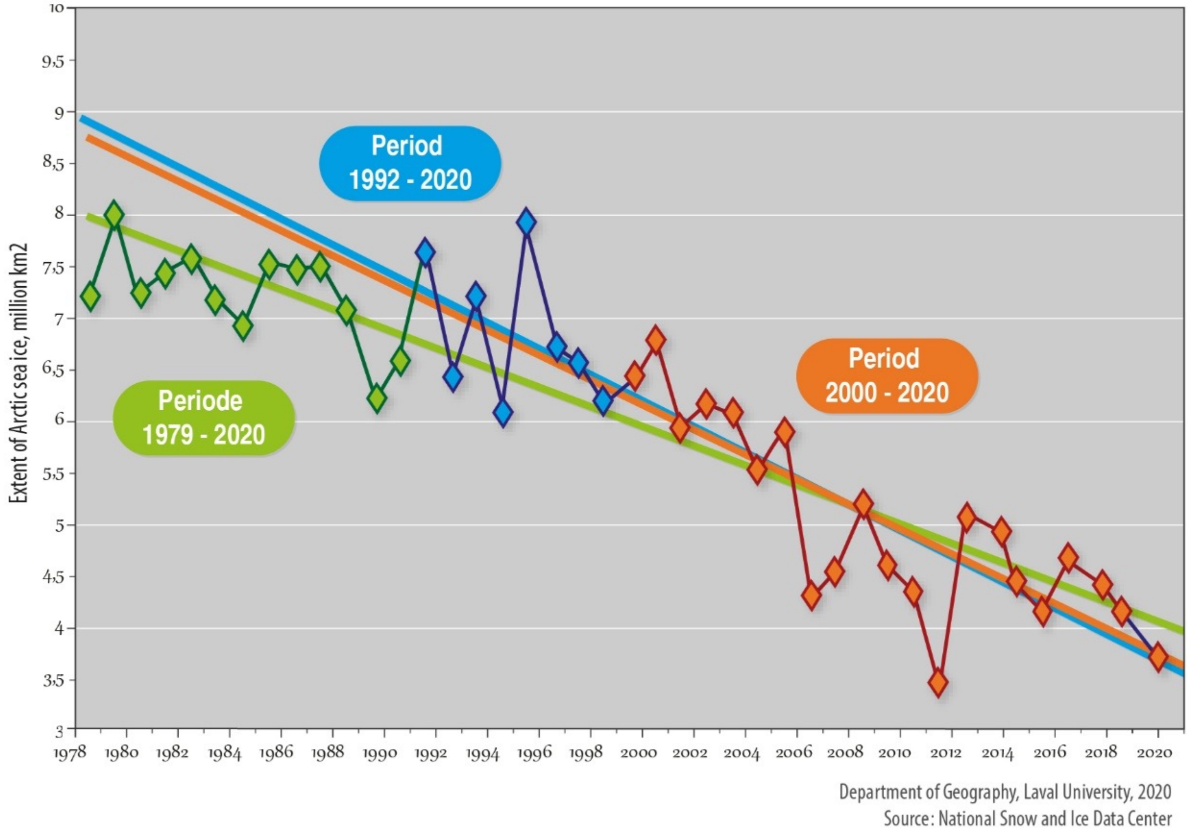
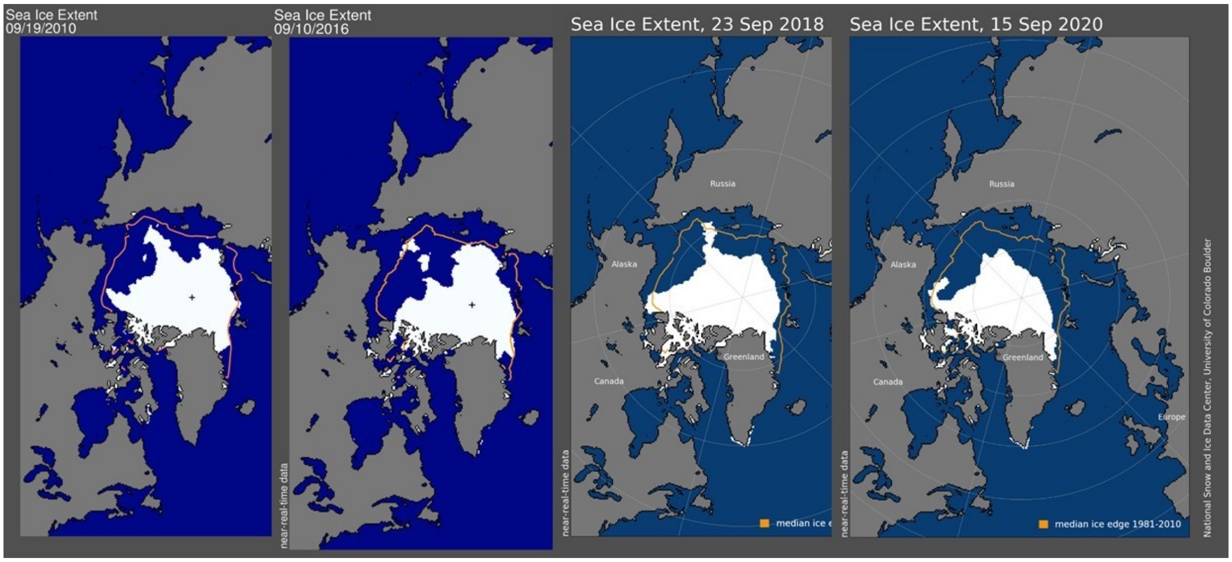
APPENDICES

