

Article

Ice-Breaking Fleets of the United States and Canada: Assessing the Current State of Affairs and Future Plans

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Abstract: In recent years, a continuous decline of ice-coverage in the Arctic has been recorded, but these high latitudes are still dominated by earth's polar ice cap. Therefore, safe and sustainable shipping operations in this still frozen region have as a precondition the availability of ice-breaking support. The analysis in hand provides an assessment of the United States' and Canada's polar ice-breaking program with the purpose of examining to what extent these countries' relevant resources are able to meet the facilitated growth of industrial interests in the High North. This assessment will specifically focus on the maritime transportation sector along the Northwest Passage and consists of four main sections. The first provides a very brief description of the main Arctic passages. The second section specifically explores the current situation of the Northwest Passage, including the relevant navigational challenges, lack of infrastructure, available routes that may be used for transit, potential choke points, and current state of vessel activity along these routes. The third one examines the economic viability of the Northwest Passage compared to that of the Panama Canal; the fourth and final section is investigating the current and future capabilities of the United States' and Canada's ice-breaking fleet. Unfortunately, both countries were found to be lacking the necessary assets with ice-breaking capabilities and will need to accelerate their efforts in order to effectively respond to the growing needs of the Arctic. The total number of available ice-breaking assets is impacting negatively the level of support by the marine transportation system of both the United States and Canada; these two countries are facing the possibility to be unable to effectively meet the expected future needs because of the lengthy acquisition and production process required for new ice-breaking fleets.

Keywords: arctic shipping; infrastructure support; ice-breaking vessel; sustainability



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1. Introduction

An extremely simplistic definition of the “Arctic,” would be to describe it as the areas around the North Pole. This region was, until recently, considered a harsh and unapproachable environment; but, unprecedented climate change (e.g., significant decline of the oceanic ice cover, rising atmospheric and ocean temperatures) combined with technological advances now available to mitigate adverse environmental conditions, provide an extraordinary opportunity to capitalize on a plethora of untapped resources. The Arctic is considered a promising field for future economic activities, such as offshore energy and exploration, tourism, fishing, and last but not least, maritime transport. The promise for shorter voyages from Asia toward Europe and/or the Americas (and vice-versa) is very enticing; navigation along the Northern Sea Route (NSR) and/or the Northwest Passage (NWP) is now more feasible [1,2]. It is therefore no coincidence that the Arctic region has become a site of intense geopolitical intrigue between practitioners and spectators of geopolitics and international relations [3–7].

Before proceeding any further, it is necessary to clarify that for the purposes of the analysis in hand, the “Arctic” is defined as the area containing the Arctic Ocean as well as the respective territories of the States with a latitude higher than the Arctic Circle ($66^{\circ}33'48.3''$ N); the land within the Arctic Circle is divided among eight countries: Norway, Sweden, Finland, the Russian Federation, the United States of America (Alaska), Canada, Denmark (Greenland), and Iceland (where it passes through the small offshore island of Grimsey) (Figure 1).



Figure 1. Map of the Arctic from the Perry-Castenada Library Map Collection Courtesy of the University of Texas Libraries, The University of Texas at Austin. The dashed blue circle indicates the definition used by the Arctic Council; the red line represents the 10-degree isotherm.

The Arctic marine ecosystem and the communities that depend upon it continue to experience unprecedented changes as a result of warming air temperatures, declining sea ice, and warming waters [8]; their survival and ensuring a prosperous future will require certain interventions, under the notion of sustainability. The 2019 Arctic Report Card draws particular attention to the Bering Sea Region, where declining winter sea ice exemplifies the potential for sudden and extreme change. Over the past forty-two years, the annual average sea-ice extent has substantially decreased, melting trends have rapidly accelerated, and Arctic temperatures have soared at unprecedented rates; various statistics compiled in the 2019 Arctic Report Card continue to set new records to back up these developments. The average annual land surface air temperature north of 60 °C for October 2018–August 2019 was the second warmest since 1900 (after 2015/16) and the Arctic sea ice extent at

the end of summer 2019 was tied with 2007 and 2016 as the second lowest since satellite observations began in 1979. While statistical data show slight variation on a yearly basis, the annually averaged Arctic air temperature for the past six years (2014–2019) all exceeded previous records since 1900 and set a precedence that the Arctic region has embarked on a new normal [8].

Furthermore, it is useful to note that the winter sea ice extent in 2019 narrowly missed surpassing the record low set in 2018, leading to record-breaking warm ocean temperatures in 2019 on the southern shelf. Coupled with the sea ice extent, the thickness of the sea ice has also decreased, resulting in an ice cover that is more vulnerable to warming air and ocean temperatures as highlighted by the August mean sea surface temperatures in 2019 that were 1–7 °C warmer than the 1982–2010 August mean in the Beaufort and Chukchi Seas, the Laptev Sea, and Baffin Bay [8]. There is also a declining trend in the extent of the sea ice cover, particularly the oldest, thickest ice (>4 years old) that makes up just a small fraction of the sea ice cover. For comparison, in March 1985, at the end-of-winter maximum extent, 33% of the ice cover within the Arctic was made up of very old ice, but in March 2019 old ice constituted only 1.2% of the ice cover.

While these trends seem to indicate less of a need for ice-breaking capabilities in the Arctic region, it is in fact, the volatile and unpredictable nature of first-year ice that make maritime navigation in this region more dangerous because of the unanticipated ice floes and jams and therefore requires access to ice-breaking support. Furthermore, the warming is vastly altering the Arctic ecosystem thus creating challenges for the Indigenous peoples that rely heavily on the local land and water for access to subsistence foods and the stability of the environment for cultural and economic well-being, forcing them to travel on unstable ice farther and farther away from traditional hunting grounds. As a multi-functional platform, icebreakers are also vital to the search and rescue (SAR) mission in the Arctic and their enhanced presence is needed to support the region and its Indigenous peoples that are in peril due to Arctic amplification of global warming [9].

Because of all these changes, the Arctic is just now considered “more suitable” for economic activities and a region within which certain industries will be able to facilitate their operations. This, of course, comes as no surprise given the past harsh year-long environmental conditions that significantly hindered or even completely blocked the necessary access and transport connections [10]. Therefore, over the last couple of decades, when referring to the global volume of maritime traffic, the total contribution of the Arctic region was (and remains) rather small. Also, the vast majority of its coastal areas were (and still are) characterized by a severe lack of transportation infrastructure, inhibiting their significant contribution to global economic activity. But, the present environmental status within the Arctic landscape, in conjunction with the future trajectories of sea ice retreat provides a good motive for competing entities within the maritime transport sector to explore these northern routes, also called “Arctic Passages,” as alternatives to more traditional transcontinental corridors. For those looking to explore the once inaccessible routes of the Arctic, navigation along the NSR and/or NWP (Figure 2) can now provide shorter travelling times between Asia and Europe/the Americas compared to the traditional routes via the Suez and Panama Canals. Furthermore, it is important to consider that the days when navigation is possible in these northern routes are expected to follow an increasing trend: from about 70 days (now) up to 125 in the year 2050, and as many as 160 in 2100 [11].

