Future Perspective:
The Maritime Arctic in 2050

Lawson Brigham

PREFACE

The Arctic is a complex place undergoing great change early in the twenty-first century, and there is much uncertainty and speculation about what the future might hold for this once remote and inhospitable region of the globe. One methodology that can enhance strategic planning in regard to the Arctic is the use of scenarios and the creation of plausible stories about the future. These stories can challenge the preconceived mental maps that readers might have about the Arctic. The plausible story or scenario that follows, a relatively positive look at the future, is focused on the maritime Arctic (as opposed to the entire Arctic) since most of the 'top of the world' is ocean. This scenario relies on such key studies as the work of the Intergovernmental Panel on Climate Change (for global climate projections); the Arctic Council's Arctic Climate Impact Assessment (2004); scenarios developed in the Council's Arctic Marine Shipping Assessment (2009); and the EU's Arctic, Climate Change, Economy and Society (ACCESS) project (2014).[1]

One important goal of developing this scenario narrative is to highlight the complexity of the maritime Arctic and the key uncertainties that will determine the region's future. Another key objective is to challenge our perceptions of this region's future and help identify the implications of such an alternative future scenario to the Arctic states and global community. While the future is unknowable, the uncertainties in the case of the

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maritime Arctic can be studied rigorously and prioritized for their significance. The goal here is to develop a scenario rich and challenging to readers' assumptions about the future.

ARCTIC MARITIME SCENARIO:

It's 2050: The maritime Arctic is a busy place, with natural resource development taking center stage and driving the need for marine transport systems. Linked to the global economic system and global commodities markets as never before, the region sees record levels of cargoes of oil, gas, and hard minerals exit by ship, and Arctic local and indigenous communities in select regions are reaping the benefit of this expanded economic resurgence. Importantly, the Arctic remains one of the more peaceful regions on the planet in 2050, with broad cooperation among the eight Arctic states—Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States—and the Arctic's many marine users and stakeholders from the global maritime industry. The Arctic states have continued their focus in the Arctic Council on sustainable development and environmental protection issues. Indeed, globalization, climate change, and Arctic geopolitics—the three key drivers of the Arctic's fast-paced evolution—have interacted in complex ways to influence the Arctic region's recent past.

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Profound Arctic Sea Ice Changes

One of most extraordinary landmarks in the maritime Arctic, and perhaps among the most profound environmental changes in human history, occurred in 2038. The last vestige of old and multi-year ice disappeared that summer from the northern Canadian and Greenlandic coasts, as earlier predicted by global climate models, leaving only thinner, first-year sea ice throughout the central Arctic Ocean.[2] Minimal Arctic sea ice was observed by satellite in September 2038, and only annual sea ice would cover the entire Arctic Ocean in subsequent winters. This will be the state of Arctic sea ice during the remainder of the century and beyond. Climate

modelers and their sea ice simulations had, for more than three decades, anticipated this disappearance, yet it was still difficult to believe. The advance and retreat of Arctic sea ice now, in 2050, resembles the seasonal transitions of sea ice observed for centuries in the Baltic Sea and the freshwater ice of the North American Great Lakes.

An extraordinary amount of heat would be required to melt the ice entirely during the polar night, and thus Arctic sea ice remains present throughout the winter, spring, and autumn in 2050. In winter 2049, as in previous years, 2200 nautical miles of Arctic sea ice remains across the Arctic Ocean, averaging 1.3 to 2.0 meters in thickness, compared to *summer* thicknesses of 1.0 to 2.7 meters along a 1994 expedition from the Chukchi Sea to the North Pole.[3] However, marine accessibility is greatly increased, and longer seasons of navigation are available for ocean-going and ice class ships in most coastal regions of the maritime Arctic. The ocean's expanding marine access was highlighted in summer 2033 by the first crossing of the central Arctic Ocean—a track line from Bering Strait to the North Pole and out to Fram Strait between Greenland and Svalbard—by a sailing yacht, the *Flying Ranger*, which averaged a comfortable ten knots under sail during the passage. No one who lived during the twentieth century could have anticipated such a unique sailing voyage across the Arctic Ocean!

