Chapter 6

Governance and Economic Challenges for the Global Shipping Enterprise in a Seasonally Ice-Covered Arctic Ocean

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The Arctic Ocean is undeniably undergoing fundamental environmental changes in response to a warming planet. One highly visible manifestation of these changes is the profound retreat of Arctic sea ice in extent, in thickness and in its very character as detected during the last half-century by satellite and surface observations.[1] The sea ice cover is transitioning from one composed partly of multi-year ice, ice that survives one or more melt seasons, to one that is entirely composed of seasonal, or first-year sea ice. Without multi-year ice, this *new*, seasonal sea ice cover is likely to be more navigable, but it will also be more mobile and present unforeseen challenges to marine navigation. Recent climate simulations suggest that perhaps before mid-century the Arctic Ocean will become seasonally ice-covered and in many respects will approximate the Baltic and Bering Seas, and the freshwater North American Great Lakes. However, the key exception to this direct comparison to more temperate seas is that the Arctic Ocean will retain a much longer (6-7 months) period of ice coverage in late autumn, winter and spring.[2] The practical result is that the Arctic Ocean will remain fully or partially ice-covered for a lengthy period, limiting non-polar (large) ship operations and remining a significant impediment for regular and economically viable trans-Arctic voyaging on a large scale.

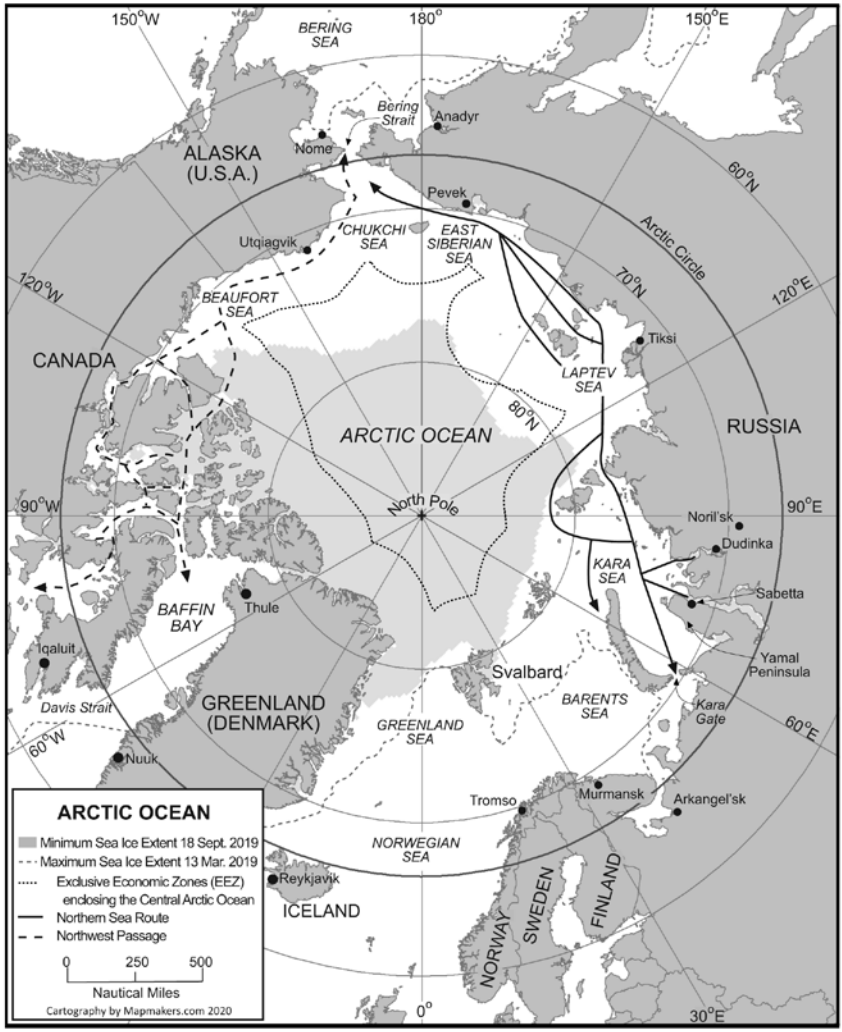
In truth (and contrary to hyped up, sensationalist arguments by the mainstream media), the future use of the Arctic Ocean by commercial shipping will be determined less by sea ice changes than by the following three key drivers: (1) the pace and continuity of Arctic natural resource developments, driven principally by global commodities prices; (2) the economics of the global shipping enterprise; and (3) governance of the Arctic Ocean and coastal state waterways, especially Russia's Northern Sea Route (NSR). Continued sea ice retreat and greater access will certainly remain important factors. However, climate change is inexorably

linked to the economics of Arctic (and global) oil and gas development and uncertain future demand will influence the levels of Arctic marine trafffic. The further development, implementation and enforcement of the International Maritime Organization (IMO) regulations for ships operating in polar waters will also significantly influence the design, construction and safe operation of Arctic commercial ships throughout the century.

