Russian Ambitions to Control Freedom of Navigation and Arctic Access: Refined Data Challenging Moscow's Northern Sea Route Claims

Troy Bouffard, Gennaro D'Angelo, Gabrielle F. Gundry, Travis R. Pitts, Stephen F. Price, and Andrew F. Roberts

This article examines Russia's efforts to regulate navigation along the Northern Sea Route (NSR) and tests the legal premise for those efforts under UNCLOS Article 234 ("ice-covered areas"). We present updated, model-based risk estimates derived from CMIP6 sea-ice projections and the IMO POLARIS framework. Results indicate steadily declining navigation risk for PC6 (and stronger) vessels for six months of the year through the 2030s, undermining Russia's risk-based justification for expansive regulatory control out to the EEZ. We outline implications for freedom of navigation and the dangers of allowing these practices to calcify into customary international law, and we recommend how user states can incorporate refined risk evidence into legal, diplomatic, and operational responses.

Introduction

Russia's current Northern Sea Route (NSR) regulatory posture rests on a risk-based reading of Article 234 that expands coastal-state control well beyond accepted practice. This article reassesses that risk premise with updated data and shows where Moscow's reasoning – and the evidence it relies on – no longer supports expansive control inconsistent with international navigation norms. As a result, this work explores a segment of data to shed light on direct connections with Kremlin policy and practice. In particular, we show that the previous data-related contributions and reasoning of Moscow's NSR policies require clarification and updates. Our findings indicate that Russia's excessive maritime claims largely rest on outdated assumptions and faulty risk reasoning.

Article 234 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) establishes a special legal regime for "ice-covered areas" within a coastal State's exclusive economic zone (EEZ). Under this provision, when particularly severe climatic conditions and ice coverage for most of the year create "obstructions or exceptional hazards to navigation," the coastal State may

Troy Bouffard, Director – Center for Arctic Security and Resilience, University of Alaska Fairbanks.

Gennaro D'Angelo, Scientist, Los Alamos National Laboratory,

Gabrielle F. Gundry, Environmental Planner, Vanasse Hangen Brustlin, Inc,

Travis R. Pitts, Science Program Manager, Los Alamos National Laboratory,

Stephen F. Price, Scientist, Los Alamos National Laboratory,

Andrew F. Roberts, Scientist, Los Alamos National Laboratory.

adopt and enforce non-discriminatory laws and regulations, beyond those in Articles 192 and 194, for preventing, reducing and controlling marine pollution from vessels operating in those waters. These measures must give "due regard to navigation," apply equally to domestic and foreign ships, and be justified by the environmental risks posed by sea ice. In practice, Arctic States have used Article 234 to regulate shipping through routes like the Northern Sea Route and Northwest Passage, though its vagueness about what qualifies as an ice-covered area has led to differing interpretations and occasional disputes over freedom of navigation (Postler, 2020).

The development and protection of the Russian NSR remains one of Moscow's top national economic and security priorities (Moe, 2020; Bouffard, 2024). To that end, Kremlin goals in recent decades included efforts to control access to the surface waters of the NSR from the coast to the Exclusive Economic Zone (EEZ) boundary 200 nautical miles out from established and claimed straight baselines (Maritime Claims Reference Manual, 2024). Such a maritime claim represents an official conflict for the United States based on its positions on international and operational law. Operational law is the applied body of domestic and international law that governs how military and other government operations are planned and executed, combining treaty law (e.g., UNCLOS), customary law, rules of engagement, U.S. statutes/directives, and commander authorities like self-defense. In this article's context, it's the framework the United States uses to design and conduct Freedom of Navigation operations and related assertions, (e.g., deciding whether to refuse coastal-state pilotage, fees, or pre-approval on the NSR), so that actions both advance navigation rights and remain legally compliant. Specifically, the United States does not recognize portions of Moscow's claims where they conflict with freedom-of-navigation principles under UNCLOS (international law) and the U.S. Freedom of Navigation Program (operational law) (Cregge & O'Conner, 2023; Grimes et. al., 2006).

Other user states have objected as well. The EU and the UK have repeatedly signaled non-acceptance of Moscow's NSR rules where they exceed UNCLOS authorities, and China, prior to recent commercial alignment with Russia on Arctic shipping, explicitly resisted Soviet/Russian claims that conditioned transit on coastal-state permission. While several of these actors have been quieter lately amid joint commercial interests, their earlier legal positions are part of the record and underscore that this is not a U.S.-only dispute. The issue has two dimensions. First, traditional sovereignty and delimitation disputes, most notably the use of straight baselines and other excessive maritime claims. Second, attempts to entrench an NSR regulatory regime (e.g., pre-approval, mandatory pilotage/escort, routing) by treating it as general state practice supported by *opinio juris*, in effect seeking to crystallize it into customary international law. Maritime straight baselines are an official way to define a state's boundary near and along a coast, which establish an essential status where waters landward of the baseline (known as "internal waters") fall under total sovereign control, including the surface waters, water columns, seabed, and below. Regions zero-to-twelve nautical miles from the baseline are defined as territorial waters and regions twelve-to-twenty-four nautical miles are known as the contiguous zone. Both require maritime "innocent passage" based on different requirements governed internationally by UNCLOS. States often attempt to "push out" their straight baselines to gain total control and avoid undesirable innocent passage issues; this practice falls under traditional UNCLOS and dispute resolution processes. On the other hand, Moscow asserts authority to subject NSR transits, including in the EEZ, to domestic controls: advance notification and route approval, mandatory Russian pilotage and (fee-based) icebreaker escort, designated traffic lanes and reporting, carriage of Russian ice advisors, and prior authorization for foreign state/warships with the option to deny passage. This package of measures diverges from common state practice and precedent under UNCLOS, effectively treating broad areas of international waters as if they were subject to coastal-state permission on a pollution-risk rationale. The remainder of this article evaluates these specific measures and the legal theory, principally reliance on Article 234, invoked to justify them.

To date, the Kremlin has invoked UNCLOS Article 234, to justify a regulatory regime controlling access to NSR surface waters. Article 234 allows for expanded control of areas that are ice-covered for most of the year under the premise of safety and risk assessments regarding the dangers of navigating and operating in sea-ice-covered waters. However, these claims presuppose that data and evidence regarding its "ice-covered waters" are accurate and legitimate. Article 234 itself does not mandate a risk-reporting protocol; it allows non-discriminatory pollution-prevention measures in ice-covered waters (with due regard to navigation), while UNCLOS Article 211 and IMO GAIRAS, operationalized via the Polar Code and POLARIS, supply the evidence-based standards against which such measures are judged. As a result of Moscow's position, the research question for this article explores the extent to which Russia's data- and risk-based assessments justify regulatory control of the NSR. Here, we offer updated data and evidence that counter Russia's regulatory position in this regard, potentially strengthening the international legal position of the U.S. (unilaterally or otherwise) and adding value to its freedom of navigation-related dispute efforts.

The background section will provide the major components of necessary context regarding the legal definition of the NSR as well as the relevant international (Article 234) and operational law freedom of navigation). The next section presents updated data on NSR sea-ice concentrations as well as risk index outcomes, followed by discussion and conclusions.

Background

The Northern Sea Route

The origins of the NSR can be traced to 1932 when it was first defined (Østreng, 2010), followed by decades of minor developments leading to the next most substantial update with Russian Federal Law No. 132-FZ on July 28, 2012 (Кремль, 2012). This included the addition of Article 5.1 on "Navigation in the Waters of the NSR" and its definition extending from the Bering Strait to Novaya Zemlya (Figure 1), (Президент Путин, 2012). Russian Federal Law No. 132-FZ (28 July 2012) defines the waters of the Northern Sea Route as the water area adjoining the northern coast of the Russian Federation within its internal waters, territorial sea, contiguous zone, and EEZ**,** from the Kara Gate in the west to Cape Dezhnev/Bering Strait in the east, with specific boundary coordinates set by regulation. Of note, the Barents Sea is not part of the NSR under this legal definition. It is critical to understand that when Russia officially invokes the NSR for any purpose, the established definition is what they are referring to and nothing else. This is essential to understand and reference correctly because ever since Soviet times, Russian official reference of the NSR is specifically based on that fundamental definition.

The Kremlin's objective to control access to the surface waters of the NSR has strongly influenced and guided the behavior of Russia in its maritime Arctic since the end of the Soviet Union. Discerning the importance of international law, specifically UNCLOS, Moscow is aware it must conform and appeal to the authorities and intent of UNCLOS to secure such control over access to the NSR. Although Russia could likely enforce its position through military intervention, the Kremlin has an opportunity to ultimately establish their goal as customary law – a far more enduring and enforceable outcome than episodic military enforcement, which would require more aggressive deterrence. Details concerning Russia's soft-power (legal recourse among other options) vs. hard-power approach have been modestly researched and discussed (Pincus, 2020; Rumer et. al., 2021; Kjellén, 2022).