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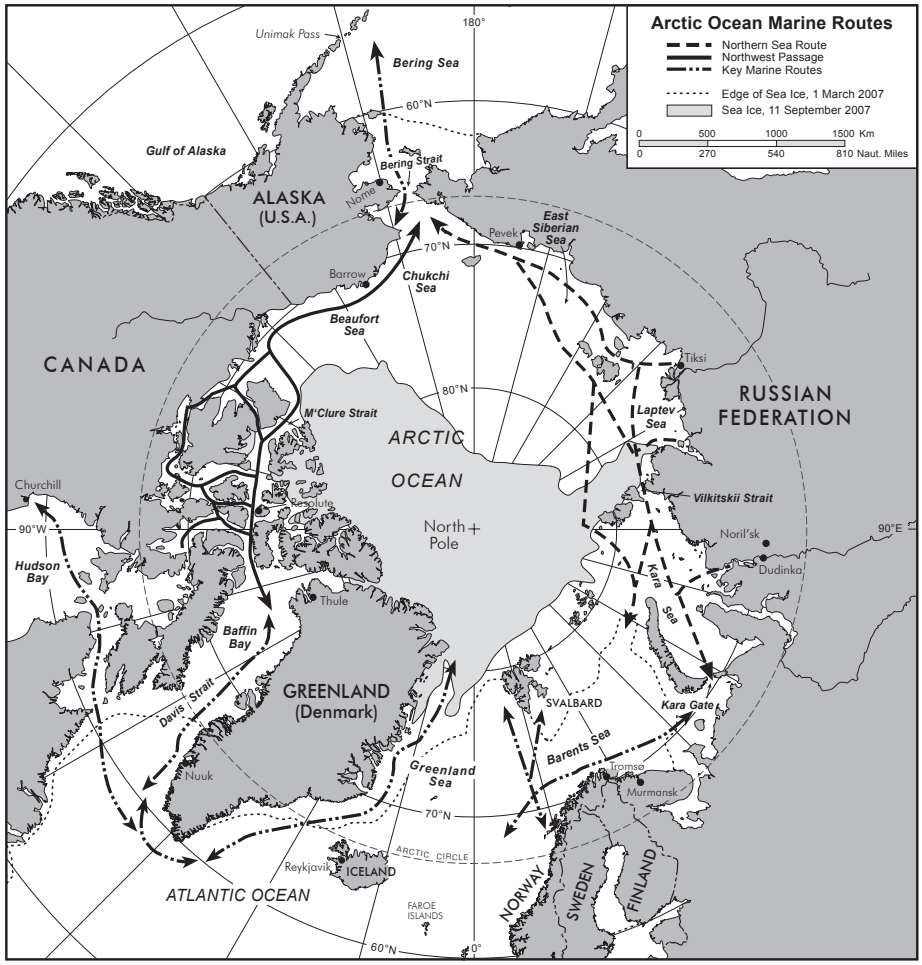

Figure 1. *The Arctic maritime region with key marine routes and coastal seas, 2007. The Arctic sea ice area depicted for September 2007 is the second lowest area on record; September 2012 is the lowest; and September 2014 is the 6th lowest. The map for September 2050 and the scenario narrative would have no sea ice in the Arctic maritime region for much of the month. Source: Lawson W. Brigham, University of Alaska Fairbanks.*

The Russian Maritime Arctic and Northern Sea Route

The Northern Sea Route (NSR) across the top of Eurasia from Kara Gate to Bering Strait now has a navigation season that extends to nearly six months in the eastern regions of the Laptev and East Siberian seas. As before, Russia's future is firmly tied to natural resources, and full development of those resources in the Russian Arctic has been underway since 2020. Nearly 45 million tons of natural resources (oil, gas, and hard minerals)

have been shipped out from northern Europe and the Russian Arctic along the NSR east bound during the 2045 navigation season; the western end of the NSR has continued year-round navigation (since 1979), and more traffic has been associated with offshore oil development in the Kara Sea that has continued since early exploration in 2014.[4] Icebreaking tanker shuttles have continued moving oil year-round from the eastern Barents and Kara seas to the service port of Murmansk. The seaport of Sabetta on the Yamal Peninsula has been fully operational since 2022 (construction commenced in 2012). Shipments of LNG have been moving in icebreaking LNG carriers to China, Korea, and Japan during a six-month extended navigation season in 2045 with icebreaker escort. LNG carriers out of Sabetta have sailed westbound to Europe during November to April.