A map of the Arctic Ocean and surrounding coastlines provides a glimpse of the complicated geography that is a primary controller of Arctic marine operations and shipping. The Canadian Arctic Archipelago is a complex set of islands and straits that encloses a key portion of the Northwest Passage (composed of multiple navigation routes) that stretches from Baffin Bay to Bering Strait. The retention of sea ice within the straits and island system limits the commercial ship navigation season and access to the summer; winter marine traffic in this region remains difficult even for the most capable of the world's polar icebreakers. In contrast, across the Russian maritime, a region that encompasses more than 45 percent of the Arctic maritime space, the northern island archipelagoes and straits are separated by coastal seas generally open to the central Arctic Ocean.[3] The Arctic's sea ice retreat has been the most extensive along this broad and shallow continental shelf region and the environmental change has created longer seasons of navigation along the optional routes of the NSR (see Figure 1).

The boundary of the Central Arctic Ocean (CAO), a high seas area and global commons, is established by the extension of the Exclusive Economic Zones (EEZ) (each 200 nautical miles wide) by the five Arctic Ocean coastal states (Canada, Denmark, Norway, Russia and the United States). On September 18, 2019, the date of the summer minimum extent of Arctic sea ice, most of the CAO remained ice-covered as well as the northern straits of the Canadian Arctic; in comparison on the same date the entire length of the NSR was ice-free. Notably during the date of maximum extent of Arctic (winter) sea ice for 2019 (March 13), the port of Murmansk and most of the Barents Sea were ice-free – an annual, natural phenomena created by the Gulf Stream, the northward flow of warmer Atlantic waters. These examples illustrate the important role of geography in not only shaping the future of Arctic marine navigation, but also influencing the development of an effective governance regime that enhances marine safety and environmental protection in this unique marine environment.

Figure 1. The Arctic Ocean in 2019, indicating the annual sea ice extent maximum and minimum, the Central Arctic Ocean, and the multiple routes of the Northwest Passage and the Northern Sea Route.



Source: Lawson W. Brigham, University of Alaska Fairbanks

Implications of Greater Marine Access

The observed changes in Arctic sea ice provide for greater marine access throughout the Arctic Ocean and *potentially* longer seasons of ship navigation.[4] Potentially is an appropriate word to emphasize since quantifying and predicting future ice navigation seasons are complex tasks influenced by many uncertainties. Ice navigation seasons are dependent on a set of key criteria including: sea ice thicknesses along the route; the mobility of sea ice under the action of the wind and currents (causing ice pressure on ship hulls); the type or class of polar or non-polar ship that is operating during the ice season; and, if icebreaker escort is readily available within the regional, ice-covered waters.

Again, one central fact remains that is directly relevant to future Arctic marine operations and shipping: the Arctic Ocean will be partially or fully ice-covered for six to seven months through the century. Possible trans-Arctic routes of 2,000 to 3,000 nautical miles in length (and especially the Transpolar Sea Route, TSR) will be ice-covered, *not* ice-free, for more than half the year; and during this same period the entire region will be in total or partial darkness, a key, natural challenge for safe and efficient marine navigation in ice-covered waters that is not usually an issue for navigating in the open ocean.[5] These are consequential factors for all proposed trans-Arctic voyages and their ability to compete economically, safely and efficiently with more traditional and global trade routes including those using the Suez and Panama canals.