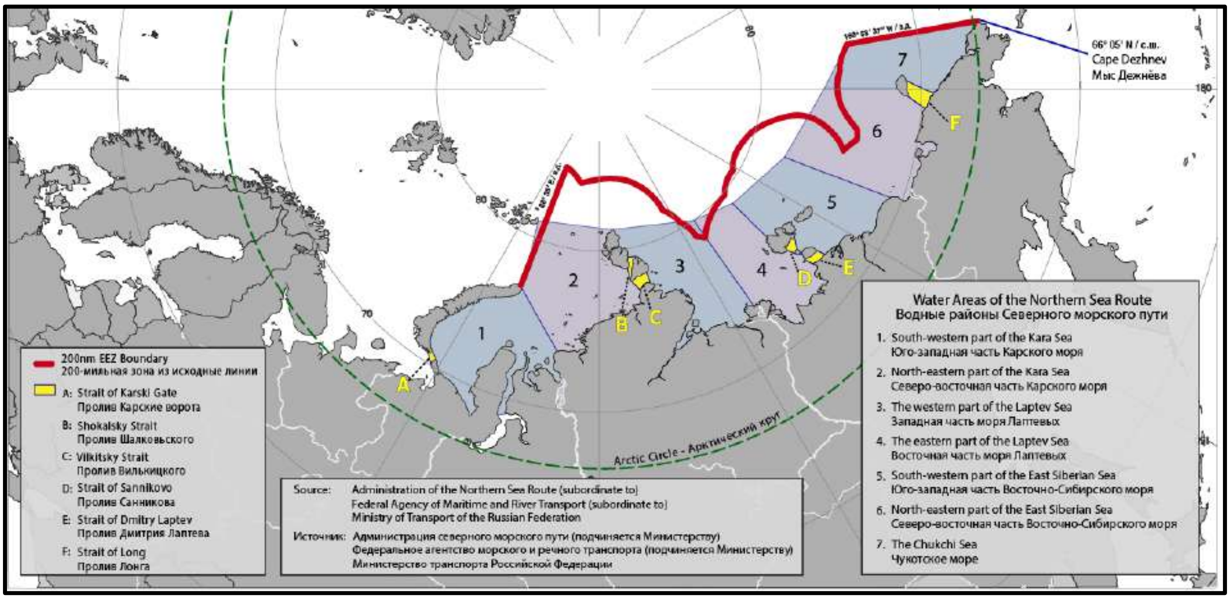

Figure 1: Northern Sea Route (NSR) legal extent from Kara Gate to Bering Strait**,** per Law No. 132-FZ (2012). Straits enclosed by straight baselines**,** Kara Gate**,** Vilkitskii Strait**,** Dmitry Laptev Strait, and baseline systems around the New Siberian Islands and Severnaya Zemlya are depicted as internal waters under Russian law. Source: Base map from Wikipedia adapted by authors

Article 234 of UNCLO

The UN Convention on the Law of the Sea states as followed:

Section 8: Ice-Covered Areas

Article 234

> 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 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.

Solski (2020, p. 388) provides a contemporary summary of the clause in its current understanding, stating that:

> It suffices to underline that Article 234 is a unique clause, although not the only one in UNCLOS, which, owing to its ambiguous language, managed to satisfy multiple delegations with divergent interests. The provision leaves extensive discretion to the coastal State to balance opposing interests, subject to unclear limitations, primarily the requirement to have due regard to navigation. At the same time, Article 234 includes normative standards that, in the event of dispute settlement, may be subject to interpretation by an international court or tribunal.

Within Article 234 the phrase "due regard" represents the main point of ambiguity and vagueness, allowing for the interpretive latitude and flexibility that is at the root of issues challenging international norms, specifically Russia's claim for absolute control of NSR surface waters out to its EEZ boundary. As explained by Williams (2017, p. 405), "while Article 234 of UNCLOS does allow Coastal States to promulgate and enforce navigational laws in the EEZ, the language requiring 'due regard for navigation' implies that Coastal States must still allow ships some opportunity for navigation and that they may not bar ships from passing through either their own territorial waters or EEZs." Yet "due regard" is not recognized by Russia when they require permission for passage, especially when such passage is also articulated as necessary by the legally binding *IMO Polar Code* (International Code for Ships Operating in Polar Waters, n.d.). Some consider that even Russian legal acts do not offer purposeful language for such a position, with the exception of one explanatory note introducing amendments to NSR regulations in 2012 (On Amending Certain Legislative Acts of Russian Federation in Terms of State Regulation of Merchant Shipping in the Northern Sea Route, 2012). Additionally, "some experts argue that Russia interprets UNCLOS too broadly and the Russian NSR legislation hardly meets the requirements of 'due regard to navigation' and 'presence of ice covering such areas for most of the year' set out in Article 234" (Todorov, 2022, p. 2). We return to and discuss this latter clause in detail below.

Regulatory Regime

Whereas Russian legislation might be deficient in legal articulation, the Kremlin's regulatory regime continued to develop regardless. Under the assumption that Russia has the right to control access to passage, media outlet *Independence* reported in March 2019 that:

> (f)rom now on warships and vessels of foreign countries have to inform Russia forty-five days in advance about their plans to pass through the NSR. Rules require specifying names of warships and [state] vessels, the purpose of their movements, routes, and sailing dates. In addition, the basic parameters of watercrafts must be reported, including displacement, length, width, draft and characteristics of the power plant. Military ranks and names of their captains are also required (Nezavisimaya Gazeta, 2019).

However, to date the regulation has not been established into power (i.e., legally codified), (Moe, 2020). Further increasing their requirements, the Russian government submitted a bill to the State Duma in August 2022 requiring foreign warships to provide a ninety-day notice to transit the NSR (TASS, 2022). The following year, Moscow published a decree (Sep 18, 2020 - № 1487) involving extensive rules for navigation in the waters of the NSR (Northern Sea Route Administration, n.d.). Through geographic coordinates and feature names, the decree illustrates a breakdown of the NSR into twenty-eight districts (appendix 3 of the decree). Additionally, appendix 2 of the decree specifies criteria for admission of ships in the NSR, which includes ice class of the ship (twelve types), ice navigation method (independent or with icebreaker), four types of ice conditions (none, light, medium, heavy) with indications for prohibited (-) or permitted (+) navigation in each district. Of note, the decree also demonstrates two distinctly critical issues of legal and principal concern, including Russia's excessive maritime claims involving internal waters through various straits (a more traditional territorial dispute situation) versus the enormously disparate intent to exercise control over NSR surface waters to the EEZ. A further complication is implementation. Russian authorities have at times allowed non-Polar-Class ships to operate along the NSR, reflecting capacity limits in screening and enforcement, thereby increasing operational risk and undercutting the premise that existing measures are calibrated to safety. Robust, non-discriminatory enforcement of the IMO Polar Code would itself confer substantial regulatory control over commercial shipping in polar waters, potentially reducing Moscow's incentive to lean on UNCLOS Article 234 for broader, EEZ-wide permission regimes.

Freedom of Navigation

Although Moscow does not claim the NSR waters beyond the contiguous zone as territorial or internal, their regulatory requirements and operational controls represent obviously similar circumstances. For the U.S. and others, this represents a textbook "excessive maritime claim", which is detailed in the U.S. Navy Maritime Claims Manual. To prevent Russia's claim from becoming customary law, the U.S. (and others) keep the issue active through a counter-position that officially does not recognize these claims. Usually, the competing position is communicated via official communique through diplomatic channels and high-level public pronouncements, articulating the principles, norms and values involving international law. At other times, when a counter-position needs to be emphasized – for effect or otherwise – surface vessels might pursue a Freedom of Navigation Operation (FONOP), conducted under operational law and within the authorities provided by National Security Directive 49 of October 1990 and managed through the U.S. Freedom of Navigation Program of 1979 (National Security Law Department, 2022). Other ways counter-positions might be delivered include strategically communicating an associated perspective for public and media consumption, such as remarks in 2019 from Secretary of State Pompeo and Secretary of the Navy Spencer (Auerswald, 2019).

For the U.S., freedom of navigation in the NSR remains an issue of principle first and foremost. Operationally, the need to navigate in the NSR is not currently as pressing a concern as is the desire to uphold international norms. Also, it remains unclear what the downstream effects of allowing Russia to maintain its claim might be. There are other contested Arctic waters: Canada claims the Northwest Passage and adjoining Arctic Archipelago waters as internal waters, a position the U.S. and other states dispute, in some respects more restrictive than Russia's NSR approach, so any NSR precedent could echo beyond Russia. However, Ottawa's assertions are based on legal interpretation and conditions that are far more reasonable that Moscow's. In the long term, a lack of sea ice altogether might render the issue moot; a lack of sea ice means a lack of sea ice-related risk. This seems to be associated with the approach that China maintains for challenging Russia's control over the NSR, where Beijing might be willing to wait for trans-Arctic shipping condition rather than compete with Moscow for open access especially given Russia's growing dependance on Chinese NSR-related investments and hydrocarbon purchases (Mekhdiev et. al., 2021). Eventually, trans-Arctic shipping could be possible and Russia's control over the

NSR will become less concerning. However, the U.S. remains concerned that Russia's efforts could result in their practice of controlling the NSR to eventually become customary law.

