
SYSTEMIQ
BREAKING THE ICE?
THE FUTURE OF TRANS-ARCTIC SHIPPING AND IMPLICATIONS FOR THE EU
AUTUMN 2026

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ACKNOWLEDGEMENTS

This report was developed between April and May 2026 by Systemiq in collaboration with the University of Oxford Environmental Change Institute. The report was authored by Peter Hulshof, Moritz de Chaisemartin, Lloyd Pinnell, Boris Vergote, Evelien van den Brekel and Noah Mihan (Systemiq), while the economic modelling was undertaken by Johannes Lumma (University of Oxford Environmental Change Institute).

We would also like to recognise the important contributions provided by the following people:

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DR LAWSON BRIGHAM - Research Professor at the International Arctic Research Center of the University of Alaska Fairbanks; former U.S. Coast Guard polar icebreaker captain

DR TONY CABUS – Research Scholar at the Walther Schücking Institute for International Law

PROFESSOR HEATHER BOUMAN – Professor of Biogeochemistry at the University of Oxford Martin School

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CALL TO ACTION

As rising temperatures accelerate sea ice cover loss in the Arctic, states and companies are increasingly considering the potential to exploit commercial shipping routes via the Arctic.

However, modelling conducted for this report by the University of Oxford finds that shipping via Arctic routes will account for less than 0.2% by 2050 based on cost optimization factors (without accounting for other non-cost challenges), rising to below 0.6% by 2090. Total cost savings for industry based on this re-routing come to just ~$95 million.

Nevertheless, even small volumes of shipping via the Arctic could have important risks with potentially major knock-on consequences. Most importantly, ice-breaking and albedo effects from shipping accelerate ice loss, potentially further disrupting the jet stream, with massive impacts on EU climate conditions. Additionally, oil spills would be virtually impossible to clean up, and disrupted marine migratory patterns could affect fishing stocks, threatening EU food security. There is still a lack of clear scientific evidence on the nature and scale of these risks.

The forthcoming new EU Arctic policy is a timely and unique opportunity to influence real world outcomes in the region for decades to come. The EU can use its position as a central political player in the region to promote a precautionary approach, limiting traffic via the Central Arctic Ocean in particular until clearer scientific and operational conditions for responsible governance are in place and extend funding to close these gaps.

Furthermore, the EU can push for additional standards via the IMO on noise, light, black carbon, while acting to close existing loopholes on the HFO ban.

EXECUTIVE SUMMARY

INTRODUCTION & CONTEXT

- **The European Union (EU) has announced its new Arctic Strategy in October 2026.** This updated strategy reflects the new economic stakes and geo-political pressures that have emerged in the region since the previous framework adopted in 2021, including accelerating ice loss, emerging shipping routes, environmental risks, Russia-China collaboration and governance gaps, among others.

- **One important factor to consider is the potential evolution of commercial shipping in the Arctic region.** Arctic shipping today remains marginal in global terms: just under 40 million tonnes of cargo transited via the region in 2024 (vs ~1 billion tonnes through the Suez Canal alone), accounting less than 0.3% of global seaborne trade by volume.

- **However, as global temperatures continue to rise and sea ice increasingly retreats, the Arctic is set to become navigable for a greater number of days**, opening new trading routes between Asia, Europe and North America that will be shorter than existing options and avoid key trade chokepoints.

- **There are 3 potential shipping corridors across the Arctic that may become commercially relevant across different timescales**: the North-Eastern Passage (NEP henceforth), the North-Western Passage (NWP) and the Transpolar Route (TPR). The NEP is the only route that is already in operation, but transits requires approval and escort from Russia. Crucially, the three are not interchangeable: the NEP and NWP follow national coastlines and run largely through coastal-state waters, whereas the TPR alone crosses the high seas of the Central Arctic Ocean (CAO) – the least-studied and most fragile of the three. This distinction runs through the analysis that follows, and the environmental case turns on it: general "Arctic shipping" should not be conflated with transit through the CAO via the TPR. This prompts a two-pronged question for policymakers:

  1. Whether the EU wants to accommodate Arctic shipping and how?
  2. If so, which of the three routes should be (de) prioritised and why?

  This report provides the first global modelling exercise to estimate the potential future scale and impact of commercial shipping in the Arctic and build upon the new Arctic Strategy, using the University of Oxford Global Marine Trans-Shipping model.

IMPACT ASSESSMENT

- **Opportunity.** As Arctic routes between Asia and §Europe/North America are shorter than existing routes, they offer potential economic savings for commercial shipping of ~$100 mn per year, while moderately reducing reliance on existing trade chokepoints (e.g., Suez Canal).

- **Known costs.** Unlocking this opportunity requires direct economic costs, including response infrastructure in the region, additional vessel costs, high insurance costs and other investment and operating costs, which explain the low economic savings of Arctic shipping. A shorter distance does not translate into a cheaper voyage: on a per-trip basis Arctic transits are typically more expensive than the longer conventional routes, as slower transit speeds, ice-class vessel and retrofitting requirements, elevated insurance premiums, and the unpredictability of routing

around sea ice all raise the average cost per trip.

- **Strategic risks.** Greater Arctic shipping would create its own set of geopolitical risks. It would see greater traffic transiting via Russian waters through the NEP, with a series of new chokepoints potentially emerging along the route. Most significantly, every Arctic route between the Pacific and Europe must pass through the Bering Strait, a single corridor barely 50 miles wide and shared by Russia and the United States. Arctic routing therefore does not escape chokepoint exposure so much as concentrate it into one strait jointly held by a strategic competitor: recent events have shown that one side of such a strait can close it to commercial transit without military dominance, leaving EU-bound traffic exposed to denial overnight. Russian sanctions already in place would also materially restrict economic opportunities tied to the NEP.

- **High environmental impact uncertainties.** The Arctic is one of the world's most ecologically valuable and fragile marine environments. It is uniquely vulnerable to the disruption that commercial shipping would introduce. There are three primary types of climate and environmental risks from Arctic shipping with potentially serious knock-on consequences:

  1. **The albedo ice effect** from black carbon emissions and ice-breaking compounds the climate change already underway in the Arctic, creating a self-reinforcing feedback loop with uncertain but potentially far-reaching second-order effects on Europe's climate.
  2. **Migratory marine species** are highly sensitive to disturbance from shipping (via noise, light, wakes etc.), with major potential consequences for the local and global marine food systems, as well as the 400,000 indigenous people in the Arctic who are dependent on these for their livelihoods.
  3. **Water pollution risks**, from ballast water, fuel emissions, spill risk, and waste discharge, are much harder to remediate in the Arctic due to the lack of response infrastructure. Oil spills in this region would have devastating consequences that would be virtually impossible to remediate.

  These risks pose serious macro-structural challenges for the EU: Arctic warming is already disrupting the jet stream, linked to Europe's increasingly severe heat waves and cold spells, while shifting fish stocks strain EU fisheries governance and threaten food security.

- **The three Arctic routes are not equivalent in commercial nor environmental terms**. The TPR is projected at 0.02% of global trade by 2050: a rounding error in economic terms. Yet traversing the CAO, the world's least-studied marine ecosystem, would bring the risk of irreversible disturbance from industrial activity. The asymmetry between the economic opportunity ceiling and the environmental risk floor is starker than for any other route.

- **The balance of costs and benefits case points clearly toward precaution**: the economic gains do not justify the known and unknown environmental costs, and the EU has both a strategic interest and a clear role in ensuring proactive governance before commercial pressure makes restrictions significantly harder to introduce. This case is clearest for the TPR and the surrounding CAO.

POLICY RECOMMENDATIONS:

- While several governance instruments relevant to Arctic environmental protection have been established over the last decade, none fully address the environmental risks posed by shipping in the region at present. This justifies a comprehensive set of policy responses that acknowledge the potential opportunity, yet takes a precautionary approach to safely engage in Arctic shipping.

EU UNILATERAL INITIATIVE

- **In the short term**, the EU should advocate that commercial shipping in the Arctic region, only proceed when the scientific and operational conditions for responsible governance are in place. The priority would be on **shielding the Central Arctic Ocean** (**CAO**) from passage via the Transpolar Route, as the CAO is uniquely vulnerable to industrial scale interventions. This approach can build on the momentum and model proven by CAO Fisheries Agreement (CAOFA).1

- **Scientific understanding of the CAO ecosystem remains thin**, and the response infrastructure needed to manage an accident or environmental incident does not exist yet. Acting now in line with the precautionary principle, before traffic becomes entrenched, is considerably easier than imposing restrictions later.

- **In the medium term**, the EU could position itself as the leading proponent of **Arctic ecosystem science** in the window before the Fifth International Polar Year (IPY-5) in 2032–33, directing Horizon Europe and the European Polar Coordination Office (EPCO) toward the critical gaps: mapping species' seasonal migratory corridors (especially for cetaceans and critical fisheries) and their trajectory of change, and low-disturbance shipping technologies.

- **In the longer term**, the EU is well-placed to make **EU market access conditional** on environmental compliance for vessels, leveraging its position at the western terminus of the NEP and the fact that Asia-Pacific (APAC) to Europe is the dominant trade flow Arctic shipping would serve. Engaging insurers and vessel operators extends EU influence beyond its formal jurisdiction, shaping behaviour through commercial pressure where rules cannot reach. Market access rules can be calibrated by route, and in particular safeguard the CAO from shipping via the TPR.

EU CONTRIBUTION TO COALITION INITIATIVES:

- At the **International Maritime Organization** (IMO), the EU is well placed to lead diplomatic efforts to close the Arctic HFO ban exemptions, as these effectively undermine the ban until 2034 (to be accompanied by further research on alternative fuels and propulsion). It should also push for IMO standards on noise, light and black carbon, where regulation has lagged despite evidence of harm.

- Beyond regulation, the EU can consider joint **funding of select maritime infrastructure**, covering search and rescue capacity, oil pollution response, and monitoring and surveillance. This can be focused on creating safe conditions for the NEP and NWP routes, while keeping the TPR closed.

Any EU policy initiatives need to consider the voices and interests of Indigenous Peoples and Local Communities. Further consultation and participation of key IPLC stakeholders (beyond the scope of this analytical effort) is recommended as an immediate next step.

[1] CAOFA is a precautionary moratorium on commercial fishing in the CAO pending science-based management that was ratified in 2021 by all major Arctic fishing nations and interests.

KEY MODELLING FINDINGS

Assuming global temperatures rise by 2.5-3.0˚C by 2100, the Arctic is expected to become navigable for between 175-225 days per year for polar class vessels, depending on the route, in the period between 2050-2070 (240-270 days between 2070-2090).

While Arctic shipping routes offer shorter port-to-port travel distances relative to existing options for certain transits, the average speed of travel is slower and the average cost of shipping is higher (due to greater vessels, insurance, staff, maintenance costs etc).

The modelling undertaken for this report optimises global shipping trade flows based on shipping speed and costs. It finds that by 2050, ~0.17% of global annual trade volumes could be re-routed via the Arctic based on these factors ($25.9 bn based on the current value of global trade, with ~650 transits), rising to ~0.41% in 2070 ($46.2 bn, ~1,200 transits), and ~0.55% by 2090 ($62.3 bn, ~1,600 transits).

The diverted trade would principally be re-routed via the NEP, which accounts for ~85% of Arctic traffic in 2050 and a similar share in 2070 and 2090.

The majority of this re-routed trade is expected to connect Northern and Western Europe with Eastern Asia and vice versa, for which the Arctic routes could account for 5-10% of total traffic by 2050 . The sectors expected see the largest diversion of traffic are transport equipment, electrical and machinery (0.75-1.5% of total global trade via Arctic by 2050), with 90%+ travelling via container ships.

INTRODUCTION

THE ARCTIC

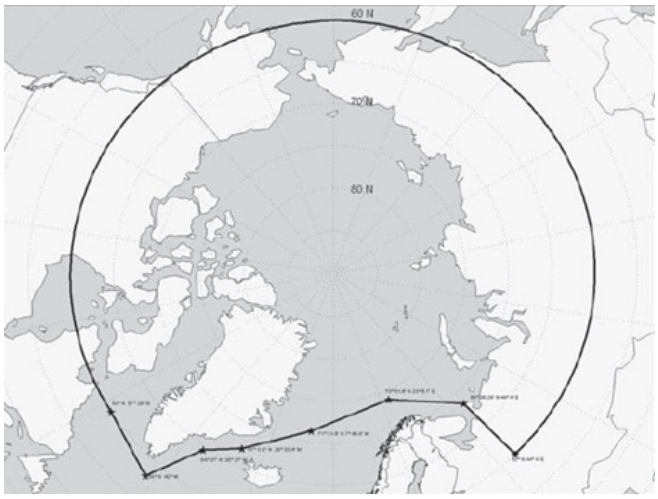
The Arctic is the northernmost region of Earth, centred on the North Pole and encompassing the Arctic Ocean and the surrounding territories of Canada, Greenland, Finland, Iceland, Norway, Russia, Sweden, and the United States. It is generally defined as the area north of the Arctic Circle (approximately 66°34'N) - the latitude above which the sun does not set on at least one summer day, and does not rise on at least one winter day.

For shipping purposes, this report uses the IMO Polar Code area as its operative definition of Arctic waters. The Polar Code defines Arctic waters based on sea ice presence and operational risk rather than an astronomical line. Norway's and Iceland's coastline fall outside this boundary, as the Gulf Stream keeps their waters largely ice-free year-round.

Arctic shipping encompasses four categories of activity, this report focuses on trans-Arctic shipping: full ocean crossings between the Pacific and Atlantic using the Arctic as a transit corridor. The others are destinational (vessels sailing to/from Arctic ports, primarily for resource extraction); intra-Arctic (voyages between Arctic ports); and cabotage (coastal trade within a single Arctic state).



ARCTIC CIRCLE 66° 34' N



POLAR CODE AREA

THE ROLE OF THE EU IN THE ARCTIC

The EU has direct institutional representation in Arctic governance. The Arctic Council comprises all eight Arctic states as full members. This includes three EU member states, Finland, Sweden, and Denmark (whose sovereignty over Greenland further anchors EU interests at the geographic centre of the High North).[2] Norway and Iceland are closely integrated with the EU through the European Economic Area (EEA). The EU itself holds observer candidate status in the Arctic Council.

The EU also has a direct physical presence in the Arctic through infrastructure, resources, and industrial capacity. Finnish firms design and construct ~80% and ~60% of the world's icebreakers respectively.[3] Norway operates several ice-free Arctic ports which serve as key logistics hubs, including Narvik, Tromsø, Hammerfest, and Kirkenes. Narvik is a key iron ore and critical raw material (CRM) hub, handling ~ 22 mn tonnes of iron ore annually, primarily from LKAB's Kiruna mine, a designated EU CRM Act strategic project.[4] Lastly, Greenland also has several ports within the Polar Code area, including Nuuk, Sisimiut, and Ilulissat.