Figure 1. The Decreasing Extent of Sea Ice at its September Minimum



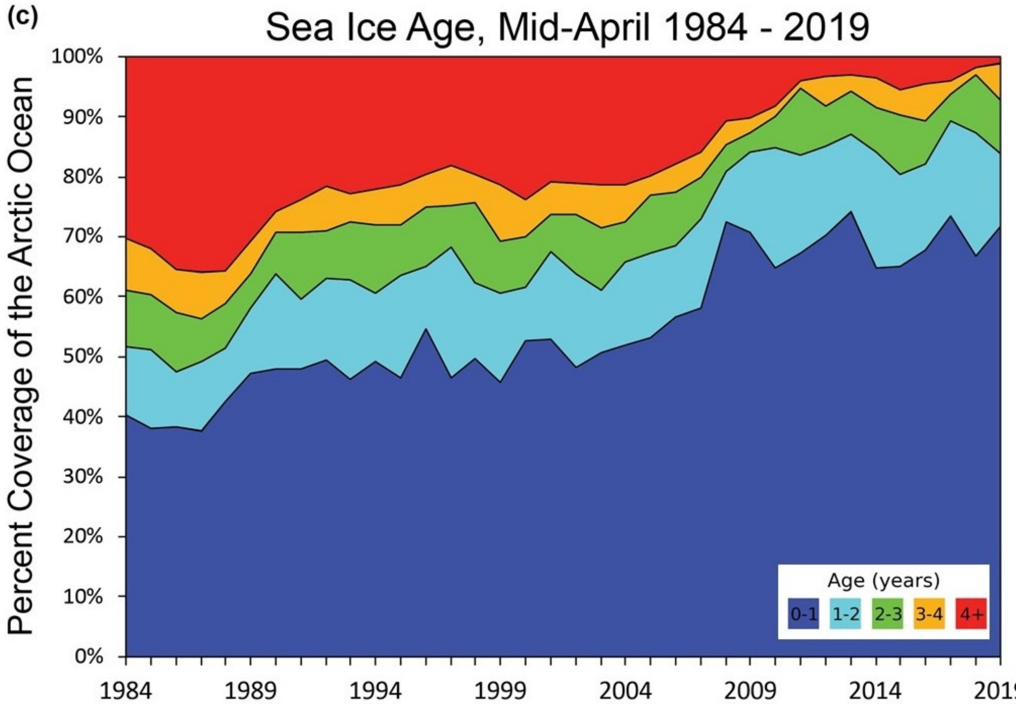
Source: Data compiled by F. Lasserre from NSIDC annual figures.

