Chapter 7

Climate Change and the Opening of the Transpolar Sea Route: Logistics, Governance, and Wider Geo-economic, Societal and Environmental Impacts

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For centuries, the Northeast Passage and the Northwest Passage (NWP) have been plied by Indigenous Peoples, mariners, explorers, and more recently militaries and shipping and cruise lines. Now, climate change and rapid sea ice melt may lead to the opening of a third Arctic shipping lane: the Transpolar Sea Route (TSR), which directly links the Atlantic and Pacific Oceans via the North Pole. Although mythologized since at least the Age of Exploration, the TSR only began to be used in the second half of the twentieth century for occasional military, scientific, and more recently, tourist purposes. By the middle of the twenty-first century, in the case of an ice-free Arctic Ocean during late summer, the TSR could be 56 percent more accessible relative to its early 21st-century baseline,[1] making possible voyages between Asia and Europe that are 1-5 days faster than the Northern Sea Route (NSR).[2] Ultimately, the TSR could challenge the utility of the NSR and NWP for transit shipping.

Climate change is accelerating, but changes to Arctic shipping, including any potential move from the NSR to the TSR, will likely be gradual rather than sudden.[3] There is thus still time to inform and craft policies to manage future activities along the TSR and in the wider Central Arctic Ocean (CAO), which has witnessed an increase in attention from policymakers and scientists in recent years.[4] In light of these environmental, political and regulatory shifts and on the basis of the existing research into the transpolar maritime industry, the CAO, and the TSR, in what follows, we explore: (i) the possible timeline for the TSR's opening; (ii) scenarios for its commercial and logistical development, addressing both what would push traffic away from the

NSR towards the TSR and what would stimulate the mobilization of icebreakers, polar class vessels, and the construction of transshipment hubs; (iii) the geopolitics of the TSR, focusing on international and national regulatory frameworks and the roles of Russia, a historic power in the Arctic, and China, an emerging one; and (iv) the environmental and socioeconomic impacts of the TSR's development for people living along its entrances in the Bering and Fram Straits.

Timeline for the TSR's Opening

We consider the "opening" of the TSR to concur with the onset of short annual periods of ice-free conditions in the Arctic Ocean, which scientists predict will occur before mid-century. Reaching this threshold requires adding between +0.6 and +0.9°C to the current global mean temperature.[5] Predicting the TSR's initial opening date typically involves analysis of sea ice outputs from multiple global climate models representing a range of environmental and anthropogenic uncertainties, which are constrained by observations of natural cycles.[6]

Current models predict an ice-free Arctic Ocean considerably sooner and across a wider range of warming scenarios than estimates made just a few years ago. A study published in 2020 relying on the latest climate model ensemble from the Coupled Model Intercomparison Project (CMIP6), which will feature in the Sixth Assessment Report of the Intergovernmental Panel Climate Change (IPCC) in 2021, projects sea-ice-free conditions in the Arctic in September before 2050 regardless of whether emissions are controlled.[7] In contrast, research based on CMIP5 estimated that permanently recurring summer ice-free conditions were very unlikely if warming was limited to 1.5°C.[8] Even so, CMIP5 studies projected sea-ice-free conditions by 2040 or later, though acknowledging that these estimates remained conservative in light of the rapid observed decline in ice area and thickness.[9] In the early 2010s, CMIP3 studies had put the date closer to 2070.[10]

Declines in sea ice thickness (SIT) also matter for transpolar shipping, as the measure is a major determinant of the polar class (PC) vessel type required in ice-covered waters. Like sea ice extent, SIT has been declining: at the North Pole, while average SIT was measured to be ~4m between 1958-1976, by 2011-2017, it dropped to <1m.[11] SIT

decline means that PC vessels of lower classes may eventually be able to transit the TSR. Sailing in thinner ice requires less fuel, which could help to lower emissions from ships and reduce fuel costs.[12]

