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## Arctic Navigation and Climate Change: Projections from Science for the Law of the Sea

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*Charles H. Norchi and Amanda H. Lynch*

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# Arctic Navigation and Climate Change: Projections from Science for the Law of the Sea

*Charles H. Norchi\* and Amanda H. Lynch\*\**

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## I. INTRODUCTION

Above latitude 66°33'44" north of the Equator lies the Arctic Circle.<sup>1</sup> The center of the Circle is water, mostly covered by ice. The smallest of the world's five oceans, it has been paddled, sailed, and traversed over centuries—to access its abundant resources, to reach the magnetic north pole, to discover routes connecting the Atlantic and Pacific Oceans, to expand scientific knowledge, to live, to discover, and to conquer. Peoples indigenous to the Arctic have long thrived in the lands and near-shore environments that bound the ocean.<sup>2</sup>

By the age of European exploration of the Arctic, the 1648 Peace of Westphalia had ushered in the nation-State system and modern international law.<sup>3</sup> The *mare liberum* character of the oceans that Hugo Grotius proclaimed had eclipsed the *mare clausum* argument of John Seldon.<sup>4</sup> Freedom of navigation, subject to certain servitudes, was honored.<sup>5</sup> From the sixteenth century onward, Arctic voyages and expeditions originating in Europe and North

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1. The Arctic Monitoring and Assessment Program, an Arctic Council Working Group, adopts a definition that includes “the terrestrial and marine areas north of the Arctic Circle (66°32'N), and north of 62°N in Asia and 60°N in North America, modified to include the marine areas north of the Aleutian chain, Hudson Bay, and parts of the North Atlantic, including the Labrador Sea.” Janine L. Murray et al., *Physical/Geographical Characteristics of the Arctic*, THE ARCTIC MONITORING AND ASSESSMENT PROGRAMME 9, 10 (1998) <https://www.amap.no/documents/download/88>.

2. The first Arctic peoples were Dorset and Thule. Presently, the Arctic is home to at least nine indigenous language groups, including Inuit and Saami. The Indigenous Peoples' Secretariat of the Arctic Council formally represents six Arctic indigenous organizations. *See We are the Indigenous Peoples of the Arctic Council*, ARCTIC COUNCIL INDIGENOUS PEOPLES' SECRETARIAT, <https://www.arcticpeoples.com/#intro> (last visited Aug. 9, 2022).

3. *See* Leo Gross, *The Peace of Westphalia, 1648–1948*, 42 AMERICAN JOURNAL OF INTERNATIONAL LAW 20 (1948); Bruce Bueno de Mesquita, *Popes, Kings and Endogenous Institutions: The Concordat of Worms and the Origins of Sovereignty*, 2 INTERNATIONAL STUDIES REVIEW 93 (Summer 2000).

4. Grotius wrote:

the sea appears capable of being made a property by the power possessed of the shore on both sides of it; . . . But this right of property can never take place where the sea is of such a magnitude, as to surpass all comparison with that portion of the land which it washes. And the right, which one people or prince possesses, may also be shared by a great number of states, among whose respective territories the sea flows.

HUGO GROTIUS, THE RIGHTS OF WAR AND PEACE 104 (A.C. Campbell trans., 1901).

5. *See generally* RALPH J. GILLIS, NAVIGATIONAL SERVITUDES (2007).

America increased—motivated by discovery, wealth, power, and knowledge. The British had defeated Napoleon, its navy ruled the waves, and London was tangling with Russia over Afghanistan in the Great Game.<sup>6</sup> And Russia posed another threat—discovering and making a polar passage. Faced with the prospects of expansion, governments sponsored high north exploration. The scramble for the Arctic, mostly on ice, was on.

This article examines the future of navigation in the Arctic by examining the projected effects of a range of climate change scenarios. We first consider the interactions between social process and climate in the Arctic, along with demands and claims to access and control. We then appraise the legal regimes applicable to the Arctic and associated navigational challenges. We calculate projections of Arctic marine accessibility and, using policy sciences analysis, identify future alternatives. Finally, we consider implications for the international law of the sea.

## II. SOCIAL PROCESS AND CLIMATE

Arctic social interactions have been limited by geography—by a mostly ice-covered semi-enclosed sea comprising archipelagos and straits surrounded by coastal tundra. The region is dark, frozen, tempestuous. Physical contours and environment have long imposed limitations on habitation, exploration, navigation, hydrocarbon exploitation, and mining. Now, anthropogenic climate change transforms sea and ice—affecting livelihoods, commerce, security, and the environment. States, mariners, indigenous peoples, and corporations operate in a social process shaped by rapidly evolving climatic conditions. Sea level rise in the Arctic is affecting baselines dynamically. Ice melt is producing more open water, raising expectations for increased human activity including navigation, tourism, and resource extraction, all affecting Arctic biodiversity.

The earlier Arctic resource scramble was for seals, whales, and bears. Now it is about the exploitation of the earth's riches—oil, gas, nickel, gold, uranium, and rare earth elements. Arctic littoral States assert power. Military bases were built and expanded during the Cold War and with the prospect of a Cold War II they are now being revitalized.<sup>7</sup> Assets are being positioned

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6. See generally Charles H. Norchi, *Culture and Law on the Durand Line: Continuity and Change*, in CULTURAL CHANGE AND PERSISTENCE: NEW PERSPECTIVES ON DEVELOPMENT 203 (William Ascher & Jay Heffron eds., 2010).

7. Dmitri Trenin, *Welcome to Cold War II*, FOREIGN POLICY (Mar. 4, 2014), <https://foreignpolicy.com/2014/03/04/welcome-to-cold-war-ii/>.

on land, sea, and underwater. The consequences of climate change could disrupt the public order of the Arctic as dwindling sea ice opens new operating areas for naval surface ships. Russia operates many high Arctic vessels—ships and submarines—including the world’s largest fleet of nuclear-powered icebreakers. The Russian military is refitting old Cold War bases and building up new facilities on the Kola Peninsula, prompting NATO responses. And President Vladimir Putin has indicated an urgent need for Russia to secure strategic, economic, scientific, and defense interests in the Arctic.

The constant has been the cryosphere.<sup>8</sup> Ice has shaped Arctic interactions—as a barrier, a modality of transport, or a haven for ice-dependent species. It was, indeed, dependable. Now the cryosphere has become a great disruptor, accelerating demands for access. Non-polar States are knocking on the Arctic door. China, India, South Korea, and Singapore have declared Arctic interests. China has emerged as a polar-capable State seeking new shipping routes, energy resources, scientific research opportunities, and a seat at the Arctic governance table. Thus, China pursues a polar silk route.<sup>9</sup>

Demands for access are met with claims to control. The five Arctic littoral States—the United States, Canada, Russia, Norway, and Denmark (Greenland)—have historically asserted the most intensive Arctic claims, followed by the non-littorals that possess territory above the Arctic Circle—Finland, Sweden, and Iceland. The most extensive have been continental shelf claims that may result in coastal State jurisdictional overlap pursuant to the international law of the sea.

Climate change is dramatically reshaping oceanic trends and projections worldwide across a range of activities owing to warming, acidification, sea level rise, and cryospheric diminution. Traditional subsistence activities, commercial fishing, oil and gas exploitation, seabed mining, conservation, tourism, search and rescue, naval operations, and maritime transport are all affected. Projections indicate the legal instruments that regulate those activities will require reappraisal. Of the world’s oceans, the critical trends, conditions, projections, and alternative futures associated with climate change are most intensely captured in the Arctic. In this context, the temporal and

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8. *What is the Cryosphere? The Cryosphere is the Frozen Water Part of the Earth System*, NATIONAL OCEAN SERVICE (last updated Jan. 11, 2022), <https://oceanservice.noaa.gov/facts/cryosphere.html>.