Data Updates and Refinements

The decline in Arctic sea ice concentration and thickness since the satellite period is well documented and quantified, with September sea ice volume having decreased by seventy-two percent over the period from 1979-2016 (National Snow and Ice Data Center, 2024; Fox-Kemper et. al., 2021). As a result of these ongoing declines, the "severe climatic conditions and the presence of ice covering … for most of the year" and the related "obstructions or exceptional hazards to navigation" have also been steadily declining. Based on the most recent set of internationally coordinated climate model projections (World Climate Research Programme, n.d.), the Arctic Ocean is projected to become "practically sea ice free" (Sea ice area below 1 million square km.) in summer before 2050 regardless of the greenhouse-gas emissions scenario under consideration (Notz & SIMIP Community, 2020). These same model projections contain detailed information on future sea ice concentration and thickness and can be combined with standard information on vessel characteristics to derive formal risk assessments for shipping in ice-covered waters, based on 'IMO Guidance on Methodologies for Assessing Operational Capabilities and Limitations in Ice'. Here, we combine Arctic sea ice projections from a select subset of CMIP6 models that meet certain criteria (Appendix A) with information on vessel-type to estimate the multi-model-averaged Risk Index Outcomes (RIO; Appendix B) for the six month period of the year (July through December) where sea ice concentration and thickness (and thus shipping risk) are likely to be at their lowest.

The RIO is an indexing system used by the International Maritime Organization to assess types and limitations of ship operations in ice-covered waters. Positive values of this index indicate normal operations. Some vessel types, e.g., the Finnish-Swedish ice classes, can also operate at negative values of the index greater than -10, albeit at a reduced speed. We calculate average values for the current (2020-2029) and next (2030-2039) decade for a Polar Class 6 (PC6) vessel, for which RIO>=0 implies normal operating conditions and -10<RIO<0 requires operating at reduced speeds.

Figures 2 and 3 below show the multi-model-mean, July-through-December monthly averaged sea ice concentration for these two decades in the context of Russia's EEZ. The spread of the results around the mean values (route plots) is quantified as the "standard deviation" (the shaded area). The standard deviation (square root of the variance of the distribution) provides a measure of how value spread around the expected value. Figures 4 and 5 quantify and map the related Arctic-wide, averaged RIO for a PC6 vessel for these same two decades and months of the year. Figures 6-9 show the multi-model-mean RIO and its spread (formally defined as one standard deviation from the mean at each point along the route) as a function of distance along two commonly used sections of the NSR, as defined by and consistent with Russia's definition discussed above (that is, the route passing through the four primary NSR straits, starting with the Kara strait in the west and proceeding (west-to-east) through the Vilkitsky, Sanikov, and Bearing straits).

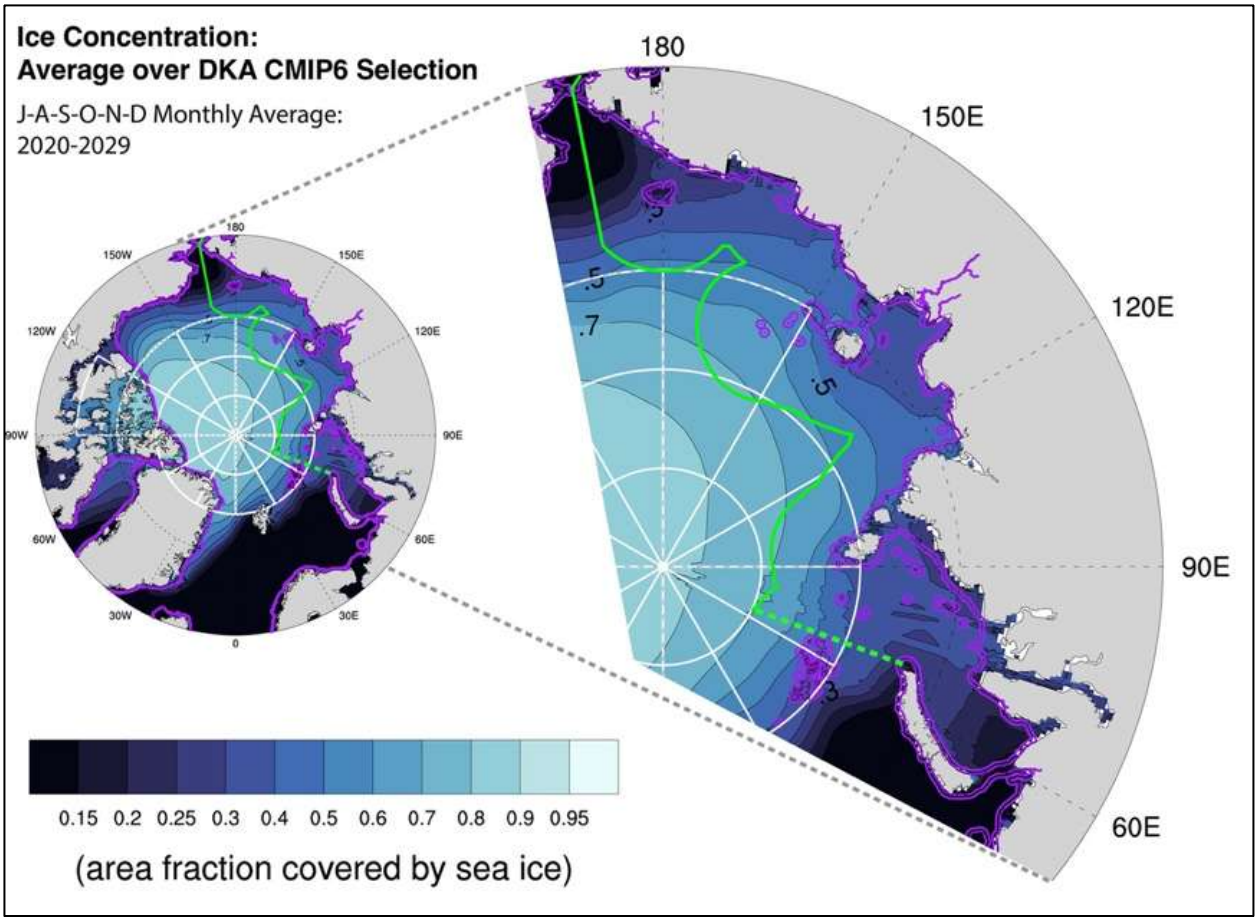

Figure 1: CMIP6 Model 1.

Projected sea-ice concentration (area fraction covered by sea ice) from an average of selected CMIP6 models (models 2 [above] and 3 [below]). Mapped values are an average of the six-month period from July to December during the decade 2020-2029 and represent the most likely outcome of the CMIP6 model selection. Purple and pink contours indicate territorial and EEZ boundaries, respectively, with the neon-green colored contour denoting Russia's EEZ boundary. White lines mark five degrees x thirty degrees latitude-longitude sectors in which the area-averaged sea-ice coverage is greater than 0.5 (or 50%). If the ice concentration of a sector is less than 0.5, its sea-surface area is mostly "ice-free". Source: Authors, Appendix A