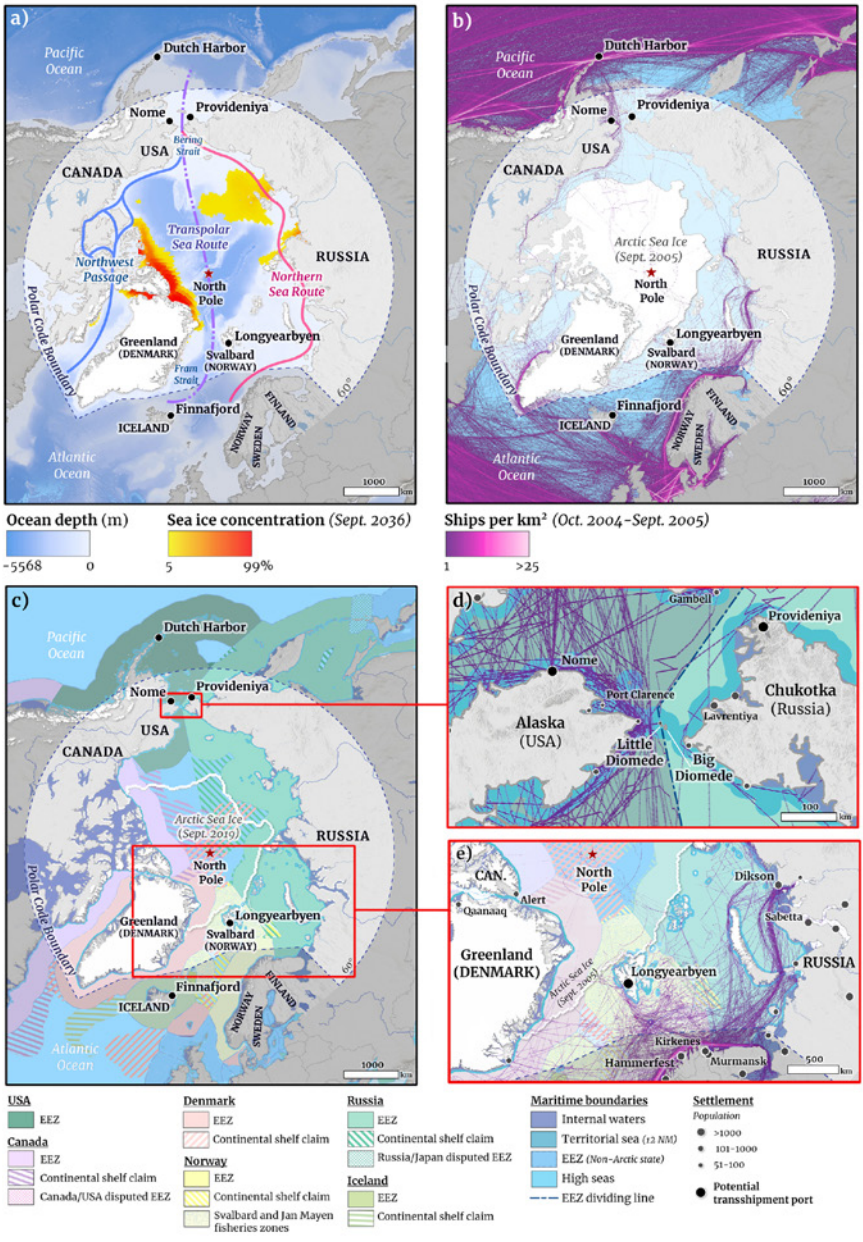
In terms of the geography and seasonality of ice loss, the Arctic Ocean is predicted to first become ice-free during the month of September, when sea ice reaches its annual minimum. Sea ice will persist in the Canadian Arctic Archipelago, where it tends to be thickest. In October, the CAO will lose its ice-free status and re-cross the 1 million km^2 threshold as it refreezes. Therefore, the first ice-free date does not in itself signal the beginning of reliable shipping accessibility along the TSR. Commercial shipping will require robust forecasts meeting more stringent criteria, such as the IPCC's definition of "nearly ice-free conditions" when sea ice extent dips below 1 million km^2 for at least five consecutive years,[13] or seasonal benchmarks of 90 days or more of operational accessibility in the CAO.[14] Making such forecasts may prove challenging in the near term since sea ice variability is projected to grow substantially even as it declines overall.[15] Nevertheless, in the long term—i.e. by mid-century and more certainly by 2100—ice-free summers are expected to occur regularly, promising greater predictability for the TSR.

Scenarios for the TSR's Commercial and Logistical Development

Representing the shortest route between Europe and Asia, the TSR crosses 2,100 nautical miles (NM) between the Bering and Fram Straits via the North Pole and connects to shipping routes in the North Pacific and Atlantic Oceans (Figure 1).[16] Besides offering a more direct route between the Atlantic and Pacific Oceans than the NSR or NWP, the TSR also has deeper bathymetry, which eliminates the need for the draft restrictions in place along the NSR and which could attract traffic to the route in the coming decades.[17]

With its direct routing, deeper bathymetry, and lack of Russian tariffs and jurisdiction, the TSR may eventually attract Europe-Asia transit shipping away from the NSR. Still, the TSR's ability to compete with the NSR, let alone the Suez or Panama Canals, faces several obstacles. First, the TSR's container shipping potential remains limited by a