9. *See China’s Arctic Policy*, THE STATE COUNCIL INFORMATION OFFICE OF THE PEOPLE’S REPUBLIC OF CHINA (Jan. 26, 2018), [http://english.gov.cn/archive/white\\_paper/2018/01/26/content\\_281476026660336.htm](http://english.gov.cn/archive/white_paper/2018/01/26/content_281476026660336.htm).

geographic distribution of change is a critical determinant of the evolving applications of the law. As a result, it is not sufficient to examine broad trends from off-the-shelf climate projections—what is required are the details of variability and change on a decision-relevant time frame and, more specifically, their manifestations in specific activities including resource exploitation, maritime trade, and navigation.

The Arctic is unique in its response to anthropogenic climate forcing from greenhouse gas emissions and other forms of pollution. Because of ice and snow feedbacks, the system, already naturally highly variable, is responding more rapidly to human forcing of the climate. These responses are manifest through warmer temperatures but also through changes in atmospheric and oceanic circulation, atmospheric moisture content, oceanic heat content and structure, glacial melt, and many other factors. As a result, the Arctic is an outlier and, indeed, an early warning system for anthropogenic climate change and its ramifications. Three key elements are relevant to the tractability of Arctic exploitation—sea level rise, storminess, and sea ice cover.

#### A. Sea Level Rise

Sea level rise, globally and regionally, is an important integrator of the anthropogenic climate signal. Increases in sea level arise from natural processes of land subsidence and human-caused effects such as the thermal expansion of warming water, glacial melting, and changes in ocean circulation. Sea level rise is a critical international law concern—maritime boundaries and zones will shift, low-lying coastal States will generate refugees, island States will disappear, populations will be reassigned, collective citizenships will be extinguished, and the law of State responsibility may be invoked.<sup>10</sup>

The sea level is already rising. Globally, the average sea level has increased around 0.2 meters since 1900 (an average rate of 1.7 millimeters per year). But the rate of increase is accelerating, with sea level over the last ten years increasing by around 3.7 millimeters per year.<sup>11</sup> Sea level responds to

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10. The United Nations International Law Commission (ILC) has formed a committee on Sea Level Rise in Relation to International Law. *See* Int'l Law Comm'n, Rep. of the Int'l Law Comm'n on its Seventieth Session, U.N. Doc. A/73/10, ¶ 369 (2018). The International Law Association (ILA) has published a report on international law and sea level rise. *See* DAVOR VIDAS ET AL., INTERNATIONAL LAW AND SEA LEVEL RISE: REPORT OF THE INTERNATIONAL LAW ASSOCIATION COMMITTEE ON INTERNATIONAL LAW AND SEA LEVEL RISE 3 (Feb. 2019).

11. Paola Andrea Arias et al., *Technical Summary*, in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT

climatic forcing more slowly than the atmosphere and is expected to continue to rise for centuries even if emissions reach net zero or even negative in the coming decades. While large measurement uncertainties accrue from the tilt of the planet and from sea ice coverage, both of which make satellite altimetry challenging, Arctic Ocean sea level rise appears to be an outlier, rising faster than the global average.<sup>12</sup>

Future projections of global average sea level rise depend on the emissions scenario. However, by the end of the twenty-first century, expectations for average sea level rise range from as low as 0.3 meters under a low emissions scenario to as much as 1.0 meter under a high emissions scenario. Approaching 2.0 meters worldwide by 2100 cannot be ruled out because of high uncertainties associated with glacial melt.<sup>13</sup> In this context, sea level rise in the Arctic Ocean is projected to occur at the high end of the estimates and could be as high as 2.5 meters by 2100 in the highest emissions scenarios.<sup>14</sup>

### B. Storminess

The response of the Arctic atmosphere is more complex. A recent report from a major Washington policy think tank, the Center for International & Strategic Studies, contends that climate change “leads to an increase in the intensity and frequency of extreme weather events, which may challenge

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REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 35, 77 (Valérie Masson-Delmotte et al. eds., 2021).

12. Stine Kildergaard Rose et al., *Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era: 1991–2018*, REMOTE SENSING 1, 1 (July 14, 2019), <https://www.mdpi.com/2072-4292/11/14/1672>; Carsten A. Ludwigsen & Ole B. Andersen, *Contributions to Arctic Sea Level From 2003 to 2015*, 68 ADVANCES IN SPACE RESEARCH 703 (July 15, 2021), <https://www.sciencedirect.com/science/article/abs/pii/S0273117719309275>.

13. See generally Richard P. Allan et al., *Summary for Policymakers*, in CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS (Valerie Masson-Delmotte et al. eds., 2021), [https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC\\_AR6\\_WGI\\_SPM.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf); Paul A. Mayewski et al., *Potential for Southern Hemisphere Climate Surprises*, 30 JOURNAL OF QUATERNARY SCIENCE 391 (2015).

14. See generally Bruno Ferrero et al., *Long-term Regional Dynamic Sea Level Changes from CMIP6 Projections*, 38 ADVANCES IN ATMOSPHERIC SCIENCES 157 (2021).

shipping.”<sup>15</sup> It is true that the recent sixth assessment conducted by the Intergovernmental Panel on Climate Change<sup>16</sup> presents evidence that some extremes are already increasing in frequency and intensity, namely, heat waves, heavy rainfall, some classes of drought, and the most intense classes of tropical cyclones. However, evidence that polar cyclones have increased in either frequency or intensity is limited<sup>17</sup> due to challenges in observing these systems, particularly at the finer scales characterized by the most intense systems. Furthermore, the models used for projections of climate change are presently too coarse to resolve the future evolution of these systems.<sup>18</sup> Authors who have developed down-scaling approaches to interrogate the projections have consistently found a *decrease* in the projected frequency of polar cyclones.<sup>19</sup> In any case, polar cyclones are predominantly a cold season phenomenon and form rarely in the high Arctic, primarily affecting the Nordic Seas, the Denmark Strait, the Labrador Sea, and Hudson Bay.<sup>20</sup> As a result, it cannot be posited that more extreme weather events are a factor that will affect Arctic activities as the Center for International & Strategic Studies report concluded.

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15. Heather A. Conley et al., *Russia's Climate Gamble: The Pursuit and Contradiction of Its Arctic Ambitions*, in A REPORT OF THE CENTER FOR INTERNATIONAL & STRATEGIC STUDIES EUROPE, RUSSIA, AND EURASIA PROGRAM 1, 17 (Sept. 24, 2021).

16. See Allan et al., *supra* note 13.

17. See Patrick J. Stoll et al., *An Objective Global Climatology of Polar Lows Based on Reanalysis Data*, 144 QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL SOCIETY 2099 (2018); Alexander F. Vessey et al., *An Inter-comparison of Arctic Synoptic Scale Storms Between Four Global Reanalysis Datasets*, 54 CLIMATE DYNAMICS 2777, 2793 (2020).

18. M. Moreno-Ibáñez, *The Challenges of Forecasting Small, But Mighty, Polar Lows*, EOS (Sept. 3, 2021), <https://eos.org/features/the-challenges-of-forecasting-small-but-mighty-polar-lows>.