Global container shipping companies are particularly challenged by a host of critical determinants: the seasonality of Arctic Ocean routes; the uncertainties in cargo arrival times (due to the vagaries of Arctic weather and sea ice); added marine insurance costs; the need for more costly polar-capable ships within their fleets; and, the non-availability of marine infrastructure such as ports, reliable communications and modern navigation charts to support their normal operations. An additional major factor is the huge size of many container ships today, the largest as of 2020 can carry 24,000 containers and are 400 meters (1312 feet) in length, 61 meters beam (200 feet) with a draft of 14.3 meters (47 feet).[6] The practical fact is that such mammoth vessels cannot easily and safely operate in the Arctic Ocean due to their sheer size, deep drafts, and lack of polar ship capability; and there is no Arctic port infrastructure to handle such mega-ships. It is highly improbable,

therefore, that the major container shipping lines will ever use the Arctic Ocean in a regular system and thereby change the network of established global container ship routes, despite the opportunities afforded by increases in marine access. Large container ships are also unlikely to navigate the NSR for trans-Arctic voyages due to a host of practical geographic and navigational limitations, without even consideration of economic opportunities, risks, and governance challenges. However, smaller (and shallower draft) container ships in niche markets, such as Liquified Natural Gas (LNG), may take advantage of seasonal, summer trans-Arctic navigation across the NSR. Such traffic in numbers of ships and volumes of cargo carried would likely be supplemental to traffic along more southern routes through the Suez Canal.

Economic Drivers

Beyond the changing environment with increasing marine access, future commercial marine use of the Arctic Ocean is primarily driven by economic factors such as Arctic natural resource development and the economics of the global shipping enterprise. A host of other uncertainties can also be influential. The Arctic Council in its *Arctic Marine Shipping Assessment* (AMSA), approved by the Arctic Ministers and released in April 2009, developed a policy framework to deal with marine safety and environmental protection challenges in response to increasing Arctic marine traffic.[7] Notably, AMSA in its scenarios creation effort identified two main drivers as axis for a four-scenario matrix: natural resource development (the level of demand for Arctic natural resources and trade) and governance (the degree of relative stability of rules for marine use within the Arctic and interntioanlly). Other uncertainties identified in the scenarios process included: a stable legal climate for the Arctic Ocean (UNCLOS provides the key legal framework); the occurrence of a major Arctic shipping disaster; limited periods for marine operations (seasonality of access); new resource discoveries onshore and offshore; global oil prices; the safety of other marine shipping routes (such as those through the Suez and Panama canals and along major international straits); transit fees along Arctic routes; escalation of Arctic maritime disputes; changes in world trade patterns; new Arctic maritime nations (such as China, Japan and Korea); more rapid climate change (resulting in the acceleration of sea

ice retreat); the engagement of the marine insurance industry; a global shift to nuclear energy; and, more. One of the most useful outcomes of AMSA's scenarios effort was the highlighting of the range and complexity of drivers and uncertainties that can influence the future of Arctic navigation, while representing a central tenet for this discussion.[8]

Arctic natural resource projects were linked in AMSA to the many requirements to achieve safe and economically viable marine transportation systems. Significantly, not only are these dependent on the long-term viability of Arctic resource projects, but they are in turn directly tied to fluctuating and unpredictable global commodities markets. AMSA's scenarios and drivers of change have been conspicuously demonstrated in current Arctic marine operations. Most large commercial ships are sailing on 'destinational' voyages carrying valuable cargoes of natural resources out of the Arctic to global markets. This is the current shipping situation in the Russian maritime Arctic where LNG icebreaking carriers, oil tankers and bulk carriers are sailing to Europe and into the Pacific Ocean from new LNG and oil facilities near the Yamal Peninsula in western Siberia (the new LNG terminal at Sabetta and the oil terminal at Novy Port in the southern Ob Gulf),[9] and from the port of Dudinka on the Yenisey River. Dudinka services via rail the industrial complex at Norilsk, the world's largest producer of nickel and palladium.[10] These polar ships sail year-round westward to Murmansk and Europe operating in ice-covered seas for eight months; some of the same ships sail eastward to Bering Strait into the Pacific during a summer navigation season that can be extended using the Russian icebreaker fleet escorting commercial ships in convoy. There are plans to increase the ice navigation season in the eastern NSR from ten to twelve months duration using new nuclear-powered icebreakers to escort highly capable icebreaking carriers.[11]

In the Alaskan Arctic large bulk carriers (non-ice class) sail into the Chukchi Sea during a three-month (ice-free) summer season to an anchorage off the coastal community of Kivilina. Barges out of this small facility service the Red Dog Mine, one of the largest zinc mines in the world.[12] High grade zinc ore is transported by bulk carriers south through Bering Strait to markets in western Canada and Southeast Asia. And, on Canada's Baffin Island, the Mary River Mine produces high grade iron ore which is transported by ship during summer (open water seasons) to ports primarily in Europe. A recent Arctic Council

PAME report on Arctic marine traffic indicates a 160 percent increase in bulk carrier distances sailed with the Arctic Polar Code area between 2013 and 2019.[13] These marine operations in Russia, the United States and Canada clearly illustrate the relationship of Arctic natural resources to the need for effective marine transportation systems and ships that can operate safely in polar waters and compete globally.