Figure 2. Spatial Distribution of Minimum Arctic Sea Ice



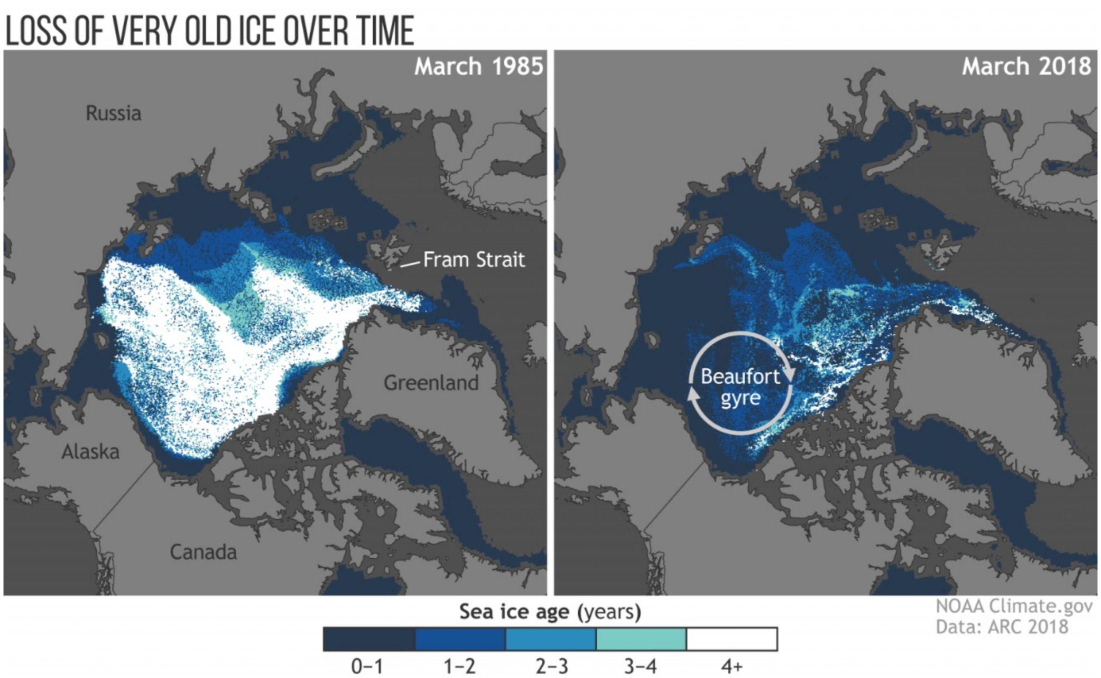
Source: Adapted by author from NSIDC maps, www.nsidc.org.

Figure 3. The Vanishing Multi-year Ice



Source: W. Meier, NSIDC (2019), Sea Ice Age Update, NSIDC, https://nsidc.org/arcticseaicenews/2019/05/ , accessed March 12, 2021.

Figure 4. Spatial Contraction of Multi-year Ice Near the Canadian Arctic Archipelago



Source: NSIDC (2020), Multiyear Ice, https://nsidc.org/cryosphere/seaice/characteristics/multiyear.html, accessed March 15, 2021.

Figure 5. Damage Caused to the Reduta Ordona by Collision with a Growler in Hudson Strait, Manitoba, July 21, 1996 (Quebec City, MIL Davie Shipyard)

Source: Courtesy Brian Hill and MIL Davie, in B. Hill (2016), "Iceberg Right Ahead: Historic Photographic Evidence May Lend Support to a Counterintuitive Strategy for Ship Captains Seeking to Survive Iceberg Collisions." *Cutting Edge*, vol. 2, http://cuttingedge.isgp.ubc.ca/journal/volume-2/2016.

Figure 6. Mining Operations and Projects 2021

Sources: Author from governments of Nunavut, NWT and Yukon; professional mining websites.

Figure 7. The Haven (small jetty facilitating the unloading for large barges) in Baker Lake

Note that the tanker is moored offshore while unloading fuel.

Source: Author using Google Earth, April 2021. Picture dated August 6, 2019.