19. See Romu Romero & Kerry Emanuel, *Climate Change and Hurricane-like Extratropical Cyclones: Projections for North Atlantic Polar Lows and Medicanes Based on CMIP5 Models*, 30 JOURNAL OF CLIMATE 279, 282–99 (2017); Oskar A. Landgren et al., *Projected Future Changes in Marine Cold-Air Outbreaks Associated with Polar Lows in the Northern North-Atlantic Ocean*, 53 CLIMATE DYNAMICS 2573 (2019); Dellang Chen et al., *Summary of a Workshop on Extreme Weather Events in a Warming World Organized by the Royal Swedish Academy of Sciences*, 72 TELLUS B: CHEMICAL AND PHYSICAL METEOROLOGY 1 (2020).

20. See Zihan Chen & Amanda H. Lynch, *Arctic Maritime Cyclone Distribution and Trends in the ERA5 Reanalysis*, 61 JOURNAL OF APPLIED METEOROLOGY AND CLIMATOLOGY 429 (2022).



### C. Sea Ice Cover

Arctic sea ice is in retreat.<sup>21</sup> The precipitous decline in summer sea ice cover has attracted widespread attention from both the scientific community<sup>22</sup> and the general public.<sup>23</sup> The summer minimum sea ice extent, which typically occurs in September each year, has retreated to levels not observed since at least 1850.<sup>24</sup> On September 16, 2021, the sea ice reached an annual minimum extent of 4.72 million square kilometers, compared to 7.05 million square kilometers in 1979, the beginning of the satellite record. The lowest sea ice extents on record have all been observed within the last fifteen years. More than any other Arctic trend, this massive transition has raised expectations that routes across the Arctic will be economically viable for shipping in the very near term. Certainly, domestic cargo tonnage between Russian Arctic ports appears to be increasing.<sup>25</sup>

However, the global climate is an agent of change in the Arctic<sup>26</sup> and nowhere is this better exemplified than at the ice edge. Time series data of the total Arctic ice extent obscure the complexity of sea ice in the real environment. Observed ice conditions vary from “open water” (under 15 percent ice coverage) to the marginal ice zone (15 to 80 percent ice coverage) to very close pack ice (almost 100 percent ice coverage). “Ice-free” is distinct from “open water” in that it contains no ice at all. The percentage of ice

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21. Aiguo Dai et al., *Arctic Amplification is Caused by Sea-ice Loss Under Increasing CO<sub>2</sub>*, 10 NATURE COMMUNICATIONS 1 (Jan. 10, 2019), <https://www.nature.com/articles/s41467-018-07954-9>.

22. See *id.*; Julienne Stroeve & Dirk Notz, *Changing State of Arctic Sea Ice Across All Seasons*, ENVIRONMENTAL RESEARCH LETTERS, Sept. 24, 2018, at 1; Robbie D.C. Mallett et al., *Faster Decline and Higher Variability in the Sea Ice Thickness of the Marginal Arctic Seas When Accounting for Dynamic Snow Cover*, 15 THE CRYOSPHERE 2429 (2021), <https://tc.copernicus.org/articles/15/2429/2021/tc-15-2429-2021.pdf>.

23. Henry Fountain, *Arctic Sea Ice Reaches a Low, Just Missing Record*, NEW YORK TIMES (Sept. 21, 2020), <https://www.nytimes.com/2020/09/21/climate/arctic-sea-ice-climate-change.html>.

24. See generally John E. Walsh et al., *A Database for Depicting Arctic Sea Ice Variations Back to 1850*, 107 GEOGRAPHICAL REVIEW 89 (2017).

25. See Laurence C. Smith & Scott R. Stephenson, *New Trans-Arctic Shipping Routes Navigable by Midcentury*, 110 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES E1195 (2013); Bjorn Gunnarsson, *Recent Ship Traffic and Developing Shipping Trends on the Northern Sea Route—Policy Implications for Future Arctic Shipping*, MARINE POLICY 1 (Dec. 25, 2020), <https://www.sciencedirect.com/science/article/pii/S0308597X20310204>.

26. See generally Amanda H. Lynch et al., *Towards an Integrated Assessment of the Impacts of Extreme Wind Events on Barrow, Alaska*, 85 BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY 209 (2004).

cover is sensitive to the area selected for calculation and, as a result, these proportions depend on the resolution of the observing system used. The details of individual icebergs and floe characteristics are not systematically tracked. As a result of this complexity, the decline in sea ice extent is as discursive as it is geophysical.<sup>27</sup> Most pertinent to shipping futures, the ice edge is defined differently across resources used for safety and compliance. Most ice forecasting operational centers use the World Meteorological Organization standards and requirements, which define the ice *edge* as the 10 percent ice cover concentration line.<sup>28</sup> This line is interpolated from microwave and synthetic aperture radar data and is dependent on the pixel size of these sensors. Equatorward of this line is defined as open water. Applying more detail with less precision, the Polar Code defines open water as a “large area” of navigable ocean in which sea ice concentrations are less than 10 percent *and* no ice of land origin—icebergs calved from glaciers—is present.<sup>29</sup> However it is defined, the clear signal of ice retreat has engendered expectations for a “Race to the North,” for national security among Arctic States, for opportunities, for navigation, and more.

For polar navigation, details matter. Russia accounts for more than half the Arctic Ocean coast and sea ice has retreated primarily from the eastern Arctic.<sup>30</sup> This has been an enabler of the expansion of a Russian Arctic presence. Indeed, expansion of infrastructure has been most rapid and extensive in the Russian Arctic: Since 2000, satellite analyses detect new developments totaling 350 square kilometers identified as oil and gas infrastructure, 140

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27. For example, the Norwegian government, through oil exploration licensing and ecosystem management plans, considers ice extent in the Norwegian Sea to be fixed in space in ways that enable the definition of zones of hydrocarbon opportunity, fisheries regulation, and biodiversity protection. Inuit cultures identify fluctuating marginal ice areas as critical for biological productivity, for ice dependent mammals such as walrus and seal as well as pelagic resources such as Arctic cod. Climate change activists use the retreating ice and its impact on charismatic megafauna such as polar bears and whales as a symbol to prompt greenhouse gas emissions reductions. See Siri Veland & Amanda H. Lynch, *Arctic Ice Edge Narratives: Scale, Discourse and Ontological Security*, 49 AREA 9 (2016).

28. World Meteorological Association, Sea-Ice Nomenclature, WMO/OMM/BMO No. 259 Suppl. No. 5. Linguistic Equivalent (2009), <https://doi.org/10.25607/OBP-1530>.

29. International Maritime Organization, International Code for Ships Operating in Polar Waters, IMO Doc. MEPC 68/21/Add.1/Annex 10 (2016) (entered into force Jan. 1, 2017) [hereinafter Polar Code].

30. See also Ron Kwok, *Arctic Sea Ice Thickness, Volume, and Multiyear Ice Coverage: Losses and Coupled Variability (1958–2018)*, ENVIRONMENTAL RESEARCH LETTERS 1, 4 (Oct. 12, 2018), <https://iopscience.iop.org/article/10.1088/1748-9326/aae3ec/pdf>.

square kilometers as mining infrastructure, and several hundred square kilometers associated with fishing, agriculture, and military activities.<sup>31</sup> These infrastructure developments both enable and drive the use of the Northern Sea Route, particularly for voyages within the Arctic. Furthermore, the expected ice refugia in the Canadian Archipelago and northwest Greenland, where summer sea ice is expected to persist throughout the twenty-first century, is likely to limit the viability of the Northwest Passage for the coming decades.<sup>32</sup>

### III. LAW AND ICE

The ice melt impact upon the Arctic social process is expanding activities and interactions in the previously insular community.<sup>33</sup> This has implications for shared norms, customs, and prescriptive codifications. Climate change now unhinges expectations about the processes of decision-making—the who and the how of authoritative procedures. It will shape aspects of Arctic law-making—a process that communicates policy, indicates control, and generates expectations of authority.<sup>34</sup>

In contrast to the Antarctic, which is subject to a single treaty regime, the constitutive process of the Arctic comprises multiple transnational instruments and institutions wherein decision outcomes and procedures clarify and secure common interests.<sup>35</sup> Key institutions are the Arctic Council, the

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31. See Annett Bartsch et al., *Expanding Infrastructure and Growing Anthropogenic Impacts Along Arctic Coasts*, ENVIRONMENTAL RESEARCH LETTERS 1 (Nov. 8, 2021), <https://iopscience.iop.org/article/10.1088/1748-9326/ac3176/pdf>.