Some believed the NSR would serve as a major, global container route, but this vision has not materialized, primarily due to the constraints of Arctic transport's seasonal nature and the large uncertainty of Arctic operations, including sea ice and weather variability. Other factors include strong competition from a year-round 'Silk Road' rail container across Asia to Europe and the inability to accommodate any of the world's largest container ships, which have been developed since 2015 (some carrying 25,000 containers) in the Arctic Ocean. However, several niche markets, using smaller ice class container ships, have used the extended navigation season to link northern Europe with Korean, Japanese, and northern Chinese markets; 2 million containers were transported across the top of Eurasia in 2049. And container ship operations carrying goods and services into the Russian Arctic during the past twenty-five years have been growing. Ports such as Tiksi and Pevek have been trans-shipment hubs for moving the containers to river vessels that service developments in the interior of the Russian Arctic.

The Suez and Panama canals continue to serve the global maritime industry as they did in the early years of the twenty-first century. Large improvements to both canals were completed in 2022 and together they carry the bulk of world maritime trade. Arctic traffic, particularly along the NSR, has been *supplemental* to the Suez Canal, providing new, seasonal routes for carrying natural resources out of the Arctic to global markets. A fledgling trans-Arctic route is also devel-

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oping north of the Eurasian Arctic out into the central Arctic Ocean. Some shippers (bulk and container traders) are hoping to have an alternative trans-Arctic route to the NSR, to avoid any fee system using high latitude transits. During a two-month navigation season (August and September) in 2040-2049, an average of twenty Polar Class 6 ships have sailed this new 'central Arctic Ocean route.' Despite these developments, at mid-century Arctic navigation *has not* revolutionized the primary global trade routes, but additional seasonal routes have evolved.

Circumpolar Maritime Development

The Mary River iron ore mine on Baffin Island in the Canadian Arctic became operational in 2027 and has been exporting iron ore by icebreaking ships to Europe. Occasional summer voyages to other global markets, including China, have been made on westbound voyages through routes of the Northwest Passage. Producing the world's highest grade iron ore, the Mary River mine complex will be operational until 2090, and likely beyond. A fleet of eight icebreaking ore carriers operates year-round on voyages primarily to European ports.

Offshore Arctic oil has reached full development between 2025 and 2040 in Alaska, northern Norway, Russia (in the Kara Sea), and in select lease areas off Greenland's east and west coast. Only in the Canadian Beaufort Sea has offshore oil development been dormant. These Arctic offshore developments have taken place during an era (from 2018-2040) when the United States was the world's leading energy producer and became nearly energy self-sufficient in 2045. The U.S. maritime Arctic in Alaska has been particularly busy since summers 2018 and 2020, with major discoveries of offshore oil in the Chukchi Sea. Marine support and transportation systems have become fixtures in all of these regions. Armadas of support vessels operate with the hydrocarbon exploration and production facilities.

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One of the wildcards suggested early in the century by the Arctic Council's Arctic Marine Shipping Assessment (circa 2009) has also come true. Bulk freshwater has been shipped out of the Arctic from northern Canada, the Russian Arctic, Alaska, and in limited quantities from Greenland, to markets in southern Europe, the Middle East, and throughout the rest of the globe. The warmest summers

on record in Europe in 2028, and again in 2035, set off a search for alternative sources for freshwater, and bulk cargoes from Arctic ports have been arriving in Europe since 2036. Freshwater globally has become a key, tradable commodity and is viewed as a valuable Arctic natural resource in 2050. Due to the continuing warming of the planet, distribution and ownership of freshwater have become significant economic and security issues. Thus, all sources of water, including the large reservoirs in the Arctic, are being viewed as valuable natural resources and national assets.

Infrastructure Developments and International Rules

Marine infrastructure developments and large investments from European, Asian, and North American interests have facilitated the growth of Arctic marine activities observed in 2050. Public-private partnerships and private capital have been the keys to successful funding of critical infrastructure for the maritime Arctic. Since 2025, investments have been made in essential marine infrastructure elements, including communications, charting and hydrography, search and rescue (SAR) response, environmental response, ice and weather forecasting, aids to navigation, key regional ports, and marine salvage. The Russian Federation completed its suite of ten SAR and emergency response centers along the NSR in 2024. Russia has also invested in hydrographic surveying of Arctic waters, such that at mid-century 70 percent of the multiple routes through the NSR are charted to international navigation standards. In 2021 a novel public-private partnership was developed to fund the creation of a comprehensive Arctic observing system to serve both the international research community (for climate change data) and the operational maritime community (for real-time weather and Arctic sea ice information). Agencies of the Arctic states combined funding with private maritime investments to fill this critical gap for an integrated Arctic observing system, finally in operation by 2026. Several new Arctic ports in Greenland, Alaska, and Russia have received funding from a regional investment bank established in 2025 through the efforts of investors working closely with the Arctic Economic Council, and new communications satellites have been primarily funded since that time by private

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investors to foster commercial maritime interests and enhance safety of operations.