Figure 1[18]


a)
Pacific Ocean
Dutch Harbor
Nome
Provideniya
Bering Strait
USA
CANADA
Transpolar Sea Route
Northwest Passage
North Pole
Northern Sea Route
RUSSIA
Polar Code Boundary
Greenland (DENMARK)
Longyearbyen
Svalbard (NORWAY)
Fram Strait
Finnafjord
ICELAND
NORWAY
SWEDEN
FINLAND
60°
Atlantic Ocean
1000 km
Ocean depth (m)
-5568
0
Sea ice concentration (Sept. 2036)
5
99%
b)
Arctic Sea Ice (Sept. 2005)
Ships per km² (Oct. 2004–Sept. 2005)
1
>25
c)
Arctic Sea Ice (Sept. 2019)
d)
Gambell
Chukotka (Russia)
Alaska (USA)
Port Clarence
Lavrentiya
Little Diomede
Big Diomede
100 km
e)
CAN.
Alert
Quaanaaq
Dikson
Sabetta
Kirkenes
Hammerfest
Murmansk
500 km
USA
EEZ
Canada
EEZ
Continental shelf claim
Canada/USA disputed EEZ
Denmark
EEZ
Continental shelf claim
Norway
EEZ
Continental shelf claim
Svalbard and Jan Mayen fisheries zones
Russia
EEZ
Continental shelf claim
Russia/Japan disputed EEZ
Iceland
EEZ
Continental shelf claim
Maritime boundaries
Internal waters
Territorial sea (12 NM)
EEZ (Non-Arctic state)
High seas
EEZ dividing line
Settlement
Population
>1000
101–1000
51–100
Potential transshipment port

lack of intermediate markets. Second, the continued prevalence of ice throughout most of the year along the TSR poses a problem for just-in-time container shipping. The TSR's near-term potential relative to other Arctic routes therefore may lie more in bulk cargoes, which rely less on just-in-time sailing, and Atlantic—Pacific transit shipping prioritizing the speedy delivery of goods that cannot be transported by plane, such as automobiles. Third, due to a lack of hydrographical knowledge about the TSR and its unpredictability, insurance costs in the near term will likely be higher than for the NSR and NWP.[19] Fourth, much of the recent growth in Arctic shipping has been destinational, involving the transportation of cargo to Arctic locations and of resources out of the region, rather than transit, or using Arctic waterways to move cargo between two non-Arctic ports.[20]

Unlike the NSR and to a lesser extent the NWP, there is presently little demand for destinational shipping along the TSR. The route directly crosses the remote CAO without passing any natural resource extraction sites or, except along the Bering and Fram Strait entrances, communities requiring resupply. In the long term, however, should resource extraction take place in the CAO, destinational shipping could grow.

Bearing in mind the opportunities, challenges, and limitations for developing transpolar commercial shipping, we next explore the three main logistical scenarios for a TSR transportation system: 1) employing icebreakers to escort open water vessels; 2) using double acting vessels that can operate in both open water and ice; and 3) establishing a "hub-and-spoke" port system for transshipment between ice-class and non-ice-class vessels.

Outside of summer when ice-free conditions are reached, non-ice-strengthened ships will not be able to transit the NSR unless escorted by an icebreaker. Developing a TSR transportation system based on icebreaker escorts would draw on technologies and practices developed by the Soviet Union that are still employed along the NSR today. Yet it would likely require the construction of new icebreakers—a lengthy and expensive process. Along the NSR, Russian regulations continue to mandate icebreaker escorts regardless of ice conditions and vessel class, a policy which is costly for shipping lines and which requires the state to maintain a large (>40) fleet of mostly diesel- and some nucle-

by an icebreaker. They may, however, gain limited access beginning in the 2030s.[28] By 2040, high PC (1-3) vessels may be able to navigate the TSR year-round.[29]

The ongoing expansion of commercial activities in the Arctic is spurring an increase in ice-class shipbuilding, which could help advance development of the TSR. Already on Russia's Yamal Peninsula, oil and gas development has stimulated shipbuilding, shipping, and maritime infrastructure construction along the NSR.[30] A further expansion of the world's fleet of ice-class vessels, including bulk carriers and tankers, could consequently support resource development in places like northern Canada and Greenland, boosting destinational shipping via the TSR. Although Paul A. Berkman et al. have hypothesized that a reduction in sea ice has spurred the recent increase in Arctic shipping, Scott Stephenson and Laurence C. Smith have argued that to increase the potential for trans-Arctic shipping, access to PC 6 vessels is significantly more important than accelerated climate warming.[31]

The continued development of innovations like double acting technology (DAT), which allows ships to sail ahead in open water and astern in heavy ice, could also open new logistical possibilities for Arctic shipping even if the economics are not immediately favorable. DAT is currently employed in the fleet of 15 ice-class liquefied natural gas (LNG) tankers built for the Yamal LNG project. Such vessels also have significantly less need for icebreaker escorts. Yet as their operational costs remain high, their sailing distances have to be kept to a minimum and cargo switched to conventional oceangoing vessels once feasible.[32] This is one reason why trans-shipment facilities may be a preferred development option, especially for shipping lines, which would bear the costs of new vessels.