32. Stephanie Pfirman et al., *The Last Arctic Sea Ice Refuge*, 4 THE CIRCLE 6 (2009); National Research Council, *The Arctic in the Anthropocene: Emerging Research Questions* (2014), <https://nap.nationalacademies.org/download/18726>.

33. The term community “designates interactions in which inter-determination or interdependence in the shaping and sharing of all values attain an intensity at which participants in pursuit of their own objectives must regularly take account of the activities and demands of others. It is this ‘taking into account’ which generates claims perforce resolved by decision processes.” Myres S. McDougal, W. Michael Reisman & Andrew R. Willard, *The World Community: A Planetary Social Process*, 21 UNIVERSITY OF CALIFORNIA DAVIS LAW REVIEW 807, 810–972 (1988).

34. See W. Michael Reisman, *International Law-making: A Process of Communication*, 75 PROCEEDINGS OF THE ANNUAL MEETING OF THE AMERICAN SOCIETY OF INTERNATIONAL LAW 101 (1981).

35. See Charles H. Norchi, *Unlike Antarctica, There is No Arctic Treaty*, JOURNAL OF THE NORTH ATLANTIC AND THE ARCTIC (June 2018), <https://jonaa.org/content/2018/06/25/noarctic treaty>.

International Maritime Organization, and the World Meteorological Organization. And because the Arctic is ocean surrounded by land the dominant legal regime is the customary and codified law of the sea. That law balances “the special exclusive demands of coastal states, and other special claimants, and the general inclusive demands of all states in the world arena.”<sup>36</sup> The widely applicable codified instrument of the law of the sea is the United Nations Convention on the Law of the Sea of 1982 (UNCLOS),<sup>37</sup> supplemented by the Polar Code,<sup>38</sup> the International Convention for the Safety of Life at Sea,<sup>39</sup> and the International Convention for the Prevention of Pollution from Ships.<sup>40</sup>

UNCLOS establishes maritime zones; clarifies coastal State jurisdiction over zones and activities; preserves freedom of navigation, conservation of fish stocks, and environmental protections; defines procedures for marine scientific research, hydrocarbon extraction, and seabed mining; and establishes institutions. Notably, these institutions include the International Tribunal for the Law of the Sea, the Commission on the Limits of the Continental Shelf, and the International Seabed Authority. In sum, UNCLOS clarifies the rights and obligations of coastal and land-locked States. Governments negotiated multiple drafts and provisions from 1973 to 1982 in Geneva at the Third United Nations Conference on the Law of the Sea. The term “climate” does not appear in the text of the convention.

In 2008 the five littoral Arctic States concluded a declaration at Ilulissat, Greenland, asserting:

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36. Myres S. McDougal & William T. Burke, *Crisis in the Law of the Sea: Community Perspectives Versus National Egoism*, 67 *YALE LAW JOURNAL* 539, 539 (1958).

37. United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS].

38. POLAR Code, *supra* note 29.

39. International Convention for the Safety of Life At Sea, Nov. 1, 1974, 32 U.S.T. 47, 1184 U.N.T.S. 277 (as amended).

40. Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973, with Annexes and Protocols, Feb. 17, 1978, 1340 U.N.T.S. 61. An international legal instrument for conservation and sustainable use of marine resources beyond the competence of coastal States, now in drafting stage, was proposed and decided by the United Nations Generally Assembly in Resolution 69/292 of June 19, 2015 “to develop an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.” G.A. Res. 69/292 (Jan. 19, 2015).

an extensive international legal framework applies to the Arctic Ocean . . . [that] the law of the sea provides for important rights and obligations concerning the delineation of the outer limits of the continental shelf, the protection of the marine environment, including ice-covered areas, freedom of navigation, marine scientific research, and other uses of the sea. We remain committed to this legal framework and to the orderly settlement of any possible overlapping claims.

This framework provides a solid foundation for responsible management by the five coastal States and other users of this Ocean through national implementation and application of relevant provisions. We therefore see no need to develop a new comprehensive international legal regime to govern the Arctic Ocean.<sup>41</sup>

Although the five Arctic littoral States have affirmed their commitment to UNCLOS, aspects of that international law framework are unstable, owing to climate change.

#### A. *Baselines*

Baselines are the fundamental edifice of the law of the sea because they determine coastal State jurisdiction over marine space and every zone seaward is measured from the baseline. Pursuant to UNCLOS, a normal baseline follows the sinuosity of a coast or can consist of straight lines enclosing deep indentations and geographic anomalies such as the Norwegian *skjærgaards*. Until climate change, baseline continuity was reliable on human decision timescales. With sea level rise, the limits of the twelve nautical mile territorial sea, the twelve nautical mile contiguous zone, and the two hundred nautical mile exclusive economic zone will require adjustment. As sea level rises from thermal expansion and land ice melt, baselines and maritime zones, presumed to have been settled under conventional and customary international law, will change.<sup>42</sup> However, because it is already displacing its equivalent water volume on the ocean, sea ice melt does not contribute to sea level rise.

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41. Ilulissat Declaration, May 28, 2008, *reprinted in* 48 INTERNATIONAL LEGAL MATERIALS 382 (2009).

42. *See* Davor Vidas, *Sea-Level Rise and International Law: At the Convergence of Two Epochs*, 4 CLIMATE LAW 70 (2014).

Nevertheless, we project that key UNCLOS provisions pertaining to baselines, ice-covered waters, navigation, and straits will be acutely affected in the Arctic.<sup>43</sup>

*B. Ice-Covered Waters*

During deliberations of the Third UN Conference on the Law of the Sea, two negotiating parties joined in common cause seeking additional jurisdictional competence over their adjacent waters. In February 1976, negotiators in the United States Mission to the UN in Geneva received a cable suggesting a provision for the treaty text. The language was proposed by Canada and the Soviet Union:

The coastal state, notwithstanding the other provisions of this convention, has the right to establish non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in areas within the limits of the economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to the protection of the marine environment based on the best available scientific evidence.<sup>44</sup>

The most navigated ice-covered waters were in the Canadian and Soviet Arctic. If accepted by the Third UN Conference on the Law of the Sea and incorporated into the text, the effect would be a *lex specialis* that would authorize the competence of certain coastal States to prescribe and apply anti-pollution laws and regulations minimally limited by an amorphous “due regard” amounting to extensive servitudes upon navigation.

The interests of two consequential Arctic States, Canada and the Soviet Union, were aligned.<sup>45</sup> One was a United States adversary and the other an

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43. See UNCLOS, *supra* note 37. As a consequence, UNCLOS Articles 197 through 201, which provide for regional cooperation to protect the marine environment, prevent pollution, and collaboration on scientific research data, will also be affected.

44. Cable from U.S. Mission Geneva to Secretary of State for Ambassador Learson and John Norton Moore, Subject: Canadian-Soviet Proposal on Arctic, Feb. 3, 1976, NATIONAL ARCHIVES, <https://aad.archives.gov/aad/createpdf?rid=103042&dt=2082&dl=1345>.