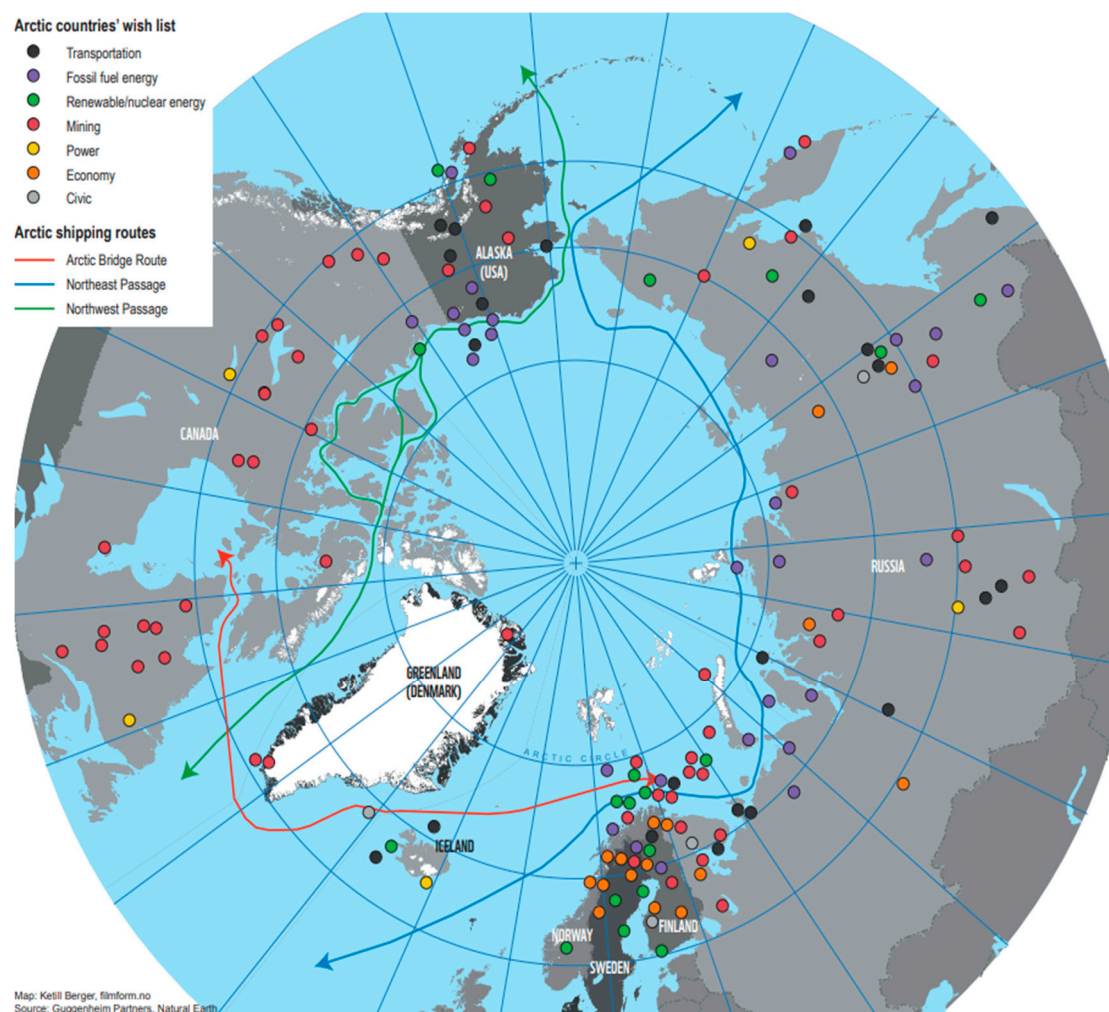


Figure 2. The Arctic routes and projects on Arctic countries' wish list, Courtesy of the WWF Arctic Programme [12].

This retreat of ice has made the Arctic more accessible, creating a renewed interest and confidence among those looking to extract major reserves of oil and gas, navigate faster shipping routes, and engage in mining, fishing, and eco-tourism opportunities (Figure 2). Regions of high concentrations of Arctic marine activity occur along the coasts of northwest Russia and in the ice-free waters off Norway, Greenland, Iceland, and in the U.S. Arctic [13,14]. Of particular interest is that computer simulation models in the Proceedings of the National Academy of Science depict the fastest routes available between 2006 and 2015 for ships without a reinforced hull (non-ice strengthened) during the summer (depicted by the blue lines), while red lines depict routes available for Polar Class 6 ships with moderate ice-breaking capacity (Figure 3A). These simulations predict that even with a moderate climate change impact, many more routes will be available around the 2040-time frame, including the possibility of Polar Class 6 ships ramming through the middle of the North Pole (Figure 3B) [15]. Currently, the fastest available routes between North Atlantic and Asian Pacific ports for non-ice strengthened vessels are along the Northern Sea Route (NSR) and the Northwest Passage (NWP). Voyage statistics for the NSR and NWP clearly demonstrate increasing traffic, although trans-Arctic voyage numbers are rather modest [16,17].