An alternative to icebreaker escorts or double acting vessels sailing along the TSR would be a hub-and-spoke system. Since the 1990s, the global shipping network has shifted from direct service involving multiport calling to hub-and-spoke systems relying on trans-shipment.[33] For shipping lines, when shipping costs are higher than inventory costs, trans-shipment becomes more attractive. Shipping costs for ice-class vessels are 9 percent higher than conventional ships when operating in open water,[34] which could push calculations in favour of constructing hub ports. While port states may be reluctant to invest in new maritime

ar-powered icebreakers.[21] The fees charged by state-owned Atomflot, the fleet operator, are reportedly only enough to cover the company's direct operations, which implies that the NSR may not have generated any profits in recent years.[22]

If a TSR transportation system based on icebreaker escorts were developed, a system involving icebreakers escorting ice-capable ships (i.e. 1A[23]) rather than open water ships may be more energy efficient with lower fuel and CO_2 emissions, as has been shown in the Baltic Sea.[24] Yet given the economic challenges already facing the NSR, a TSR transportation system dependent on icebreaker escorts leading open water vessels likely would not be cost effective given the route's icier conditions. Furthermore, the route lies largely in the high seas, complicating state management and subsidization of icebreaking escorts. Since ships with icebreaking capabilities are likely to remain critical elements of any TSR transportation system for most of the year, however, one alternative to icebreaker escorts, albeit costly, would be to rely upon ships that can break ice themselves.

A second scenario could thus involve PC and double acting vessels. PC vessels are ranked in decreasing strength from "1" (able to operate in up to 4m of ice) to "7" (up to 1.5m ice), followed by weaker "ice class" and non-ice-strengthened "open water" vessels. PC vessels typically have enhancements intended to support operations in ice including strengthened hulls, higher propulsion and maneuverability, and other winterizing features.[25] These enhancements enable them to operate for longer periods in the Arctic ranging from "year-round operation in all Arctic ice-covered waters" (PC 1) to "summer/autumn operation in thin first-year ice which may include old ice inclusions" (PC 7).[26]

Currently, all PC vessels can only operate independently during the summer in areas of the CAO where thin first-year ice predominates. Depending on the degree of ice strengthening, summer navigation seasons for independently-operating PC vessels thus typically last for only 1-2 months along the TSR compared to 2-6 months along the NSR.[27] If longer seasons and/or winter operations are required, vessels classed below PC 1 could conceivably operate along the TSR (or technically anywhere there is ice, though risks may be high) with icebreaker escorts. Otherwise, open water vessels are presently restricted to ice-free areas in the Barents and Bering Seas and along the NSR unless escorted

infrastructure, increasing investment in the world's container ports by private companies[35] and, notably, by state-supported Chinese port enterprises, may point to new possibilities for financing a transpolar port network.

As of 2020, national and municipal governments in Norway, Iceland, and the U.S. have expressed interest in expanding existing ports or building new ones that could support future transpolar shipping. Such developments could enable a TSR hub-and-spoke system featuring trans-shipment facilities at the route's two main entrances: the Fram and Bering Straits (Figure 1b). At these hubs, cargo could be switched between PC vessels using the TSR and non-ice-strengthened southbound open water vessels. Since non-ice-class ships will not be able to transit the TSR even in summer for some time, a hub-and-spoke network could reduce the required travel distance for slower, costlier PC vessels.

Geography of the Transpolar Shipping Route: Fram Strait and Bering Strait

The Fram Strait links the CAO to North Atlantic shipping routes and the NSR. Most TSR routings pass the Norwegian archipelago of Svalbard, whose main port of Longyearbyen could serve as a trans-shipment hub. While Svalbard's location (between 74°N and 81°N) is not ideal for serving the NSR, it is well-placed for the TSR and wider Arctic shipping networks (Figure 1d).[36] Growth in tourism and climate change research has led port calls in Longyearbyen to rise from under 200 in 2,000 to more than 1,500 in 2016[37] and motivated port renovations. It now bears one floating and three permanent quays with drafts of 5-9m, accommodating ships up to 335m long. This is still shallower than the facilities required by Handymax and Panamax ships and even some of the vessels currently sailing along Arctic routes. In order to further expand Longyearbyen's port, the Norwegian government has allocated NOK 400 million ($43.8 million) for a new floating dock and terminal.[38] There is also a possibility that, building upon their partnership on oil spill response in the Barents Sea, Norway could cooperate on port infrastructure with Russia, which dominates the nearby coal mining and port town of Barentsburg. Finally, as all Svalbard Treaty signatories enjoy the same rights to maritime, industrial, mining, and

commercial activities both on land and in the archipelago's territorial waters, consortiums or individual states other than Norway and Russia, such as China, could conceivably build a port on Svalbard, too, much as they have done in building scientific research stations.[39]