45. *Id.* The cable included the following comment: “In view of apparent Canadian-Soviet agreement, it would appear Task Force should address problem ASAP to defeat or modify new proposal.”

ally. Their proposal became Article 234 in the final text, by which time “due regard to navigation” was added:

Coastal States have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence.<sup>46</sup>

Article 234 allocates coastal States broad prescriptive and enforcement jurisdiction in ice covered areas.<sup>47</sup> The article contains a temporal limitation intersecting with a spatial limitation expressed in the clause, “for most of the year.” But Canada and Russia assert overly broad claims over their respective Arctic routes.<sup>48</sup>

What does ice-covered “for most of the year” mean? Decreasing ice-coverage dictates that fewer States will be able to rely on Article 234 over less marine space. This raises questions pertaining to the scope and future application of Article 234; notably, what extent of ice coverage is required for application of this provision? Is the provision applicable to the exclusive economic zone (EEZ) only? To other zones? To international straits? What, in light of the “object and purpose” of UNCLOS, is the “ordinary meaning” of “for most of the year” for purposes of interpreting Arctic 234?<sup>49</sup>

From the time UNCLOS entered into force, Article 234 has been promoted as a *lex specialis* for coastal State authority to protect the polar marine

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46. UNCLOS, *supra* note 37, art. 234.

47. Helmut Tuerk noted, “Article 234 is thus directed at preserving the fragile ecology of ice-covered areas, but only within the limits of a coastal State’s EEZ, such as the US, Canadian and Russian EEZ that extend into the Arctic.” Helmut Tuerk, *The Arctic and the Modern Law of the Sea*, in GOVERNING OCEAN RESOURCES: NEW CHALLENGES AND EMERGING REGIMES 115, 130 (Jon M. van Dyke et al. eds., 2013).

48. The United States Government contests Russian claims to internal water status of the Straits of Dimitri Laptev, Sannikov, Shokal’skii, and Vil’kitskii and enclosures via straight baselines.

49. *See* Vienna Convention on the Law of Treaties art. 31, May 23, 1969, 1155 U.N.T.S. 331.

environment for what is in reality *lex simulata* purporting to extend enforcement jurisdictions that minimize due regard for navigation. It has been invoked as authority for jurisdictional competencies not contemplated at the Third United Nations Conference of the Law of the Sea that generated UNCLOS.<sup>50</sup>

### C. International Straits

Another UNCLOS provision that will be affected by climate change-induced sea ice melt concerns straits used for international navigation. These navigational chokepoints of the world's merchant fleets and navies are critical for Arctic sea passage. The special status of straits used for international navigation was underscored in 1949 by the International Court of Justice in the *Corfu Channel* case<sup>51</sup> and by long-standing State practice. Today there is a "regime of straits" codified as UNCLOS Part III.

The existing Arctic straits are within the Northwest Passage and the Northern Sea Route. Whether these are straits used for international navigation within the meaning of Article 37 of UNCLOS is disputed. Whether innocent or transit passage applies depends on the legal characterization of the strait. Innocent passage applies in the territorial sea. There is no right of innocent passage in internal waters, other than in archipelagic waters and (as potentially in this case) inside straight baselines that enclose areas that had not previously been considered as internal waters.<sup>52</sup> The United States regards the Northwest Passage and parts of the Northern Sea Route as straits used for international navigation subject to the regime of transit passage.<sup>53</sup> Relevant to the status of the Northwest Passage is the 1988 Arctic Cooperation Agreement concluded between the United States and Canada. However, the United States views the agreement as covering transits solely for the purpose of marine scientific research.<sup>54</sup> Current trans-Arctic navigation depends upon transit passage through these straits.

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50. Such as mandatory vessel reporting and routing requirements.

51. *Corfu Channel* (U.K. v. Alb.), Judgment, 1949 I.C.J. 4 (Apr. 9).

52. UNCLOS, *supra* note 37, art. 8(2).

53. U.S. DEP'T OF STATE, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, LIMITS IN THE SEAS NO. 112, UNITED STATES RESPONSES TO EXCESSIVE NATIONAL MARITIME CLAIMS 73 (Mar. 9, 1992).

54. Canada-United States: Agreement on Arctic Cooperation, Jan. 11, 1988, *reprinted in* 28 INTERNATIONAL LEGAL MATERIALS 142 (1989). The pertinent text reads:



## IV. THE NORTHERN SEA ROUTE AND ARCTIC NAVIGATION

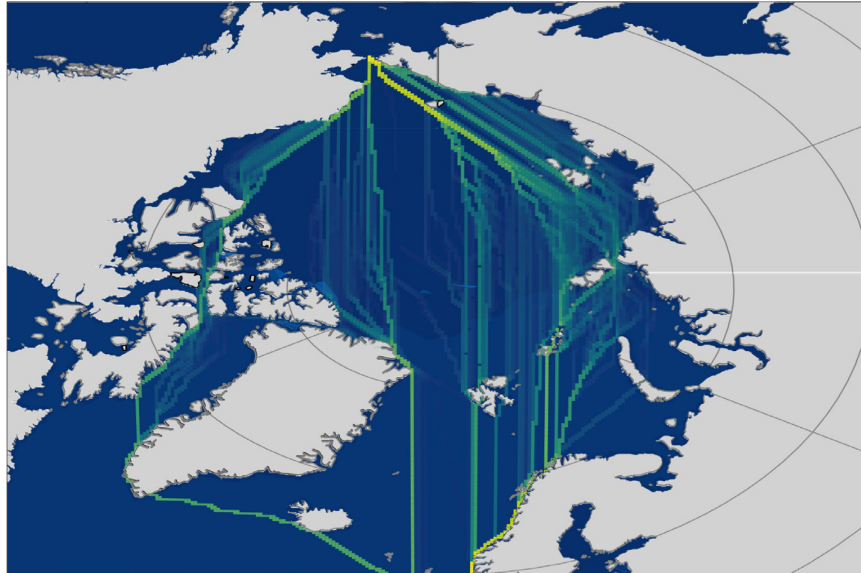


Figure 1. New navigation routes available by mid-century. Each line shows a route that will be navigable by an open water class vessel for at least ten days per shipping season (green lines) and up to a hundred days per season (yellow lines) based on a future high emissions scenario using the Max Planck Institute Earth System Model. Note that under these climatic conditions, even the Northwest Passage is navigable for short periods, although the Northern Sea Route remains more reliable.

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In recognition of the close and friendly relations between their two countries, the uniqueness of ice-covered maritime areas, the opportunity to increase their knowledge of the marine environment of the Arctic through research conducted during icebreaker voyages, and their shared interest in safe, effective icebreaker navigation off their Arctic coasts:

- The Government of the United States and the Government of Canada undertake to facilitate navigation by their icebreakers in their respective Arctic waters and to develop cooperative procedures for this purpose;
- The Government of Canada and the Government of the United States agree to take advantage of their icebreaker navigation to develop and share research information, in accordance with generally accepted principles of international law, in order to advance their understanding of the marine environment of the area;

The Government of the United States pledges that all navigation by U.S. icebreakers within waters claimed by Canada to be internal will be undertaken with the consent of the Government of Canada.