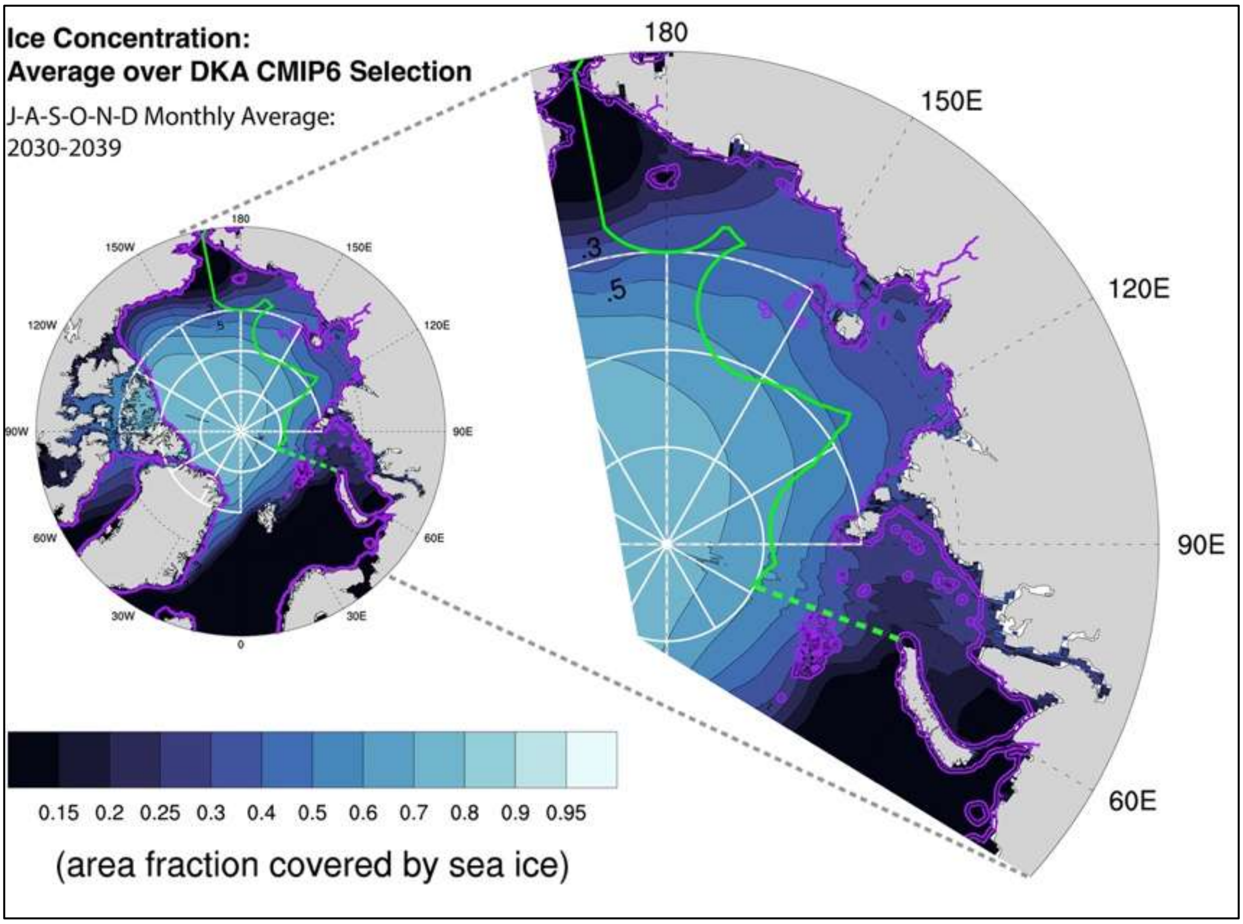

Figure 2: CMIP6 Model 2

As in Figure 2 but for the decade 2030-2039. Source: Authors, Appendix A.

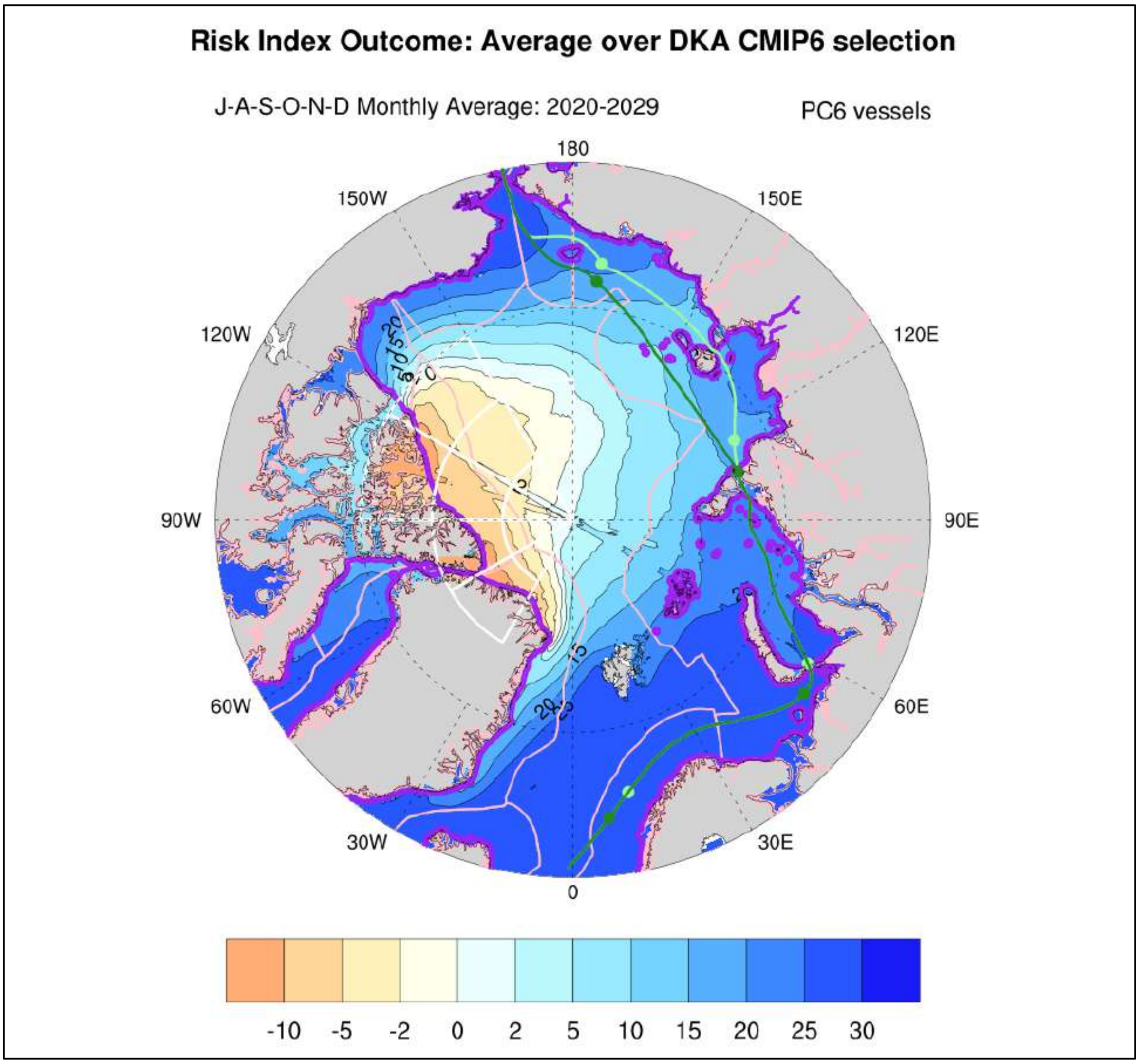

Figure 3: RIO Model 1

Risk Index Outcome (RIO) for a Polar Class 6 (PC6) vessel for the current decade during the six-month period from July to December. At each location, the RIO is a linear combination of the Risk Index Values (RIV) of the vessel and sea-ice concentrations. RIV values depend on sea-ice thickness, sea-ice age, and vessel type. PC6 vessels can operate under normal conditions when the RIO>=0 and at a reduced speeds when -10<RIO<0. As with the sea ice concentrations shown in Figures 2 and 3, mapped RIO values represent a multi-model average over the six-month period and provide the most likely outcome of the CMIP6 model selection. White lines on the map mark five degree x thirty degree latitude-longitude sectors in which the area-averaged RIO is negative. The Purple and pink contours are as in Figures 2 and 3. The green curves indicate two possible variations of near-coastal routes within the NSR corridor, one (light green) transiting both the Sannikov and Long straits and one (dark green) avoiding them by passing to the north. Purple, and pink colored lines are as described in Figure 2. Source: Authors, Appendix B.