Though nearly 1,000 NM farther south of the Fram Strait than Svalbard, Iceland seeks to develop a TSR transshipment hub on the country's remote northeast coast in Finnafjord near three fishing villages. In 2015, the Icelandic government, Icelandic engineering consultancy Efla, and German company Bremenports agreed to invest ISK 450 million (~$3.1 million) into the planned facility, which would host an ice-free hub port entailing 6 km of quays with depths of >50 m and 1,200 hectares of hinterland development to support trans-Arctic shipping, a base port for Arctic oil and gas extraction, and a service port for potential offshore oil and gas and Arctic shipping industries.[40] Progress on the Finnafjord Harbor Project continued in 2019 with the establishment of the Finnafjord Port Development Company, a joint venture. That same year, Efla, Bremenports, and the local municipalities signed an agreement on port construction (planned from 2021-2023) and operations (to be maintained through at least 2040).[41] As the TSR may not open until then, some might argue that feasibility studies modeling port demand beyond that year may be worthwhile. Yet an Icelandic government-commissioned study in 2019 concluded that transshipment via Iceland was less economical than transshipment via Norway or direct shipping to Rotterdam on ice-strengthened vessels.[42] The likelihood that Finnafjord can only be competitive if very large container ships begin transiting the TSR suggests that at least until mid-century, Longyearbyen may offer a more economically viable option for a trans-shipment hub in the Fram Strait.

Similar questions abound in the 44-NM-Bering Strait linking the CAO to Pacific shipping routes such as the Great Circle Route between East Asia and western North America. A transshipment hub could be built on either the American or Russian side. Alaska's Bering Strait coast has viable ports in the city of Nome and in Red Dog, the world's largest zinc mine. Other locations that have been considered include Port Clarence, a former U.S. Coast Guard Long Range Navigation (LORAN)-C station 100 km to the northwest of Nome, and various ice-free deepwater ports in the Aleutian Islands, namely Dutch Harbor.[43]

Recent developments suggest that Nome, whose municipal government has examined the possibility of turning the city into a CAO shipping hub, may be the likeliest contender. The city's port already serves as the staging ground for seasonal ice-free operations north of the Bering Strait and as a transshipment hub for western Alaska. In June 2020, the U.S. Army Corps of Engineers approved a $618 million plan to increase the port's outer basin from 6.7 m to 8.5 m and dredge a new deepwater basin of 9-12 m: depths similar to Longyearbyen, but shallower than Finnafjord. As of October 2020, the plan awaits approval from the U.S. Congress.

On the Russian side are the ports in Provideniya, Anadyr, Evgenikot, and Beringovsky.[44] The port of Provideniya is deeper than Nome's, with depths of 9 m near the berths and 30-35 m in the bay,[45] and already has oil spill response equipment. While it technically serves as the NSR's eastern gateway, more improvements are required to enhance Provideniya's capacity for operations along that route, not to mention the TSR. Whether the Russian government intends to invest further in Provideniya's port's facilities, let alone those of its other three Bering Strait ports, is an open question. For the time being, the momentum within the Bering Strait for building infrastructure that might eventually support the TSR appears concentrated on the Alaskan side.

Geopolitics and Governance of the TSR

One of the TSR's main purported advantages is that in the absence of ice, it would offer a navigationally and politically simpler alternative to the NWP and NSR.[46] Yet the governance and geopolitics of the TSR remain complicated. The opening of a new route previously plied only by submarines and icebreakers may affect relations between governments both within and outside the Arctic region, especially maritime states. In what follows, we address three topics of geopolitical complexity along the TSR: international governance and the roles of Russia—the Arctic's largest littoral state—and China, an extraterritorial power with global reach, increasing interest in the Arctic, and a capacity and willingness to invest in the region's infrastructure and development.

Trans-Arctic shipping is regulated by a mix of international and national regulations.[47] Unlike the NWP, which Canada claims as internal waters,[48] and the NSR, along which Russia de facto controls navigation of foreign vessels,[49] the TSR crosses the high seas, where international regulations apply. Chief among them are the United Nations Convention on the Law of the Sea (UNCLOS 1982) and the International Maritime Organisation's (IMO) Polar Code (2017) (Figure 1c). UNCLOS (which, among the Arctic states, the U.S. signed in 1994 and recognises as international law, but has thus far not ratified) governs use of the oceans, including the high seas, which constitute 4.7 million km^2 of the Central Arctic Basin.[50] UNCLOS Article 87 allows all states the use of the high seas for freedom of navigation, overflight, laying submarine cables and pipelines, constructing artificial islands and other installations permitted under international law, fishing, and scientific research. The TSR's opening in the 2030s or 2040s could facilitate the development of several of these maritime activities, especially fishing. The 2018 Fisheries Agreement notably prohibits commercial fishing in the CAO initially until 2034. That means an extension would be on the cards just a few years before the earliest predictions of a seasonally ice-free Arctic Ocean.