The Northern Sea Route traversing Russia's 24,140-kilometer (15,000-mile) Arctic coastline from its border with Norway in the Barents Sea to the Bering Strait in Alaska, is the most trafficked Arctic Ocean route and the shortest shipping route connecting Europe and Asia (Figure 1).<sup>55</sup> It is a marine corridor north of the Russian Federation wherein vessel traffic passes through distinct maritime zones of internal waters, territorial sea, archipelagic waters, straits, and EEZ.<sup>56</sup> Russian law describes the Northern Sea Route as "a historically developed national transport communication of the Russian Federation."<sup>57</sup> Significantly, Russia employs straight baselines claiming that segments of the route lie within internal waters. The official Russian view appears to have evolved to characterize the entire Northern Sea Route as internal waters.<sup>58</sup>

Much of current Arctic navigation, particularly through the Northern Sea Route, is subject to servitudes<sup>59</sup> and encumbrances derived from law and science. The legal encumbrances are national regulations of Russia.<sup>60</sup> During the 1990s the Russian Federation, invoking UNCLOS Article 234, adopted

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55. The Northern Sea Route is defined variously as the entire eastern route linking the Pacific and Atlantic Oceans (also called the Northeast Passage), or in Russian legislation as only that component of the Northeast Passage that lies entirely within the Russian EEZ. See Viatcheslav Gavrilov, *Russian Legislation on the Northern Sea Route Navigation: Scope and Trends*, 10 THE POLAR JOURNAL 273, 275 (2020).

56. "Open water depths for the NSR vary from 20 to 200m. Different route options require transiting one or more of the many straits along the route." James Kraska, *Russian Maritime Security Law Along the Northern Sea Route: Giving Shape to Article 234 in the Law of the Sea Convention*, in CHALLENGES OF THE CHANGING ARCTIC: CONTINENTAL SHELF, NAVIGATION AND FISHERIES 593, 602 (Myron Nordquist et al. eds., 2016).

57. Gavrilov, *supra* note 55, at 275.

58. Pavel Gudev, *Conflicting Interests in Regulating Navigation in the Bering Strait*, RUSSIAN INTERNATIONAL AFFAIRS COUNCIL (Oct. 8, 2015), <https://russiancouncil.ru/en/analytics-and-comments/analytics/kollizii-regulirovaniya-sudokhodstva-v-beringovom-prolive>.

59. A corollary in American law pertains to the U.S. Constitution's Fifth Amendment Takings Clause, which limits the government's sovereign power of eminent domain but includes an exception that allows the Federal government to exercise its power to regulate and control the nation's navigable waterways without paying compensation—a navigational servitude.

60. See Betsy Baker, *Beyond the Northern Sea Route: Enhancing Russian-United States Cooperation in the Bering Strait Region*, POLAR PERSPECTIVES NO. 8 (Nov. 2021), [https://www.wilsoncenter.org/sites/default/files/media/uploads/documents/Polar%20Perspectives%20No.%208\\_Beyond%20the%20Northern%20Sea%20Route.pdf](https://www.wilsoncenter.org/sites/default/files/media/uploads/documents/Polar%20Perspectives%20No.%208_Beyond%20the%20Northern%20Sea%20Route.pdf).

regulations applicable to the entire Northern Sea Route.<sup>61</sup> These now include mandatory insurance requirements, navigation rules including authorization procedures, the requirement to carry a State pilot aboard, and mandatory ice breaker pilotage to be paid for in accordance with a published schedule of charges. They apply to all vessels, including warships and government vessels, which under the international law of the sea are accorded immunity and are thus beyond the scope of UNCLOS Article 234.<sup>62</sup>

The U.S. Department of State objects to the Russian regulatory scheme for the Northern Sea Route as *prima facie* inconsistent with international law. According to the United States, violations include the permit requirements to enter and transit the EEZ and territorial sea and the “persistent characterization of international straits that form part of the NSR as internal waters; and the lack of any express exemption for sovereign immune vessels.”<sup>63</sup> The United States government contends that regulatory Northern Sea Route schemes do not comport with UNCLOS Article 234.<sup>64</sup> The United States position is that Russian Northern Sea Route regulations infringe upon “freedom of navigation within the exclusive economic zone, the right of innocent passage in the territorial sea, and the right of transit passage through straits used for international navigation.”<sup>65</sup>

Furthermore, there are science-derived encumbrances deriving from the frozen, dark, tempestuous, and remote nature of the Arctic. Arctic routes for through-shipping present a plausible alternative to the Suez Canal for many reasons. Whether by the Northern Sea Route (7,350 nautical miles from Rotterdam to Yokohama), the Northwest Passage, or the Transpolar Route (a non-coastal route that traverses the central Arctic Ocean), the voyage is significantly shorter than the Suez route (11,250 nautical miles). Even accounting for slower vessel speeds, this has the potential to result in lower emissions as well as lower costs. The Arctic routes are not subject to the kinds of single vessel blockages so recently exposed by the *Ever Given* incident in March,

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61. The 1998 Federal Law on the Exclusive Economic Zone and the Federal Law on the Internal and Territorial Marine Waters, Territorial Sea and the Adjacent Zone provides authority for Russian regulation of its maritime zones, including Northern Sea Route uses.

62. Kraska, *supra* note 56, at 593–612.

63. RUSSIA-NORTHERN SEA ROUTE, 2015 DIGEST OF UNITED STATES PRACTICE IN INTERNATIONAL LAW 526.

64. *Id.* at 527.

65. *Id.*

2021. The blockage was estimated to have cost \$400 million per hour.<sup>66</sup> With the ice already in retreat, however, Arctic through-shipping is not as active as might be expected. The Arctic remains risky because of limited satellite navigation coverage, challenges for emergency management, and crews who are inexperienced in the polar cold and dark conditions. The Arctic remains expensive to transit due to the cost and limited size of polar class vessels under the Polar Code, as well as regulatory requirements that include an ice breaker escort on the Russian-controlled Northern Sea Route.<sup>67</sup> Concerns remain regarding impacts on the fragile Arctic environment due to increased traffic. These potential impacts range from aerosol deposition to oil spills.

The dynamic nature of access to seasonally ice-covered Arctic waters and the straits that provide passage presents an additional complexity. Decision-making for shipping operators takes place under considerable uncertainty, whereby the projected length of a continuous shipping season is challenging to determine. Individual transits of the Northern Sea Route require ten days to two weeks of reliable ice conditions, which is at the limit of present forecasting capacity, even in more data-rich regions of the globe.

In the Arctic, predictive forecasts are more challenging due to sparse and dirty data, and the projection of an entire shipping season is outside the capacity of the best models and forecasting centers. The development of expectations for marine accessibility is challenged by considerable inter-model variation which does not provide sufficient guidance for reliable near-term operational planning (Figure 2, below). The fact that the spread of predicted season lengths in any given year can span from zero days of viable open water for shipping to more than three months is particularly problematic for making decisions that are economically defensible.<sup>68</sup> Indeed, the average of all models provides no relief, since any sufficiently skillful model scenario is as likely as any other, and the ensemble average is not significantly more likely than any single model realization. Thus, while expectations for the

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66. James Baker et al., *Suez Canal Remains Blocked Despite Efforts to Refloat Grounded Ever Given*, LLOYD'S LIST (Mar. 24, 2021, 1655 GMT), <https://lloydlist.maritimeintelligence.informa.com/LL1136229/Suez-Canal-remains-blocked-despite-efforts-to-refloat-grounded-Ever-Given>.

67. Interview by Dr. Lynch with Dr. Veland Norvald Kjerstad, in Ålesund, Norway at the Docent at Institutt for Havromsoperasjoner og byggtknikk (2016).