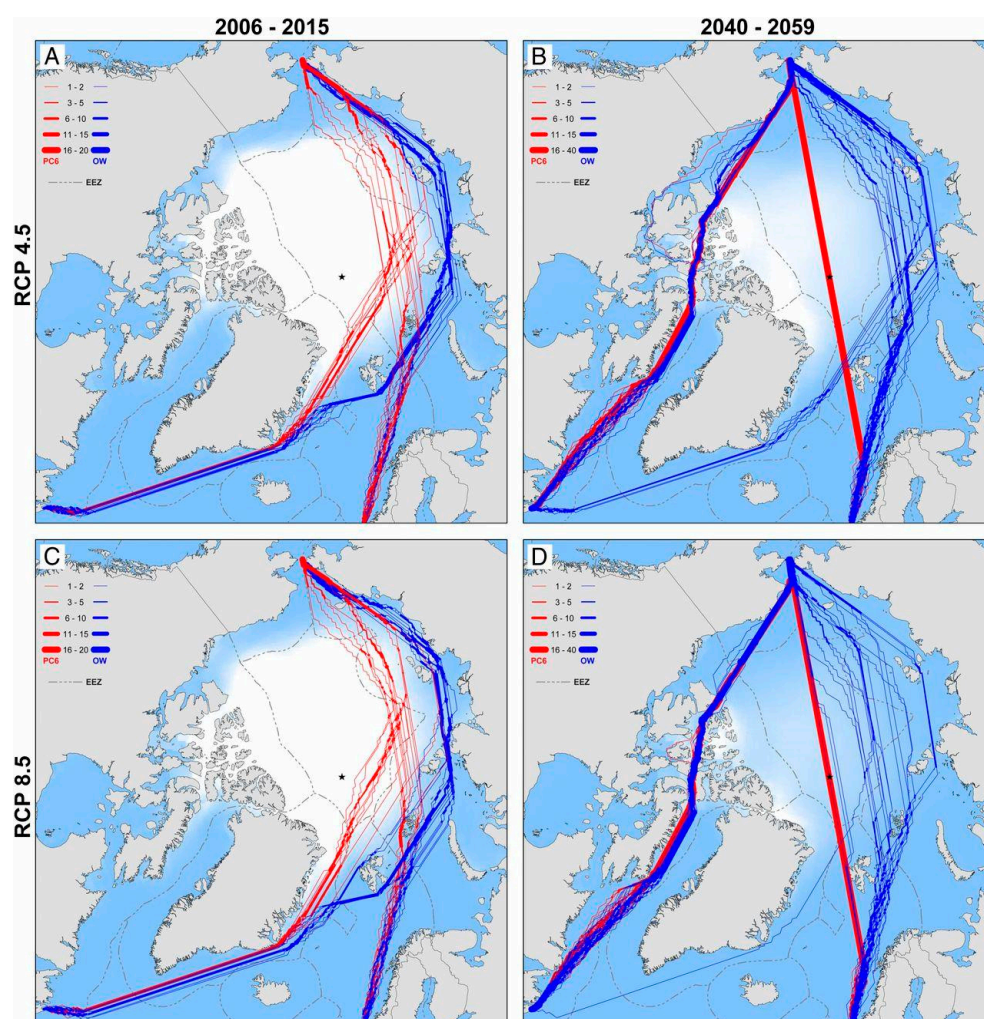


Figure 3. Fastest routes available for common-water ships and Polar Class 6 ships from 2006–2015 and projected routes from 2040–2059 (Smith, L.C.; Stephenson, S.R. New Trans-Arctic shipping routes navigable by midcentury. *Proceedings of the National Academy of Sciences* **2013**, 110(13), E1191–E1195; DOI:10.1073/pnas.1214212110). Representative concentration pathways (RCPs) used to make projections are based on several factors to include greenhouse gas emissions. RCP4.5 portrays an intermediate scenario (A,C) whereas RCP8.5 highlights a scenario impacted by very high greenhouse gas emissions (B,D) [18].

It is also important to consider that a certain number of Arctic States heavily rely on fishing activities as a tool to support local economies. It is indicative of the fact that there are approximately 214 fishing vessels registered in Northwest Russia and 3500 registered in the Northern Norway region, with 150 being large trawlers and pelagic fishing vessels. Additionally, the Icelandic fishing fleet has remained fairly constant over the last decade and consists of approximately 1700 vessels (50 large vessels). Fishing in Greenlandic waters is conducted by a limited number of shrimp trawlers and numerous small-sized boats, ranging between 1500 and 2000 in total number [19]. The current analysis is contributing into the wider Arctic literature by examining the current state of affairs in relation to the total number of icebreakers operating in vicinity of the Northwest Passage, including the plans for future upgrades and building of new vessels. Its importance is made clear by the fact that ice and ice-packs will remain a concern in the future and therefore the support of icebreakers are still needed to facilitate the safe passage of ships. Icebreakers have multiple uses; from resupplying isolated communities and outposts to scientific exploration, search

and rescue (SAR), as well as an issue of critical importance for shipping: ensuring that sea lines of communication remain ice-free for commercial use.

In order to provide the necessary background for the Arctic in terms of geographic details, a brief discussion of the “Arctic Passages” is provided next. Additionally, it is important to factor in that icebreakers are the backbone of any presence in the Arctic, both military and civilian. This is a critical issue as there is a contradicting view between the United States and Canada concerning the legal status of the NWP and icebreakers may play a critical role in exerting a nations sovereignty in addition to their other multiple uses; from resupplying isolated communities and outposts to scientific exploration, search and rescue (SAR), and of utmost importance for shipping: ensuring that sea lines remain ice-free. Considering that ice and ice-pacts will remain a concern in the future, the support of icebreakers will still be needed to facilitate the safe passage of ships. Describing the state of these types of vessels currently available is the main aim, with a particular focus on the United States and Canada. Additionally, a critical evaluation of future plans in relation to the introduction of icebreakers into service is taking place.

2. Description of Arctic Passages

The Arctic Ocean is an area of approximately 14 million square kilometers and is confined by landmasses of Norway, Greenland, Canada, the United States, and Russia. Connection to the Pacific Ocean is through the Bering Strait and to the Atlantic Ocean predominately through the Greenland and Barents Sea. For the purposes of this section, the focus will be on the two main routes connecting the Pacific Ocean and the Atlantic Ocean.

The Northeast Passage (NEP) connects the Atlantic and Pacific Oceans through the eastern part of the Arctic Ocean; its boundaries are extending from Novaya Zemlya (west) to the Bering Strait (east). Its significance lies in its potential as an alternative to the Suez Canal Route, making the distance travelled between Asia and Europe around 40% shorter compared to crossing the Indian Ocean. A portion of the NEP along the northern Russian coastline and Norway, called the NSR, has so far attracted the greatest majority of the Arctic maritime traffic. In 1932, the Council of People’s Commission of the USSR formally asserted it as a legal entity under Russian jurisdiction [20]. It is important to note that in order to increase the attractiveness of the NSR, the Russian authorities have committed to provide the required icebreaker support and SAR response year-round through the Marine Rescue Coordination Center in Dikson, Northern Russia, with additional support during the months of July through October from the two allocated marine rescue sub-centers of Tiksi and Pevek [14]. Russia currently advertises the support of five icebreakers, two of which possess diving equipment and oil spill response equipment along the NSR [2].

On the western edge of the Arctic Ocean, the NWP runs between Greenland and Newfoundland in the Atlantic Ocean, and along the northern coast of Canada and Alaska, ending in the Bering Strait. The NWP links the Atlantic and Pacific Oceans through the Canadian Arctic Archipelago. The route is 9000 km shorter than the Panama Canal transit and 17,000 km shorter than the Cape Horn route [21]. The NWP route classification has been categorized by Donat Pharand in his book under the title “The Arctic Waters and the Northwest Passage: A Final Revisit” as a compilation of seven possible routes through the Canadian Arctic. The west is comprised of three feasible paths: The M’Clure Strait, the Prince of Wales Strait and the Peel Sound. In the East, the passage is traditionally limited to the Lancaster Sound [22]. The Beaufort Sea region generally becomes ice free in August-September, while in most years the M’Clure Strait is prone to being blocked by Old Ice (OI) [23].

The next section will further elaborate on the NWP, taking into account that this route is increasingly sea ice-free as a result of unprecedented sea ice loss, with increased vessel traffic expected by midcentury [15]. Despite the increasing ice-free state of routes along the NWP, a further analysis of the different routes and potential choke points will occur, including their viability to support maritime activities in the future, and the continued need for ice-breaking assets as a result of the potential marine hazards that will still arise

because of the rapid rate at which sea ice is dissolving. This rapid thawing will give way to the increased likelihood of hull-penetrating, high-latitude multiyear ice (MYI) flowing into the NWP shipping lanes [24].

3. Current Situation of the NWP

The number of vessels navigating these waters is lower compared to the NSR. This is due to various reasons, including complex geography (there are many narrow and shallow corridors along this specific passage), as well as ocean currents, along with drifting ice packs that block many of the entrance and exit sites. Also, there is a different view between Canada and the U.S. regarding the legal regime of the passage (Canada maintains the position that these waters are “internal” therefore fall under its jurisdiction, but the U.S. maintains the high seas status respectively) [25,26]. Hinterland connection is another setback; venturing transport through the northern territories of Canada and Alaska has been characterized as the logistical equivalent of a lunar landing [27]. The NWP is mainly regarded as an alternative to the Panama Canal, though the investments on the latter to increase its size and crossing speed will help maintain its competitiveness in the near future. Additionally, icebreaker services in this area are extremely low both in quantity and quality compared to those offered by Russia for the NSR.