Figure 8. Bathurst Inlet Haven Servicing Sabina Gold Project

The carrier uses pushed barges, most likely exploited by MTS.

Source: George (2018)/Sabina Gold and Silver Corp.

Figures 9 and 10. Unloading Operations in Arctic Communities

Source: Varga in Rogers (2014); Ryan (2017).

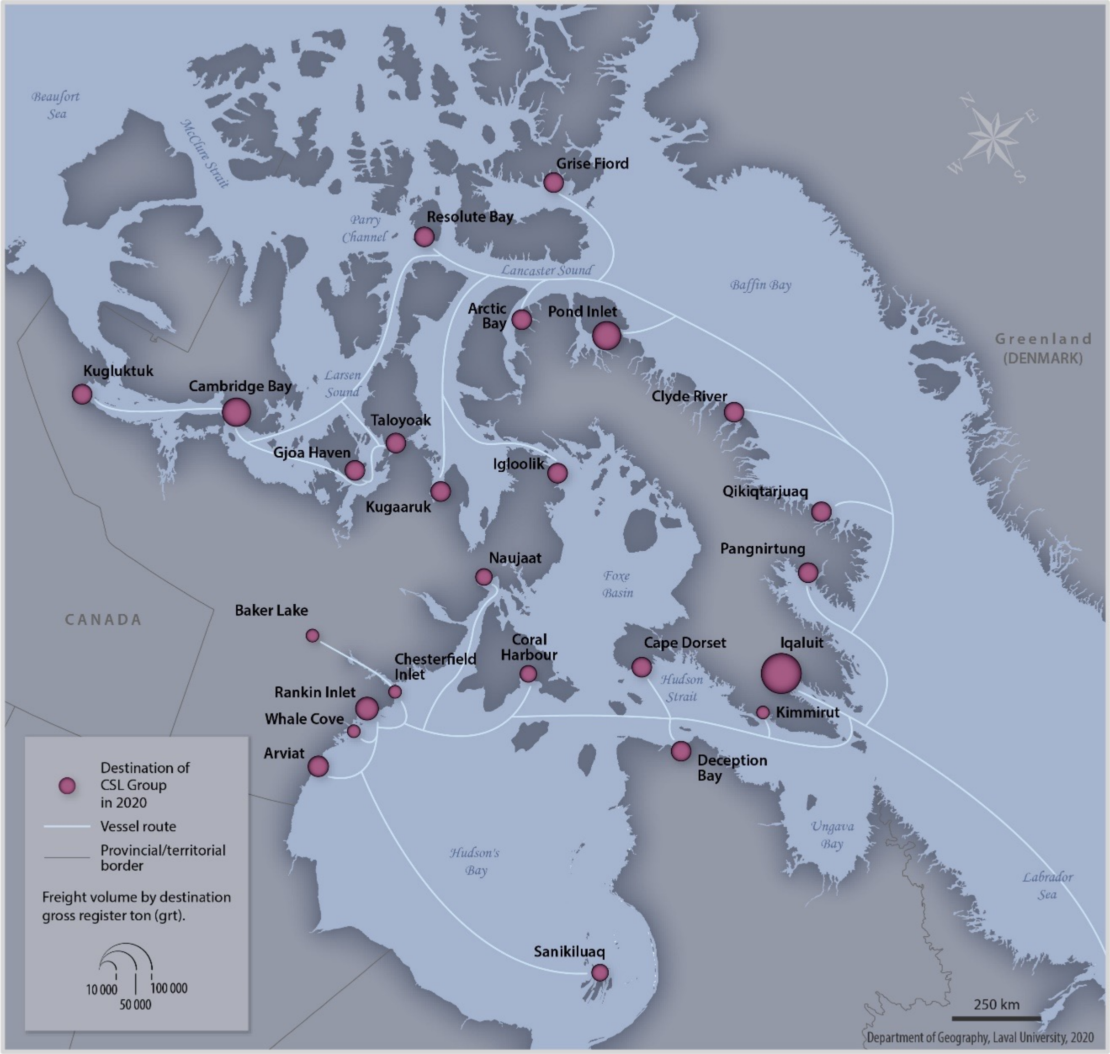
Figure 11. Network Serviced by NTCL 2008

Source: Author from NTCL timetable.