68. Michael A. Goldstein et al., *Economic Viability and Emissions of Multimodal Transportation Infrastructure in a Changing Arctic*, WEATHER, CLIMATE, AND SOCIETY (2022), [https://journals.ametsoc.org/view/journals/wcas/aop/WCAS-D-21-0151.1/WCAS-D-21-0151.1.xml?tab\\_body=pdf](https://journals.ametsoc.org/view/journals/wcas/aop/WCAS-D-21-0151.1/WCAS-D-21-0151.1.xml?tab_body=pdf).

Race to the North are rising, the realities of Arctic maritime operations remain highly contingent. As a result, shipping along this route has grown only moderately in recent years and primarily as destination shipping for Russian industrial, fisheries, and strategic purposes.<sup>69</sup>

#### A. Projections of Arctic Marine Accessibility

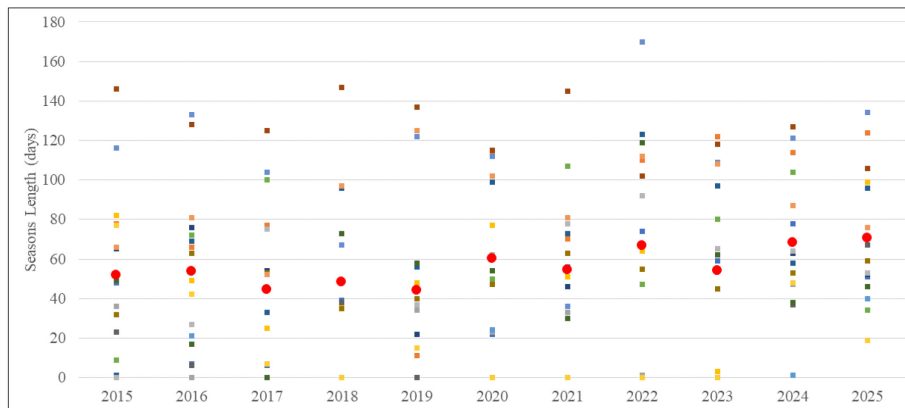


Figure 2. Viable shipping season length for open water class vessels. Each square represents the estimate from a particular model of the number of continuous days of open water shipping available along any Arctic route over the period 2015–2025. The larger red circle shows the mean of all estimates.

Figures 1 and 2 were formulated by conducting calculations of current and projected sea ice cover and route accessibility using output from sixteen global climate models that participated in the Coupled Model Intercomparison Project Phase 6 (CMIP6).<sup>70</sup> The models were driven by recent past and

69. See Heather A. Conley et al., *Russia's Climate Gamble: The Pursuit and Contradiction of Its Arctic Ambitions*, REPORT OF THE CENTER FOR INTERNATIONAL & STRATEGIC STUDIES, (Sept. 24, 2021) (positing the Northern Sea Route as an exaggerated economic benefit).

70. See generally Veronika Eyring et al., *Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) Experimental Design and Organization*, 9 GEOSCIENTIFIC MODEL DEVELOPMENT 1937 (May 26, 2016), <https://gmd.copernicus.org/articles/9/1937/2016/gmd-9-1937-2016.pdf>.

current emissions and projected into the future using a high emissions scenario.<sup>71</sup> This is but one of many alternative futures, but at the time of writing appears to be the most likely path forward.

By analyzing ice categories to compute corresponding risk index values for defined Polar Class vessels, we identify “go or no-go” situations and their safe travel speeds. The resulting map of travel speed is then used to identify the optimal least-cost route using Dijkstra’s algorithm.<sup>72</sup> The optimal route and its travel time are only recorded when a transit can be realized in full from the start location of Rotterdam, Netherlands, to the destination location at the Bering Strait. It is important to note that on any given day, routes can be generated that conform to the Northern Sea Route, the Northwest Passage, or the Transpolar (or Central Arctic) Route.

Once the least cost routes are calculated for every model realization and every day that is not impassable, a season length for each year can be calculated.<sup>73</sup> For a given year from April 1st to March 31st of the following calendar year (known as the “ice year”), the recorded navigable days are counted towards the season length calculation, shown in Figure 2 for example. Specifically, the season length only considers continuously navigable days without any impassable days, allowing a shoulder of five days at the beginning and end of the season to align with more realistic operational decision processes. From this, the start day and the end day of the season can be recorded, as well as the season length.

The possible pathways to a seasonally ice-free Arctic are uncertain, but projections allow some useful assessments. For example, it is clear that the retreat of ice from the eastern Arctic is likely to continue, continuing the pattern of ice cover reducing more rapidly for the Northern Sea Route than the Northwest Passage.

Furthermore, it is possible to make projections into the coming decades specifically for open water transit routes that do not pass through Russian territorial waters. We have designed and performed this calculation, the results of which are shown in Figure 3, below. These routes require transits

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71. This pathway is defined by the Intergovernmental Panel on Climate Change as the Shared Socioeconomic Pathway (SSP) 5 and the Representative Concentration Pathway (RCP) 8.5 scenario (referred to as SSP5-8.5).

72. Edsger Dijkstra developed a simple procedure for calculating the shortest path between nodes on a graph. The procedure is known as Dijkstra’s algorithm. Edsger W. Dijkstra, *A Note on Two Problems in Connexion with Graphs*, 1 NUMERISCHE MATHEMATIK 269 (1959).

73. See Lawrence R. Mudryk et al., *Impact of 1, 2 and 4° C of Global Warming on Ship Navigation in the Canadian Arctic*, 11 NATURE CLIMATE CHANGE 673 (2021).

through the Bering Strait, but they do not require icebreaker transport, nor indeed Polar Class vessels. As for the present decade, the projected length of the navigable season for these routes varies widely from one model to another, with some models suggesting no navigability by 2065, while others project a relatively reliable open water season. However, useful information can still be gleaned. Taken together, the models indicate that the start date of the shipping season is earlier at a rate of almost three days per decade, and this result is statistically significant. There is no significant change in the close of the shipping season in these projections. Perhaps most usefully, it is possible to assess the likelihood of an open water shipping season that avoids Russian territorial waters. The projections suggest that the likelihood of these seasons will increase over time and be realized with some reliability by the 2060s.

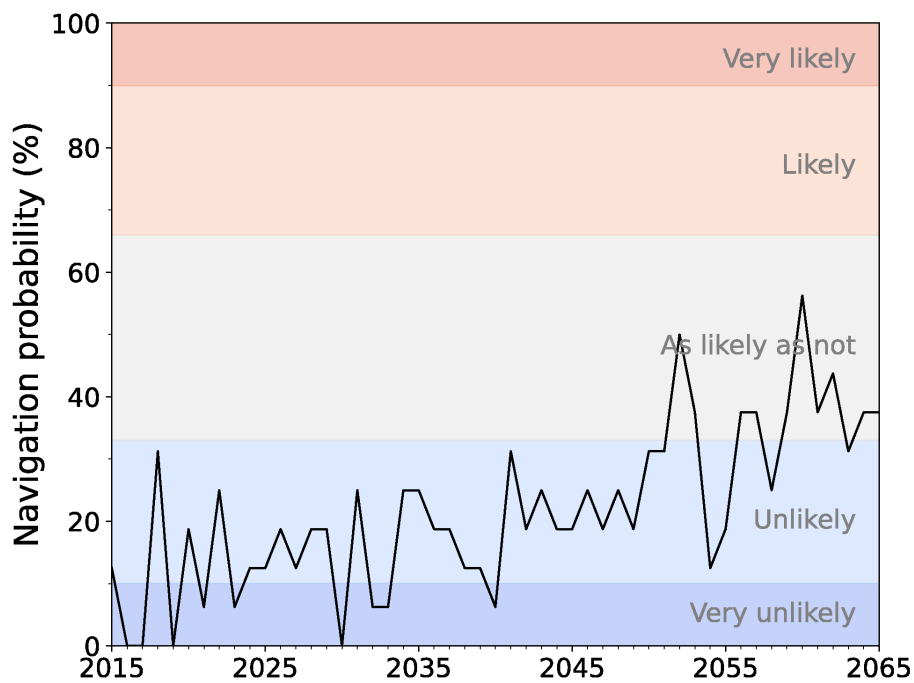


Figure 3. Projections of the probability of Arctic navigability outside Russian territorial waters over the period 2015–2065. The annual navigation probability is a pragmatic measure, calculated as the fraction of the sixteen CMIP6 models that have a season length greater than twenty days, which with the shoulder allowances suggests an open water shipping season of a

month or more. The level of confidence for this assessment corresponds to the Intergovernmental Panel on Climate Change convention, that is, very likely expressed as 90–100% probability, likely 66–100%, as likely as not 33–66%, unlikely 0–33%, and very unlikely 0–10%.