In addition to navigation challenges and lack of infrastructure and response capabilities, coupled with the potential of unforeseen maritime accidents and environmental disasters, there are looming energy, infrastructure, and geopolitical ambitions amongst many countries with a vested interest in the region (Figure 2). For many countries, the Arctic presents an investment opportunity to elevate their strategic and economic significance as well as boost their international status. Russia, the United States, Canada, Denmark, and Norway have all been trying to assert jurisdiction over part of the Arctic. In fact, Denmark, Canada, Norway, and Russia have already made submissions in relation to the Arctic seabed to the United Nations Commission on the Limits of the Continental Shelf (CLCS), which was established by the 1982 United Nations Convention on the Law of the Sea [28]. Recently, in August of 2015, Russia resubmitted a bid to the CLCS claiming vast territories in the Arctic, specifically laying claim to 1.2 million square kilometers (km) of sea shelf extending more than 350 nautical miles from the shore [29].

Furthermore, for these countries claiming a presence in Arctic developments, it is imperative that a prominent maritime presence is clearly established. It is important to fully understand that major technological advances in overall safety systems onboard ships to include design and construction standards and navigational aids and equipment have renewed the interest of both Canada and the United States regarding the benefits associated with the NWP [30]. Canada maintains the position that the NWP, especially those areas in the Arctic Archipelago, are internal waters to Canada and should be provided with the right to prohibit transit [23]. This interpretation is not held by most maritime nations, including the United States and a certain number of European Union’s member-states that consider the NWP as an international strait according to the description outlined in the 1982 United Nations Law of the Sea Convention [28]. This distinction is incredibly important because applying the UNCLOS provisions limits Canada’s rights to enact fishing and environmental regulations, fiscal and smuggling laws, shipping safety laws, but leaves the passage as an international strait open to all nations [31].

The earliest traverse of the Northwest Passage was completed in 1853 but used sledges over the sea ice of the central part of Parry Channel [32]. Since that time, 313 complete maritime transits of the Northwest Passage have been made through the end of the 2019 season, before winter began and the passage froze [33]. The seven routes that have been used for transits of the NWP are shown in Figure 4 and detailed below as follows:

1. Davis Strait, Lancaster Sound, Barrow Strait, Viscount Melville Sound, McClure Strait, Beaufort Sea, Chukchi Sea, Bering Strait. This route is considered the shortest and deepest, but difficult, way owing to the severe ice of McClure Strait. This route is

preferred by submarines because of its depth (only two crossings of this type have ever been reported).

2. Davis Strait, Lancaster Sound, Barrow Strait, Viscount Melville Sound, Prince of Wales Strait, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This route is considered an easier variant of Route 1, which may avoid severe ice in McClure Strait. It is considered suitable for deep draft vessels.
3. Davis Strait, Lancaster Sound, Barrow Strait, Peel Sound, Franklin Strait, Victoria Strait, Coronation Gulf, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This is considered the principal route; used by most larger vessels of draft less than 14 m.
4. Davis Strait, Lancaster Sound, Barrow Strait, Peel Sound, Rae Strait, Simpson Strait, Coronation Gulf, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This route is a variant of Route 3 for smaller vessels if ice from McClintock Channel has blocked Victoria Strait. Simpson Strait is only 6.4 m-deep and has shoals and complex currents.
5. Davis Strait, Lancaster Sound, Prince Regent Inlet, Bellot Strait, Franklin Strait, Victoria Strait, Coronation Gulf, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This route is dependent on ice in Bellot Strait, which has complex currents. This route is mainly used by eastbound vessels.
6. Davis Strait, Lancaster Sound, Prince Regent Inlet, Bellot Strait, Rae Strait, Simpson Strait, Coronation Gulf, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This route is a variant of Route 5 for smaller vessels if ice from McClintock Channel has blocked Victoria Strait. Simpson Strait is only 6.4 m deep and complex currents run in it and in Bellot Strait.
7. Hudson Strait, Foxe Basin, Fury and Hecla Strait, Bellot Strait, Franklin Strait, Victoria Strait, Coronation Gulf, Amundsen Gulf, Beaufort Sea, Chukchi Sea, Bering Strait. This is considered a difficult route owing to severe ice usually at the west of Fury and Hecla Strait and the currents of Bellot Strait. This route is mainly used by eastbound vessels as an alternative is practicable [32].

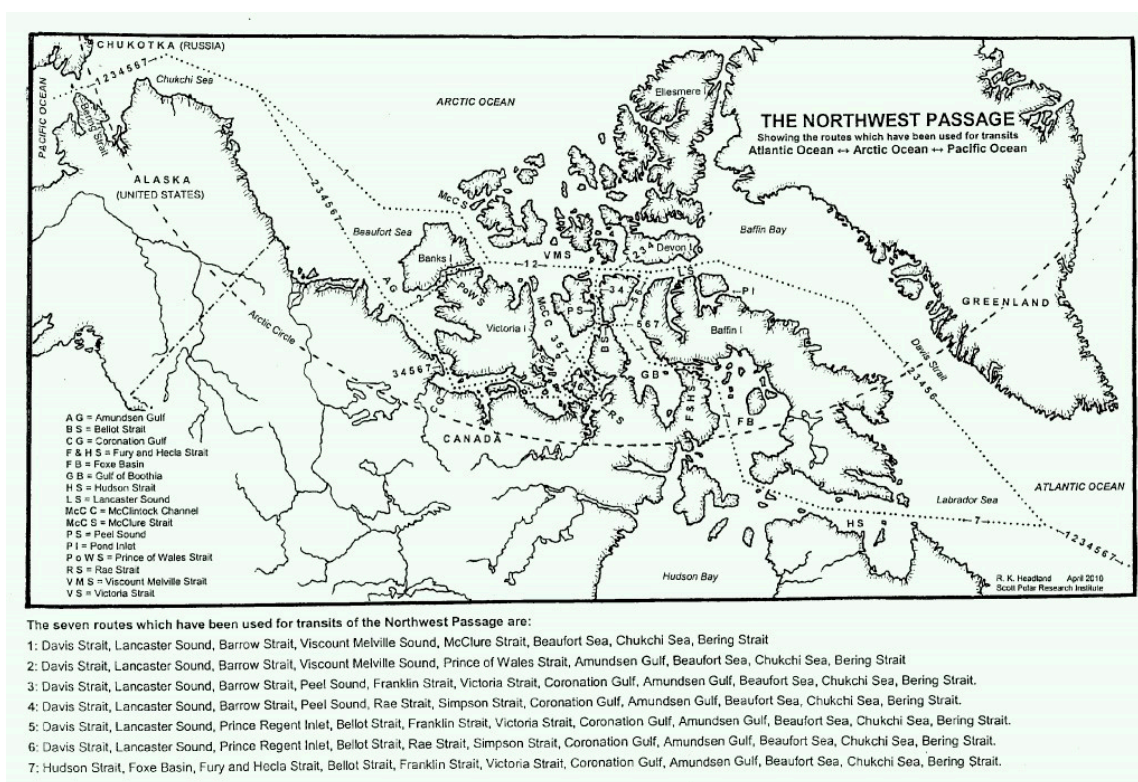


Figure 4. Seven routes used for transits of the Northwest Passage, Courtesy of R. K. Headland, Scott Polar Research Institute [32].

Complete transits have been made by 239 vessels from 41 registries out of the 313 complete maritime transits of the NWP that have been made through the end of the 2019 navigation season [33]. Most vessels enter the western portion of the NWP from the east through a southern route along the main coast—the Amundsen Gulf—or through two northern routes, either north or south of Banks Island [34]. Vessels have to steer around numerous natural configurations, shallow water, or floes, therefore adding or saving nautical miles or time per journey. Both of these main routes are open for a few months each year, in summer and early autumn. Even during this period, icebreaker escort may be required to support crossing traffic [35]. There are two possible choke points in the NWP shipping lanes as a result of increased MYI flows, one is the Viscount Melville Sound and the second is in the M'Clure Strait [24]. Therefore, it is imperative that ice-breaking services are available in these crucial areas given the renewed interest in using the NWP as an alternative and viable route to the Panama Canal.