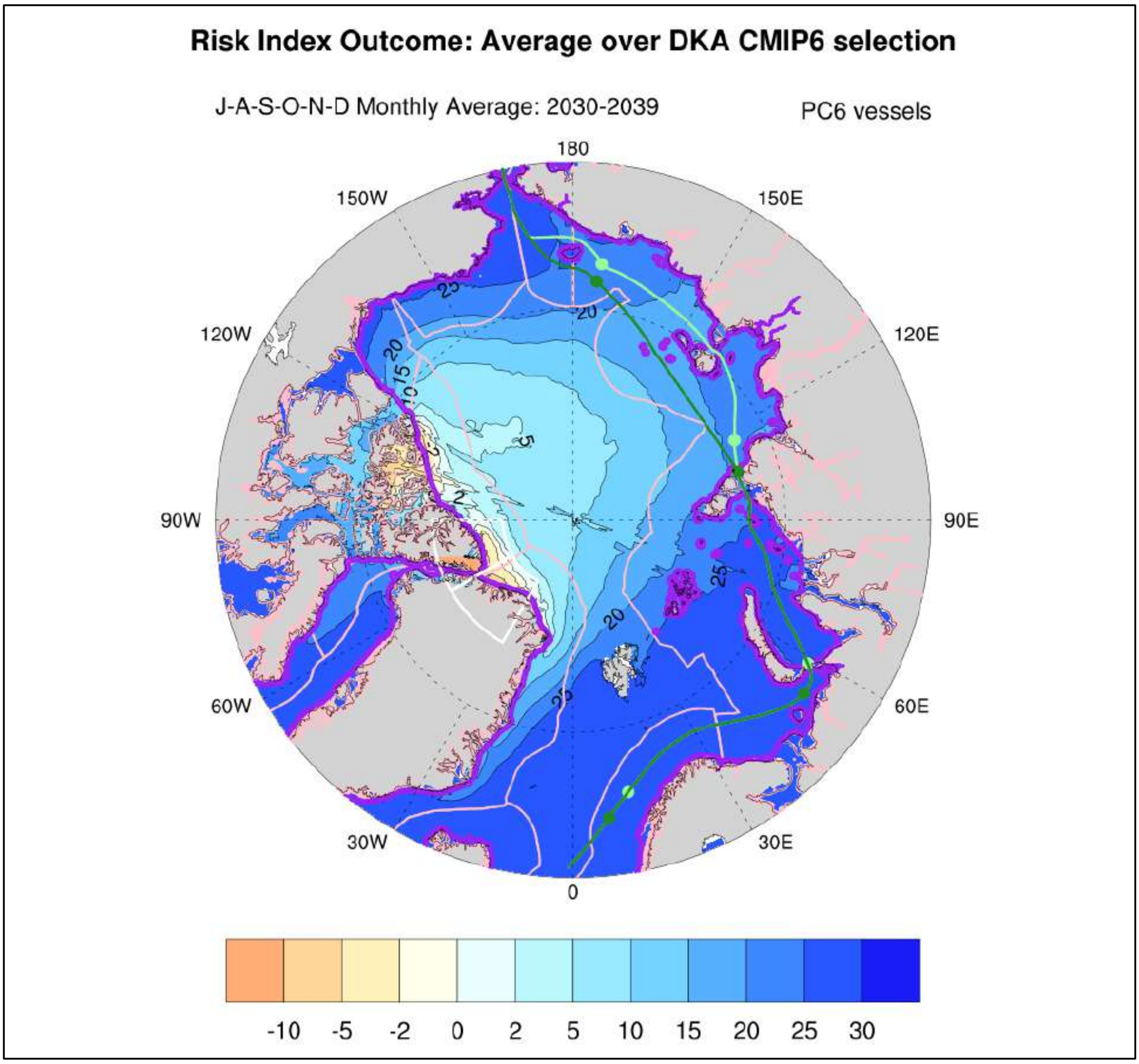

Figure 4: RIO Model 2

As in Figure 4 but for the decade 2030-2039. Source: Authors, Appendix B.

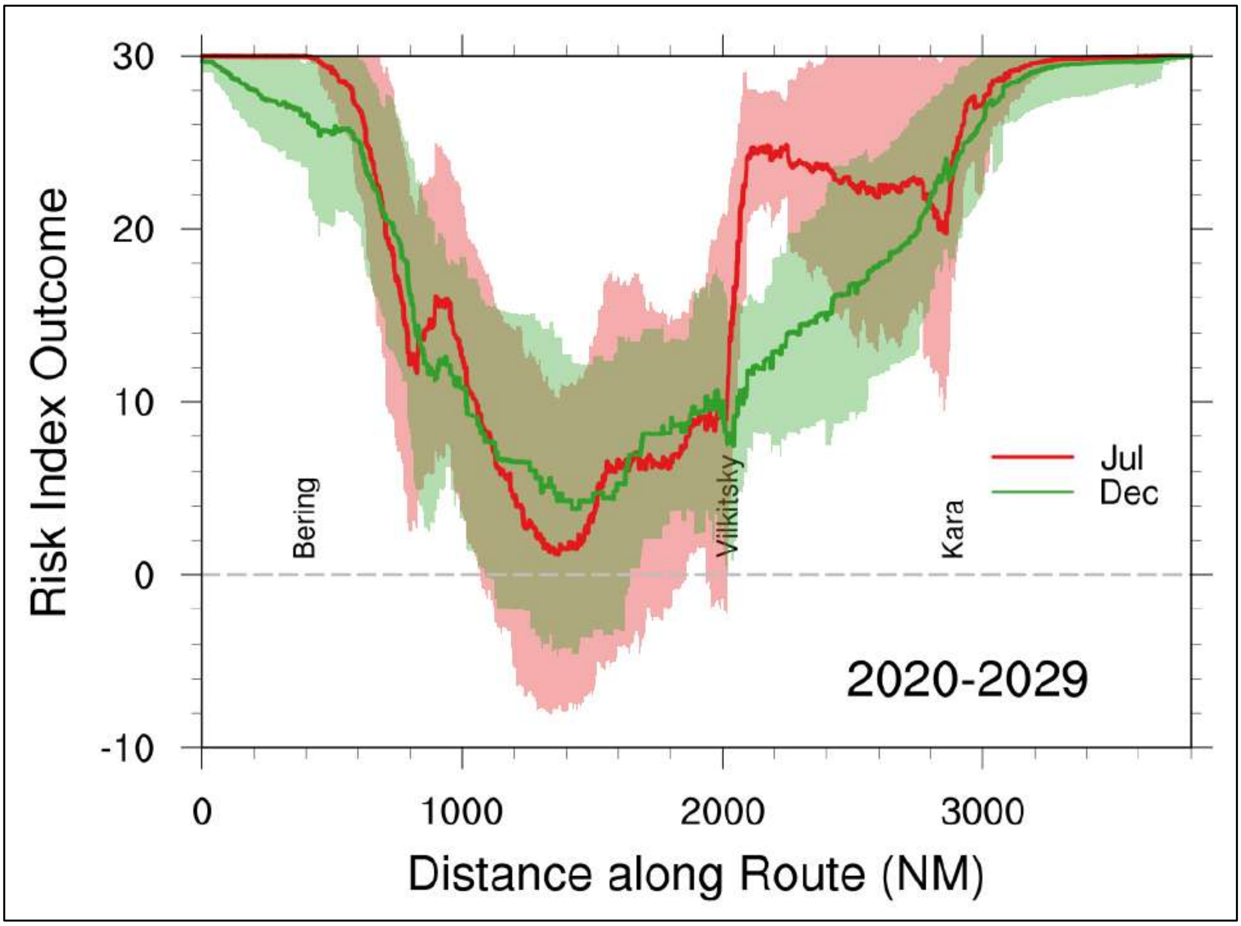

Figure 5: RIO Route Model 1

The solid lines in this plot indicate the RIO value computed along the NSR corridor, specifically the northernmost route (shown in dark green) in Figures 4 and 5. Values represent the multi-model, time-average RIO for the months of July and December (as indicated by legend) during the current decade and for a PC6 vessel. From July to December, such vessels would be able to navigate the route under normal conditions, according to the projections of CMIP6 models considered herein. The shading represents the uncertainty in RIO values resulting from the spread in model outcomes. For shading crossing into -10<RIO<0, PC6 vessels can still navigate albeit at reduced speeds. Source: Authors, Appendix B.

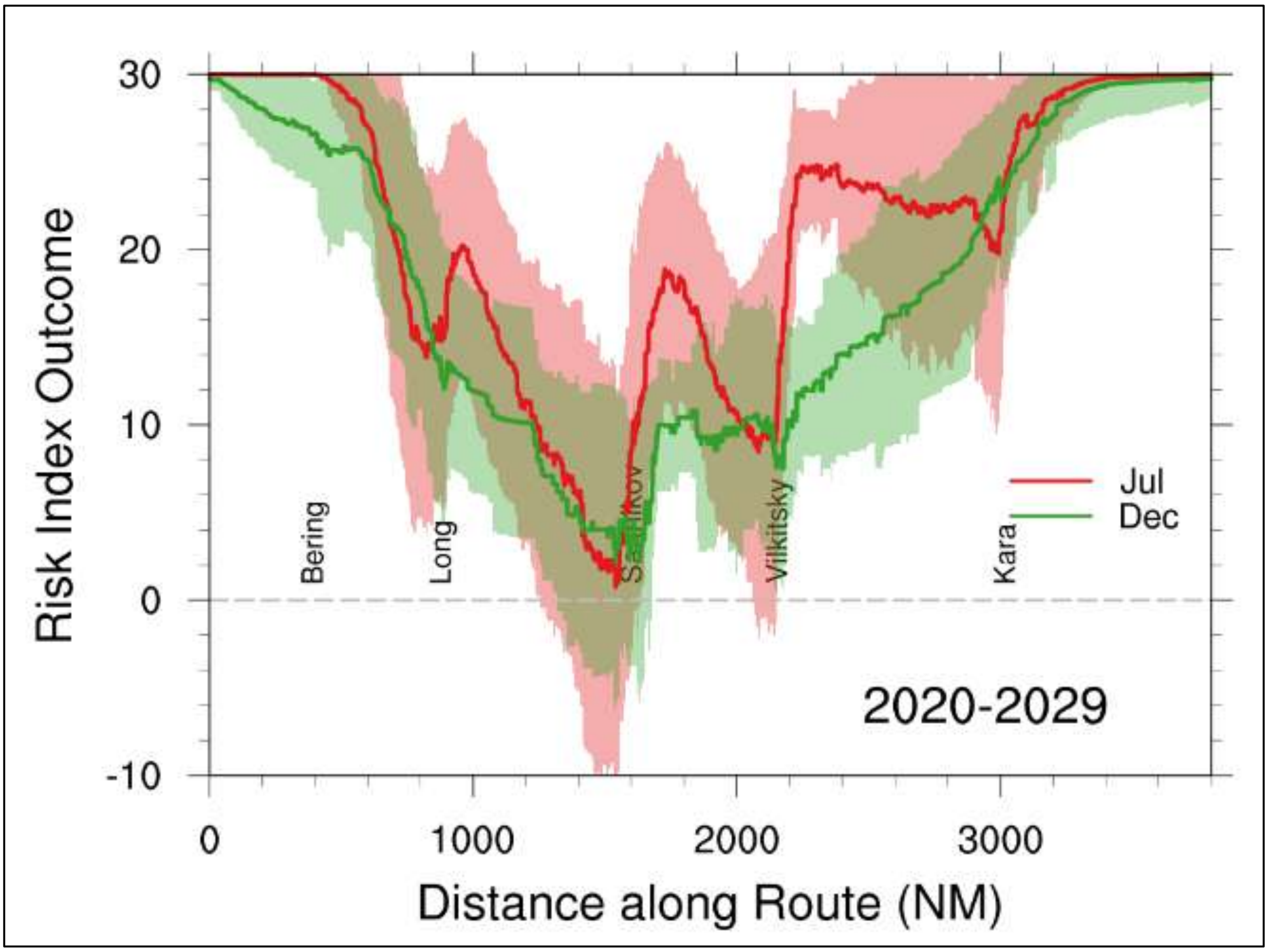

Figure 6: RIO Route Model 2

As in Figure 6 but for the light-green route in Figure4. Source: Authors, Appendix B.