[2] Greenland has opted out of the EU under its Overseas Countries and Territories status but remains within Denmark's foreign policy and defence remit

[3] Business Finland, cited in: "Finland: A Birthplace for Icebreakers," Marine Link, 2023; Wilson Center, "Icebreaking Explained," 2024. https://www.wilsoncenter.org/article/icebreaking-explained-finland-europes-icebreaker-superpower

[4] LKAB, "LKAB Strengthens the Strategic Iron Ore Line Route with a New Ship Loader in Narvik," lkab.com, November 2025. https://lkab.com/en/press/lkab-strengthens-the-strategic-iron-ore-line-route-with-a-new-ship-loader-in-narvik/

1 THE CURRENT STATE OF ARCTIC SHIPPING

KEY MESSAGES

- A sizeable majority of global international shipping today connects Asia to North America and Europe (Asia – Europe accounts for ~30% of total global container and bulk shipping volume; Asia – North America for ~15%).
- In both cases, transiting via the Arctic would reduce the total distance of these shipping routes significantly (30-40% for Asia—Europe , 15-20% Asia—North America), although these savings do not necessarily translate into lower transport costs. This is due to slower, more expensive and less predictable shipping.
- Arctic shipping remains negligible by global standards today, at less than 0.3% of global seaborne trade by volume, since ice cover makes it impossible to transit across the region for most of the year. The vast majority of existing non-fishing activity in the Arctic is resource extraction shipping within Russian domestic waters.
- However, activity has increased significantly in the last decade, with the fastest growth coming from cargo and LNG shipping in Russia's waters (i.e. cabotage and intra-Arctic shipping).
- As temperatures rise and ice cover retreats, 3 potential shipping corridors across the Arctic may become relevant for international commercial trade across different timescales: the North Eastern Passage (NEP), the North Western Passage (NWP), and the Transpolar Route (TPR).
- Of the three, only the NEP is in regular commercial use, though transit is governed by Russian authorities, requiring permission and icebreaker escort, under an assertion of UNCLOS Article 234, which grants coastal states regulatory authority over ice-covered EEZ waters .
- The TPR is the furthest from commercial relevance: it remains ice-covered year-round at present and carries no commercial traffic, far removed from infrastructure and unlike the NEP and NWP it crosses the high seas of the Central Arctic Ocean, outside any national jurisdiction.
- The EU already has substantial interests in the Arctic through member states, associated partners, infrastructure, critical raw materials, maritime regulation, and shipping industries, making future developments in Arctic navigation strategically relevant for EU policymakers.
- Arctic shipping remains small today, may grow in future, but its significance for the EU stems primarily from geopolitics, governance, and strategic dependency rather than from transport efficiency alone.

1.A. ECONOMIC ACTIVITY & INFRASTRUCTURE

Presently, the vast majority of global international shipping connects Asia to Europe and North America. The world's busiest trade route by volume today links east Asian ports (Shanghai, Shenzhen, Singapore etc.) with Europe, carrying a total of 24 million twenty-foot equivalent units (TEU)[9] per year via the Straits of Malacca and the Suez Canal[10]

[5] Lewis, I. (2026, February 11). Record-breaking year for global container volumes in 2025. *TradeWinds*. https://www.tradewindsnews.com/containers/record-breaking-year-for-global-container-volumes-in-2025/2-1-1942307; Loadstar Staff (2025, February 10). Container trades ended 2024 robustly, but eyes will now be on Far East exports. *The Loadstar*. https://theloadstar.com/container-trades-ended-2024-robustly-but-eyes-will-now-be-on-far-east-exports/

[6] Liu, M. and Kronbak, J. (2010). 'The potential economic viability of using the Northern Sea Route (NEP) as an alternative route between Asia and Europe'. *Journal of Transport Geography*, 18(3), pp. 434–444.

[7] Somanathan, S., Flynn, P. and Szymanski, J. (2009). 'The Northwest Passage: A simulation'. Transportation Research Part A: Policy and Practice, 43(2), pp. 127–135.

[8] UNCLOS Article 234 (1982).

[9] TEU is a standard, non-physical unit of measurement in maritime logistics used to quantify cargo capacity on ships, at ports, and in terminals. It is based on the volume of a standard 20-foot-long (6.1 m) intermodal ISO shipping container. Global container shipping volume reached a record high of 192.9 million TEUs (Twenty-foot Equivalent Units) in 2025.

[10] UNCTAD (2024) Review of Maritime Transport 2024. Geneva: United Nations Conference on Trade and Development.

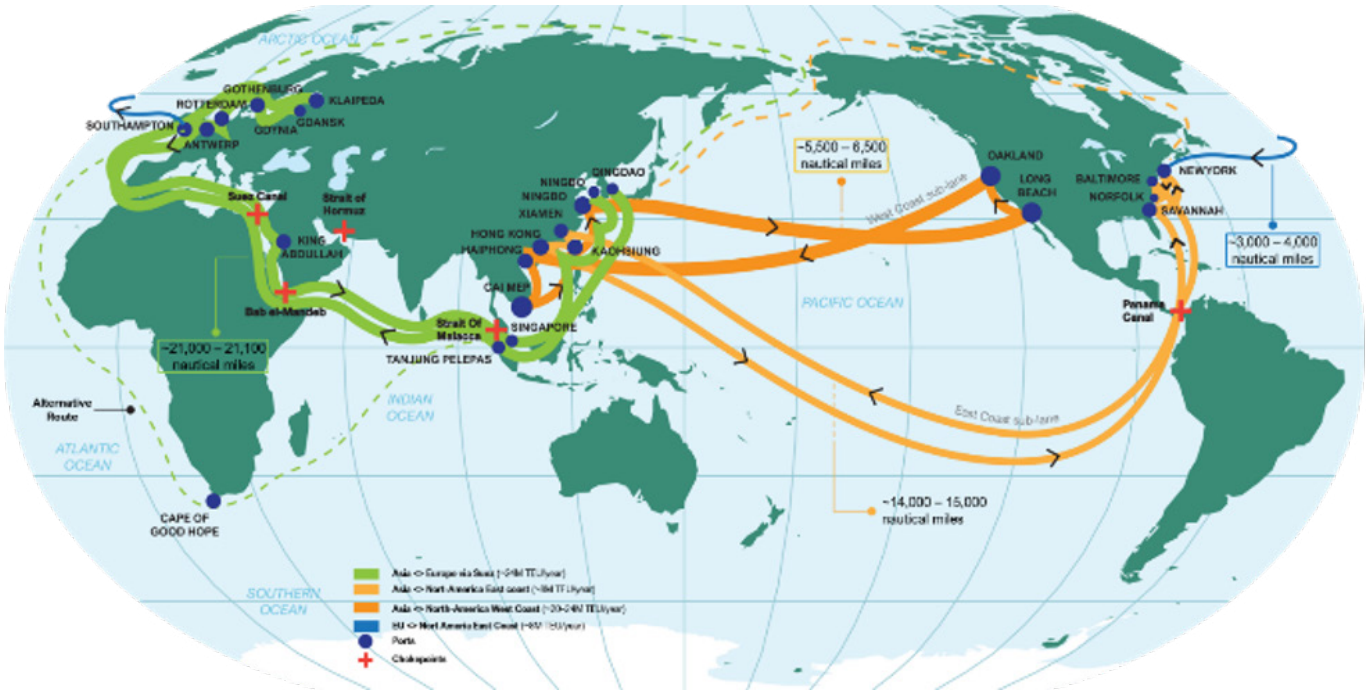


FIGURE 1: GLOBAL SHIPPING TRAFFIC VOLUME BY ROUTE (2025)

(~30% of global TEU in 2025[11]). The next busiest route connects Asia with the east coast of the North America (20-22 mn TEU p.a.) and transits via the Panama canal.[12] A further 6-8 mn TEU transits directly from east Asia to the west coast of the United States. The volume shipped across the Atlantic between Europe and North America is relatively smaller, at ~8 million TEU annually.[13]

Transiting directly via the Arctic would significantly reduce shipping distances between Asia and Europe or the east coast of America. The total distance of shipping routes linking Asia to Europe would be around 30-40% less if these were to travel directly through the Arctic rather than via the Suez Canal.[14] Similarly, travelling via the Arctic instead of via the Panama Canal could reduce travel distances by around 15-20% between Asian and ports on the eastern American coast. Shorter distances do not, however, translate directly into commercial competitiveness: slower transit speeds, ice-class vessel requirements, insurance premiums, and limited seasonal navigability all erode the savings (see Section 2).

There are 3 potential shipping corridors across the Arctic, which may become relevant for international commercial trade across different timescales. The Northeast passage (NEP) runs along Russia's northern coastline and through the Barents Sea.[15] The Northwest Passage (NWP) cuts through the Canadian Arctic Archipelago and is narrow and shallow in many stretches. The Transpolar Route (TPR) directly crosses the high seas of the Central Arctic Ocean (CAO) and is covered by ice year-round at present. None of these routes are currently formally designated shipping lanes or managed corridors (e.g. the Suez Canal); they are emergent natural pathways whose navigability depends on ice conditions that vary annually and seasonally.

[11] Notteboom, T., Pallis, A. and Rodrigue, J-P. (2022). *Port Economics, Management and Policy*. New York: Routledge. Chapter 1.3: Interoceanic Passages. https://porteconomicsmanagement.org/pemp/ contents/part1/interoceanic-passages/ & Atlantic Council (2025). A Lifeline Under Threat: Why the Suez Canal's Security Matters for the World. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/a-lifeline-under-threat-why-the-suez-canals-security-matters-for-the-world/

[12] UNCTAD. (2024). *Containerized cargo flows on major container trade routes in 2024, by trade route* (in million TEUs). Statista. https://www.statista.com/statistics/253988/estimated-containerized-cargo-flows-on-major-container-trade-routes/

[13] Hall, J.W. and Lumma, J. (2024) *OxMarTrans: Oxford Maritime Transport Model*. Programme for Sustainable Infrastructure Systems, Environmental Change Institute, University of Oxford.

[13] Liu, M., & Kronbak, J. (2010). The potential economic viability of using the Northern Sea Route (NEP) as an alternative route between Asia and Europe. *Journal of Transport Geography, 18*(3), 434–444.

[13] NEP is distinct from, but can include, the Northern Sea Route (NSR), which transits entirely through Russian-controlled waters.

Arctic shipping remains negligible by global standards today. The total cargo shipped via the Arctic in 2024 was just under 40 million tonnes[16], accounting for less than 0.3% of global seaborne trade by volume, almost all via the Northeast passage (NEP). The vast majority (~90%) of this is destination shipping serving Russian Arctic resource extraction rather than transits between oceans. For comparison, the Suez Canal handles roughly 1 billion tonnes annually.

However, Arctic shipping activity has roughly doubled in the last decade. The total distance travelled by ships in the Arctic region nearly doubled from 2013 (6 million nautical miles) to 2025 (12 million nautical miles). The number of unique ships entering the Arctic each year increased by approximately 35% over the same period to 1,812 in 2025.[17] The majority of this increase in shipping distances comes from fishing activity in the Barents Sea (~75%), off the coast of northern Norway and Russia. At the other end of the spectrum, the Northern Canadian Archipelago accounted for just 0.01% of the total, while the Central Arctic Ocean held a 0.1% share.[18] Most of the commercial ships operating in the Arctic today are icebreakers in their own right (LNG icebreaking carriers) or ice capable vessels able to operate independently of icebreakers.

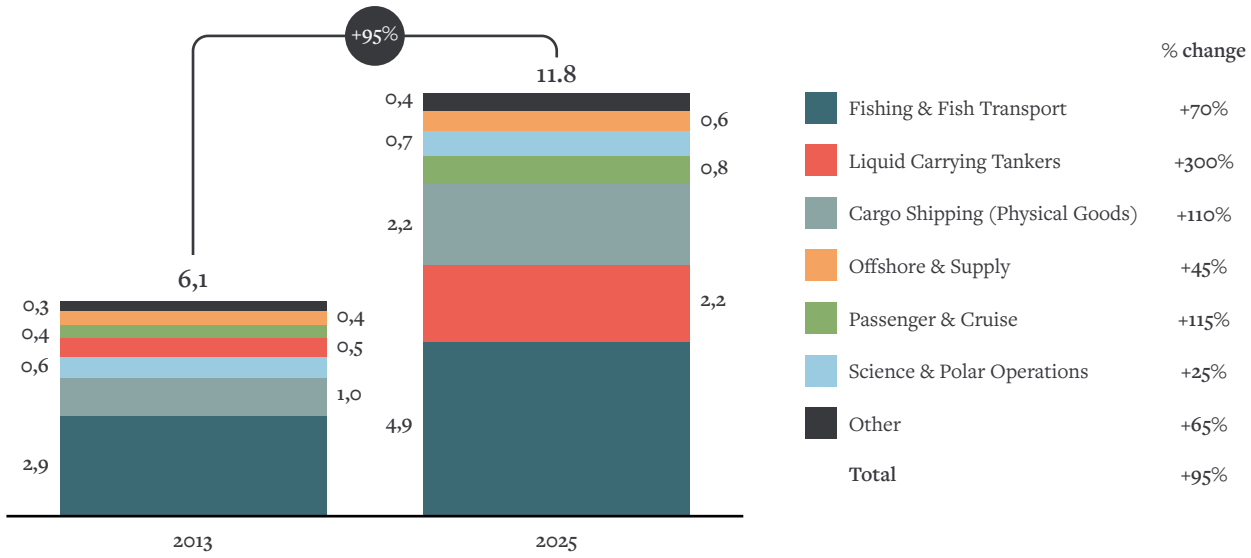


FIGURE 2: ARCTIC VESSEL ACTIVITY HAS ROUGHLY DOUBLED SINCE 2013, BUT MOST GROWTH REFLECTS REGIONAL FISHING AND RESOURCE EXTRACTION RATHER THAN GROWTH IN TRANS-ARCTIC COMMERCIAL SHIPPING.

Distance sailed in Arctic Polar Code Area, million nautical miles

The most-significant category in Arctic shipping in recent years has been LNG tankers, driven by Russian resource extraction in the Kara Sea.[19] In 2012, Russia passed new federal legislation codifying the Northeast passage as a national transportation artery. Since this time, it has pursued deliberate reinvestment in its Arctic infrastructure and fleet, while accelerating ice loss has extended the navigable season.[20] Shipping traffic growth in the region has been driven in large part by the development of new natural gas extraction projects on the Yamal and Gyda Peninsulas in the Kara Sea. Yamal LNG, completed in 2018, along with the subsequent Arctic LNG 2 project, together dispatched 287 LNG cargoes in 2024 alone.

[16] Rosatom. (2025). *Northern Sea Route cargo traffic statistics 2024*. State Atomic Energy Corporation Rosatom.

[17] PAME (Protection of the Arctic Marine Environment) (2020, updated 2026). *Arctic Shipping Status Report #1: The Increase in Arctic Shipping 2013–2025*. Arctic Council. Updated February 2026. Available at: www.astd.is

[18] The Barents Observer article is a more accessible summary of the same research, published in April 2026: https://www.thebarentsobserver.com/partner-content/ship-traffic-is-growing-in-the-high-arctic-but-very-unevenly/449509

[19] gCaptain / PAME (2026, February 17). Arctic Ship Traffic Hits Record High in 2025 as Resource Projects Drive Growth. https://gcaptain.com/arctic-ship-traffic-record-2025-pame-astd/

[20] Lackenbauer, P.W. (2025). *The Strategic Information Environment of the Northern Sea Route*. US Department of Defense. https://media.defense.gov/2025/Sep/25/2003808535/-1/-1/1/EURO%20-%20LACKENBAUER%20-%20DISCLAIMER.PDF

[iv]**Increased tourism in the Arctic is also driving a surge in passenger traffic.** In 2022, 78 cruise ships made 250 entries into the Arctic Polar Code area, a number that more than doubled since 2013. While out of scope of this study, this will be an important field to both monitor and regulate due to environmental impacts, governance challenges and other critical implications.