4. Viability of the NWP

There have been numerous studies undertaken to analyze the economic viability of the NWP with diminished sea-ice covering the North Pole compared to the traditional and well-established Panama Canal. An economic analysis of container shipping through Canadian NWP published in 2016 concluded that the NWP has an advantage over the Panama Canal if it is open for free international passage regardless of ship size. However, if it is not free, its advantages depend on its toll fee. The lower the toll fee, the more advantages the NWP will boast [23].

Overall, vessel traffic has increased 166% between 2004 and 2016 in the NWP as a result of sea ice retreat and longer seasons [36]. Total of 22 vessels completely transited the NWP in 2012 followed by 24 vessels in 2013 including the first large ice-strengthened bulk carrier, the Nordic Orion, which conveyed 73,000 tons of coal from Vancouver to Finland in 2013. This was followed by a decline to only 15 vessels in 2014 due to a short and cold summer. More recently, there were 32 vessel transits in 2017 including the second journey of the cruise ship Crystal Serenity that traversed Pond Inlet under escort by RRS Sir Ernest Shackleton with approximately 1400 passengers and crew onboard. The 2019 season was a busy shipping season with 27 ships making a full transit through the Northwest Passage and 24 vessels making a partial transit according to the Canadian Coast Guard. While these numbers are lower than 2017, the 2019 season marked a rise in commercial traffic for the first time since 2016 after only five full transits in 2018 due to extremely challenging ice conditions.

The number of transits has increased in the last 22 years because of an increase in shipping activity by tug-supply vessels (half of them with ice-breaking capacity) involved in the oil and gas industry in Beaufort Sea. However, other types of ships, such as passenger ships offering Arctic tourism opportunities, oil/fuel tankers, drill ships, seismic vessels, and many others are taking advantage of the specific route. While it is not evident when the NWP may be suitable for regular commercial traffic based on lackluster physical and information infrastructure, destination traffic, mostly associated with current and future mining development, is expected to increase substantially in the Canadian Arctic [37]. The Baffinland mine alone exported roughly 3 million tons of iron ore in 2016, 4.1 million tons of iron ore in 2017 during its 75-day open-water shipping season and has applied for a permit to ship up to 12 million tons by 2020 [38] transported in 176 voyages of ore carriers between July and November each year [39].

In the U.S. Arctic, predictions show anywhere from a 100% (low-growth economic scenario) to a 500% (high-growth economic scenario) increase in vessel traffic [38]. Predictions vary greatly because of the uncertainties relating to expansion of oil and gas north in the region, infrastructure development, the number of vessels transiting the NSR and NWP and other variables [40]. It is also interesting to note that small-sized crafts dominate the maritime traffic. These are the most difficult types of vessel to deal with in SAR operations because of their limited associated equipment. In any case, even with the increase in shipping traffic in the NWP and the Beaufort Sea, conditions remain difficult

to navigate and the Canadian Ice Service warns that promoting increased shipping in the NWP should be done with caution and requires a high degree of preparedness for potential environmental incidents due to unmarked shallow areas, shifting topology of the seabed, fog, and dangerous weather. It was stated that “Shell was trying the logistical equivalent of a mission to the moon” [27].

There have long been concerns among the U.S. government federal agencies and Congressional leaders regarding the lack of U.S. Arctic infrastructure to keep pace with the growing demands of shipping, mining, oil, and gas exploration, and tourism. To prioritize action items to lessen the gap in available Arctic infrastructure (reliable charts, aids to navigation, communication, rescue capabilities, ports, etc.) the U.S. government outlined the U.S. National Strategy for the Arctic Region (NSAR) to include a follow on January 2014 Implementation Plan that tasked the Department of Transportation to prepare for an increase in activity in the Marine Domain. The International Council on Clean Transportation (ICCT) was commissioned in 2015 to assess possible scenarios for vessel activity in the U.S. Arctic over the course of the next decade. Specifically, the ICCT conducted a baseline analysis of vessel activity from 2011–2013 and examined current activity trends and inter-annual differences [40]. An economic analysis of variables was also conducted to evaluate the potential impacts on global growth on business-as-usual shipping in the Arctic as well as a diversion of traffic from other international shipping lanes [40]. The area of focus was limited to the Arctic vessel traffic through the Bering Strait and the North Slope of Alaska as influenced by potential growth in the NSR and NWP, in addition to resource exploration and development activities [40]. The vessel activity examined the northern Bering Sea, the Bering Strait, and the Chukchi and Beaufort seas.

Results of the ICCT 2015 study concluded that between 2015 and 2025, there may be a 500 percent increase in Bering Strait Transits over levels assessed between 2011 and 2013 (Table 1 and Figure 5). Specifically, maritime traffic north of the Bering Strait has increased 128 percent since 2008 [41]. While these numbers may not seem staggering, this is quite a large potential growth projection for the U.S. Arctic region.

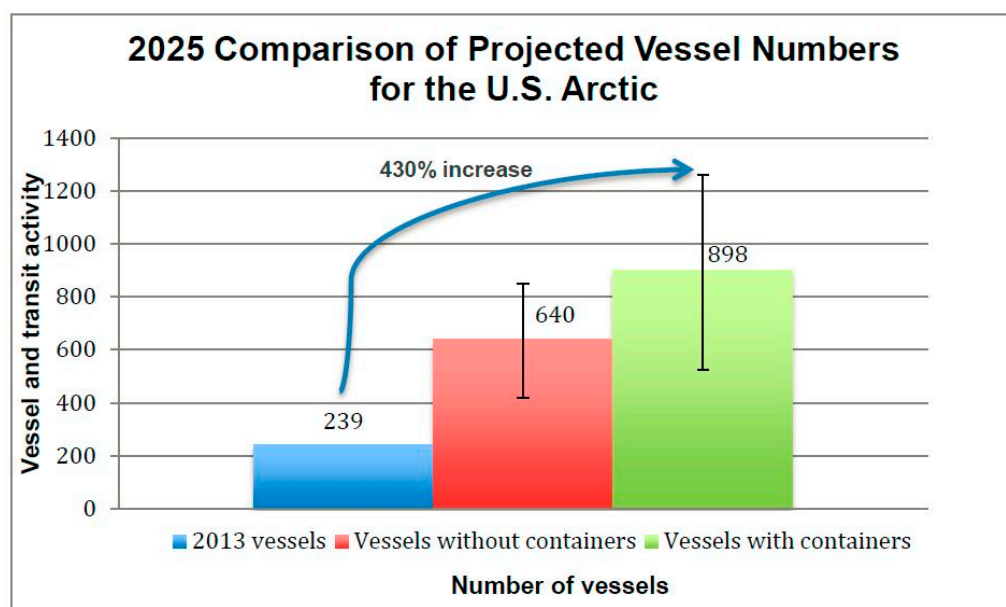


Figure 5. ICCT 2015 Study—comparison of projected vessel numbers in 2025 for the U.S. Arctic passing through the Bering Strait, Courtesy of ICCT.