Figure 12. MTS Network, 2020

Source: Author from MTS timetable.

Figure 13. Coastal Shipping Ltd. Network, 2020



Source: Author from CSL schedule.

Figure 14. NEAS Network, 2008

Source: Author from NEAS schedule.

Figure 15. NEAS Network, 2020

Source: Author from NEAS schedule.

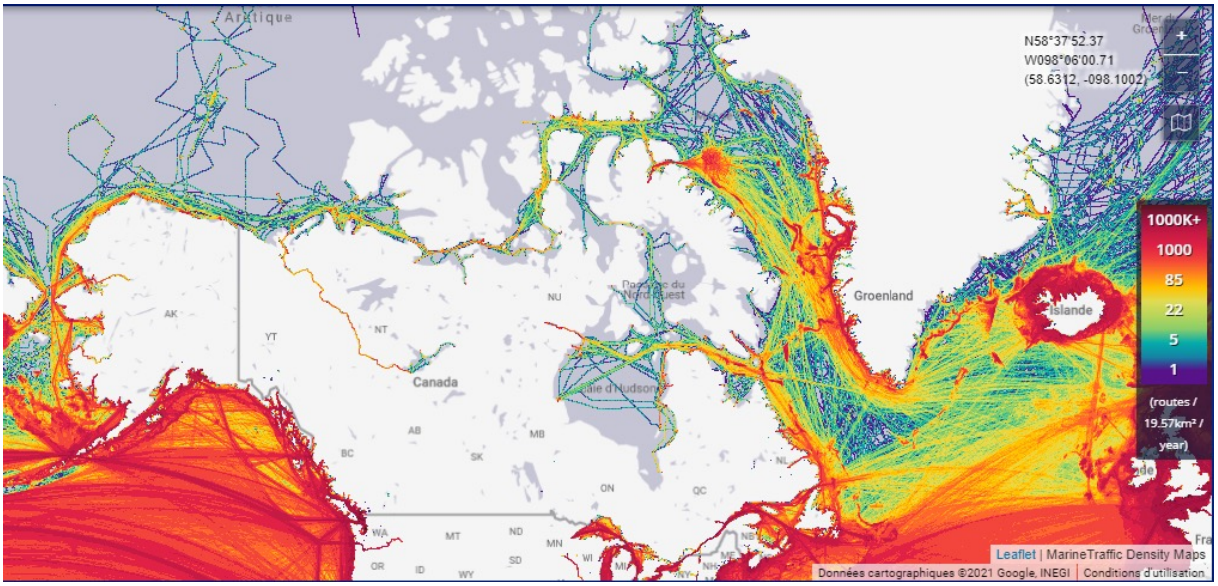
Figure 16. Desgagnés Network, 2008.

Source: Author from Desgagnés' schedule.

Figure 17. Desgagnés Network, 2020.

Source: Author from Desgagnés' schedule.

Figure 18. Traffic Density in 2019



Source: Marine Traffic, AIS data, 2021, https://www.marinetraffic.com/.

About the Author

Frédéric Lasserre holds a Master of Commerce (ESC Lyon, 1990), an MBA (York U., Toronto, 1991), an MA in Geopolitics (U. Paris VIII, 1992) and a Ph.D. in Geography (U. Saint-Étienne, France, 1996). He worked as a consultant with the European Observatory of Geopolitics (OEG, Lyon, France) on the political and economic transformations of Central and Eastern Europe after the fall of the Berlin Wall, then as a foreign language instructor in Japan, then as Advisor in International Affairs on Asian Desks at the Quebec Ministry of Trade and Industry; and then with Investissement Québec, the Crown corporation responsible for the promotion of foreign investment in Quebec. He is Professor since 2001 in the Department of Geography at Laval University (Quebec City). He acted as Project Director with the international ArcticNet research network. He is also researcher with the Ecole Supérieure d'Études Internationales (ESEI) and chairs the Conseil québécois d'Études géopolitiques (Quebec Council for Geopolitical Studies, CQEG) at Laval University.

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