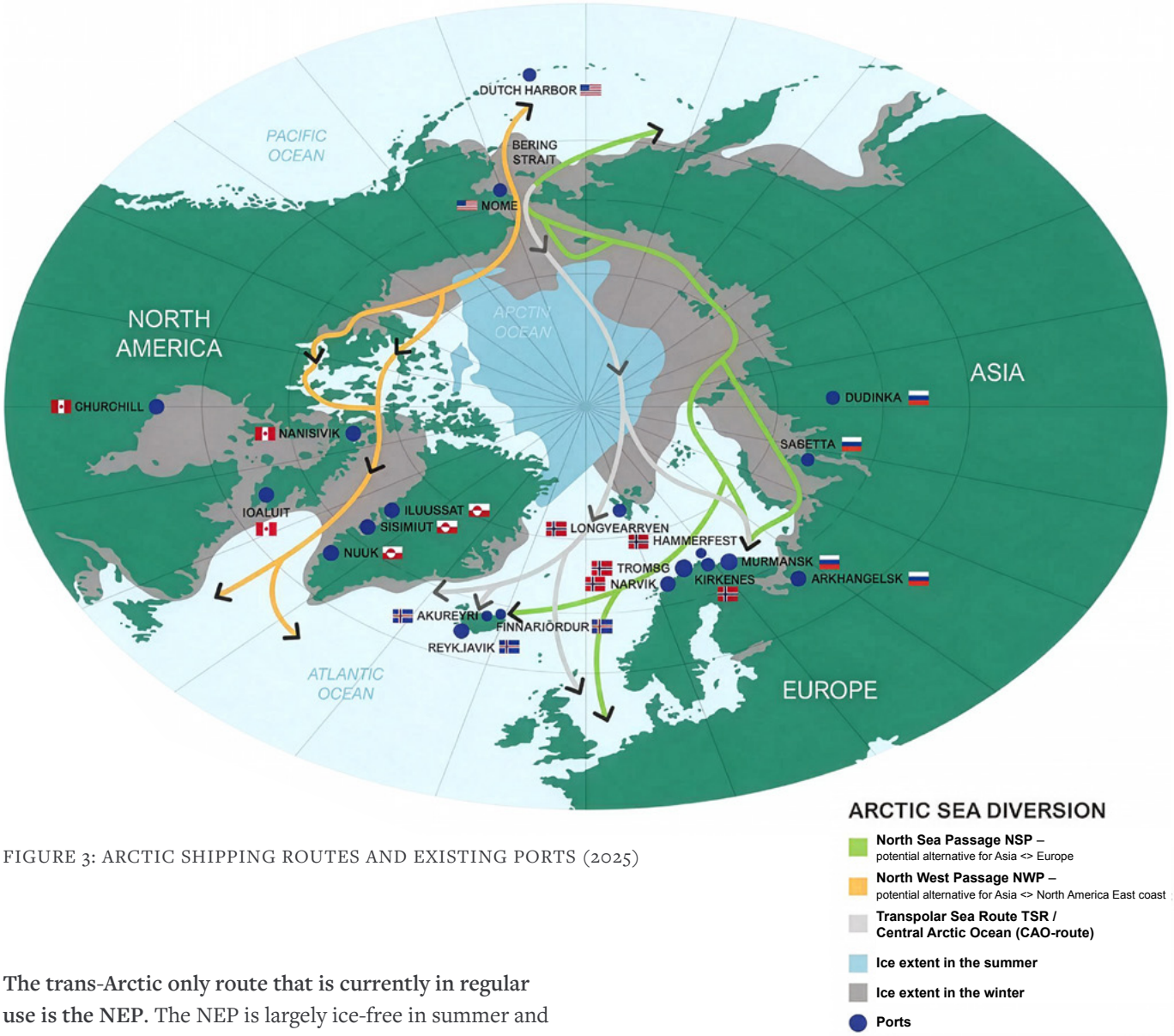


FIGURE 3: ARCTIC SHIPPING ROUTES AND EXISTING PORTS (2025)

The trans-Arctic only route that is currently in regular use is the NEP. The NEP is largely ice-free in summer and shaves 2,500 nautical miles off the 10,600 nautical-mile journey from Shanghai to Rotterdam via the Suez Canal. It has seen a 10x increase in traffic over the last 10 years, mainly from Chinese operators, who completed 14 transits via the route in 2025.[21] A significant part of the route passes through the Russian exclusive economic zone (EEZ) and transits require authorization from Russian authorities, as well as a paid ice-breaker escort. It is currently largely inaccessible for European operators due to the existing sanctions regime.

[21] Captain (2026) 'China expands Arctic container shipping with record 14 voyages in 2025', 11 February. Available at: https://gcaptain.com/china-expands-arctic-container-shipping-with-record-14-voyages-in-2025/

Route	Infrastructure	Activity	Viability
Northeast Passage (NEP)	• 6 formally designated Russian ports along NEP; Murmansk (ice-free) & Arkhangelsk act as primary commercial / logistics hubs • All facilities currently inaccessible to EU-flagged vessels due to sanctions regime	• Mainly used for Russian LNG & bulk exports; 10x increase in cargo volumes in last 10 years (~10% of total traffic) • Mandatory Russian icebreaker escort and fee ($300–700k / transit)	**Medium**—only operationally active route today
Northwest Passage (NWP)	• No deep-water commercial ports; potential sites (Churchill, Iqaluit, Nanisivik) are seasonally inaccessible due to ice cover • Largely devoid of rescue services	• Virtually no commercial cargo has transited to date; total of ~430 transits in recent history, majority being expedition / tourism vessels • Difficult ice conditions and depths	**Low**—lack of infrastructure and variable route conditions
Transpolar Route (TPR)	• Limited port infrastructure – sites in Greenland (Nuuk, Sisimiut, Ilulissat) serve local supply functions; Longyearbyen in Svalbard has limitations on size, with max draughts ~9 meters • No ports for refuge along most of route	• Remains purely hypothetical as a commercial corridor; long-term viability depends on future ice loss	**Future only**—no infrastructure, prohibitive ice

TABLE 1: OVERVIEW OF CURRENT INFRASTRUCTURE, ACTIVITY AND VIABILITY OF ARCTIC SHIPPING ROUTES

Existing port infrastructure in the Arctic is limited and concentrated in Russia, with a cluster also in the Nordic regions. At present, port capacity in the Arctic region is mainly concentrated along the NEP on the Northern Russian coast, which remains largely inaccessible to EU operators due to sanctions. However, there are several commercial ports that are ice-free year-round along the Norwegian and Icelandic coast, some of which are deep-water (Tromsø, Hammerfest), while others act as region regional logistics or export hubs. These primarily service the western entrance of the NEP and TPR and, to a lesser extent, the NWP. Outside of these regions, no deep-water port capable of supporting regular commercial operations exists on any of the three routes. Additionally, search and rescue coverage is sparse across all three corridors, and bunkering infrastructure outside the Russian NEP corridor is effectively absent.[22]

Arctic routes require ice-class vessels, built at a ~20% newbuild premium over standard hulls.[23] The Polar Code, adopted by the IMO and mandatory since 2017, sets binding international standards for vessel design, equipment, and operations in polar waters, classifying ships by ice capability from PC1 (year-round multi-year ice) down to PC7 (thin first-year ice, summer only).[24] Outside Russia, the capacity to design and build polar-capable vessels is currently relatively limited. The Helsinki Shipyard alone has historically built around half of the world's icebreakers, making Finland the dominant Western shipbuilder in this space, while South Korea and China are investing but remain focused on broader commercial tonnage rather than high ice-class construction.

[22] A transiting vessel does not need to make a port call under normal conditions, but only in the event of a technical failure, medical emergency, or fuel shortfall.

[23] Lasserre, F. (2014). Case studies of shipping along Arctic routes. *Transportation Research Part A*, 66, 144–161 (Table 2); Solakivi, T., Kiiski, T. & Ojala, L. (2019). On the cost of ice. *Maritime Economics & Logistics*, 21, 207–222, *estimates range from 8% (IA/IAS container vessels) to 20–36% depending on ice class and vessel type.*

[24] Citation: IMO (2017) *International Code for Ships Operating in Polar Waters* (*Polar Code*). London: International Maritime Organization. https://www.imo.org/en/MediaCentre/HotTopics/Pages/polar-default.aspx

1.B. GOVERNANCE & LEGAL STATUS

The three Arctic shipping corridors each pass through a complex patchwork of jurisdictions. See Appendix B for an in-depth explanation of the jurisdiction of Arctic waters. The NEP runs almost entirely through Russian territorial waters and EEZ. The Russian state has the legal authority to regulate access due to a special provision of the United Nations Convention on the Law of the Sea (UNCLOS) for ice-covered waters. The NWP passes through waters Canada claims as internal, a position the US and much of the international community contests, treating it as an international strait open to transit passage.[25] The TPR crosses the high seas of the CAO, outside any national jurisdiction for most of the route. Beyond the 200-nautical-mile EEZ, however, several Arctic states (Russia, Canada, Denmark, and Norway) have submitted overlapping continental shelf claims to the UNCLOS, with Russia's claim covering a substantial portion of the Arctic seabed.[26]

Arctic shipping governance is divided across several institutions, with none having a specific mandate to regulate Arctic shipping.

- The **United National Convention on the Law of the Sea** (UNCLOS) governs jurisdiction over Arctic waters and the seabed.
- The **International Maritime Organization** (IMO) sets binding vessel standards through the Polar Code. The IMO is the primary institution governing vessel operations in international waters: hence it provides a natural springboard for multi-lateral policy initiatives. Since it operates as a consensus-based organisation, new regulations require support of all members.
- The **Arctic Council** is the primary intergovernmental forum for international cooperation but has no binding power. However, the EU is not a formal member, and activities are currently largely suspended. The council comprises the eight Arctic states and six Indigenous Peoples' organisations as permanent participants. Following Russia's invasion of Ukraine in February 2022, the seven non-Russian member states suspended participation in Council meetings and activities. The Council has since partially resumed work on non-Russian projects; but approximately one third of its 130 active projects remain suspended.[27] The EU holds observer candidate status and does not have a formal seat at the table.
- The newly-created **Biodiversity Beyond National Jurisdiction** (BBNJ) agreement, aimed at protecting marine biodiversity in international waters, provides a mechanism to regulate shipping in the high seas for the first time. The BBNJ introduces for the first time a legal mechanism through which states can collectively designate area-based management zones in high seas areas, including the CAO, and attach binding environmental and operational conditions to those zones. No single state holds jurisdiction, but a coalition of willing parties now has a legal pathway to govern how activities, including shipping, operate there. The EU and 16 of its Member States have ratified, while many countries, such as the US, Canada, and Russia have not yet ratified.
- The **Central Arctic Ocean Fisheries Agreement** (CAOFA) stands as the most successful recent example of multilateral Arctic governance. Ratified in 2021, it brought together all ten major Arctic fishing nations and interests (the EU, US, Russia, China, Norway, Japan, South Korea, Iceland, Canada, and Denmark in respect of Greenland and the Faroe Islands) in a precautionary moratorium on commercial fishing in the CAO pending science-based management. Crucially, it achieved this unanimously and without the paralysis that has characterized other multilateral Arctic discussions.

Three key factors made the CAOFA politically feasible, which all carry over to shipping. Firstly, the activity regulated was not yet commercially viable, so parties were constraining a future industry rather than surrendering existing revenue; trans-polar transit sits at the same pre-commercial threshold today (see Section 2). Secondly, the agreement was framed as precautionary and science-led, allowing each party to present ratification as protecting an option rather than foreclosing one; the same framing would fit a shipping instrument tied to ice and ecosystem science. Finally, it covered only the high-seas portion of the CAO, side-stepping the EEZ and continental shelf disputes that have stalled other Arctic negotiations; a CAO-only shipping regime would inherit the same advantage. Full recommendation for EU policy is discussed in Section 4.

[25] *The Economist* (2019). Who owns the Northwest Passage? https://www.economist.com/the-economist-explains/2019/05/22/who-owns-the-northwest-passage

[26] See appendix B for a further explanation of existing legal status of Arctic waters.

[27] Belfer Center (2026, February 24). Revitalizing the Arctic Council. Harvard Kennedy School. https://www.belfercenter.org/research-analysis/revitalizing-arctic-council

Instrument	Governance layer	Legal force	Scope & key gaps	Parties
Arctic Council (1996)	Soft law forum	**Non-binding**	• 8 Arctic states + 6 indigenous permanent participants • Suspended with Russia since 2022; ~1/3 of projects on hold • Guidelines and assessments only — no binding powers	• 8 members; 13 observers; NGOs andintergovernmental agencies ► **EU observer candidate only — no formal seat**
United National Convention on the Law of the Sea (UNCLOS) (1982)	International treaty	**Binding**	• Legal bedrock for all Arctic jurisdiction • Art. 234: coastal states may regulate ice-covered EEZ • CAO high seas beyond national jurisdiction, with limited Arctic specific governance mechanisms • Overlapping continental shelf claims unresolved	• 168 parties ► **All EU member states party**
Polar Code – International Maritime Organisation (IMO) (2017)	IMO instrument	**Binding**	• Mandatory vessel design, equipment and crew training standards • STCW amendments: dedicated polar crew certification required • HFO carriage ban from 2024 — Russian exemptions to 2034 • No emission standards • Rules cover all Arctic routes incl. CAO	• 175 IMO members ► **EU included**
Biodiversity Beyond National Jurisdiction (BBNJ) Agreement (2023)	International treaty	**Pending ratification**	• Covers CAO high seas directly • Enables area-based management tools and mandatory EIAs • Legal basis for a CAO Marine Protected Area (MPA	• 91 signatories; ~40 ratifications to date ► **EU signed; ratification by individual Member States ongoing**
Central Arctic Ocean Fisheries Agreement CAOFA (2018/2021)	Multilateral	**Binding**	• Precautionary moratorium on commercial fishing in CAO high seas • Direct governance template for shipping regulation • COP Brussels, June 2026 — key EU window to extend model	• 10 parties: EU, US, Russia, Canada, China, Norway, Japan, S. Korea, Iceland, Denmark (Greenland, Faroe Islands)

TABLE 2: SUMMARY OF ARCTIC KEY LEGISLATION & REGULATIONS[28]

[25] Systemiq review of relevant legal documentation

1.C. GEOPOLITICAL LANDSCAPE

Russia is the country with by far the strongest established presence in the Arctic today, with a fleet of 57 ice-breaker ships,[29] more than the rest of the world combined. Russia's Arctic policy is driven simultaneously by economic, strategic, and security objectives. Russia has over 2 million citizens residing in the Arctic circle. It has recently reopened and modernized more than 50 cold-war bases along its 15,000 miles of Arctic coastline,[30] while reviving the Soviet era "Bastion" concept.[31] Commercial transit represents only a marginal share of NEP traffic today and consists almost entirely of Russia-China flows. Russia has nonetheless publicly stated its intention to grow total NSR cargo through 2035, primarily through expanded resource exports rather than opening the route to international transit.[32]

Russia and China are increasingly cooperating to develop commercial shipping in the Arctic via the NEP. In 2018, China declared itself to be a 'near Arctic' state and announced that it planned to create a "polar silk road". Since this time, it has increased investments in the region and has developed 4 polar ice-breaker ships, with a fifth under construction. In November 2024, Russia and China held the inaugural meeting of their NEP Cooperation Sub-Commission, establishing commercial terms and operational standards for the NEP. In October 2025, the Chinese-operated ice-strengthened container ship 'Istanbul Bridge' completed a demonstration voyage from Ningbo-Zhoushan to the UK via the NEP in 20 days,[33] though such transits remain isolated and exploratory rather than scheduled commercial service. Chinese financial exposure to the region is more substantial in the resource sector than in shipping: Chinese banks provided around 11 bn EUR in project financing for Yamal LNG in 2016, and Chinese state-owned companies (CNPC, CNOOC, the Silk Road Fund) hold equity stakes in both Yamal LNG and Arctic LNG 2.[34]

The EU has a significant geographic and economic presence. Through its Arctic Council observer status, its member states Finland, Sweden and Denmark (Greenland), and its link to Greenland under the Overseas Countries and Territories framework, the EU has direct territorial, scientific, and regulatory ties to the region. The Arctic's transformation carries real consequences for Europe: shifting shipping routes, resource competition, and rising geopolitical tensions create significant second-order effects for European trade and security. European partners Norway, Iceland, and Greenland sit alongside EU interests in the region - and increasingly, Greenland sits at the centre of the contest over the High North.