Table 1. ICCT 2015 summary table of estimated growth for the Bering Strait and the North Slope, Courtesy of ICCT.

Vessel and Transit Growth for the Bering Strait and North Slope in 2025					
Type			Low	Medium	High
Bering Strait	% Change including container diversion	Vessels	120%	275%	430%
		Transits	150%	325%	500%
	% Change without container diversion	Vessels	75%	170%	255%
		Transits	100%	200%	300%
North Slope	% Change	Vessels	165%	260%	340%

5. Current Ice-Breaking Capabilities by Country

5.1. Status of the United States Icebreaker Fleet

The current condition of United States' icebreakers and this country's ability to protect the Arctic environment, regulate activity, and respond to crises is surprisingly very limited [42]. During loftier times, the U.S. fleet possessed eight icebreakers, but that number has dwindled to just two icebreakers over years of neglect and lack of attention. Currently, the country has only two polar icebreakers: one heavy (the Polar Star) and one medium (the Healy) [43]. The heavy icebreaker is more than 44 years old and acquires spare parts from her sister ship, the Polar Sea, which experienced an engine failure in 2010 and will not be put back into service following a 2017 cost-benefit analysis that concluded a refurbishment was too expensive. To make matters worse, the U.S. Coast Guard is in the beginning states of a long, complex, and expensive repair of the Healy, which suffered a crippling engine fire in August of 2020 in Seward, Alaska. The repair work involves the removal of its 106-ton engine, and floating a 23-year old replacement engine by barge from Baltimore, Maryland through the Panama Canal to the West Coast. As a result of the August fire, the United States had no operational icebreakers capable of deploying since the heavy icebreaker Polar Star recently completed a scheduled overhaul to prepare for a planned annual deployment to Antarctica in November in support of Operation Deep Freeze, which leads the breakout of McMurdo Sound to allow resupply of the McMurdo Station. Citing concerns stemming from the coronavirus pandemic and growing concerns of security in the arctic region, the U.S. Coast Guard announced on 1 November 2020, that it has reassigned its icebreaker, the Polar Star, to the Arctic in December 2020 instead of its normal role in supporting Antarctic affairs [44].

The U.S. Coast Guard's (USCG) own standard calls for three medium and three heavy icebreakers, a requirement that the service is nowhere near filling [45]. Despite the fact that the Coast Guard has a need for three Heavy Polar Icebreakers and three Medium Polar Icebreakers, the program emphasis is on Heavy Polar Icebreakers [43]. This apparent crisis is long in the making as the U.S. ice-breaking fleet has been neglected and the program has been routinely placed on the back-burner by Washington, D.C. The U.S. icebreaker fleet is operated by the USCG, but the exorbitant cost of funding the new generation of icebreakers falls way outside of an already limited Coast Guard budget. Making matters worse, not only is an ice breaker expensive, costing at least \$1 billion each, but it could take the U.S. shipbuilding industry—which has long ceased to build icebreakers—at least ten years to build a brand new one [46].

In an attempt to initiate the process of rectifying the U.S. preparedness gaps in the Arctic region, the U.S. Senate introduced a bill in March 2016 to contribute to bridging the icebreaker gap [47]. In a Request for Information (RFI), released on 25 October 2016, the USCG sought feedback from industry on the notional Heavy Polar icebreaker acquisition approach and schedule. The "Program" incorporated industry feedback from March 2016 into the published notional program schedule in the RFI and sought feedback from industry on how the construction of Heavy Polar Icebreakers may be further accelerated. Although

the schedule is a major driver, the USCG acknowledges that program affordability is a constant consideration that must be balanced.

More recently, on 2 March 2018, the U.S. Navy, in collaboration with the USCG under an integrated program office, released a request for proposal (RFP) to advance procurement and detail design for the Coast Guard's heavy polar icebreakers, with options for detail design and construction for up to three heavy polar icebreakers [48]. On 23 April 2019, the U.S. Coast Guard and Navy, awarded VT Halter Marine Inc., of Pascagoula, Mississippi, a fixed price incentive (firm) contract for the detail, design, and construction of the lead Polar Security Cutter (PSC). Construction of the first PSC is planned to begin in 2021 with delivery planned for 2024 [49]. If current plans hold, however, the Coast Guard will take delivery of three new PSCs over the next six years. Currently, only the first two have received funding and until such time that the Coast Guard receives the first new PSC, the service will keep the Polar Star operational although they acknowledge that a minimum of two heavy icebreakers is necessary to ensure national year-round access to the Polar Regions and to provide some self-rescue capability.

In a statement to Breaking Defense, USCG Admiral Karl Schultz stated "projecting leadership and protecting our national interests in the Arctic requires effective presence. The Coast Guard is the nation's most visible, agile, and adaptive force able to project U.S. sovereignty and vigorously compete for advantage in the region. Repairing Coast Guard Cutter Healy is critical to America's national security interests in the high latitudes" [45]. Given the bleak U.S. fleet of polar icebreakers, the respective American capabilities for the time-being remain rather limited as this is a significant disadvantage for the NWP. Acknowledging these failures, Admiral Karl Schultz called the situation "a woefully unacceptable level of presence in an area where we must be a leading force" during his State of the Coast Guard speech in February 2020.

Stemming away from operational assets and looking at the strategic planning outlook, the United States seems to be in the infant stages of development when it comes to their future Arctic policy compared to Russia. Until recently, policies from the Obama-era such as the 2013 National Strategy for the Arctic Region and the 2014 U.S. Navy Arctic Roadmap governed U.S. policy and strategies and focused on Russia as the key player and threat in the Arctic region. Only in April 2015, the United States International Security Advisory Board (ISAB) on Arctic Policy undertook a study of Russia's interests, intentions, and capabilities including an increased presence both military and civilian in the Arctic [50]. This ISAB study recommended six key areas that the U.S. should focus as it develops its future Arctic policy. All six recommendations are applicable to this analysis and urge the United States to: (1) continue U.S. leadership in the Arctic, (2) speed ratification of UNCLOS as an urgent imperative for U.S. national interests, (3) advance increased presence and domain awareness in the Arctic region, (4) increase and continue cooperation among the Arctic nations, (5) adopt appropriate policies regarding Russian interests, policies, and activities in the Arctic, and (6) strengthen possible 'Transparency and Confidence Building Measures' in the Arctic.

The United States has long neglected its roles and responsibilities of defining and implementing a comprehensive polar strategy and funding budgetary requests by the U.S. Coast Guard to grow and maintain the existing U.S. ice-breaking fleet. Recognizing these long-standing deficiencies, the United States Government has begun to put a greater focus on U.S. Arctic policy recognizing that "The Arctic is no longer an emerging frontier, but is instead a region of growing national importance," said Vice Admiral Linda Fagan, Commander of U.S. Coast Guard Pacific Area. In June 2020, the Trump Administration released its first presidential memorandum on the Arctic titled "Safeguarding U.S. National Interests in the Arctic and Antarctic Regions." This marks a significant step in crafting a strategy for the region, driven in part, by the desire to push back against the expansion of Russian and Chinese influence and military force projection in the region, as outlined in the 2018 U.S. National Security Strategy and in the Pentagon's June 2019 Department of Defense Arctic Strategy [51].