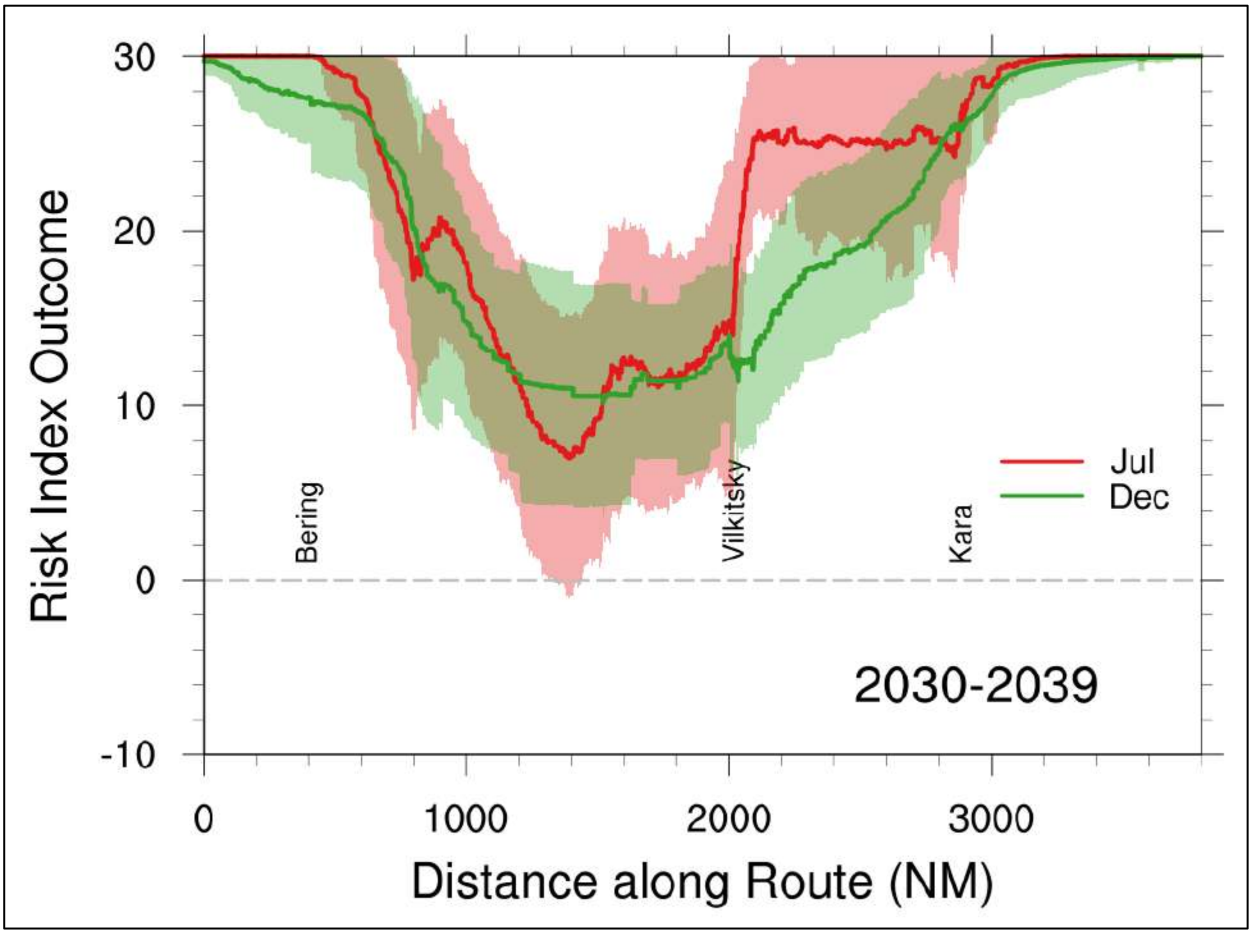

Figure 7: RIO Route Model 3

As in Figure 6 but for the decade 2030-2039. Source: Authors, Appendix B.

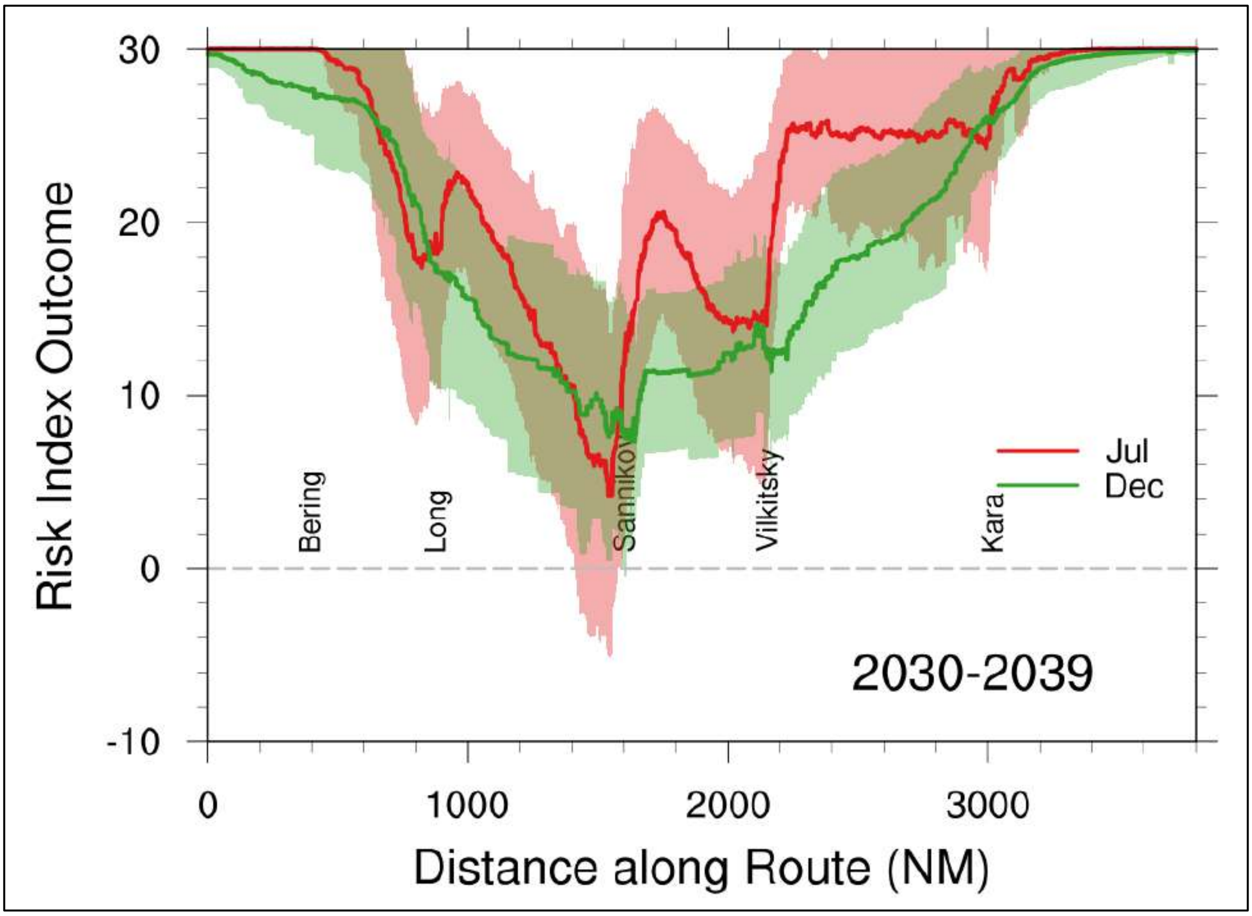

Figure 8: RIO Route Model 4

As in Figure 7 but for the decade 2030-2039. Source: Authors, Appendix B.