EU countries do not currently have a significant icebreaker fleet, though Finland is one of the leading global production hubs for Arctic ships. Finland, home to Aker Arctic, the world's leading icebreaker engineering firm, is the largest EU player, and already a core member of the trilateral ICE Pact with Canada and the US. The EU recently awarded €42mn toward a new Finnish icebreaker due in service by 2029,[35] but this remains a one-off rather than part of a broader strategy.

The United States is increasingly approaching the Arctic primarily through a security and competition lens. The 2024 Department of Defense Arctic Strategy explicitly frames the region as one of strategic competition with Russia and China, and recent statements on Greenland reflect a growing US preoccupation with who controls the gateway between the Arctic and the North Atlantic.[36] In July 2025 the US also allocated an additional $9bn to new icebreaker development.[37] For the US, the key strategic stake in the region is preventing Russian-Chinese consolidation of an Arctic transit corridor that could

[29] Atlas Institute for International Affairs (2025), 'Arctic Icebreaker Fleets: The Great Gap'.

[30] CSIS (2026, April 23). The Ice Curtain: Russia's Arctic Military Presence. Center for Strategic and International Studies. https://www.csis.org/analysis/ice-curtain-russias-arctic-military-presence

[31] Chatham House (2022). The Militarization of Russian Polar Politics: The European Arctic, the Kola Bastion and the High North. https://www.chathamhouse.org/2022/06/militarization-russian-polar-politics/02-european-arctic-kola-bastion-and-high-north

[32] High North News (2023) 'Russia says Northern Sea Route to transport 270m tons by 2035', 17 April. Available at: https://en.highnorthnews.com/business/russia-says-northern-sea-route-transport-270m-tons-2035

[33] *Buchanan, M. (2025, October 13). Chinese containership 'Istanbul Bridge' reaches UK via Arctic route in record 20 days. gCaptain.* https://gcaptain.com/chinese-containership-istanbul-bridge-reaches-uk-via-arctic-route-in-record-20-days/

[34] *Basquill, J. (2016, May 9). China funds mega Yamal LNG project. Global Trade Review.* https://www.gtreview.com/news/europe/china-funds-mega-russian-lng-project/

[35] Finnish Ministry of Transport and Communications (2025, July 3). Over EUR 90 million in EU funding awarded to Finnish transport projects including new icebreaker. https://lvm.fi/en/-/over-eur-90-million-in-eu-funding-awarded-to-finnish-transport-projects-including-new-icebreaker

[36] US Department of Defense (2024, July 22). 2024 Department of Defense Arctic Strategy. https://media.defense.gov/2024/Jul/22/2002215972/-1/-1/1/2024-DOD-ARCTIC-STRATEGY.PDF

[37] gCaptain (2025, July 4). Trump Bill Secures $9 Billion for US Arctic Surge, Six New Icebreakers to Counter Russian and Chinese Dominance. https://gcaptain.com/trump-bill-secures-9-billion-for-u-s-arctic-surge-six-new-icebreakers-to-counter-russian-and-chinese-dominance/

erode the maritime dominance the US currently exercises through Pacific and Atlantic chokepoints.

Canada is increasingly asserting its sovereignty over its Arctic waters and boosting its Arctic capabilities. Canada has recently begun construction on its first heavy polar icebreakers in over 60 years.[38] Canada has long treated the NWP as internal waters and has resisted international transit claims,[39] but recent commitments, such as the Icebreaker Coalition Effort (ICE) Pact with the US and Finland,[40] reflect a shift from passive defence of sovereignty to active build-out of Arctic capability.

NATO's Arctic posture has been fundamentally reshaped since Russia's full-scale invasion of Ukraine in 2022. Finland and Sweden's accessions to NATO in 2023 and 2024 respectively mean that seven of the eight Arctic Council member states are now NATO members, isolating Russia and substantially strengthening the Alliance's collective defence depth in the High North. NATO's "Regional Plan North" reportedly focuses on cohesive transatlantic defence, strategic deterrence, and preserving freedom of navigation. NATO's key maritime priorities in the Arctic include keeping the Greenland-Iceland-UK (GIUK) gap open for reinforcements, ensuring freedom of navigation for civilian and commercial traffic, and protecting Allied maritime territory. Western sanctions have imposed a constraint on Russia's Arctic ambitions, targeting technology transfer, financing, and the acquisition of specialised icebreaking LNG carriers.[41]

Japan and South Korea are also increasing investing in Arctic shipping as they stand to potentially gain economically from trade via the NEP. Korean shipbuilders Hanwha, Samsung Heavy Industries, HD Hyunda have built the majority of the world's ice-class LNG tankers, including Russia's Arc7-class fleet. In September 2025, Seoul announced a EUR 1.15 billion program to expand Busan as a future Arctic shipping hub and subsidize construction of ice-capable vessels domestically, with a second polar research icebreaker entering procurement in May 2026. Trial Arctic route operations are planned for 2026.[42] Japan's first purpose-built Arctic icebreaker is due for delivery in November 2026, and Japanese trading companies have already invested in Arctic LNG shipping.

	State	Arctic EEZ (km²)	# of ports within ~100km of Arctic routes
	Russia	~7.0 Mn	9
	Canada	~3.5 Mn	3
	Norway	~2.5 Mn	6
	Greenland (Denmark)	~2.5 Mn	3
	United States	~1.0 Mn	2
	China	None	None
	Japan	None	None
	South Korea	None	None

TABLE 3: SUMMARY OF ARCTIC ASSETS BY STATE

[38] Seaspan (2025, April 3). Seaspan to Build Made-In-Canada Heavy Polar Icebreaker. https://www.seaspan.com/press-release/seaspan-to-build-made-in-canada-heavy-polar-icebreaker/

[39] *The Economist* (2019, May 22). Who owns the Northwest Passage? https://www.economist.com/the-economist-explains/2019/05/22/who-owns-the-northwest-passage

[40] Canada signs new partnership agreement with the United States and Finland to produce Arctic and polar icebreakers. https://www.canada.ca/en/public-services-procurement/news/2024/11/canada-signs-new-partnership-agreement-with-united-states-and-finland-to-produce-arctic-and-polar-icebreakers.html

[41] Bykova A., Wynne Houck O. (2024), NATO in the Arctic: The Arctic Institute's NATO Series 2024-2025. https://www.thearcticinstitute.org/nato-arctic-the-arctic-institutes-nato-series-2024-2025/

[41] High North News (2025) 'South Korea to subsidize construction of ice-class vessels and expand port in support of Arctic shipping', 15 September. https://en.highnorthnews.com/politics/south-korea-to-subsidize-construction-of-ice-class-vessels-and-expand-port-in-support-of-arctic-shipping/156258

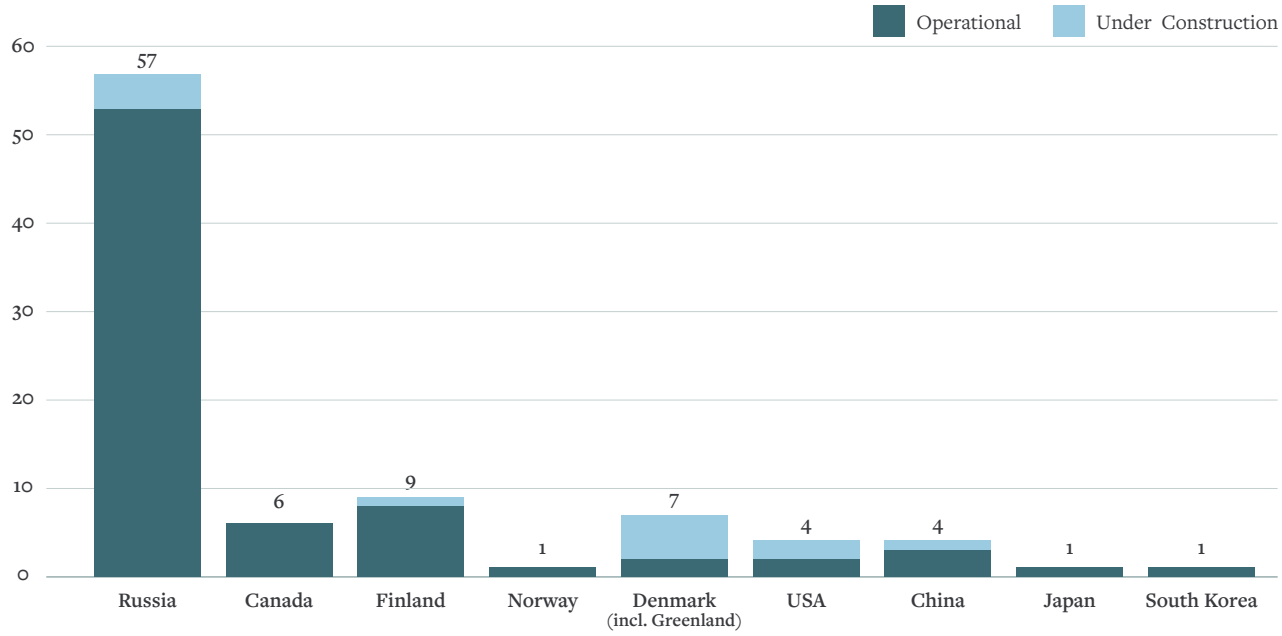


FIGURE 4: POLAR ICEBREAKER FLEET BY STATE (OPERATIONAL + UNDER-CONSTRUCTION, 2025)

Source: International Institute for Strategic Studies (IISS), via Statista (2022); Atlas Institute for International Affairs (2025).

Includes icebreakers and ice-capable patrol ships. Russia figure includes 4 vessels under construction. Denmark figure includes 5 vessels under construction (announced 2025)

* Fleet figures include vessels with varying roles: icebreaking polar research ships (China, Japan, South Korea), ice-capable patrol ships (Denmark/Greenland), and navy/coast guard vessels (Norway). Only Russia and Canada routinely deploy icebreakers for commercial escort. USA figures reflect current USCG heavy polar icebreakers; 11 Arctic Security Cutters are contracted with two under construction.

1.D. STAKEHOLDER POSITIONS

The Arctic is home to a diverse set of stakeholders holding sharply divergent views on development, governance, and environmental risk.[43] At one end of the spectrum, Arctic indigenous communities, including the Inuit Circumpolar Council[44] and the Saami Council,[45] oppose expansion outright, demanding Free, Prior and Informed Consent under the United Nations Declaration on the Rights of Indigenous Peoples as a legal precondition for any development that affects their territories and subsistence livelihoods. Environmental bodies, from WWF[46] to the Clean Arctic Alliance, share this opposition, calling for an effective HFO ban, black carbon standards, and precautionary governance of the Central Arctic Ocean before commercial activity begins. Allied Arctic states (i.e. Norway, Canada, Denmark, Finland, and Sweden) and EU-aligned observers take a more conditional stance,[47] balancing climate and sovereignty obligations against resource and trade interests. Divergent interests and priorities among allied Arctic states further complicate positioning. At the other end, Russia treats the Northeast passage as a sovereign economic asset, while Asia-Pacific powers such as China, Japan, and South Korea pursue commercial access,[48] and shipping operators weigh potential route savings.

There are many actors who will drive enforcement of Arctic environmental regulations as activity grows. First, flag states ensure vessels on their registry comply with international conventions, several EU member states, including Greece, Malta, and Cyprus, operate

[43] See appendix C.

[44] Inuit Circumpolar Council (2022). *International Maritime Organization (IMO) Position Paper.* https://www.inuitcircumpolar.com/icc-activities/united-nations-and-human-rights/imo/

[45] Saami Council (2021). EU has launched its new Arctic strategy. https://www.saamicouncil.net/news-archive/eu-has-launched-its-new-arctic-strategy; Saami Council (2025)

[46] WWF Arctic (2023). No time to waste: IMO must tackle black carbon emissions in the Arctic. https://www.arcticwwf.org/newsroom/features/no-time-to-waste-imo-must-tackle-black-carbon-emissions-in-the-arctic/

[47] Norway in the High North — Arctic policy for a new reality. https://www.regjeringen.no/en/aktuelt/norway-in-the-high-north-arctic-policy-for-a-new-reality/id3116990/

[48] China Media Project (2026). Polar Silk Road. https://chinamediaproject.org/the_ccp_dictionary/polar-silk-road/; Institute for Security and Development Policy (2026).

among the world's largest maritime administrations. Second, ship classification societies set and verify the technical standards vessels must meet. Third, the marine insurance industry, underwriting the financial risk of Arctic operations, is likely to become an increasingly significant constraint on future activity. Fourthly, the shipping industry's own narrow margins and sensitivity to operational risk also act as a natural brake on unregulated expansion. This holds particularly for container shipping, for which Arctic complexity makes it a structurally unattractive environment. Lastly, ports of destination (or origin) are literally the gates in between shipping routes and the markets for shipped goods.

Forward looking, these actors also provide potential compliance points for any Arctic policies the EU. From this perspective ports of destination, large flag states that are EU member states and the maritime insurance industry provide clear leverage points. Each of those relies upon a different set of core national stakeholders. Flag state leverage depends on Greece, Malta and Cyprus; and port of destination leverage relies on the Netherlands, Germany and Belgium as the largest destinations of Asia-Europe transshipments. The maritime insurance industry would rely on UK coordination (without the use of extremer measures with unintended and escalatory economic and political impacts, e.g. conditioning foreign financial institution market access upon extra-territorial compliance).

2 PLAUSIBLE OUTLOOKS FOR ARCTIC SHIPPING

KEY MESSAGES

Even under substantial Arctic warming, transshipment routes through the Arctic are projected to capture <1% of global seaborne trade by the end of the century, and for the Transpolar Route this will remain below 0.1% of global trade, with negligible economic savings of rerouting.

The OxMarTrans model estimates that by 2050, ~0.17% of global shipping transits are projected to divert through the Arctic (~650 per year). This represents ~$26 billion in annual trade value, but only ~$95 million in savings. Arctic shipping is expected to reach only 0.41% by 2070 and 0.55% by 2090.