The International Maritime Organization (IMO) Polar Code has been in force throughout the maritime Arctic since 2017. During the past three decades, Arctic-specific regulations have been added as amendments to the Safety of Life at Sea (SOLAS) and Prevention of Pollution from Ships (MARPOL) conventions. A key move to regulate ship emissions in the Arctic came in 2026 with a new IMO Emissions Control Area designation for the Arctic (using the same area as that for the Polar Code). A regulation for control of black carbon ship emissions from Arctic ships was implemented in 2028. The IMO standards for training and experience of polar mariners were also revised and enhanced in 2026.

Arctic Continental Shelf Claims

The Arctic Ocean seabed partition and extended continental shelf process stipulated under Article 76 of the United Nations Convention of the Law of the Sea (UNCLOS) has continued for the entirety of the twenty-first century. Fortunately the United States finally ratified UNCLOS in 2027. Only recently did the world witness progress to reach agreement by the five Arctic Ocean coastal states—Russia, Canada, Denmark, Norway, and the United States—on boundaries for the extended continental shelves; however, a complete jurisdictional map of the Arctic Ocean still remains elusive in 2050. The United Nation's Commission on the Limits to the Continental Shelf (CCLS) decided and advised in 2036 that the seabed at the bottom of the North Pole would not be contained wholly within a single state's jurisdiction; two so-called 'donut holes' were also delineated. The 'mad scramble in the Arctic' advanced by the media early in the twenty-first century has not materialized since all of the past and current hydrocarbon development projects in the maritime Arctic have been within coastal state jurisdiction. Exploratory mining of the Arctic's seabed was conducted by Chinese and French interests in 2030 and 2033, but the efforts have not proven economically viable.

Arctic Fishing Complexities

International fishing in the global oceans in 2050 is under serious pressure from overfishing and acidification. Even the Southern Ocean around Antarctica has been illegally overfished to the point where many stocks have collapsed. Non-arctic fishing fleets during the past two decades

have been moving to northern latitudes, intensifying pressure on coastal marine ecosystems. Since 2035 significant law enforcement operations have been conducted in the Bering and Barents seas against illegal fishing; more than one hundred serious actions have been reported between fishing vessels and the regional coast guards in the past decade. The negotiation of an international agreement to declare a moratorium on fishing in the Arctic Ocean collapsed in 2019 and again in 2032, as many non-Arctic states, including China, Japan, Korea, and Spain simply could not agree to any moratorium in the central Arctic Ocean. Though language in the proposed treaty would allow fishing to resume once enough science could be gathered to understand the basic marine ecosystem, the non-Arctic states had little confidence that the central Arctic Ocean, once closed, would ever open again. American, Russian, Norwegian, and Canadian scientific data have shown that several fish stocks have moved into the Arctic coastal seas—a response to the relentless retreat of sea ice and warming waters. However, a wealth of data also suggest that acidification in polar waters is having a fundamental, *negative* impact on coastal productivity, rendering unlikely the growth of large and sustainable fish stocks in the central Arctic Ocean. Thus, in 2050 Arctic fishing remains an uncertain, challenging, and difficult issue, creating tension among the Arctic states and several non-Arctic nations whose fishing vessels increasingly sail in high latitude waters.

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Notable Arctic Maritime Accidents

The growth in Arctic maritime activities during the last quarter of a century has not been without incident. Two serious events in the maritime Arctic have highlighted the risks of Arctic navigation and have forced greater attention on marine safety and protection of the Arctic marine environment. In April 2025 a large, bulk chemical carrier (a polar class ship under a non-Arctic state flag) grounded on the western end of St. Lawrence Island in the Bering Sea. The *Arctic Endeavor* had just sailed eastbound along the Northern Sea Route in an early spring voyage and was heading south from Bering Strait in dense fog and ice conditions. Trying to avoid a moving ice field, the ship grounded with resulting hull damage and release of cargo. Significant damage was incurred by local populations of seals and

walrus, and world attention was drawn to the serious impact of this disaster on the region's indigenous communities. Action followed quickly as IMO established a number of Special Areas, including one around St. Lawrence Island, whose ship restrictions are focused on protecting Arctic people and the marine environment.