Many media reports and research papers on Arctic marine shipping, have touted shorter trade routes as the reason for using the Arctic Ocean, *in lieu* of southern routes.[14] Their focus is often solely on trans-Arctic voyaging and sailing container ships between the Atlantic and Pacific, potentially altering today's global trade routes; rarely mentioned is that fact, that the majority of Arctic ships are sailing on destinational voyages. A widely published map (used in government, academic and media reports) of the global shipping routes shows a comparison of routes across the Russian maritime Arctic with the southern routes through the Suez Canal; both options link shipping between European and Asian ports with distance and time savings included for ships sailing between key ports. Very few of the maps include any hint of Arctic sea ice or navigation limitations (such as ship's draft) and most indicate clear voyaging under perhaps ideal conditions. The shorter geographic distances on a map are obvious, but the realities of Arctic navigation are more directly related to overall ship speeds along the length of a voyage. Maintaining higher ship speeds along 'shorter' trade routes in the Arctic Ocean is one the significant uncertainties and potential limitations of Arctic marine navigation. Slower transit speeds due to the presence of sea ice, shipboard icing, low visibility, and icebreaker escort in convoy can quickly negate any distance savings using Arctic voyages compared to southern routes. Ship speeds, draft limitations, and a host of other factors related to the vagaries of the Arctic marine environment are the key determinants of whether shorter sailing distances can be achieved in the high latitudes.

The use of more expensive Arctic ships, higher insurance rates (linked to higher risks), pilotage fees, and icebreaker escort fees are all considerable economic factors that weigh heavily on the viability of trans-Arctic voyages and comparisons with open water sailing. Recent global shipping strategies of using 'slow steaming' by container ships and tankers on long voyages, depending on fuel prices and market conditions for oil and gas, can also render Arctic shipping routes less

attractive to global shippers.[15] A final wildcard factor could emerge if trans-Arctic shipping, particularly along the NSR, became more viable and efficient with longer seasons of navigation: the Suez and Panama canals could adjust their transit fees accordingly on a seasonal basis to maintain normal traffic levels.

Arctic Ocean Governance under the UNCLOS

The governance of Arctic marine operations and shipping, and in some sense the overall geopolitics of Arctic marine use, must be viewed initially through the overarching legal framework for the Arctic Ocean, and all oceans, the United Nations Convention on the Law of the Sea (UNCLOS).[16] The UNCLOS provides the basic regulation of shipping based on maritime zones of jurisdiction; in the Arctic marine environment there are five coastal states bounding the Arctic Ocean, and Iceland located just outside (Sweden and Finland have no Arctic coastlines). Each Arctic state has established a set of maritime zones: internal waters; a territorial sea (12 nautical miles); a contiguous zone (24 nautical miles); and, an exclusive economic zone (200 nautical miles). The coastal state can exercise full sovereign rights and jurisdiction in their internal waters; within the territorial sea, coastal states have full sovereignty. However, foreign ships have the right of innocent passage through the territorial seas provided the passage is continuous, expeditious and does not disrupt security, pollute, or conduct fishing or other operations. It is this right of innocent passage that is critical to commercial shipping and international trade.

Applicable to the Arctic Ocean coastal states, the UNCLOS provides a special clause, Arctic 234, which allows the coastal state to adopt and enforce non-discriminatory pollution prevention, reduction and control laws within the waters of the EEZ that are ice-covered for most of the year.[17] Both Russia and Canada have implemented special rules and regulations (in domestic law) for the NSR and Canadian Arctic using Article 234 as a key legal basis for their more restrictive shipping regimes. The application of Article 234 and the closure of Arctic navigation straits to international navigation by designating them as internal waters (with complete sovereign control) by Canada and Russia remain controversial actions. And this could plausibly cause future international disputes. The issue of how Article 234 applies in an era

of rapid climate change and diminishing Arctic sea ice, when a region may no longer be ice-covered for even half the year, has yet to be addressed.[17] In sum, the legal framework for control and management of coastal navigation in Arctic waters is well-articulated in the UNCLOS. While there will continue to be disagreements among maritime states regarding specific actions and the application of domestic rules by coastal states, commercial shippers will likely abide by these domestic rules to gain access to marine routes and sources of natural resources provided there are viable economic incentives.