- The Arctic is warming four times faster than the global average, and sea ice is now receding at approximately 12% per decade, significantly increasing the number of navigable days per year. Under current trends, assuming global temperatures increase on average 2.5-3.0˚C by 2100, polar class vessels are expected to be able to cross the arctic for 175-225 days per year between 2050-2070, depending on the route.[49,50]
- The TPR remains commercially negligible in comparison to the other two Arctic routes. The NEP dominates near-term diversion as the only currently navigable corridor; the NWP emerges later.
- Yet, shorter distances of Arctic routes do not translate into equivalent time savings, since shipping via the Arctic is considerably slower and unpredictable compared to existing commercial routes. Additionally, Arctic shipping costs are materially higher than conventional routes due to various factors, such as ice-class vessel requirements, higher insurance and staff costs etc. Annual costs savings from re-routing are projected at just $95mn in 2050, and $230mn by 2090.
- The modelling carries caveats: geopolitics, insurance, infrastructure, and ice variability can all impact outcomes, injecting uncertainty on routes. Critically, commercial viability depends less on occasional accessibility than on predictable, reliable operational windows: schedule integrity and year-to-year consistency matter as much as average navigability.
- A route navigable in some years would still be commercially unattractive if conditions fluctuate significantly year to year. This can significantly lower incentives for shippers. Uncertainty and variability is expected to be highest on the TPR through the emerging CAO, making this route significantly less attractive to shippers and insurers.
- Increased shipping traffic via the Arctic could provide economic opportunities for the EU ports and operators. However, capturing this would require significant investment in infrastructure and vessels while risking risky investment lock-in towards uncertain routes as well as greater dependence on Russia (even for the TPR on the Asian end of the route). Given the extremely small viable volumes and high uncertainty, investing in the TPR would be very high economic risk.

[49] In the most extreme climate scenarios (~RCP 8.5), near-ice-free Arctic summers are likely by the 2030s, with the NSR potentially navigable year-round by 2060 and the TPR viable by the 2050s; while under moderate scenario (~RCP 2.6), ice-free summers remain uncertain before 2100, pushing meaningful Arctic shipping further into the future.

[50] Note that these refer to Arctic-wide averages, whereas warming rates, ice loss, and navigability vary significantly across regions, seasons, and routes. In practice, this means that increases in navigable days are likely to be uneven across the NSR, NWP, and TPR, and may fluctuate considerably year-to-year despite the broader long-term trend.

2.A. SEA ICE COVER PROJECTIONS AND FUTURE NAVIGABILITY

The Arctic ice sheet is already retreating rapidly and will increasingly recede as global temperatures rise. The Arctic is, by some estimates, warming at close to four times the rate of the rest of the planet, and maximum sea-ice extent is declining by an average of 12% per decade.[51] While different areas of the Arctic vary significantly in ice loss and warming rates, the trend is clear: in 2025 the year's minimum ice cover was almost 30% less than in 1970-2010 average.[52]

IPCC SSP2-4.5 (+2.5-3.0˚C global warming by 2100) presents the most likely scenario for the Arctic Ocean, reflecting realistic current global policy trajectories. While previous research has covered both higher and lower emissions pathways, the extremes, SSP5-8.5 (3.3-5.7˚C by 2100) and SSP1-2.6 (~1.8˚C by 2100), are widely acknowledged to be implausible, making SSP2-4.5 the appropriate basis for this analysis.[53]

The retreating sea ice cover in the Arctic leads to longer periods for which Arctic Shipping routes are navigable across the year. A day is considered navigable when ice concentration falls below the threshold a given vessel class can safely transit, meaning the figure varies by ship type and will grow as the Arctic warms. Academic literature such as Min et al. (2022) and Li et al. (2025) have taken the SSP2-4.5 warming scenario and converted projections of sea ice cover into per-year predictions of navigable days. This forms the basis of our trade modelling exercise.

This analysis covers two vessel types: open water ships and PC6 ice-class vessels. Open water ships are conventional vessels, the kind that carry the vast majority of global trade today, and can only operate in ice-free conditions. PC6 ice-class vessels, by contrast, are purpose-strengthened to navigate through light first-year ice and represent the most commercially realistic option for near-term Arctic transit.[54]

		Projected Navigation Season (days/year)			
Route	Vessel Class	2030–2050	2050–2070	2070–2090	2090–2110
Northwest Passage (NWP)	Open Water (OW)	~90	~105	~130	~155
	IA/IAS (PC6 equiv.)	~155	~185	~240	~290
Northeast Passage (NEP)	Open Water (OW)	~105	~130	~145	~152
	IA/IAS (PC6 equiv.)	~185	~225	~260	~285
Transpolar Route (TPR)	Open Water (OW)	~20	~75	~135	~165
	IA/IAS (PC6 equiv.)	~85	~175	~270	~310

TABLE 4: ESTIMATED NAVIGABLE DAYS PER ROUTE, VESSEL CLASS, AND TIMESPAN UNDER SSP2-4.5

Today, Arctic navigation remains severely constrained, with the NWP is accessible to open-water vessels for as few as 30–45 days per year, the NEP for 90–120 days, and the Transpolar Route is effectively impassable without ice-class capability.

Sources: Projected seasons derived from ACIA (2004) / Liu & Kronbak (2010) for NSR baseline; Smith & Stephenson (2013) and Melia et al. (2016) for route-specific projections under RCP 4.5–8.5 scenarios; Arctic Shipping Deep Research synthesis (Systemiq, 2026). Current (c. 2025) estimates based on Policy Brief v2 (Systemiq, Apr 2026) and PAME ASSR #1 (Feb 2026). Values are approximate central-case figures and subject to scenario uncertainty.

Note: Twenty year timeframes were taken to subdue intense seasonal variations of sea ice in the Arctic Ocean.

[51] NASA (2026) 'Arctic Sea Ice Minimum Extent', *NASA Climate Vital Signs*. https://climate.nasa.gov/vital-signs/arctic-sea-ice/

[52] National Snow and Ice Data Center (2025, September 17). 2025 Arctic Sea Ice Minimum Squeezes into the Ten Lowest Minimums. https://nsidc.org/sea-ice-today/analyses/2025-arctic-sea-ice-minimum-squeezes-ten-lowest-minimums; NOAA Arctic Report Card 2025. https://arctic.noaa.gov/report-

[53] Van Vuuren, D.P. et al. (2026) 'The Scenario Model Intercomparison Project for CMIP7 (ScenarioMIP-CMIP7)', *Geoscientific Model Development*, 19, pp. 2627–2656. https://doi.org/10.5194/gmd-19-2627-2026

[54] PC6 is a classification and can refer to any ship strengthened to withstand medium, first-year ice.

2.B. EXISTING VS ARCTIC ROUTE COST COMPARISON

This analysis estimates how much global shipping traffic could divert through the Arctic using a modified version of the OxMarTrans shipping model.[55] The model draws on AIS data and assumes that vessels take the most economical and logistically straightforward route available. We added each Arctic route (the NEP, NWP and TRP) along with Arctic-specific cost assumptions and paired it with our navigable days projections to determine how many ships, and how much cargo value, would divert from traditional routes. The result is a year-by-year prediction of the share of global trade rerouted over the Arctic as navigable days increase over time.

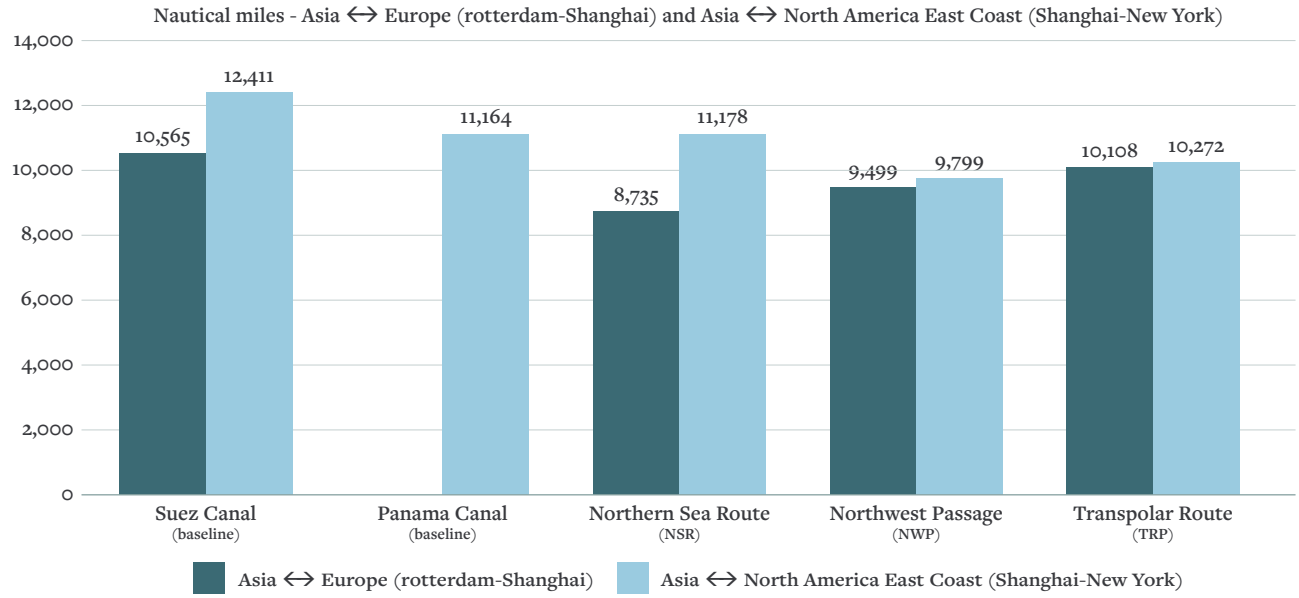


FIGURE 5: ARCTIC ROUTES – DISTANCE VS. TRADITIONAL ALTERNATIVES

Arctic routes will often still be faster than alternative routes, despite slower transit speeds. Arctic conditions often force vessels to slow significantly: from a typical open-water cruising speed of around 20 knots to as low as 13–14 knots in ice zones. In practice, the NEP's 39% distance advantage over Suez translates into transit time savings of roughly 7–10 days vs. 22–25 days Rotterdam–Yokohama. Other passages like the NWP or TRP are slower, with constrained speeds inside the passage eating into its nominal distance advantage. Delays from unpredictable events like dwell time and adverse weather can erode these savings further.

Some international transit shipping will be more cost effective via the Arctic in future relative to existing routes. The per-mile costs of Arctic shipping are typically higher than via conventional shipping, due to a variety of factors. This analysis made a set of assumptions based on the academic literature available to calculate the differential in costs for each type of transit. See Annex F for a detailed breakdown. This differential has been summarised in figure 6 below, which compares the cost per transit for Arctic routes compared to existing options for a typical shipment.

[55] University of Oxford Programme for Sustainable Infrastructure Systems, led by Prof. Jim Hall and Dr. Johannes Lumma.

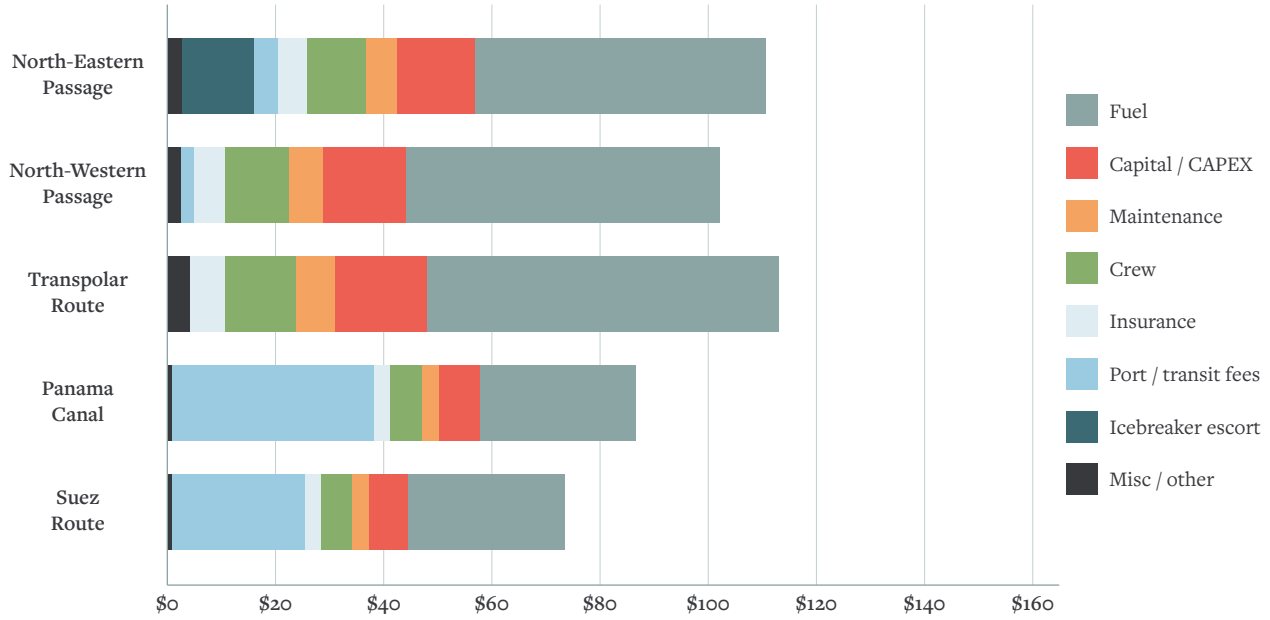


FIGURE 6: COST COMPARISON PER TRANSIT BY ROUTE FOR ROTTERDAM—SHANGHAI BULK CARGO SHIPMENT

2.C. ROUTE DIVERSION PROJECTIONS

The OxMarTrans model predicts that the increase in the number of navigable days per year results in ~0.17% of global shipping transit to be diverted through the Arctic Ocean by 2050.

- 2050—0.17% of global maritime trade via Arctic routes, equivalent to ~$19.1 bn, ~650 transits
- 2070—0.41%, equivalent to ~$46.2 bn, ~1,200 transits
- 2090—0.55%, equivalent to ~$62.3 bn, ~1,600 transits

Note that the model does not project future growth in trade volumes or value, so economic values refer to the potential Arctic share of total global maritime traded values, based on existing observed voyages. The full detail behind these figures and the assumptions underpinning them are set out in Annex F.

Route	2050	2070	2090	2110
North Eastern Passage	$21.9B | 0.14%	$39.0B | 0.35%	$52.7B | 0.46%	$61.1B | 0.54%
Transpolar Route	$2.7B | 0.02%	$4.9B | 0.04%	$6.6B | 0.06%	$7.6B | 0.07%
North Western Passage	$1.3B | 0.01%	$2.2B | 0.02%	$3.1B | 0.03%	$3.6B | 0.03%
Total of 3 Arctic routes	$25.9B | 0.17%	$46.2B | 0.41%	$62.3B | 0.55%	$72.3B | 0.64%

TABLE 5: GLOBAL SHIPPING TRANSITS DIVERTED BY ROUTE AND YEAR.

Value of shipped goods in USD billions and % of global trade via respective routes, all vessels combined (bulker, container, tanker).

Arctic shipping routes stand to divert a modest but growing share of global maritime trade, rising from 0.17% ($25.9B) in 2050 to 0.55% ($62.3B) by 2090. The NEP accounts for the overwhelming majority of this shift, handling roughly 85% of all rerouted trade value across every time window. The NWP emerges as a secondary corridor from 2050 onwards, initially attracting bulk and energy cargo before broader adoption.