Unique among the world's oceans, the Arctic is the only one surrounded by continents with just one high seas point of access: the Fram Strait between the Greenland and Norwegian Seas (Figure 1e). At the Bering Strait entrance, shipping regulations are more complex. Generally, the Bering Strait is considered a strait used for international navigation, defined as connecting one part of the high seas or a state's exclusive economic zone (EEZ), which extends up to 200 NM out from a country's baseline, with another part of the high seas or an EEZ.[51] Vessels consequently enjoy the right of transit passage under Article 37. The Bering Strait's two main navigational channels pass through the territorial seas of Russia and the U.S. Since Article 42 allows states bordering international straits to adopt regulations pertaining to maritime traffic and pollution prevention so long as they do not hamper the right of transit passage, vessels crossing both U.S. and Russian waters in the Bering Strait may be subject to differing laws. The U.S. and Russia, motivated by their observations of decreasing sea ice and increasing economic activity in the region, have cooperated to establish a two-way shipping system through the narrow Bering Strait to improve

navigation safety and protect the environment.[52] In February 2018, the IMO approved the two countries' joint proposal to implement six two-way routes, six precautionary areas, and three areas to be avoided in the Bering Sea and Bering Strait, which took effect later that year.

Depending on its routing, the TSR may also cross the EEZs of Canada, Denmark/Greenland, Norway, and Iceland. Article 58 grants all UNCLOS signatories the aforementioned rights of Article 87 in other countries' EEZs, including navigation. Navigation along the TSR should remain unaffected by the competing claims submitted by Canada, Russia, and Denmark to the UN Commission on the Limits of the Continental Shelf to extended continental shelves in the CAO, each of which includes the North Pole. As the waters over extended continental shelves constitute the high seas, they will remain free to navigate regardless of how the claims are resolved.

Less certain are the impacts of climate change on UNCLOS Article 234, which allows coastal states to "adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels" in areas that are covered in ice "for most of the year"[53] within their EEZs. Whether and how the reduction of sea ice will affect the applicability of Article 234 remains debated.[54] Assuming it stands, ships sailing along the TSR may have to adhere to varying environmental regulations, some potentially more stringent than others, depending on the EEZ. One additional regulatory scenario is that if Norway were to transform the already-disputed Svalbard Fisheries Protection Zone into an EEZ,[55] the country could implement Article 234 around the archipelago.[56]

The IMO's International Code for Ships Operating in Polar Waters (Polar Code 2017), which mandates precautions like a Polar Ship Certificate and careful voyage planning to ensure safety at sea and pollution prevention, also applies to the TSR.[57] The organization's now binding framework regulating Arctic and Antarctic shipping evolved from the initially voluntary Guidelines for Ships Operating in Polar Waters adopted in 2009. The Polar Code comprises a series of amendments to existing IMO conventions including the International Convention on the Safety of Life at Sea (SOLAS 1974/1988) and the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978). This regulatory evolution underscores the

standardization and formalization of polar shipping and the expansion of the sector's "pluralistic governance" involving both Arctic coastal/port states and flag states.[58]

Currently, no additional requirements apply to shipping within the CAO vis-à-vis the rest of the Arctic. In the future, new measures could be promulgated including the establishment of an emissions control zone similar to those in the Baltic Sea and off the coasts of the United States,[59] MARPOL Special Areas, Particularly Sensitive Sea Areas, Marine Protected Areas, ballast water and anti-fouling regulations, and stricter measures for ship routing and reporting systems.[60] Ultimately, enforcement of the Polar Code and additional measures depends on Arctic port state control, or governments' wills and capacities to inspect foreign-registered vessels. While a key attraction of the TSR for the shipping industry is that it largely transits international rather than internal waters, this very feature challenges the enactment and enforcement of environmental regulations.

With regard to national governance, Russia, with its well-established legal framework for the NSR and fleet of icebreakers, is strongly positioned to offer expertise and services along the TSR. Yet unlike along the NSR, shipping lines are not legally obligated to avail of them. The TSR is situated farther north than the northernmost extent of the NSR, which Russian federal law asserts falls entirely within the country's EEZ, territorial sea, and internal waters.[61] Nevertheless, with some Russian scholars emphasizing the "leading role of Arctic coastal States in specifying [the] legal regime of Arctic marine regions,"[62] the Kremlin might attempt to influence regulation of the TSR or, in what would be a highly controversial move, consider enforcing national transit regulations in the high seas north of their EEZ through which parts of the route run.