Russia's Northern Sea Route as an International Waterway?

The Soviet Union signed the UNCLOS on December 10, 1982 (the Russian Federation acceded to the Treaty on March 12, 1997), and in January 1985 established by decree a system of strait baselines enclosing many of the bays, estuaries and navigation straits along its Arctic coast.[18] The waters inside these baselines became the internal waters of the USSR with complete sovereign control. Importantly for domestic and international marine traffic, today the major NSR navigation straits through the Arctic islands and archipelagoes remain enclosed by these strait baselines: from west to east, Kara Gate and Vilkitsky, Sannikov and Dimitry Laptev straits are proclaimed the internal waters of the Russian Federation. The legal status of these navigation straits remains highly contested regarding the right of innocent passage and other potential Russian regulatory restrictions. The Russian Federation notably also introduced a new legal regime for the NSR in Federal Law 132-FZ dated 28 July 2013,[19] according to which the new 'NSR Water Area' is a large marine space encompassing the internal seas, straits, territorial sea, contiguous sea and most of the exclusive economic zone (EEZ) of the Russian maritime Arctic. Excluded is the Barents Sea, but the NSR Water Area includes all waters to the east. It is bounded in the west by Novaya Zemlya, and extends east to the Bering Strait terminating at the Arctic Circle. For specific relevance to Arctic marine operations and shipping, UNCLOS Article 234 is applied within the NSR Water Area providing Russia with a higher degree of regulatory control of marine navigation with the implementation of special regulations by the NSR Administration. Included in these NSR regulations are mandatory pilotage and fees for icebreaker escort and navigation support.

Three additional initiatives focused on the NSR suggest greater Russian control of what it calls its 'National Arctic Waterway.' First, in December 2017 a law was passed by the Duma restricting the loadings of coal, oil and natural gas along the NSR to Russian-flag ships. A special exemption was necessary since the original fourteen LNG icebreaking carriers operating out of the new LNG port of Sabetta are all foreign-flagged, including the one Russian-owned carrier that is operated by Sovcomflot, Russia's largest shipping company.[20]

Second, new legislation in December 2018 encompassed a revised management structure for the NSR. The state nuclear power agency, Rosatom Corporation, became the management authority for the NSR and the lead agency for the development of the Russian maritime Arctic.[21] This was a surprising shift of authority away from the Ministry of Transport which has its own NSR Administration. Indeed, Rosatom's NSR Directorate will not only manage the state nuclear icebreaker fleet (which it has done since 2008), but will now plan the region's infrastructure development. Not surprisingly, plans appear to include procuring a larger nuclear icebreaker fleet which remains key to the escort of commercial ships in convoy and enhanced control of Arctic shipping in the NSR Water Area. This system is clearly a legacy of the Soviet era. All indications are that Rosatom will have the influence and attain the levels of government investment necessary to advance modernization of the NSR's infrastructure.

A third initiative involves a proposal to develop a state-owned (and controlled) container shipping system along the NSR. Trans-shipment container ports would be built on either end of the Russian maritime Arctic, likely on the Kola Peninsula near Murmansk and in Kamchatka.[22] The state-run operation would use Russian-flag container ships escorted by nuclear and non-nuclear icebreakers. The construction of this new fleet would contribute to subsidizing Russia's shipbuilding industry. One of the key questions is whether global container shippers would be attracted to use such a system for the movement of cargoes between the Pacific and Europe. One of the intriguing aspects of such a venture, and a positive feature for global shippers, would be the assumption by the Russian government of all risks associated with navigation along the NSR. The Kremlin, in other words, would have complete control of this shipping enterprise, but at what cost? And, is such an Arctic shipping system along the NSR economically viable

for potential shippers operating in global markets? For commercial shippers, what would be the time delays in using trans-shipment ports at either end of the Arctic route and what types of cargo would best fit this system? The future of this proposal is dependent on the health of Russia's economy and how much investment can be devoted by the state to this high risk and large Arctic project. This proposed state enterprise, as a component to the overall development of the NSR, is also dependent on the continued support of President Putin and how long he stays in power, now feasibly to 2036. Russian prestige and pride in development of its Arctic region should not be underestimated.