Discussion

Figures 4, 6, and 7 indicate that, during the current decade (2020 through 2029), the risk to a PC6 class vessel should be minimal (RIO>0) along the majority of the NSR. Detailed RIO values are given for two different routes, one remaining closer to the coast that includes the Sannikov and Long Straits (light-green route in Figure 4 and RIO values in Figure 6) and a second more optimal route that passes to the north of both straits (dark-green route in Figure 4 and RIO values in Figure 7). Some combination of these two routes provides a reasonable approximation for the majority of NSR transits in 2021 and 2022 (Arctic LIO, 2021; Arctic LIO, 2022). Within the range of uncertainty provided by the multi-model statistics (shaded coloring in Figures 6 and 7), operations at reduced speeds in the vicinity of Sannikov and Vilkitsky Straits may be required. For the next decade (2030-2039; Figures 5, 8, and 9), risk is further reduced, becoming essentially negligible even when considering the spread in projections. These statements are conservative with respect to vessels of a higher polar class than PC6; e.g., risks for a PC3 vessel will be significantly *less* than those implied by Figures 4-9. When accounting for vessel type and route, it can be argued that projected risks to the Arctic environment and ecosystems due to maritime operations in sea-ice-covered waters can be minimized. Hence, we argue that Russia's legal argument for exerting excessive control over its EEZ surface waters to prevent "pollution of the marine environment caus[ing] major harm to or irreversible disturbance of the ecological balance" is unfounded. When information regarding vessel type is combined with the best available, consensus-based projections of the future sea ice environment, risks are likely to become insignificant during the current decade and even more so in the following decades. The authors also acknowledge the works of Li and Lynch (Li et. al, 2023; Lynch et. al., 2022), which provide exceptional complimentary data and analysis to the topic. This work differs effectively and provides a distinct perspective, specifically regarding ambiguity and the recalibration of Article 234 of the UNCLOS under climate change using RIO versus projected routes, as well as PC6 versus OW. This work also highlights exactly where the risk profile may be significantly affected over seasons and decades.

The issue of what can and should be done with the models and analysis depends on two concerns: 1. principle, and 2. practicality. Russia will increasingly become more driven to establish their NSR regulatory regime as customary law as soon as possible. The revised data presented in the above models provides additional evidence that could be used in legal (international and operational) and/or diplomatic processes to facilitate compromise or full contestation between the coastal State (Russia) and user States. Whether Russia's intent and potential for excessive control to access of the surface waters of the NSR could represent a legal precedent to elsewhere in the world, or not, has yet to be determined. It would seem reasonable to speculate that Western actors risking the latter without challenge is unwise at the very least, as new precedent could potential trigger maritime regulatory difficulties elsewhere in the world. Additionally, the Kremlin stands to gain many more benefits should the circumstances remain unchanged. For example, under the status quo, the Kremlin would be permitted to control a maritime defensive buffer zone with a boundary out to the EEZ, which is an operational advantage unlike any in the world. Russian control of access to the NSR surface waters directly impacts the fact that seaward of the territorial sea (12nm and out), States have the absolute right under international law to conduct intrusive ISR operations against another State (Pedrozo 2022). This means, among other things, that Russia could prevent otherwise normal maritime ISR activities. As part of global maritime shipping enterprise practices, the ability for user States or allies to escort and protect critical vessels could also be denied by Moscow (including icebreakers). Russia can also (continue to) impose administrative and operational burdens to scientific research opportunities of the NSR involving the surface waters and below. These reasons and more help to explain the importance of access to the NSR and U.S./Western concerns.

Conclusion

As the maritime Arctic becomes an increasing part of the globalizing world, developing security through management and safety systems will have to help adapt to such changes. Without doubt, the Arctic will require innovation and novel approaches not previously experienced. Yet, at the same time, implementation of aspects involving international laws to new regional regulatory-based applications offers Russia an opportunity to control an unprecedented amount of maritime surface territory. With time, Moscow hopes for their intent to control access to NSR surface waters to become permanent. In general, customary international law "offers few legal and institutional features – such as detailed obligations, flexibility clauses, and structured countermeasures [common in treaties for example], – to support reciprocity or retaliation" (Verdier & Voeten, 2014, p. 390). In particular to this case, the Kremlin also has the advantage of proximity to enforce and compel behaviors regardless of the conceptual and practical difficulties associated with customary law. To that end, should Russia establish control of the surface waters of the NSR out to the EEZ as customary law, it could change precedent and affect access waters to other parts of the maritime world, thereby diminishing the critical importance of freedom of navigation.

Territorial disputes are still common enough worldwide and relatively well managed. The authors of this project hope that the presentation of new data, analysis, and discussion offers important information from which to support the efforts of U.S. authorities and policies, such as independent, scientific voyages of the U.S. Coast Guard Cutter *'Healy'* through the East Siberian Sea onto northern Europe (United States Coast Guard, 2023). Our work has demonstrated that the foundation of the Russian NSR regulatory regime could be challenged based on the most up-to-date sea ice risk projections from current best-in-class scientific models, whereas Moscow's assessments of risk based on decades-old assumptions do not justify their "excessive maritime claims" as interpreted through international law (Article 234 of UNCLOS). Specifically, when the best available projections of Arctic sea ice concentration and thickness (see Appendix A) are combined with information on vessel type to derive formal metrics of shipping risk, we argue that shipping risk along the NSR is likely to be minimal for at least 6 months of the year during the current decade, and minimal to non-existent for 6 months of the year during the next decade, specifically applying to vessels rated at PC6 and above.

With time, environmental conditions will continue to change, and both scientific models and consensus will improve. While our projections come with typical levels of uncertainty, the results are nonetheless compelling and contribute to serious consideration involving the basis for Russia's regulatory justification that impact critical maritime norms and principles. U.S. national interests abroad involving freedom of navigation are well established. The South China Sea territorial challenges highlight the importance of proactive and assertive measures during early competitive phases are critical to manage and prevent conflicts. Otherwise, a passive approach in this case generates the potential for a powder-keg once crisis-level reactive measures become necessary.

References

Arctic LIO. (2021, October 15). NSR shipping traffic activities in January 2021. Arctic LIO. https://arctic-lio.com/transit-voyages-on-the-nsr-in-2021-the-results-as-of-the-current-date/

Arctic LIO. (2022, January). NSR shipping traffic activities in January 2022. Arctic LIO. https://arctic-lio.com/nsr-shipping-traffic-activities-in-january-2022

Auerswald, D. (2019, October 11). Now is not the time for a FONOP in the Arctic. *Texas National Security Review*. https://warontherocks.com/2019/10/now-is-not-the-time-for-a-fonop-in-the-arctic/

Bureau Veritas. (2017). Ice reinforcement selection in different world navigation areas (NI543 R01). https://marine-offshore.bureauveritas.com/ni543-ice-reinforcement-selection-different-world-navigation-areas

Bouffard, T. J. (2024). National security interests of Russia's Northern Sea Route: Additional elements of domestic and international importance. In L. Strauss & N. Wegge (Eds.), *Defending NATO's northern flank: Power projection and military operations* (Chapter 5). Routledge.

Cregge, K., & O'Conner, C. (2023). Build a coalition for Northern Sea Route security. *Proceedings, 149*(8). https://www.usni.org/magazines/proceedings/2023/august/build-coalition-northern-sea-route-security

Docquier, D., & Koenigk, T. (2021). A review of interactions between ocean heat transport and Arctic sea ice. *Environmental Research Letters, 16*(12), Article 123002.

Fox-Kemper, B., Hewitt, H. T., Xiao, C., Adalgeirsdottir, G., Drijfhout, S. S., Edwards, T. L., & Golledge, N. R. (2021). Ocean, cryosphere and sea level change. *AGU Fall Meeting Abstracts, 2021*.

Grimes, D. I., Rawcliffe, J., Smith, J., Baime, L. E., Benjamin, L. M., Dorn, M. J., & Fredrikson, M. C. (2006). *Operational law handbook*. The Judge Advocate General's Legal Center and School.

International Maritime Organization. (n.d.). Polar Code. IMO. https://www.imo.org/en/OurWork/Safety/Pages/Polar-Code.aspx

International Maritime Organization. (2019). International code for ships operating in polar waters (Polar Code). https://www.imo.org/en/ourwork/safety/pages/polar-code.aspx

Kjellén, J. (2022). The Russian Northern Fleet and the (re) militarisation of the Arctic. *Arctic Review on Law and Politics, 13*, 34-52.

Li, X., & Lynch, A. H. (2023). New insights into projected Arctic sea road: operational risks, economic values, and policy implications. *Climatic Change*, 176(4), 30.

Lynch, A. H., Norchi, C. H., & Li, X. (2022). The interaction of ice and law in Arctic marine accessibility. Proceedings of the National Academy of Sciences, 119(26), e2202720119.

Maritime claims reference manual. (2024). Navy JAG Corps. https://www.jag.navy.mil/national-security/mcrm/

Mekhdiev, E., Zakharevich, E., Mammadova, P., & Jumayev, F. (2021). Northern Sea Route-Russian and China: Competition or partnership. *Journal of World Economy: Transformations & Transitions, 1*(01).

Moe, A. (2020a). A new Russian policy for the Northern Sea Route? State interests, key stakeholders and economic opportunities in changing times. *The Polar Journal*, 1-19.