Taken together, these best available assessments of scientific knowledge suggest that transit shipping through the Arctic that avoids not just Russian territorial waters but also the requirements for ice breaker escorts and high Polar Class vessels will be viable as we transition to the second half of the twenty-first century. However, the pathway to this future state is fraught with high uncertainty and is sensitive to other global conditions, including shocks and conflict. What will this mean for alternative futures?

## V. PROJECTIONS AND FUTURE ALTERNATIVES

Flexibility and realism will require recalibrating the international law of the sea in the face of ice retreat and sea level rise. As we have demonstrated, the end point of climate change as manifest in the Arctic is certain, but the trajectory is not. As argued cogently by meteorologist Eric Kraus: “First, we can never know the present completely; second, we are not able to make errorless deductions from what we know; and third, our limited imaginations may prevent us from asking the right questions.”<sup>74</sup> While climate science has advanced considerably in the intervening half-century, the system remains complex and chaotic. It is possible for science to place bounds on the evolution of the system, but the human response to that evolution remains the domain of law.

Thus, our projections of routes through the Northern Sea Route in the face of retreating sea ice, the opening of alternative routes generating increased shipping choice and reduced economic friction indicate that reappraisal of Article 234 is merited. This requires present decision-maker attention by governments, shipping owners, and lawyers based on available science. The breadth of new routes we have calculated as potentially available for open water vessels by mid-century are shown in Figure 1.

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74. Eric Kraus, *The Unpredictable Environment*, 63 NEW SCIENTIST 649, 652 (Sept. 12, 1974). See also FRANK EDWIN EGLER, THE NATURE OF VEGETATION, ITS MANAGEMENT AND MISMANAGEMENT: AN INTRODUCTION TO VEGETATION SCIENCE 18 (1977) (“Nature is not more complicated than you think, it is more complicated than you CAN think”).



With a new ice-free route outside of the Northern Sea Route, maritime transportation operators will be commercially motivated to eschew the burdensome Northern Sea Route waters claimed as internal and territorial by Russia. Disagreements over the legal status of the Northern Sea Route as a strait used for international navigation will be largely moot. Sea traffic will traverse the Russian EEZ seaward of coastal islands and thus be subject to fewer navigational servitudes. Pursuant to UNCLOS, the EEZ navigational encumbrances are minimal. The treaty only authorizes coastal State regulations to ensure compliance with environmental protection, fisheries conservation, and marine scientific research.<sup>75</sup> The tyranny of Article 234 will recede. The consequences for Arctic shipping and global maritime trade will be profound.

#### VI. CONCLUSION: SCIENCE IN THE CONSTITUTIVE PROCESS OF THE ARCTIC

Our projections have implications for the law of the sea in the Arctic and potentially beyond. The UNCLOS text must be understood in context. Ice melt could spawn the reappraisal of key provisions. Article 234 may fall into desuetude; rarely invoked and thus rendered inapplicable.<sup>76</sup> It is in the dynamic nature of international law that prescriptions do not remain constant. Conflicting demands, expectations, and a stream of outcomes spawned by international incidents can cause norms to be terminated. There is *lex imperfecta*, that is, prescriptive norms may be clear, but an effective administrative process may be absent. And there is *lex simulata*—the announcement of statutory instruments which might appear to operate, yet neither the elites nor the target audience actually expect it to apply. The real laws, inclusive of the Arctic, are those processes of decisions consistent with community members' expectations about what is right and effective. State practice, *opinio juris*, and government elite responses to critical incidents will be affected by the climate, which could affect the object and purpose of the treaty. International agreements can succumb to desuetude.

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75. UNCLOS, *supra* note 37, arts. 53, 73.

76. As Helmut Tuerk noted, "The question may, however, be asked what will happen to Article 234 if the ice should disappear—would it then become obsolete and with it the special rights granted thereunder to the coastal States concerned with respect to the protection of the environment." Tuerk, *supra* note 47, at 130.

For the Arctic, the fundamental problem will be how to balance exclusive interests to ensure a greater common interest for people and States.<sup>77</sup> Thus what prescriptions, legal instruments, and mechanisms might ensure robust and responsive regional governance in an environment affected by ice-melt that is accelerating Arctic events? The problems manifest in overlapping claims to navigation, maritime boundaries, polar safety, maritime security, shipping, energy, indigenous rights, tourism, marine conservation, environmental protection, and emerging demands of non-polar States such as China, India, South Korea, and Singapore. These claims implicate law, science, trade, and geopolitics. State and non-State actors undertake activities to attain a range of outcomes that are not all guided by responsible custodianship. Thus, there is an urgent need for robust international law and policy arrangements to effectively accommodate and regulate activities shaped by dramatic climatic transformations that will best fulfill human dignity.

We conclude that Article 234, long promoted as a *lex specialis* for coastal State authority to protect the polar marine environment, has been operating as a *lex simulata* to extend enforcement jurisdiction, invoked as authority for coastal State regulations only loosely associated with environmental outcomes.

Article 234 obsolescence would be but one consequence of the irrepressible march of climate change; the condition that has become the inescapable context of the UNCLOS text. Many circumstances that were in place through the decade of negotiations at Geneva will have fundamentally changed, *rebus sic stantibus*.<sup>78</sup> A critical question is how the Arctic constitutive process, driven by an ever-intensifying process of claims, will evolve in a context shaped by unprecedented cryospheric conditions.<sup>79</sup> How will power be allocated and structures of authority designed? Who will be the decision-makers and what will be the procedures for that “process of human beings making choices” that we know as law?<sup>80</sup> The policy problem is access versus

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77. As Betsy Baker has noted, “How the regional regime for the marine Arctic will develop depends in part on how the balance will be struck between the interests and roles of the many actors that claim equities in the region.” Betsy Baker, *The Developing Regional Regime for the Marine Arctic*, in *THE LAW OF THE SEA AND THE POLAR REGIONS* 35, 37 (Erik J. Molenaar et al. eds., 2013).

78. See Vienna Convention on the Law of Treaties, *supra* note 49, art. 62.

79. See Charles H. Norchi, *The Arctic in the Public Order of the World Community*, 22 *OCEAN AND COASTAL LAW JOURNAL* 5 (2017).

80. W. MICHAEL REISMAN & AARON M. SCHREIBER, *JURISPRUDENCE: UNDERSTANDING AND SHAPING LAW* 595 (1987).

control, for whom, and by whom.<sup>81</sup> The answers will turn on science, law, and policy.

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81. As Lasswell asked, “Who gets what, when, how?” HAROLD D. LASSWELL, *POLITICS: WHO GETS WHAT, WHEN, HOW* (1936).