A strong argument can be made that the NSR is moving in the direction of a more domestic (internal) rather than an international waterway. Despite President Putin's past proclamations regarding the NSR as a global trade route (and trans-Arctic corridor), even competing with the Suez Canal for traffic, the reality appears very different. New federal laws focus on tighter control of all shipping within the NSR Water Area. Legislation mandating only Russian-flag carriers of oil, natural gas and coal loaded in Russian ports is a notable protectionist strategy and appears inconsistent with facilitating international trade and shipping. The nuclear icebreaker-centric plan for convoying also harks back to the Soviet era of tight overall control of commercial ships along the NSR.

The reality then is that the vision for the NSR as a new international waterway facilitating ocean-to-ocean traffic has diminished considerably during the past decade as focus of the NSR as a critical national Arctic waterway has taken on greater prominence in supporting Russia's economic future. The rapid rise of tonnages of LNG and oil being shipped out of the Ob Gulf to global markets is testament to Russia's highest priority strategy for the NSR.

The Role of the International Maritime Organization and the Polar Code

The most influential global organization that deals with international shipping is the International Maritime Organization (IMO), a specialized UN agency that focuses on a broad range of marine safety, maritime security and environmental protection issues.[23] Relevant to

this discussion on Arctic navigation, after more than two decades of development by IMO, the International Code for Ships Operating in Polar Waters (the Polar Code) came fully into force on July 1, 2018 when mariner training and experience requirements were mandated; for new ships the Polar Code initially came into force on January 1, 2017.[24] The Code is not an entirely new IMO instrument but is a set of amendments to three existing conventions: the International Convention for the Safety of Life at Sea (SOLAS); the International Convention for the Prevention of Pollution from Ships (MARPOL); and, the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Included in the Polar Code are regulations for ship construction, safety equipment, mariner training and experience, and restrictions on pollution discharges. Ships certified under the Code must also have a Polar Ship Certificate issued by the flag state (or a ship classification society on behalf of the flag state) and carry a ship-specific Polar Water Operational Manual that details the operational capabilities and limitations while operating in polar waters. In addition the Code includes a set of Polar Ship Classes that are managed by the International Association of Classification Societies: the highest level ship is PC 1 (capable of year-round operation in ice) and the lowest is PC 7 (capable of summer/autumn operations in first-year ice).[25]

Rules for polar ships continue to evolve and very recently negotiations have been held at IMO to ban the use of heavy fuel oil powering ships in the Arctic Ocean. Voluntary ship routing measures have been approved by IMO for the Bering Strait region following a joint submission by Russia and the United States. Also being explored are the needs for further ship emissions controls in the region and perhaps a designated Arctic Ocean Emissions Control Area similar to other marine regions (the Baltic Sea, the North Sea, North America and in the Caribbean). The bottom line for addressing the overall governance and regulation of Arctic commercial marine use is that there are in place a legal framework (UNCLOS) and an international regulatory body (IMO) that provide a structure, however imperfect, for international cooperation and action on issues related to a 'new' Arctic Ocean with greater marine access. While Arctic maritime issues are highly complex and have a global impact, the current state of engagement is quite orderly with close cooperation among the Arctic and maritime

states. The mandatory IMO Polar Code also provides an historic and solid framework around which future, more effective regulations can emerge.

The IMO Polar Code is particularly applicable to potential trans-Arctic voyaging especially for ships crossing the Central Arctic Ocean. All such ships must be Polar Code certificated and will enter (or exit) the Polar Code boundary at 60 degrees North in the Bering Sea and sail through the Bering Strait; the Code's boundary in the North Atlantic has been adjusted northward to account for warmer waters and a higher latitude position of the maximum winter ice edge.[26] These commercial ships most likely will need to meet the capabilities of PC 6 or PC 7 vessels. Further, in order to reach the Central Arctic Ocean, ships must sail across multiple EEZs of the coastal states who may each enforce their own special safety and environmental protection regulations. The maritime enforcement operations of the Arctic Ocean coastal states will likely become more robust and there may be multi-lateral agreements developed on joint law enforcement. The concept that non-polar containerships, bulk carriers and cruise ships could sail legally and safely in seasonally ice-free Arctic waters appears precluded. The only other option for trans-Arctic shipping might be using trans-shipment ports and transferring cargoes from polar to non-polar ships. But here, the overall economics, regular (and timely) flow of cargoes and potential seasonality of trans-shipment operations must be further studied.