The TPR remains negligible throughout the modelling horizon, consistent with the scientific literature, which places viable CAO transit firmly beyond 2050 under this scenario. The policy implication is clear: the shipping opportunity for the TPR is a rounding error in economic terms, hence, there is no significant rationale to accommodate for environmental and other risks from shipping ghat passes through the CAO.**The corridors**

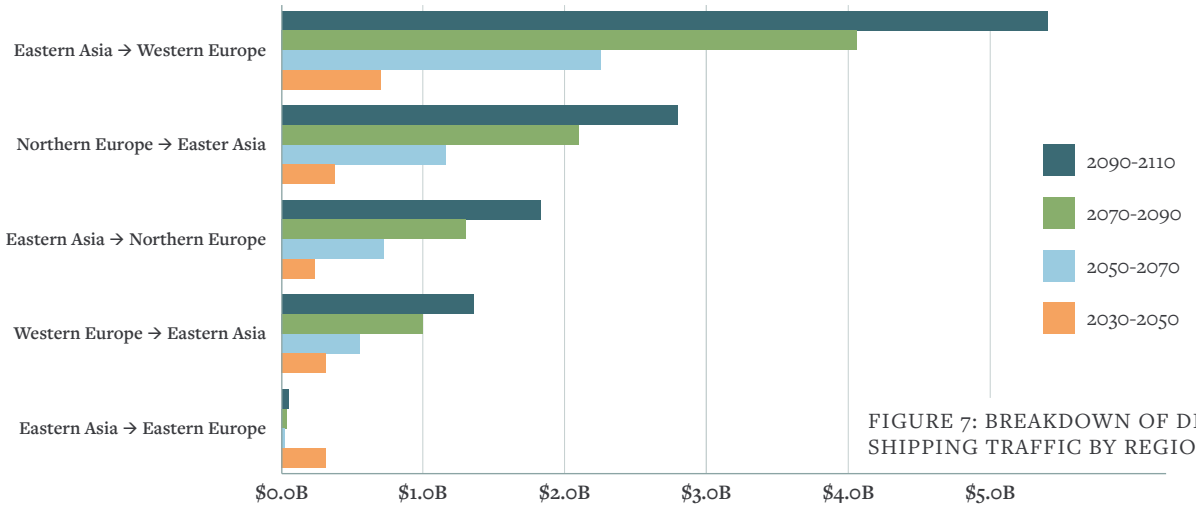


FIGURE 7: BREAKDOWN OF DIVERTED SHIPPING TRAFFIC BY REGION

connecting Eastern Asia with Western and Northern Europe see the largest absolute diversions. The Eastern Asia to Western Europe lane alone grows from $0.7B to over $4B in rerouted value by 2090. This reflects the NSR's structural geographic advantage for trans-Eurasian trade, with direct relevance to EU shipping competitiveness and infrastructure planning.

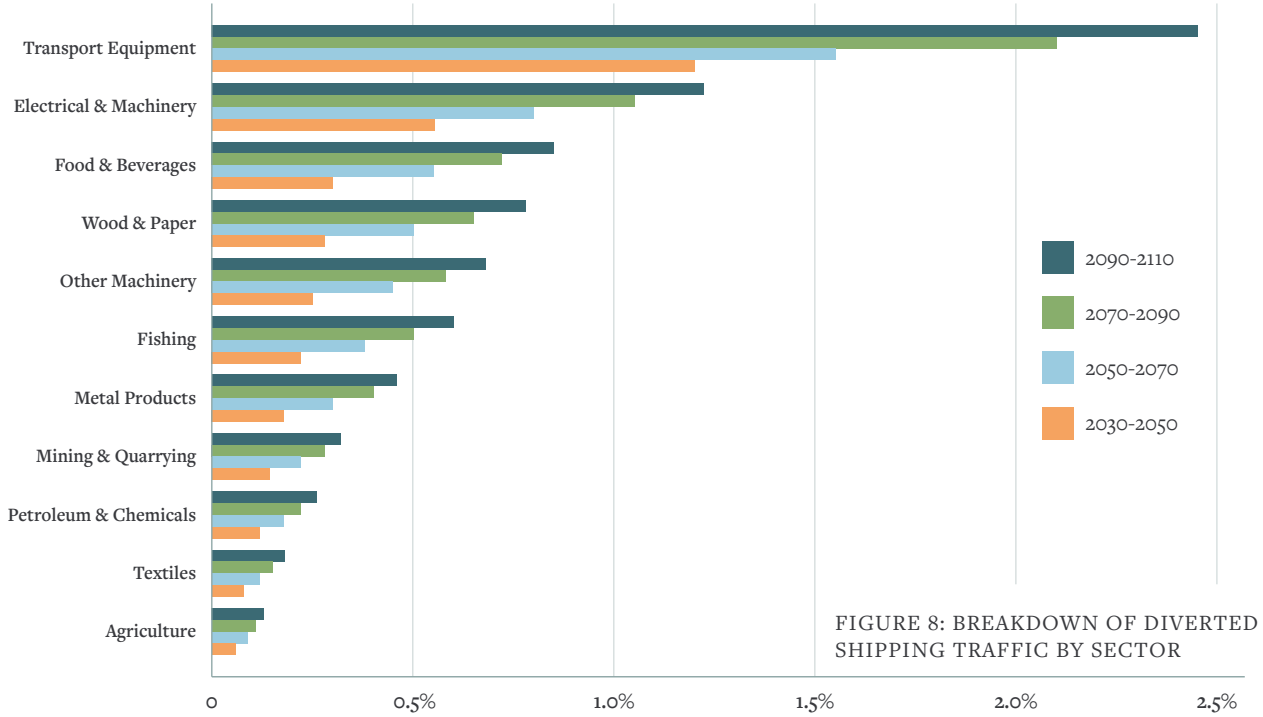


FIGURE 8: BREAKDOWN OF DIVERTED SHIPPING TRAFFIC BY SECTOR

Rerouted trade share (5) = share of each sector's global trade diverted via Arctic routes. IA/IAS vessel class. Source: OxMarTrans model.

Transport Equipment and Electrical & Machinery consistently account for the largest diverted trade shares across all time windows. This is driven by their near-total reliance on container shipping, the vessel class with the greatest potential for cost savings from Arctic rerouting. Agriculture, textiles, and petroleum remain largely unaffected, given their dependence on bulk and tanker vessels for which Arctic with less cost savings from rerouting.

There are several important caveats to our modelling approach:

- **Geopolitics:** the model does not account for disruptions such as Russia closing the NEP to European traffic, which could alter route availability and insurance costs overnight.
- **Insurance:** entrenched resistance by major financial institutions to cover Arctic voyages could prove a binding constraint that no climate scenario can override.
- **Routing assumptions:** the model assumes ships take the most economical route, which holds for bulk cargo but poorly approximates container shipping, where fixed port call sequences prevent opportunistic rerouting.
- **Port infrastructure:** Arctic-adjacent port capacity outside Russia's NEP network is extremely thin and could become a binding constraint before ice conditions do.

Several factors could materially shift our results in either direction:

- **Sea ice pace:** under a higher emissions trajectory, navigable days expand faster and diverted trade could be multiples of our central estimate
- **ETS and fuel costs:** rising carbon pricing amplifies the distance advantage of Arctic routes, potentially accelerating diversion beyond what our model captures
- **Fleet capital requirements:** the scale of IA/IAS fleet investment needed could suppress growth if financing conditions tighten or the insurance market hardens
- **Inter-annual ice variability:** a cluster of anomalous ice years in the 2030s could delay commercial adoption by a decade; an unusually ice-free stretch could trigger faster-than-expected uptake
- **Schedule reliability:** Arctic viability depends less on average navigability than on predictable, reliable operational windows. Inter-annual ice variability means that even routes with improving average navigability can be disrupted by anomalous ice years, eroding the schedule integrity that shippers require — particularly for time-sensitive cargo.
- **Container shipping:** The model's routing assumptions hold reasonably well for bulk and energy cargoes, but poorly capture container shipping, which operates hub-and-spoke networks built around fixed schedules, integrated logistics chains, and transshipment architecture at major gateway ports. Unlike bulk vessels, container lines cannot opportunistically reroute without disrupting every downstream node in the network. Therefore, until Arctic corridors offer reliable year-round windows and adequate port density, Arctic container shipping is tough to implement.
- **Value of time:** we have not considered in this modelling exercise the economic value of shipping time for each industry. Certain sectors value time more highly as their products or business models depend on faster delivery. In principle, sectors with high time values (i.e., preference for speed) would favour shorter routes via the Arctic if these reduce shipping times.

The figures presented above should thus be considered as a highly uncertain and illustrative maximum estimate of the potential trade diversion via the Arctic over time based on purely economic factors.

2.D. BOX: SHIPPING OF ARCTIC NATURAL RESOURCES

The Arctic holds some of the world's largest untapped reserves of oil, gas, and critical raw materials, making it an increasingly contested frontier. The region is estimated to hold around 13% of the world's undiscovered oil and 30% of its undiscovered natural gas, concentrated largely in the Russian Arctic and on the Alaskan North Slope.[56] Beyond hydrocarbons, the Arctic seabed and surrounding landmass contain significant deposits of nickel, copper, cobalt, rare

[56] *Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle.* US Geological Survey Fact Sheet 2008-3049. Available at: https://pubs.usgs.gov/fs/2008/3049/

earth elements, and phosphate, many of which are on the EU's critical raw materials list. As ice cover recedes and global material demand intensifies, the region's resources are increasingly becoming considered for exploitation by public and private actors.

The EU and its member states are themselves significant players in Arctic resource extraction. The European Arctic hosts some significant CRM deposits:[57] northern Sweden's iron ore, copper, and rare earth operations, with LKAB's Kiruna mine exporting via Narvik, feed into European and global markets. The EU's 2021 Arctic Communication identifies Narvik, Luleå, Kemi, Oulu, and Hammerfest as TEN-T ports, nodes in the Trans-European Transport Network that explicitly connect Arctic freight flows to European logistics networks. Greenland holds some of the world's largest rare earth deposits outside China,[58] and Svalbard has historically hosted coal extraction under Norwegian sovereignty. Oil and gas (O&G) still dominate the current project pipeline, and Norwegian Barents Sea operations alone rank among Europe's most significant O&G assets, but CRM projects are attracting growing strategic attention from the EU and US as part of supply chain diversification away from China.[59]

Destination shipping from Arctic resource extraction could become a mutually reinforcing factor for trans-Arctic shipping and contribute to infrastructure lock-in. Destination shipping (i.e. vessels travelling to and from Arctic extraction sites rather than transiting through) for natural resource trade is the fastest growing shipping category in the Arctic today, and this pattern is likely to intensify as new extraction projects come online.[60] LNG tankers serving Russia's Yamal and Arctic LNG 2 projects are among the heaviest users of the NEP today.[61] As ice retreats, previously uneconomical deposits become accessible, and the infrastructure logic becomes self-reinforcing.

For the EU, this raises intersecting strategic questions for its position on commercial shipping in the Arctic. Firstly, resource extraction in the Arctic may undermine the environmental objectives established in relation to commercial shipping in the region. Secondly, beyond environmental protection, engagement in Arctic shipping governance can serve as a blueprint for shaping the terms on which CRMs are extracted and transported to European and global markets.[62] Lastly, given the higher viability of the NEP for commercial shipping, questions on shipping cannot be dissociated from questions around Russian sanctions.

2.E. STRATEGIC IMPLICATIONS

Trans-Arctic shipping volumes are expected to remain modest across all time horizons. The modelling exercise conducted for this study suggests that at most 1.2% of global traffic by 2050 will be diverted to transit via the Arctic, with the NEP as the only viable corridor in the near to mid-term. See Section 2.C for modelling projection outcomes.

However, even this relatively moderate level of growth would require a step-change in Arctic-capable fleet capacity and supporting infrastructure, which is currently highly limited. While large-scale trans-Arctic transit remains largely a post-2050 prospect, developing fleet capacity still involves long construction lead times (typically 5–10 years[63]) from order to delivery for polar-class newbuilds. This means that investment decisions taken now will determine the fleet composition of the 2030s and beyond. European companies would need to build ~75 polar-class commercial vessels to meaningfully participate in Arctic trade flows. The same logic applies to port infrastructure, search and rescue coverage, and bunkering capacity along Arctic corridors. The strategic implications of these investment decisions differ by route. There is a critical question if the commercially viable shipping viable would even justify a dedicated Arctic fleet expansion. Given high uncertainties around future shipping prospects in the Arctic, private investors will be warry of taking such risks.

Arctic shipping could reduce exposure to existing chokepoints in the Suez and Panama canals, but may

[57] See Annex X for list of major Arctic resource extraction projects

[58] CSIS (2026) 'Greenland, Rare Earths, and Arctic Security'. Available at: https://www.csis.org/analysis/greenland-rare-earths-and-arctic-security

[59] Arctic Economic Council (2024) Arctic Mining Report 2024. Available at: https://arcticeconomiccouncil.com/wp-content/uploads/2024/10/aec-arctic-mining-report-2024-sample.pdf

[60] PAME (2026) *Arctic Shipping Status Report #1 (updated February 2026)*. Arctic Council. Available at: https://www.pame.is/index.php/projects/arctic-marine-shipping/arctic-ship-traffic-data

[61] High North News (2025) 'Russia's Arctic Yamal LNG gas plant saw a record 287 cargo loadings in 2024', 30 April. Available at: https://en.highnorthnews.com/business/russias-arctic-yamal-lng-gas-plant-saw-a-record-287-cargo-loadings-in-2024/158575

[62] 31 of the EU's 34 listed critical raw materials are present in the Arctic. Each of these projects generates dedicated vessel traffic — LNG tankers, bulk ore carriers, supply ships — that adds to Arctic shipping pressure independently of any trans-Arctic transit growth.

[63] Real-world polar icebreaker programmes illustrate these lead times: the US Polar Security Cutter was contracted in 2019 with delivery expected in 2030 (11 years); Canada's polar icebreakers contracted in 2025 are expected in the early 2030s (~8 years); and Germany's Polarstern replacement contracted in 2024 is scheduled for 2030 (~6 years).

create new chokepoints such as in the Bering Strait. Arctic routing would bypass some of the world's most exposed maritime chokepoints, which have been used or threatened as a point of pressure in the past. For states whose trade or energy security depends on these chokepoints, an alternative routing is a strategic asset, independent of its commercial economics. However, any Arctic transit between the Pacific and Europe must pass through the Bering Strait, a narrow corridor just over 50 miles wide, shared by Russia and the United States. The recent war in Iran demonstrates how one side of a Strait can close a chokepoint for commercial transit without military dominance.

The EU could stand to benefit economically from greater traffic on the NEP. The NEP is the only Arctic corridor with meaningful near-term commercial viability, and while EU operators are currently excluded by sanctions and Russian transit approval requirements, the EU is geographically well-positioned to capture a share of the economic activity this corridor could generate. Norwegian ports such as Tromsø and Longyearbyen would be the primary beneficiaries, positioned as natural transshipment nodes connecting NEP traffic to European distribution networks. Yet this would require significant supportive action, including expanded port capacity and dredged deep-water access. Major load centres such as Rotterdam and Hamburg could see increased volumes of Arctic-origin energy and bulk cargo, but would likely receive this traffic downstream of Norwegian nodes rather than directly. The net effect on northern European port hierarchies will depend heavily on which ports move first to develop Arctic-capable handling infrastructure.

Any greater EU economic reliance on the NEP carries a structural strategic risk. The corridor is controlled by Russia, whose approval is required for every transit: a vulnerability that sanctions have already shown can be activated overnight. Beyond Russian territorial control, the route passes through a series of narrow straits, including the Kara Gate, the Vilkitsky Strait, the Sannikov Strait, and the Dmitry Laptev Strait, before reaching the Bering Strait. Access can be denied, even with physical navigability. With a geopolitical competitor, sanctions can become a form of self-denied access as larger strategic interests speak louder than direct economic interests. There is a risk that what looks like economic opportunities today become geopolitically stranded assets tomorrow.

While the EU is geographically well-positioned to shape the TPR, it remains highly uncertain whether this route will be commercially viable or environmentally feasible. Svalbard's location makes it a natural future logistics hub as TPR navigability increases, and Norway's sovereignty over the archipelago gives the EU an advantage, even though Longyearbyen currently provides limited commercial capacity. Competing actors are present: Russia already maintains a permanent settlement in Barentsburg on Svalbard and China is deploying five research vessels. Infrastructure and polar-fleet investment now secures a seat at the table. Yet, given significant annual ice variability and unresolved questions on environmental feasibility, the investment case is highly uncertain.