Given the importance of Arctic shipping for Russia, the country may differ from other Arctic coastal states in its regulatory preferences. During February 2020 IMO meetings debating amendments to the Polar Code, Russia—in contrast to other Arctic states—preferred a delayed rather than immediate ban on heavy fuel oil (HFO) in the Arctic and was furthermore supported by China. This Sino-Russian alliance in Arctic policymaking, which could spill over into TSR governance, reflects the two countries' strengthening relationship, with Russia relying on China for investment and export markets and China on Russia

for the latter's natural resources.[63] Regardless of whether Russia (and other Arctic coastal states, for that matter) seeks to influence TSR governance, in the case of an emergency or shifting ice conditions, a vessel may have to enter the waters of Russia, the Nordic states, or the United States, potentially falling under national regulations.[64]

Finally, Russia will have to consider whether the TSR's opening will negatively impact its economy. With climate change, shipping lines may select routes that minimize distance rather than ice avoidance, possibly making routes north of the NSR and eventually the TSR itself preferable.[65] The Russian government may then find it difficult to maintain or attract transit shipping to the NSR. On the plus side, if ships were to shift northward towards the TSR, this could mitigate risks to Russia's coastal environment.

If Russia has seriously looked to developing its northern regions for over a century, China's commercial and scientific activities in the Arctic Ocean are relatively new. While the country was one of the 1920 Svalbard Treaty's first contracting parties, signing in 1925, its Arctic activities began gaining force in the early 2000s.[66] Recently, the government in Beijing has paid particular attention to the TSR. To the best of our knowledge, China is the only country to have led official expeditions of all three Arctic shipping passages, including the TSR. In 2017, during an 83-day, 20,000-NM voyage, the country's original icebreaker, MV Xue Long, sailed via the TSR en route to the NWP. Chinese state media heralded this journey as the country's first crossing of the CAO.[67]

China's first domestically built icebreaker, MV Xue Long 2 (launched in 2018), can also navigate throughout the CAO in summer and embarked on its first expedition to the area in July 2020. Both China's Arctic Policy and publications by Chinese scholars posit that the TSR forms an integral part of a future Arctic shipping network, one that China seeks to help develop. As its Arctic Policy explains: "The Arctic shipping routes comprise the Northeast Passage, Northwest Passage, and the Central Passage." It further affirms that the country "hopes to work with all parties to build a 'Polar Silk Road' through developing the Arctic shipping routes."[68] This description represents a more expansive vision of the Polar Silk Road (PSR) compared to its initial conception as a more eastward-focused version of the NSR to be jointly developed by Russia and China, which grew out of the "Vision for Mar-

itime Cooperation under the Belt and Road Initiative" with three specific "blue economic passages" (*lanse jingji tongdao* 蓝色经济通道): the Indian Ocean-Mediterranean route, the Oceania-South Pacific route, and the Arctic Ocean route.[69]

The PSR is thus meant to form one of several corridors within China's Belt and Road Initiative, a multitrillion-dollar plan to enhance trade and transportation routes to connect China with markets and resources in Eurasia, Africa, and beyond. While China seeks to play a more prominent role in both Arctic and global development and governance, at the same time, like other Asian states, the country is being integrated into Arctic regional governance structures that continue to give primacy to territorial states.[70]

Environmental and Socioeconomic Impacts of Transpolar Shipping

Should serious commercial use of the TSR and the wider CAO commence, shipping would likely generate significant environmental and socioeconomic impacts at a range of scales that would be most acute near coastlines. Localized externalities from shipping that could disturb Arctic marine environments include vessel oiling, air pollution, noise, collisions, icebreaker-induced habitat disruption,[71] and the introduction of invasive species.[72]

Ecologically sensitive places along the TSR like Svalbard already face heightened risks of oil spills and air pollution due to an increase in vessel traffic.[73] As vessels approach the mid-point of the TSR near the North Pole, they will obviously pose fewer threats to coastal ecosystems and communities. Here, however, search and rescue and spill response capacities will be severely limited, meaning the impacts of a disaster could be harder to immediately contain than if it were to take place closer to shore.

Shipping via the TSR may deliver certain benefits to people living in communities along the route's entrances in the Fram and Bering Straits, like new jobs and greater availability of imported goods. Yet the industry also threatens local residents' socioeconomic, cultural, and spiritual well-being. In Svalbard, residents already express frustration with existing levels of tourists and cruise ships.[74] Shipping-induced strains on the environment and society are perhaps more severe in the

Bering Strait, where they affect Indigenous peoples who still depend on the marine environment for subsistence.[75] Shipping could disturb or lead to the loss of sea mammals, threatening food security. Similarly, activities relating to Iceland's proposed Finnafjord port could disturb fishing activities based out of nearby villages, while the port's planned 1200-hectare hinterland could affect land-based activities like farming. Finally, across the Arctic, port construction could threaten cultural and archaeological resources and increase costs of living.

Nevertheless, certain places with a history of shipping activity, such as Longyearbyen, have been shown to be able to develop local institutional and regulatory responses to counteract the industry's negative impacts.[76] Yet local capacity can and should be built before ships begin to dock through a variety of means including establishing community harbor safety committees, integrating traditional and Western knowledge, training villagers in Arctic search and rescue, and providing for supporting subsistence practices when expanding ports, like by ensuring access for small skiffs.[77] Such capacity building could empower local communities and give them not only a stake in any maritime industry spurred by the TSR, but a degree of control over it, too.