The Future of Arctic Marine Transportation to 2040

Despite the extraordinary changes in the Arctic sea cover during the last five decades and the changes expected to be observed during the next two decades, the principal global container shipping routes will almost certainly *not* be revamped to go across the Arctic Ocean. The economic and operational constraints – such as more costly polar ships, higher insurance rates, the seasonality of routes, and weather vagaries – are just too onerous to sustain economically viable and routine trans-Arctic voyages. And critically, the major container shipping companies and their routes are linked to global hub ports (along the marine routes) and population centers where most consumer markets are located. The Arctic is not conducive to this global system. However, new niche market opportunities may evolve for trans-Arctic navigation

in summer using smaller container ships, and this shipping activity – likely on the NSR – could become supplementary to the more southern trade routes through the Suez and Panama canals.

The future use of the NSR, however, is uncertain as an international waterway, either for foreign-flag ships on trans-Arctic voyages, or ships sailing on destinational voyages. By 2040, trans-Arctic navigation across the NSR and across the Central Arctic Ocean by bulk carriers and select specialized ships (such as car carriers) is plausible. Sailing across the Central Arctic Ocean for a short, two-month season could be attractive to avoid any costs and difficulties of using the coastal NSR. Yet, all such ships will have to be Polar Code certified and meet any additional requirements that the coastal states in their EEZs may require. What's more, shipping companies have to realise that as a result monitoring and surveillance of all Arctic ship traffic will be greatly enhanced, and enforcement improved by 2040. And finally, it is highly plausible that Arctic marine traffic levels in the decades ahead will continue to be primarily driven by natural resource developments, particularly in Russia and Canada. Arctic projects will be challenged to survive the fluctuations of global commodities prices and global carbon mitigation efforts. Despite the emergence of a blue, ice-free Arctic Ocean in summer, the future of Arctic marine operations and shipping thus remains as complex as it remains highly uncertain.

Notes

1. Satellite sensors have monitored Arctic sea ice since the 1970s. These changes have been recorded and analyzed by the National Snow and Ice Data Center at the University of Colorado, Boulder, Colorado, https://nsidc.org/crosphere/quickfacts/seaice.htm/.

2. A. Neiderdrenk and D. Notz," Arctic Sea Ice in a 1.5 Degree C Warmer World," *Geophysical Research Letters* (2018), pp. 1963-71, https://doi.org/10.1002/2017GL076159. Also, K.R. Barnhart et. al., "Mapping the Future Expansion of Arctic Open Water," *Nature Climate Change* 6 (2016), pp. 280-5, https://doi.org/10.1038/nclimate2848.

3. L.W. Brigham, "Arctic Ocean," in J.B. Hattendorf, ed., *The Oxford Encyclopedia of Maritime History*, Vol. 1. (Oxford: Oxford University Press, 2007), pp. 135-43.

4. ACIA, *Impacts of a Warming Arctic: Arctic Climate Impact Assessment* (Cambridge: Cambridge University Press, 2004), pp.82-5.

5. Note: The thickness of first-year sea ice during March, the month of maximum thickness and extent, is estimated to be 1.8 to 2.5 meters (5.9 to 8.2 feet) thick considering the normal growth of winter sea ice growth. Ships sailing for 2000 to 3000 nautical miles would likely experience these thicknesses for most of the winter months.

6. The largest container ship in the world is HMM Algecires, operating since April 2020 and owned by the South Korean company HMM.

7. Arctic Council, *Arctic Marine Shipping Assessment* (AMSA) 2009, pp. 158. AMSA can be found on the web site for the Arctic Council's Protection of the Arctic Marine Environment Working Group: https://www.pame.is/index.php/projects/arctic-marine-shipping/amsa.

8. *Arctic Marine Shipping Assessment*, op cit., pp. 92–93.

9. L.W. Brigham, "Russia Developing New Arctic LNG Marine Routes," *U.S. Naval Institute Proceedings*, Jan. 2019, p. 94, https://www.usni.org/magazines/proceedings/2019/january/oceans-russia-developing-new-arctic-lng-marine-routes.

10. Note: Nornickel is a large mining and industrial complex in the Siberian city of Norilsk. Company site: www.norickel.com. The Norilsk Railway runs to the port of Dudinka where processed nickel, palladium and copper are loaded aboard icebreaking carriers.

11. T. Nilsen, "Moscow Confirms Go-ahead for Giant Nuclear Icebreaker," *The Barents Observer*, March 3, 2019, https://thebarentsobserver.com/en/arctic/2019/03/moscow-confirms-go-ahead-giant-nuclear-icebreaker.