Moe, A. (2020b). A new Russian policy for the Northern Sea Route? State interests, key stakeholders and economic opportunities in changing times. *The Polar Journal, 10*(2), 209-227.

National Security Law Department. (2022). Operational Law Handbook. The Judge Advocate General's Legal Center and School. https://tile.loc.gov/storage-services/service/ll/llmlp/2022_Operational_Law_Handbook/2022_Operational_Law_Handbook.pdf

National Snow and Ice Data Center. (n.d.). Arctic sea ice seasonal change and melt/freeze climate indicators from satellite data, Version 1. https://nsidc.org/data/nsidc-0747/versions/1

Notz, D., & SIMIP Community. (2020). Arctic sea ice in CMIP6. *Geophysical Research Letters, 47*(10). https://doi.org/10.1029/2019GL086749

Northern Sea Route Administration. (2012). On amending certain legislative acts of Russian Federation in terms of state regulation of merchant shipping in the Northern Sea Route [Explanatory note to draft law]. http://www.nsra.ru/en/ofitsialnaya_informatsiya/zakon_o_smp.html

Østreng, W. (2010). The Northeast Passage and Northern Sea Route. *Arctis*. http://www.arctis-search.com/The+Northeast+Passage+and+Northern+Sea+Route+2

Pedrozo, R. P. (2022). The legal framework applicable to intrusive intelligence, surveillance, and reconnaissance operations in the air and maritime domains. *International Law Studies, 99*(1), 847-864.

Pincus, R. (2020). Three-way power dynamics in the Arctic. *Strategic Studies Quarterly, 14*(1), 40-63.

Postler, Ashley. (2020). *UNCLOS in the Arctic: A Treaty for Warmer Waters*. Georgetown Security Studies Review. https://georgetownsecuritystudiesreview.org/2020/02/24/unclos-in-the-arctic-a-treaty-for-warmer-waters/

Rumer, E., Sokolsky, R., & Stronski, P. (2021). *Russia in the Arctic - a critical examination*. Carnegie Endowment for International Peace. https://carnegieendowment.org/research/2021/03/russia-in-the-arctica-critical-examination

Solski, J. J. (2020). The Northern Sea Route in the 2010s: Development and implementation of relevant law. *Arctic Review on Law and Politics, 11*(2020).

TASS. (2023, January 18). Russian defense ministry reports successful test of new missile. TASS. https://tass.com/defense/1563227

Todorov, A. (2022). Dire straits of the Russian Arctic: Options and challenges for a potential US FONOP in the Northern Sea Route. *Marine Policy, 139*.

United States Coast Guard. (2023, September 28). U.S. Coast Guard Cutter Healy completes mission with U.S. National Science Foundation in East Siberian Sea. https://www.news.uscg.mil/Press-Releases/Article/3538713/us-coast-guard-cutter-healy-completes-mission-with-us-national-science-foundati/

Verdier, P-H., & Voeten, E. (2014). Precedent, compliance, and change in customary international law: An explanatory theory. *American Journal of International Law, 108*(3), 389-434.

Williams, L. C. (2017). An ocean between us: The implications of inconsistencies between the navigational laws of coastal Arctic Council nations and the United Nations Convention on the Law of the Sea for Arctic navigation. *Vanderbilt Law Review, 70*(1), 379-412.

World Climate Research Programme. (n.d.). CMIP Phase 6 (CMIP6). https://wcrp-cmip.org/cmip-phase-6-cmip6/

Кремль. (2012, July 28). Закон о Северном морском пути [Law on the Northern Sea Route]. http://www.nsra.ru/ru/ofitsialnaya_informatsiya/zakon_o_smp.html

Президент Путин. (2012). О внесении изменений в отдельные законодательные акты Российской Федерации в части государственного регулирования торгового мореплавания в акватории Северного морского пути [On amendments to certain legislative acts of the Russian Federation regarding the state regulation of merchant shipping in the waters of the Northern Sea Route] (№ 132-ФЗ). http://publication.pravo.gov.ru/Document/View/0001201207300027

Nezavisimaya Gazeta. (2019, March 11). Россия не намерена сдавать Арктику [Russia Does Not Intend to Surrender the Arctic]. http://www.ng.ru/armies/2019-03-11/8_7527_regulations.html

Appendix A: CMIP6 Model Selection Criteria

Our projections of sea-ice-related maritime risk are based on the most recent suite of publicly available climate simulations, conducted by international climate modeling centers from across the world (CMIP6), (World Climate Research Programme, n.d.). Based primarily on the study carried out by Docquier and Koenigk (2021), but also on several of our own criteria, twenty-three models representing efforts from seventeen different countries were selected from the larger CMIP6 database. This selection includes models with relevant Arctic oceanographic properties, able to reproduce historical observations (1979–2014 or 2000–2014) of sea ice area or volume. Our focus here is on the relatively high-greenhouse-gas-emissions scenario, SSP5-8.5, which refers to an additional atmospheric radiative forcing of 8.5 W/m^2 by the end of this century relative to 1850). The global-mean warming under this emission scenario is ≈4 degrees C for the period 2081–2100, relative to the period 1995–2014. Under this scenario, the multi-model mean of the selected models predicts that Arctic sea ice area and volume will reduce, respectively, by forty-five percent and seventy-eight percent in March (seasonal maximum extent) by the end of the century, compared to the period 2015–2019. For the same time periods, the multi-model means of Arctic sea ice area and volume in September (seasonal minimum extent) predict reductions by 90% and 98%, respectively. Although affected by a large uncertainty, the multi-model mean also suggests that the Arctic Ocean will become practically ice-free (defined as having a sea ice area of less than 10^6 km^2) by September of 2061. Many models, however, predict an almost complete loss of sea ice by September by or before the year 2050 (Notz & SIMIP Community, 2020).

We note that overall sensitivity of CMIP6 Arctic sea ice projections to the particular choice of emissions scenario is relatively low prior to 2050. For example, Notz et al., (p. 7) show that the simulated sea ice area in March and September does not differ appreciably between SSP2-4.5 and SSP5-9.5 until after 2050 (their Figure 2). Prior to 2050, the distribution of model outputs under SSP2-4.5 and SSP5-8.5 overlap such that we expect our conclusions to hold under the more moderate SSP2-4.5 emissions scenario. Relative to observations, CMIP6 models (on average) underestimate the rate of sea ice area loss per degree of global mean temperature increase and per given increase in atmospheric CO_2 emissions (Figures 1c and 1d in Notz & SIMIP Community, 2020) (p. 4). This suggests that CMIP6 modeled rates of Arctic sea ice area loss are conservative relative to historical observations.

Appendix B: Risk Index Outcome

POLARIS, the Polar Operational Limit Assessment Risk Indexing System, was developed by the International Maritime Organization (IMO) to assess the type of operations and operational limitations of vessels navigating through sea ice. Within POLARIS, the evaluation of the risks posed to a ship by various ice conditions is related to the ship's assigned ice class. POLARIS assigns a scale of Risk Index Values (RIVs) to a vessel based on its ice class and on different ice regimes. Ice classes in POLARIS include Polar Classes ranging from PC1 (year-round operation in all polar waters) to PC7 (summer and autumn operation in thin first-year ice with some old ice inclusions) as well as Finnish-Swedish ice classes (IA Super, IA, IB, and IC), primarily intended for merchant and cruise-ferry ships (International Maritime Organization, n.d.). POLARIS also defines RIVs for vessels without an assigned ice class (referred to as non-ice-strengthened ships). The ice classes ARC 9 to ARC 4, assigned by the Russian Maritime Register of Shipping, can be considered equivalent to the Polar Classes PC1 to PC7, with a one-to-one correspondence except for ARC 5, which corresponds to Polar Classes PC5-6 (Bureau Veritas, 2017). By convention, RIVs *decrease* (transitioning from positive to negative values) as risks *increase* within a given ice class. The RIV constitutes the basis for the definition of the Risk Index Outcome (RIO), which POLARIS uses to assess types and limitations of ship operations in sea ice. The determination of the RIO for navigation in an area with the presence of *N* different ice types, including open water, proceeds by associating a RIV to each ice type based on its thickness and age. The RIO value at any location is calculated as the sum over the *N* RIV values (ice types) at that location with each RIV first weighted (multiplied) by its respective concentration at that location. In this analysis, the RIO at each route point is calculated based on the mean of the sea ice concentration and thickness distribution from all model values. The calculated RIO value is used to determine the operational limitations of ships navigating without icebreaker escort according to the following criteria: RIO ≥ 0 defines "normal operation" for all ice classes; $-10 \leq \text{RIO} < 0$ defines "elevated operational risk" for PC1–PC7 ice classes. In an "elevated operational risk" situation, vessels with an ice class PC3–PC5 are recommended to limit their speed to five knots (eleven hours of navigation per one hundred km). Ships with an ice class below PC5 are recommended to reduce their speed to three knots (eighteen hours of navigation per one hundred km). For non-Polar Class vessels, a negative RIO identifies "operations subject to special consideration", which ought to be avoided for route planning purposes.