While the localized impacts from TSR shipping and port development may be serious, the regional and global impacts of commercial Arctic shipping appear comparatively less so. By 2050, the entire Arctic shipping industry is predicted to contribute less than 1% of black carbon deposited north of 60°N.[78] Shipping via the TSR may even reduce Arctic warming by 1°C as sulphur oxide emissions from ships lead to an increase in clouds.[79] Given the paucity of research and coordination at regional and cross-boundary scales in the CAO,[80] more work is required to understand and plan for the impacts of shipping via the TSR at a regional scale. As a start, the Arctic Council's Protection of the Arctic Marine Environment (PAME) Working Group is undertaking region-wide initiatives such as the Integrated Ecosystem Assessment for the CAO and the Arctic Ship Traffic Data project.

As the negative environmental impacts of Arctic shipping across a range of scales come to light, there is growing pushback from shipping lines like CMA CGM, Evergreen, Hapag-Lloyd, and Mediterranean and consumer goods companies like H&M and Columbia. These corporations have committed to refrain from using Arctic routes for glob-

al transshipment by signing the "Arctic Shipping Corporate Pledge," which was spearheaded by the Ocean Conservancy, an environmental non-governmental organization, and Nike in 2019. The pledge's popularity parallels recent decisions by several investment banks to not invest in Arctic oil and gas projects, much to the consternation of Alaska Native politicians and businesses with industry stakes.[81]

As more corporations with international influence opt out of the Arctic's maritime and extractive industries, their reluctance is likely to impact Arctic shipping's commercial viability. The private sector's withdrawal could also lead to a preponderance of the public sector in developing the TSR, especially state-backed shipping lines and terminal operators. Either way, refusing to participate in Arctic shipping may undermine efforts to make certain that, if the industry develops, it does so sustainably and equitably. Indigenous communities and organizations often recognize that subsistence practices and economic development can be balanced. Should the TSR take off, ensuring that local hunting and fishing can continue safely alongside global shipping will require not the abstention of global corporations, but rather the serious integration of local and Indigenous people, knowledge, and needs into policymaking.

Conclusion

As open water replaces the ice that has shaped northern livelihoods and environments for millennia, local communities, national governments, and international policymakers will need to reckon with the consequences of a seasonally navigable polar sea. For several decades, international organizations like the UN, IMO, and Arctic Council and national governments such as those of Russia and Canada have established norms and practices enabling Arctic peoples and coastal states to accommodate different uses of northern waters. The opening of the CAO and TSR will test the flexibility and responsiveness of these regimes, particularly as extra-regional maritime states seek to exert influence, too. Yet within a policymaking timeframe, there is still ample room to consider the commercial, logistical, geopolitical, and socio-environmental issues that are emerging.

First, the lack of intermediate markets and the continued existence of sea ice outside of summer will challenge the regularization of ship-

ping across the North Pole, particularly container shipping. But over time, the opening of seasonal navigation along the TSR may encourage the development of an icebreaker transportation system, the use of PC vessels (especially double acting ones), or a hub-and-spoke system with transshipment ports along the two main entrances in the Fram and Bering Straits. Longyearbyen and Nome appear the most likely candidates for building deepwater ports, which could ultimately support both the TSR and commercial activities in the CAO.

Second, the TSR may seem to offer a geopolitically straightforward alternative across the high seas compared to Russia's NSR and Canada's NWP. Yet the TSR also crosses six countries' EEZs and territorial waters, which complicates its regulatory environment. The IMO Polar Code applies, while UNCLOS Article 234 still does, too. Russia, given its experience in managing the NSR, may seek to influence governance of the TSR. China, capitalizing on its efforts to develop the PSR and experience in navigating all three polar routes, may play a pivotal role in the TSR's commercialization and perhaps its governance, too. Despite these complexities, the international regulatory framework for shipping across the CAO appears robust, with the region's coastal states continuing to dominate policymaking while including other maritime states, especially Asian ones, in negotiations.

Third, the environmental and socioeconomic impacts of the TSR will likely be felt more acutely at local rather than regional or global scales. While the emerging shipping route promises new avenues for economic development, it may jeopardize the health of coastal ecosystems and viability of subsistence activities. Although the CAO is uninhabited, thousands of people live in communities along its edges and entrances. Empowering Indigenous and local communities to exercise stakeholder rights while reducing the industry's impacts—and, if possible, finding ways that development of the TSR could provide tangible benefits, such as by expanding rather than limiting subsistence access when new ports are constructed—is crucial.

The increasing accessibility of the TSR epitomizes the ambivalence of changes to the Arctic in the Anthropocene. While the opening of a truly trans-Arctic shipping route is a symbol of mankind's greater freedom of navigation, it also presents a stark reminder of the social and environmental costs of this freedom, the conditions that have given rise to it, and the sudden transience of a long-frozen region.

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