The devised plan calls for the launch of three heavy icebreakers by 2029 and the establishment of two domestic and two international support bases [52]. While the U.S. government is beginning to take more of a strategic focus on devising and implementing policies to govern and protect U.S. national interests, the presidential memorandum highlights the U.S. current Arctic policy as being overwhelmingly military in focus and catching up with Arctic competitors, namely China and Russia, although each bring a different threat level to the Arctic region and U.S. interests [53]. Therefore, there is much work to be done by the U.S. policymakers to divert resources and attention to anticipate all threats (both military and non-military), as well as streamline the necessary working to patch security weaknesses and promote stability and rule-based order by investing in diplomatic capital and regional partners [53].

5.2. Status of the Canadian Icebreaker Fleet

Under the Oceans Act, the Canadian Coast Guard is delegated the authority to provide ice-breaking services to support the safe, economical, and efficient movement of ships in Canadian waters. The Canadian Coast Guard historically deploys six icebreakers in support of marine navigation and other programs in the Canadian Arctic, with a seventh icebreaker dedicated to scientific research. These icebreakers typically operate in the Arctic region from around June through November each year. While vessel traffic is increasing in the Canadian Arctic as discussed, the results of the 2014 independent audit determined the Canadian Coast Guard's ice-breaking presence in the Arctic was in fact decreasing. Canada is experiencing a similar crisis to the United States in relation to their current and projected future ice-breaking capabilities. However, they are still in a far better position than the current state of the U.S. fleet. The government is plagued by a looming shortage of vessels and a growing threat of mechanical failures as a result of aging icebreakers that are well past their shelf life [54].

Canada possesses a total of seven heavy (CCGS Louis S. St-Laurent and CCGS Terry Fox) and medium (CCGS Molly Kool, CCGS Des Groseilliers, CCGS Amundsen, CCGS Henry Larsen, and CCGS Pierre Radison) icebreakers. The seven vessels routinely providing ice-breaking services in the Arctic are on average over 30 years old and are approaching the end of their operational lives [55].

The Canadian Coast Guard's most capable icebreaker, the Louis S. St-Laurent was credited with the escort of the first bulk carrier to transit the NWP, the Danish-owned Nordic Orion rather recently, in September 2013. This transit highlighted the importance of escort ships to take advantage of Arctic opportunities for maritime transport. However, the Louis S. St-Laurent is a 50-year old vessel (1968) and one of the two Canadian icebreakers capable of making this journey. Transport Canada and the Canadian Coast Guard still plan to construct a new icebreaker, John G. Diefenbaker, to replace the aging Louis S. St-Laurent, originally slated to be decommissioned in 2010. A refit of the Louis S. St-Laurent 17 years ago extended its service life, but the vessel has exceeded its intended operational capabilities. A life-extension refit was completed in July 2014 that included structural maintenance and various system replacements and upgrades. Furthermore, the Louis S. St-Laurent underwent a dry-dock for refit as part of a \$14 million contract in 2017 ahead of the 2017 Arctic operational season [56].

The original plan was to begin construction on the John G. Diefenbaker in 2013, but government funding was reprioritized to build naval offshore patrol ships coupled with apparent scheduling conflicts at the respective shipyard. Pre-construction engineering was slated to begin at Seaspan's Vancouver Shipyards in 2017, with a construction contract to follow in 2019 [57]. In June of 2019, the Canadian federal government announced that it intended to add a third Canadian shipyard as a partner under the National Shipbuilding Strategy to build the long awaited polar icebreaker, CCGS John G. Diefenbaker, but no decisions have been taken at this time [58]. Until such time construction of the John G. Diefenbaker begins the Coast Guard believes it may need as many as five extra icebreakers at various times over the next few years, as the current fleet goes through repairs and

upgrades and a new polar icebreaker is built [54]. According to the Coast Guard's Director General of national strategies, Canada may "face potential gaps in ice-breaking services over the next five years." Therefore, a formal request from the Canadian federal government was released to the industry on 18 November 2016, seeking the potential cost and availability of icebreakers, should the need become necessary [54].

Following a performance audit conducted by the Office of the Auditor General of Canada in 2014 and presented in the Fall Report of the Commissioner of the Environment and Sustainable Development, it was determined that not only was the Canadian Coast Guard's presence decreasing in the Arctic, but they had not assessed whether the services it provided were meeting the needs of its users, nor had it assessed the risks that decreasing icebreaker presence may pose for safe navigation in the Arctic. Specifically, the Canadian Coast Guard had decreased the number of days it operates icebreakers in the Arctic by 33 ship days of the total time it planned to deploy icebreakers in the Arctic between 2011 and 2014. Between 2012 and 2014, one less icebreaker operated in the Arctic than originally intended due to maintenance issues, and planned deployment times for those two years were not met. Furthermore, the Canadian Coast Guard had not met repeated requests by industry to support an extended ice-breaking season, leaving commercial vessels to enter earlier and depart the Arctic later than the ice-breaking assets [55]. The Canadian Coast Guard has since reviewed and updated its national Performance Measurement Strategy for Marine Navigation to include ice-breaking services and performed a preliminary analysis of the risk associated with changing the traffic patterns and fleet capacity [55]. In more recent years, the Canadian Coast Guard deployed seven icebreakers in 2016 and seven icebreakers in 2017 and expanded its Arctic season in 2017–2018 with a goal of gradually increasing its presence over the next several years [59].

In August 2018, the Government of Canada, on behalf of the Canadian Coast Guard, awarded Chatier Davie a \$827 million contract for the purchase of three used civilian icebreakers. This included conversion of the first vessel (CCGS Molly Kool—joined the fleet in December 2018) for the Canadian Coast Guard with the goal of using these icebreakers to assist with operations while the existing fleet undergoes vessel life extension, repair, and planned maintenance periods [60]. The first of these icebreakers, CCGS Molly Kool joined the fleet in December 2018 [61]. On 22 May 2019, Prime Minister Justin Trudeau announced that the Canadian Government is investing \$15.7 billion to renew the Coast Guard fleet, with up to 16 Multi-Purpose Vessels to be built at Seaspan's Vancouver Shipyards and two new Arctic and Offshore Patrol Ships to be built at Irving Shipbuilding, Inc. [62]. This new program will replace the Coast Guard's heavy and medium icebreakers that operate in Atlantic Canada and the St. Lawrence waterways during the winter and in the Arctic during the summer.

In recent years, the Canadian Government has dramatically shifted focus on its Arctic policy and strategies. While this is prevalent by the aggressive steps that Canada has recently taken to renew the Coast Guard fleet of icebreakers, it is also evident in the "Arctic and Northern Policy Framework" released in 2019 that is largely influenced by the United Nations 2030 Agenda for Sustainable Development and seeks to address the challenges in the Arctic region from a holistic perspective on a global scale. Specifically, Canada's framework will guide investments and activities through 2030 with a strong emphasis on collaboration with Canada's Arctic and northern residents, especially Indigenous people, to close the gaps of longstanding inequalities in transportation, energy, communications, employment, community infrastructure, health, and education [63]. The policies and strategies to reach Canada's vision of "strong, self-reliant people and communities working together for a vibrant, prosperous and sustainable Arctic and northern region at home and abroad, while expressing Canada's enduring Arctic sovereignty," are ambitious but they seek to understand all their country's interest and responsibilities to make informed policy decisions related to military and non-military threats, climate resilience, Indigenous community development, preservation of natural resources, and deepening diplomatic

engagement. This is a far different approach to the current U.S. approach which seeks to focus on military catchup and a focus on China to form the basis of U.S. Arctic policy.