A second maritime disaster of note in late September 2031 involved a cruise ship attempting to make the first trans-Arctic voyage by a passenger ship across the central Arctic Ocean. The ocean was not completely ice-free at the beginning of the voyage, but there was minimal sea ice in satellite images near the North Pole. The *Centurion,* carrying 2800 passengers and crew on board, was stopped by ice and lost power for several days as it drifted into an area of ridged ice—from which escape was not possible. A massive rescue operation, exercising the Arctic Search and Rescue Agreement of 2011, involved icebreakers from Russia, Canada, and the United States. Although all the passengers and crew were safely rescued, the *Centurion* itself could not be saved that season and was sunk by winter sea ice in the central Arctic Ocean that formed in March 2032. These ship disasters and the discovery in 2030 of invasive species (such as comb jellies and warm water crabs) in the Chukchi and Kara seas, likely from ballast water discharges from more southern waters, promoted the Arctic states at IMO to initiate development of more comprehensive Arctic-specific safety and prevention strategies.

2050 Summary and the Future

The maritime Arctic is very closely linked at mid-century to the global economy through natural resources. During the last quarter of a century (2025-2050) more bulk cargoes of oil, gas, and hard minerals have been transported out of the Arctic by ship than in any previous time. Small numbers of commercial ships are beginning to use trans-Arctic routes north of the Eurasian coast and outside the jurisdiction of the Russian Federation (and control along the NSR). Increasing container ship traffic has been carrying cargoes into the emerging Russian Arctic. Several niche markets for container traffic have been developed for summer navigation between Japan, Korea, and northern Europe. The eight Arctic states are in 2050, more closely aligned in the Arctic Council and intently cooperating since climatic and economic stressors in lower latitudes are creating a number of unstable states and actors, with trans-boundary human migrations becoming a significant challenge. The Arctic remains peaceful since most of the natural resource wealth has always remained in sovereign state

control, and good cooperation has been achieved on Arctic issues within international organizations such as IMO.

As we look beyond 2050, it is anticipated that a complete jurisdictional map of the Arctic Ocean will finally be agreed to in 2055. Also, the emergence of the newly independent state of Greenland—a peaceful separation from Denmark after nearly four centuries—planned for in 2052 will have further implications for the maritime Arctic. Greenland's 140,000 inhabitants (up from 56,000 early in the century) will go it alone, with tourism and the sales of oil, rare earths, hard minerals, and potentially freshwater to global markets fueling its economy, and requiring effective marine transport systems to link the new Arctic nation with the global economy. However bright the Arctic economic situation is today, in January 2050, the remaining half-century is likely to be a more challenging period for the Arctic. This forecast is due in part to the very global and dynamic economic linkages that are driving Arctic development. The Arctic states will face a more environmentally-challenged, warming globe, and a less stable world to the south. In fact, it is entirely plausible that the Arctic will remain relatively peaceful in the last half of the twenty-first century, while the rest of the world experiences much greater stress and tension. ***f***

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ENDNOTES

1 Numerous Arctic studies and reports have been used in the development of this scenario. Four key sources for additional reading include: The Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5), <www.ipcc.ch/report/ar5>; the Arctic Council's Arctic Climate Impact Assessment (ACIA), <www.amap.no/arctic-climate-impact-assessment-acia>; the Arctic Council's Arctic Marine Shipping Assessment (AMSA), <www.pame.is/index.php/project/arctic-marine-shipping/amsa>; and, the European Project Arctic Climate Change, Economy and Society (ACCESS) <www.access-eu.org>.

2 First-year sea ice is floating ice of no more than one year's growth (it has formed over just one winter); thicknesses vary between 30 centimeters and 2 meters. Old ice is sea ice that has survived at least one summer melt and can be as much as, or more than, 3 meters thick. Multiyear sea ice has survived two or more summer melts. Multiyear sea ice has much less brine (or salt), is harder, and is thus more difficult for ships to break. More sea ice information can be found on the web site for the National Snow and Ice Data Center located at the University of Colorado Boulder, <nsidc.org>.

3 Arctic sea ice thickness was much greater late in the twentieth century, even during the summer months. During *The 1994 Arctic Ocean Expedition* (an icebreaker scientific

voyage across the Arctic Ocean in July and August), ice thicknesses were measured as 1.0 (in the Chukchi Sea) to 2.7 meters at the North Pole (*The 1994 Arctic Ocean Expedition: The First Major Scientific Crossing of the Arctic Ocean*, Special Report 96-23, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. 1996).

4 This estimate of shipping tonnage for 2045 is not based on a specific projection, but is instead a plausible estimate considering the vast oil, gas, and hard mineral resources in the Russian Arctic that we know exist today.