The Northwest Passage presents negligible strategic implications for the EU in any scenario. Modelling projects diversion via the NWP at no more than $58.5m in shipping value per year by 2090 of global traffic even under the most severe long-term ice-loss scenarios. The route is geographically remote from EU trade lanes and economic activity will remain limited. Therefore, the EU policy attention directed at the NWP would not reflect the route's commercial or geopolitical relevance to European interests. Furthermore, unresolved sovereignty disputes around continental shelves and limited infrastructure today further reduce the route's attractiveness and strategic relevant for the EU.

A fundamental strategic question for the EU is whether the investment is proportionate to the environmental damage if only 0.64% of global trade is project to divert via the Arctic in the long term (2090). Arctic shipping carries risks that are more severe and harder to mitigate than on conventional routes (see Section 3.B). The investment case therefore cannot be evaluated on economic returns alone - it must weigh whether a modest share of global traffic justifies committing the EU to infrastructure and fleet decisions with severe and long-lasting environmental consequences, some of which remain poorly understood today. (See section 3B).

Arctic shipping is unlikely to transform global trade patterns but may still create strategic choices for the EU as modest traffic volumes can generate disproportionate geopolitical and environmental consequences. The EU may still be able to shape outcomes without becoming a major actor in Arctic shipping itself. Market access regulation, environmental standards, port-state control, research funding and multilateral diplomacy can each play a role to calibrate shipping outcomes closer to the broader strategic and environmental stakes.

3 ARCTIC SHIPPING IMPACT ASSESSMENT

KEY MESSAGES

Arctic shipping growth brings significant, more severe and harder to remediate environmental risks compared to on conventional routes.

Albedo loss from black carbon and icebreaking is the most direct climate risk: black carbon darkens ice and snow with a warming effect per unit mass many times greater than CO_2, and emissions from Arctic shipping nearly doubled between 2015 and 2021. Icebreaking compounds this risk by fragmenting reflective ice, as even the thin ice required for commercial viability retains roughly 50% of the albedo of thick ice. HFO-ban exemptions until 2034 and the absence of mandatory black carbon standards leave this risk largely unmitigated by regulation.

Ecosystem disturbance is most damaging where rising shipping volumes and sensitive habitat coincide. Underwater noise in parts of the Arctic doubled between 2013 and 2019 and is projected to nearly quadruple across the Arctic Ocean by 2030. Arctic-endemic whales (narwhal, beluga, bowhead) depend on acoustic communication and show acute sensitivity, with belugas detecting icebreakers up to 85 km away. Migration corridors overlap directly with the NEP and NWP, and the NWP's confined channel geometry concentrates noise while limiting any ability to re-route vessels.

Potential water pollution is compounded by the near-total absence of spill-response infrastructure. HFO-ban exemptions until 2034 raise the severity of any spill, while response capability is minimal: coverage thins eastward along the NEP and is effectively absent on the NWP and TPR. A worst-case spill into multi-year ice could persist for decades with no feasible containment or recovery under current technology, making prevention the only viable safeguard.

Across the respective routes, we can observe the following dynamics:

- The TPR carries the highest environmental uncertainty and risks of any route: the CAO ecosystem is among the least studied on Earth, and shipping disturbance risks consequences that science cannot yet predict, including potential second-order effects on global climate systems.
- The risks are most acute on the NEP due to current and expected shipping volumes. Yet, these risk can only be mitigated by diverting traffic away from the Arctic or improving the safety of shipping and infrastructure of the route itself, not diverting to other Arctic routes.
- On the NWP, in addition to the above risks, the confined channel geometry of this route would amplify acoustic damage. Yet lower projected shipping volumes limit overall impact.

Around 400,000 indigenous people across all routes depend on Arctic marine ecosystems for their livelihoods, Yet no existing Arctic shipping governance framework requires their free, prior and informed consent before shipping decisions are taken. The rights, knowledge, and interests of Arctic Indigenous peoples warrant dedicated and careful treatment beyond the scope of this analysis. These communities are present in the areas surrounding the NEP, the NWP and the TPR respective: IPLC inclusion is an Arctic-wide imperative, not a localised concern.

The significant environmental impacts and risks at stake and the limited rescue capabilities available today should give cause for caution, particularly when measured in light of the limited economic and strategic upsides of engaging in Arctic shipping (see previous chapter).

3.A. ENVIRONMENTAL & SOCIAL RISKS

The Arctic is one of the world's most ecologically valuable marine environments and is uniquely vulnerable to the disruption that commercial shipping would introduce. Arctic marine ecosystems are characterized by species and food webs that have evolved under ice-covered, undisturbed conditions over millennia. Academic research suggests it may already be approaching ecological tipping points as temperatures increase.[64] The introduction of commercial shipping activity creates three key types of environmental and climate risks, with important social impacts.

Firstly, the albedo ice effect from black carbon (BC) emissions and ice-breaking compounds the climate change already underway in the Arctic, creating a self-reinforcing feedback loop. Black carbon deposits from vessel emissions darken ice and snow surfaces, reducing reflectivity and accelerating melt, with a warming impact per unit of mass many times greater than CO_2.[65] Black carbon emissions from Arctic shipping nearly doubled between 2015 and 2021.[66] Mechanical icebreaking amplifies this by fragmenting sea ice and exposing the darker ocean surface beneath. Disruption to the jet stream driven by Arctic warming has been linked to increasingly frequent and severe heat waves and cold spells across Europe, including those of 2003, 2010, and 2011.[xxxix]

Second, ecosystem disturbance from shipping activity is more damaging in the Arctic than in other open seas. Ship noise and the introduction of artificial light are the key disturbances introduced into the habitats of species. Crucially, these specifies have very limited adaptation to persistent industrial disturbances and could be severely affected by changes in environment.

- Ship noise in parts of the Arctic doubled between 2013 and 2019, reaching up to ten times higher in the worst-affected areas such as the Barents Sea and Baffin Bay.[67] A 2025 Arctic Council report projects that median underwater noise intensity would nearly quadruple across the Arctic Ocean by 2030 as shipping increases and ice retreats.[68] Species such as narwhal, beluga, and bowhead whales depend on acoustic communication for navigation, feeding, and mating[69] and show acute sensitivity: belugas detect icebreaking vessels up to 85 km away and exhibit panic responses from 35–50 km.[70]
- Shipping also introduces artificial light, and vessel wakes into ecosystems that have no prior exposure, disrupting migratory behaviour and the seasonal ecological timing on which entire food webs depend, including far beyond the Arctic.

Third, water pollution risks, from ballast water, fuel emissions, spill risk, and waste discharge, are significantly harder to remediate in the Arctic. Remote location, ice cover, and the near-total absence of response infrastructure mean that a significant spill could cause irreversible damage to an ecosystem that research suggests is approaching a critical tipping point. Ballast water discharge also introduces the risk of introducing invasive species into the Arctic.

Arctic ecosystem disruption from shipping would directly threaten fishing and the livelihoods of indigenous communities across the region, and early signs of this disruption are already visible. The Arctic Ocean is one of the world's most productive fishing grounds; the Barents Sea alone for example generates ~1.5 billion euros in fish harvest per year hosting the world's

[64] Varotsos et al., cited in: Zhang, X. et al. (2023). Environmental impacts of Arctic shipping activities: A review. *Ocean & Coastal Management, 246*, 106931. https://www.sciencedirect.com/science/article/abs/pii/S0964569123004611

[65] Bond, T. C., et al. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. *Journal of Geophysical Research: Atmospheres, 118*(11), 5380–5552. https://doi.org/10.1002/jgrd.50171

[66] Osipova, L., & Gore, K. (2025). *Black carbon and CO_2 emissions from EU-regulated shipping in the Arctic*. International Council on Clean Transportation. https://theicct.org/publication/black-carbon-and-co2-emissions-from-eu-regulated-shipping-in-the-arctic-may25/

[67] Protection of the Arctic Marine Environment (PAME). (2021). *Underwater noise pollution from shipping in the Arctic*. Arctic Council. https://oaarchive.arctic-council.org/items/3dc8999d-d259-4cc5-8657-4fb459d9f91a

[68] Protection of the Arctic Marine Environment (PAME). (2025). *Underwater noise in the Arctic: Understanding impacts and defining management solutions — Phase II*. Arctic Council. https://oaarchive.arctic-council.org/bitstreams/99cf703f-cbf4-4049-a470-939111a33eaa/download

[69] Beluga whales have been observed fleeing in response to an icebreaking ship from 30 to 50 kilometres away, not returning for several days, while walruses change their behavior and move away from noise sources— Arctic Council (2025) *'Changing soundscape of the Arctic Ocean'*.

[70] WWF Arctic Programme. (2024). *Underwater noise threats to Arctic wildlife*. WWF Global Arctic Programme. https://www.arcticwwf.org/threats/underwater-noise/

[71] Zhang et al. (2023). Environmental impacts of Arctic shipping activities. *Ocean & Coastal Management*. https://www.sciencedirect.com/science/article/abs/pii/S0964569123004611

[72] This is a point at which small additional disturbances trigger abrupt, self-reinforcing changes in ecosystem's state that cannot be reversed.

largest Atlantic cod stock.[73,74,75] Shipping could increase the risk of sudden population collapse as temperatures rise.[76] Around four million people live in the Arctic, approximately 10% of whom are indigenous.[ix] This includes the Inuit, Saami, Chukchi, Nenets, and Siberian Yupik, who could be severely negatively affected by disruptions to ecosystems that provide food, livelihoods, and the basis of cultural identity.[77] As Arctic waters warm and ice retreats, commercially important fish species are shifting northward into less regulated waters,[78] breaking down the quota frameworks designed around stable stock locations. This was seen in the EU–Iceland mackerel dispute where shifting stocks triggered a decade-long conflict over access and allocation.[79]

Additionally, there are risks of cumulative and compounding impacts. Many of these impacts are non-linear: they could build up over longer times and then demonstrate sudden step-change effect or tipping point. They can also influence each other, creating hard to anticipate cause and effect loops. Extreme caution is justified in considering opening up ecosystems to industrial scale interventions.

3.B. COVERAGE OF ENVIRONMENTAL & SOCIAL REGULATION

In the last decade, several governance instruments relevant to Arctic environmental protection have been established, but none fully address the environmental risks. The Polar Code entered into force in 2017, the Oil Spill Treaty in 2016, the CAOFA in 2021, and the BBNJ agreement in January 2026 (see Section 1.B for a full overview), together representing the most significant multilateral effort to date to govern environmental standards in Arctic waters. However, they remain a patchwork against the myriad risk dimensions in Arctic ecosystems.

[73] Based on current EUR/NOK exchange rate.

[74] Misund, O. A., Heggland, K., Skogsholm, R., Rinjes, E., Røttingen, I., Skjoldal, H. R., & Ulltang, Ø. (2020). Responding to global warming: New fisheries management measures in the Arctic. *Progress in Oceanography, 188*, 102420. https://www.sciencedirect.com/science/article/abs/pii/S0079661120301622

[75] Across the wider Arctic, the total economic value of its ecosystems and natural resources, from fisheries and climate regulation to mineral reserves, has been estimated at over $280 billion annually.

[76] Steele, J. et al. (2020). Synergistic interactions among growing stressors increase risk to an Arctic ecosystem. *Scientific Reports, 10*, 21163. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7721797/

[77] Meredith, M., et al. (2021). Societal implications of a changing Arctic Ocean. *Ambio, 50*, 1490–1503. https://pmc.ncbi.nlm.nih.gov/articles/PMC8287843/

[78] Frainer, A., et al. (2023). Three decades of increasing fish biodiversity across the northeast Atlantic and the Arctic Ocean. *Proceedings of the National Academy of Sciences, 120*(8). https://doi.org/10.1073/pnas.2120869120

[79] Spijkers, J., & Boonstra, W. J. (2017). Environmental change and social conflict: The northeast Atlantic mackerel dispute. *Regional Environmental Change, 17*(6), 1835–1851. https://doi.org/10.1007/s10113-017-1150-4

		IMO Polar Code (2017)	IMO HFO Ban (2024)	Arctic Council Oil Spill (2016) & SAR Treaties (2013)	UNCLOS (1994)	CAOFA / AMSA / UNDRIP / Other
		• Mandatory for vessels >500GT on all routes • Enforcement state responsibility — no control	• Binding; but Arctic states exempt until 2029, flag state waivers until 2034	• Binding; but Russia's partial suspension from Arctic Council (2022) limits joint exercises and coordination • No response capacity in high seas	• Binding; but US not ratified • Establishes legal framework for maritime zones (EEZ, high seas)	• CAOFA: binding fisheries moratorium for CAO; in force 2021; 10 parties incl. EU • AMSA: non-binding Arctic Council rec.'s (2009) • UNDRIP: non-binding UN declaration on indigenous rights incl. FPIC • IMO Ballast Water Conv.: binding; in force 2017
ENVIRONMENTAL	**Ecosystem disturbance (noise, light, vibration, wakes)**	• Not covered	• Not covered	• Not covered	• Not covered	• In development • IMO EMC studies Underwater Radiated Noise emissions until 2028 as evidence base for possible future mandatory measures. No binding standard yet. • Partial coverage: A fishing moratorium in CAO (CAOFA)
ENVIRONMENTAL	**Albedo ice effect (black carbon, ice breaking)**	• Partial coverage • Addresses vessel construction and pollution prevention broadly, but BC is not covered.	• Partial coverage • HFO ban reduces BC, but full implementation delayed to 2034. Icebreaking-driven albedo loss not addressed at all.	• **Not covered**	• **Not covered**	• **In development** • **IMO MEPC drafting mandatory BC regulations; targeted adoption 2026 — not yet agreed or in force.**
ENVIRONMENTAL	**Water pollution (ballast, direct emissions, fuel spill, waste)**	• Partial coverage • Prohibits discharge of oil and oily mixtures in polar waters.	• Partial coverage • Eliminates the highest-risk fuel when fully in force — but HFO remains in use until at least 2034.	• Partial coverage • Oil Spill Treaty covers preparedness and response coordination between Arctic states. But response capacity in CAO waters does not exist.	• Partial coverage • Obliges states to protect the marine environment but creates no spill-specific liability mechanism for CAO incidents.	• Not covered
SOCIAL	**Coastal communities' livelihoods**	• Not covered	• Not covered	• Not covered	• Not covered	• Partial coverage • AMSA calls for indigenous marine use surveys and community engagement. Implementation uneven. No binding instrument protects livelihoods.
SOCIAL	**Coastal communities' governance**	• Not covered	• Not covered	• Not covered	• Not covered	• Partial coverage • UNDRIP establishes FPIC as a right but non-binding. Arctic Council gives 6 indigenous groups permanent participant status — presence, non-voting. No instrument makes consent a precondition for decisions.
UN BBNJ Agreement (in force since 2026, High Seas Treaty)	This is the first legally binding treaty governing the high seas in force since 2026 (145 signatories and 88 ratifications). Its main tool relevant to Arctic shipping is the ability for any party — including EU — to propose Marine Protected Areas (MPAs) in the CAO high seas, which could restrict or set conditions on commercial shipping activity before routes open. Limitations: the treaty's institutions are not yet operational, US has not yet ratified, Russia has not signed, no MPA has been proposed anywhere under it, and each party could veto a proposal.					