6. Future Outlook of Ice-Breaking Capabilities

6.1. United States Icebreaker Fleet

The U.S. Coast Guard and Navy, under an integrated program office, will actively monitor the contract awarded to VT Halter Marine Inc., of Pascagoula, Mississippi for the first three Polar Security Cutters. Funding for the first cutter has been secured and construction is scheduled to begin in 2021 with delivery planned for 2024, which should time out with the decommissioning of the Polar Star [49]. Historically, the U.S. Coast Guard icebreaker fleet has been homeported in Seattle, Washington. However, there is an aggressive push by Alaskan Senators Lisa Murkowski and Dan Sullivan to ensure some of America's new icebreakers are homeported in Alaska closer to where they will serve rather than approximately 2800 miles away from the Arctic Circle, by considering that the "tyranny of distance" could result into devastating consequences for life, national security, and the environment.

In a separate initiative, in August 2020, the U.S. Coast Guard delivered plans for a new generation of potentially nuclear-powered icebreakers, just a couple months after the Trump Administration issued a surprise public directive in the form of a memorandum to do so within 60 days [45]. In an effort to help protect U.S. national interests in the Arctic and Antarctic regions, and to retain a strong Arctic security presence alongside allies and partners, the memo launched a multi-agency effort to conduct a review of the Polar Security Program to ensure a ready, capable and available fleet of polar security icebreakers (both polar ice-hardened vessels and nuclear-powered icebreakers) that is operationally tested and fully deployable by Fiscal Year 2029 along with new Arctic infrastructure [64]. It has been publicly noted that the plans presented to the White House in August 2020 will not impact the acquisition underway for the three Polar Security Cutters over a six-year period, but rather offer an alternative to the conventionally powered cutters particularly given the strategic advantage of traveling on longer voyages without refueling, a capability that Russia currently possess with a fleet of nuclear powered icebreakers.

The Trump Administration memo also directed the Coast Guard to evaluate the possibility of leasing heavy icebreakers until the fleet is operational and reviewing the capabilities of the newly contracted polar security icebreaker fleet to include the cutter's ability to support unmanned aviation, surface and undersea systems, space systems and other command and control systems [64]. While adding defensive armament to the design is not in the current plans, the Coast Guard did indicate that potential design options should leave this window open for the future, as former Coast Guard Commandant Admiral Paul Zukunft confirmed in 2018 [64].

6.2. Canadian Icebreaker Fleet

As previously highlighted, the Canadian Coast Guard expects to experience shortages in their ability to provide ice-breaking services over the course of the next five years. Given the fact that the polar icebreaker, John G. Diefenbaker, does not have a projected start or commission date, there were no further plans to enlarge the Canadian icebreaker fleet until negotiations to acquire three medium icebreakers began in January 2017 after Prime Minister Justin Trudeau announced the plan in a Radio-Canada interview [65].

As part of the \$827 million contract for the purchase of three used civilian icebreakers brokered by the Government of Canada, on behalf of the Canadian Coast Guard in 2018, only the first of these icebreakers, CCGS Molly Kool joined the fleet in December 2018. The remaining two used civilian icebreakers, the CCGS Jean Goodwill and CCGS Vincent Massey, were originally slated for arrival in spring and summer of 2020, respectively, but neither of the vessels have been delivered. According to Canada's Department of Fisheries and Oceans, the CCGS Jean Goodwill is expected to be delivered by the end of 2020 and a delivery date for the CCGS Vincent Massey has not been finalized [61].

Last, while the Canadian Government has committed to investing \$15.7 billion to renew the Coast Guard fleet, with up to 16 Multi-Purpose Vessels and two Arctic and Offshore Patrol Ships, no construction timelines have been published for this new program that will replace the Coast Guard's heavy and medium icebreakers that operate in Atlantic Canada and the St. Lawrence waterways during the winter and in the Arctic during the summer.

7. Conclusions

Shipping is an industry strongly interwoven with the environment and as such it can be directly affected by the latest developments in the Arctic [30]. As the ice coverage of the Arctic landscape maintains its downward trend coupled with the increased human activity into uncharted areas of the Arctic, it is vital to reevaluate the resource capabilities in support of transiting ships as well as the available level of response efforts and international cooperation. Specifically, the current state of ice-breaking capabilities in the Canadian and U.S. Arctic is disconcerting given the expected demand in the Arctic region in coming years coupled with the lengthy acquisition and production process required for the new ice-breaking fleets. Past studies of cases where vessels were trapped in pressured ice, officially referred to as a "besetting incident," required the assistance of icebreakers to free them. In some of these cases, as soon as the icebreaker escort operations ended, the vessels became beset again. Therefore, it is of importance to note that despite a trend of rapidly declining ice coverage, sea ice can still grow in thickness [66]. When gauging how severe the conditions are for sea travel, ice thickness is the most important criterion. Even if ice coverage is receding, it can be nearly impossible for ships to make their way through the ice if it is too thick [67].

As the northern waters of the Arctic are more approachable in the near future, shipping traffic will increase and be put at risk. The forecasted increase in human activity in the region under discussion from both ships and aircrafts that will be regularly transiting/operating in the wider region in years to come is expected to place higher demands on the related SAR infrastructure [9]. Therefore, while the warming of the Arctic may signal the need for fewer icebreakers, the growth in shipping traffic and unpredictable environmental conditions require the United States and Canada to bolster their ice-breaking fleet. Icebreakers are a vital resource to clear and maintain shipping traffic channels, necessary for defense/security reasons, Arctic drilling, and research. Their very important role in the Arctic is further highlighted by the fact that they can serve as multi-functional platforms to support SAR and mass rescue operations. Therefore, it is imperative that additional investments in new construction of icebreakers are necessary to support the expected use of Arctic passages.

In conclusion, the current state of the ice-breaking fleet, the overall maritime infrastructure and available response capabilities in the Arctic region are not adequate to effectively deal with the projected increase of maritime shipping and human activity in the High North, especially for the U.S. and Canada. While the United States is slowly waking up to the fact that they need upward of six polar icebreakers to adequately respond to the needs of the marine shipping industry, the realization is that it may be nine more years before this is possible and so far, funding has only been secured for two Polar Security Cutters. While this is an important step, it is only just a modest beginning. If intensive further action is not taken, the U.S. risks surrendering the Arctic Ocean to other interested parties that are already investing toward the roll out of the means necessary to reap the associated benefits. Therefore, it is imperative that additional resources should be acquired and at the same time further examine how to bridge this identified gap, review international policies, and available resources to provide the possibility of safe and efficient Arctic marine shipping for the future and meet the increasing demand for services.

Although Canada added one medium icebreaker to their fleet in 2018 with plans to add two more in the near future after they go through a series of modifications to meet the needs of the Canadian Coast Guard, they have still not definitively addressed the gap of replacing the *Louis S. St-Laurent*, its most capable heavy ice-breaking asset. While the

Canadian Government has committed to investing \$15.7 billion to renew the cutter fleet with medium and heavy icebreakers, there are no timelines or milestones available for this new program. In addition, the delay with starting construction on the polar icebreaker, John G. Diefenbaker indefinitely, further exacerbates this shortage. On a positive notion, with respect to ice-breaking assets, Canada is still in a far better place than the United States. However, both countries will need to intensify their efforts to procure the number of icebreakers needed to serve the Arctic region in a sustainable manner, with the issues of proper budgeting and proper time management clearly standing out.

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