12. Red Dog Mine is a large mining complex in the northwest corner of Alaska whose main products are zinc and lead. Port facilities on the Chukchi Sea near the village of Kivilina are modest and barges carry product out to anchored bulk carriers.

13. Arctic Council - PAME, *The Increase in Arctic Shipping 2013-2019—Arctic Shipping Status Report* (ASSR) # 1, March 31, 2020, p. 21 (Distance sailed by bulk carriers in the Arctic Polar Code area between 2013 and 2019), https://www.pame.is/projects/arctic-marine-shipping/arctic-shipping-status-reports/723-arctic-shipping-report-1-the-increase-in-arctic-shipping-2013-2019-pdf-version/file.

14. Reference has been made frequently during the past two decades to the distances saved comparing the NSR and Suez Canal (southern) routes between ports in Europe and Asia. A familiar map (with routes through the Arctic across the NSR and southern routes from Europe through the Mediterranean Sea and the Suez Canal and then to Asia) has been used as recently as April 2019 in the U.S. Coast Guard's *Arctic Strategic Outlook* (p. 12). Several papers in the academic *Journal of Transport Geography* make use of the same map and distance data, as have several international newspapers. The operator of Russia'a nuclear icebreaker fleet, Rosatomflot, has also used distance savings data in its promoting use of the NSR.

15. L.H. Liang, "The Economics of Slow Steaming," *Seatrade Maritime News*, October 7, 2014, https://www.seatrade-maritime.com/americas/economics-slow-steaming.

16. *Arctic Marine Shipping Assessment*, op. cit., pp. 50-4.

17. See also the chapters by Alexander Vylegzhanin and Suzanne Lalonde in this volume.

18. United Nations Convention on the Law of the Sea (UNCLOS). Article 234, Ice-Covered Waters. UNCLOS, www.un.org/Depts/los/comvention_agreements/text/unclos/unclos_e.pdf.

19. W.E. Butler, "The Legal Regime of Soviet Arctic Marine Areas," in L.W. Brigham, ed., *The Soviet Maritime Arctic* (London: Belhaven, 1991), pp. 215-218.

20. Russian Federal Law 132-FZ of July 28, 2012. On Amendments to Certain Legislative Acts of the Russian Federation Concerning State Regulation of Merchant Shipping on the Water Area of the Northern Sea Route, www.nsra.ru/en/ofitsialnaya_informatsiya/zakon_o_smp.html.

21. The Russian Duma amended the federal shipping code on December 20, 2017 to ban all foreign shipments of oil, LNG and coal along the NSR. While the new law came into force on 1 February 2018, an exemption was

included for key companies such as Novatek which is the main developer of Yamal LNG (since all its LNG icebreaking carriers are foreign flag ships). The Barents Observer reported on this legislation on December 26, 2017.

21. Russian Federal Law 525 signed by President Putin on December 28, 2018 designating Rosatom as the head agency for NSR development, https://rosatom.ru/en/press-centre/news/valdimir-putin-signed-a-law-on-rosatom-s-powers-in-northern-sea-route-development/.

22. *High North News*, June 5, 2019: https://www.highnorthnews.com/en/tag/container-shipping-O and Bloomburg News, October 20, 2019, "Russia Willing to Pay to Lure Shippers to the Arctic."

23. *Arctic Marine Shipping Assessment*, op. cit., pp. 50 and 55-61.

24. There were three phases for the IMO Polar Code: new ships came under the Code on January 1, 2017; existing ships came under the Code on January 1, 2018; and, the training and experience requirements became mandatory on July 1, 2019. IMO Site for the Polar Code: https://www.imo.org/en/MediaCentre/HotTopics/polar/pages/default.aspx.

25. Note: The seven Polar Classes, PC 1 through PC 7, all are capable of icebreaking and operating safely in Arctic waters. The Polar Code also includes three categories of ships that can operate in polar waters: Category A which can operate in medium first-year ice (PC 1 to PC 5); Category B which can operate in thin first-year ice (PC 6 to PC 7); and, Category C which are designed to operate in open water or in ice conditions less than in A and B. This scheme provides flexibility for ships such as a non-ice strengthened cruise ship operating in polar waters that are ice-free.

26. The Polar Code boundary in the Atlantic runs south of Greenland and then northeast along the east Greenland coast and north of Iceland until it intersects with the Russian Arctic coast in the Barents Sea. All of Iceland, Norway and the Kola Peninsula in northwest Russia are not inside the Polar Code area since they are ice-free year-round.