TABLE 6: EXISTING REGULATION BY KEY ENVIRONMENTAL AND SOCIAL RISK AND EXISTING REGULATION

Coverage: ●● Covered ●● Partial coverage / In development ●● Not covered

Regulation does partially cover albedo loss, but HFO-ban exemptions and the absence of black carbon standards undermine existing instruments. The Polar Code addresses vessel construction and pollution prevention broadly, but does not cover black carbon specifically. The IMO HFO ban, which reduces the highest-risk fuel contributing to black carbon,[80] is undermined on two fronts: Russia, Canada, and Finland have not ratified the amendment, meaning it holds no legal force over their vessels; and even among ratifying states, Arctic coastal state exemptions run until 2029 and flag state waivers until 2034. In practice, the ban does not constrain the vessels or waters where Arctic shipping activity is highest. Mandatory black carbon standards are being drafted by IMO MEPC with targeted adoption in 2026 but are not yet agreed to, or in force.

HFO remains the default fuel for most large vessels and produces high BC concentrations,[81] yet no alternative is without environmental risk, and further research is needed before effective regulation can follow. Alternatives to HFOs exist, such as low-sulphur substitutes introduced under the IMO 2020 sulphur cap. However, recent research suggests this may paradoxically perform worse than HFO in Arctic spill conditions, as paraffinic blends clump in cold water and evade standard spill response equipment.[82] LNG is another alternative that already in commercial use across the global fleet; while it reduces BC and SOx emissions, it carries methane slip risk.[83] Green ammonia, an emerging fuel reaching early commercial deployment, offers zero-carbon, zero-BC potential, but N_2O emissions from combustion are a potent GHG, and NH_3 slip into seawater is acutely toxic to marine life, with ecosystem consequences not yet fully understood.[84] Electric vessels eliminate combustion emissions but cannot yet cover Arctic distances, and propeller noise disturbs the ecosystem.[85]

Ecosystem disturbance is the least-regulated of the three risk categories, and no binding standard currently exists. Disturbances from underwater noise, light, vibration, and vessel wakes are known to harm ecosystems. The IMO Polar Code addresses vessel construction and crew training but contains no noise mitigation. The IMO's Expert Group on Underwater Radiated Noise is building an evidence base until 2028 as the basis for possible future mandatory measures, but no binding standard has yet been agreed.[86] The CAOFA's moratorium on commercial fishing in the CAO does not address shipping-related disturbance directly. Proposed mitigation measures under discussion include voyage planning that accounts for migration corridors, re-routing vessels away from sensitive habitats, speed reductions to 10 knots or less where shipping lanes overlap with whale migration routes, and investment in underwater noise reduction technology.[87]

Water pollution governance is the most developed of the three categories, but operational response capacity does not exist on most Arctic routes. The Polar Code prohibits the discharge of oil and oily mixtures. The Arctic Council Oil Spill Treaty covers response coordination between Arctic states, and UNCLOS obliges states to protect the marine environment, but creates no spill-specific liability mechanism for CAO incidents outside EEZs or territorial waters. Critically, response capacity in most waters does not exist, meaning the frameworks are in place without the operational capability to execute them. The IMO HFO-ban exemptions until 2034 further increase spill damage risk by allowing continued use of the most environmentally harmful fuel in the event of a spill.

Indigenous community livelihoods and governance rights are not addressed by any existing Arctic shipping-specific regulatory framework. The IMO Polar Code (see Appendix B for S&R delineations), UNCLOS, and the Arctic Council Oil Spill and SAR agreements contain no provisions on indigenous consultation, benefit-sharing, or livelihood

[80] Heavy fuel oil (HFO) is the dominant marine fuel in Arctic shipping and produces more black carbon than cleaner alternatives such as LNG or distillate fuels.

[81] Comer, B., Olmer, N., Mao, X., Roy, B., & Rutherford, D. (2017). *Black carbon emissions and fuel use in global shipping, 2015*. International Council on Clean Transportation. https://theicct.org/sites/default/files/publications/Global-Marine-BC-Inventory-2015_ICCT-Report_15122017_vF.pdf

[82] Arctic Council PAME & EPPR. (2024). *The changing tides of Arctic shipping: How new fuels impact the Arctic*. https://arctic-council.org/news/changing-tides-of-arctic-shipping-how-new-fuels-impact-the-arctic/

[83] Pavlenko, N., Comer, B., Zhou, Y., Clark, N., & Rutherford, D. (2020). *The climate implications of using LNG as a marine fuel*. International Council on Clean Transportation.

[84] Schiavo, B., Murena, F., Mocerino, L., & Quaranta, F. (2024). Climate and air quality impact of using ammonia as an alternative shipping fuel. *Environmental Research Letters, 19*(7). https://iopscience.iop.org/article/10.1088/1748-9326/ad5d07

[85] Vegiliel, M., et al. (2024). Fully electric ship propulsion reduces airborne noise but not underwater noise. *Ocean Engineering*. https://www.sciencedirect.com/science/article/abs/pii/S0029801824009533

[86] International Maritime Organization (2026, May). IMO Progresses Work on Ship Emissions, Pollution and Ocean Protection. https://www.imo.org/en/mediacentre/pressbriefings/pages/imo-progresses-work-on-ship-emissions-pollution-and-ocean-protection.aspx

[87] *WWF (2026, January). Spatio-temporal information on Arctic whale migration routes for consideration in voyage planning and other measures to reduce the impacts of underwater radiated noise on marine life. IMO SDC 12-INF.17.* https://cleanarctic.org/wp-content/uploads/2026/01/SDC-12-INF.17-Spatio-temporal-information-on-Arctic-whale-migration-routes-for-consideration-in-voyage-p.-WWF.pdf

protection for communities affected by shipping. UNDRIP establishes FPIC[88] as a right, requiring that indigenous communities are consulted and able to give or withhold consent before decisions affecting their territories are taken. However, this is non-binding under international law. These communities are not only right holders but also knowledge holders valuable to systemic decision makers. The Arctic Council grants six indigenous peoples' organizations permanent participant status, giving them a formal voice in Council deliberations, but no instrument makes their consent a precondition for shipping decisions. In practice, the degree of indigenous involvement in Arctic shipping governance varies significantly by jurisdiction, strongest in Canada, where FPIC is embedded in domestic law, and weakest in Russia, where no formal governance participation exists for affected communities.

3.C. ENVIRONMENTAL IMPACTS

Arctic shipping growth brings significant environmental risks across all routes - all of which are more severe and harder to remediate than on conventional routes. See Section 1.C for more information on the environmental risks related to Arctic shipping.

[80] *Free, Prior and Informed Consent (FPIC) is a principle under the UN Declaration on the Rights of Indigenous Peoples requiring that indigenous communities are consulted before decisions affecting their lands or livelihoods are taken, with the genuine right to withhold consent.*

	NEP	NWP	TPR
Ecosystem disturbance (noise, light, vibration, wakes)	• Migration corridors for Arctic-endemic whale species (narwhal, beluga, bowhead) overlap with NEP • Kara Strait is blue corridor for beluga but narwhal and bowhead use unknown. High migration disruption in narrow strait	• Confined geometry concentrates noise • Migration corridors for Arctic-endemic whale species (narwhal, beluga, bowhead) run through archipelago channels	• CAO ecosystem role is poorly understood; data does not exist for much of the ice-covered area • Connectivity to Atlantic and Pacific oceans potentially causes disruption to acoustic communication of species
Albedo ice effect (Black Carbon (BC), ice breaking)	• HFO ban applies, but exemptions and absence of BC standards mean residual risk • Rapidly increasing year-round LNG & oil traffic on NEP, incl. nuclear icebreakers damage thick ice (with high albedo)	• HFO ban applies, but exemptions and absence of BC standards mean residual risk • Commercial viability requires thin ice, still ~50% of albedo of thick ice, so icebreaking and BC remain concerns • Low projected commercial activity in mid-term limits impact	• HFO ban applies, but exemptions and absence of BC standards mean residual risk • CAO ice loss equivalent to 25% of CO_2 warming effect 1979–2011, additional albedo loss from shipping on once TPR opens could compound this, but scale of effect is uncertain
Water pollution (ballast, direct emissions, fuel spill, waste)	• Russian coast infrastructure exists on Western side, but coverage thins eastward • HFO exemptions until 2034 increase spill damage risk	• Complex channels make rapid containment operationally near-impossible • HFO ban in place, but today there is no effective spill response capability	• HFO ban in place as well as Oil Spill - & SAR treaties, but no infrastructure to operationalize • Oil in multi-year ice could persist decades with no remediation

TABLE 7: OVERVIEW OF ENVIRONMENTAL RISKS PER ROUTE

Medium risk	High risk	Potentially high risk / Unknown

NORTH-EAST PASSAGE

The NEP is the route where environmental risks are most acute and immediate as it carries the highest projected shipping volumes of any Arctic corridor, especially for ecosystems. All three Arctic-endemic whale species have migration corridors that overlap directly with the NEP and critical migration knowledge gaps remain. Narwhal and beluga whales have significant overlap between their blue migration corridors and the NEP, while the Bering Strait forms part of the bowhead whale corridor. The Kara Strait is a 56 km-wide section of the NEP that has been identified as a blue corridor for beluga whales, but whether narwhal and bowhead populations also use it remains unknown.[89] Since the survival of Arctic whales depends on their ability to migrate within blue corridors, the knowledge gap and increasing traffic in a narrow strait represents a significant risk.

Year-round traffic and the absence of response infrastructure on the eastern part of the route worsen environmental risks. HFO exemptions until 2034 and the absence of mandatory black carbon standards mean albedo loss risk from transit shipping is currently unmitigated by regulation. Year-round icebreaking for resource extraction including by nuclear-powered icebreakers traversing thick ice drives additional albedo loss independent of transit shipping growth. On water pollution, some response infrastructure exists on the western sections of the route, but coverage thins significantly eastward, meaning increased shipping raises the probability of incidents in areas where effective response remains impossible.

NORTH-WESTERN PASSAGE

The NWP's channels make it potentially the most acoustically damaging route per vessel and all three Arctic-endemic whale species have established migration corridors here as well. The confined channel geometry concentrates underwater noise more than open water routes, limiting the ability to re-route ships away from sensitive habitat. At Eclipse Sound, the eastern entrance to the NWP, narwhals have been documented going silent as ships approach within 20 km, disrupting navigation and foraging in a core migration habitat.[90]

Complex channels and absent response infrastructure make the NWP vulnerable to incidents, though lower projected traffic volumes limit expected damage The confined channel geometry would make rapid spill containment operationally near-impossible, and no response infrastructure exists anywhere along the route. On albedo, commercial viability requires thin ice conditions, which still carry approximately 50% of the albedo effect of thick ice,meaning icebreaking and black carbon remain concerns even at low traffic volumes.[91]

TRANS-POLAR ROUTE

The TPR presents the highest environmental uncertainty of any Arctic corridor: the CAO's ecosystem is one of the world's least studied, and consequences of disturbances are unclear. The CAO's biodiversity is largely unknown. The CAOFA's moratorium on commercial fishing was established on the basis that commercial activity should not precede scientific understanding.

The ice loss on the CAO is already contributing to global warming, and albedo loss from shipping on the TPR could compound this further. Arctic ice loss between 1979 and 2011 alone produced a climate forcing equivalent to 25% of the direct warming effect of CO2 over the same period.[92] By the time the CAO becomes navigable for commercial shipping, much of the multi-year ice will already have been lost. However, black carbon deposition from shipping onto remaining ice could accelerate residual ice loss further. The scale of this effect is uncertain, adding to the broader uncertainty around TPR environmental impacts.

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[89] Lancaster, M., Wedegärtner, R., & Gemal, E. (2024). *Arctic blue corridors: Safeguarding migrating whales from growing pressures for a connected Arctic Ocean*. WWF Global Arctic Programme. https://admin.arcticwwf.org/app/uploads/2024/09/Arctic_blue_corridors_online_report_2024_summary.pdf

[90] Ewing, J. P., Hidalgo-Pla, E., Solsona-Berga, A., Frasier, K. E., Ootoowak, A. J., Westdal, K. H., Wiggins, S. M., Hildebrand, J. A., & Jones, J. M. (2025). Narwhal acoustic presence in Eclipse Sound, Nunavut: relationships with sea ice and responses to ships. *Scientific Reports, 15*, 23126. https://doi.org/10.1038/s41598-025-04032-1

[91] Field, P. R., et al. (2018). Increasing Arctic sea ice albedo using localized reversible geoengineering. *Earth's Future*, 6. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018EF000820

[92] Pistone, K., Eisenman, I., & Ramanathan, V. (2014). Observational determination of albedo decrease caused by vanishing Arctic sea ice. *Proceedings of the National Academy of Sciences, 111*(9), 3322–3326. https://doi.org/10.1073/pnas.1318201111

[93] *RAIPON (Russian Association of Indigenous Peoples of the North) is the umbrella organisation representing approximately 300,000 indigenous people across 40 distinct ethnic groups in the Russian Arctic and Siberia. It holds observer status at the Arctic Council but has limited influence over domestic Russian resource and shipping governance decisions affecting indigenous communities.*

A spill on the TPR would be the worst-case pollution scenario of any Arctic route: oil trapped in multi-year ice could persist for decades with no remediation capability. The HFO ban and Oil Spill Treaty are formally in place, but no infrastructure exists to operationalise either. Oil trapped in multi-year ice has no effective pathway for containment or recovery under current or foreseeable technology.

3.D. SOCIAL CONSIDERATIONS

The social impacts of Arctic shipping are critical from the perspective of the Arctic communities. Yet, these impacts are often less visible and harder to quantify compared to direct economic opportunity and costs or even environmental impacts. Relatively small ecological disturbances can have disproportionate impacts in regions where alternative food sources are unavailable. In addition, cultural impacts are often overlooked when focusing on economic impact only. For example, marine ecosystems directly support both livelihoods but also represent cultural identify, traditional knowledge systems and intergenerational practices. Social and cultural disruptions are consequential for affected communities, and their consideration is key for inclusive decisions.

Arctic shipping growth directly threatens the hunting and fishing access that indigenous communities across the region depend on for their livelihoods. As primary users of Arctic marine environments, these groups 'food security depends directly on the marine ecosystems that shipping activity disturbs. Their Free, Prior and Informed Consent (FPIC) is therefore essential for any governance decisions affecting their territories. Coastal communities also hold generations of observational knowledge of Arctic whale migrations: a critical resource for filling scientific gaps that GPS tracking and research expeditions alone cannot address.[xxix] Livelihood impacts are broadly similar across routes, but formal representation in governance decisions differs significantly by route.

On the NEP, indigenous communities are rights holders that face the most immediate livelihood impacts and have the least formal protection of any route. Coastal Chukchi and Siberian Yupik communities on the eastern NEP coast depend on whale, walrus, and seal for subsistence. Shipping noise and traffic directly disrupt migration corridors, reducing hunting access to species these communities rely on for food security. Under Russian law, no FPIC process exists. RAIPON,[93] representing approximately 300,000 indigenous people across 40 groups, has limited access to governance decisions on the NEP, and impacts on traditional lifestyles accumulate with no recourse or benefit-sharing for affected communities. Recently, the organisation has also become increasingly instrumentalized by the Russian state as mouthpiece for government positions.[94]

On the NWP, Inuit communities are dependent on marine mammals for food, and while formal FPIC protections exist, they are not consistently applied in practice. Disruption to harvesting of narwhal, beluga, and bowhead whales grows directly with traffic volume. Inuit communities line the entire passage. FPIC rights for the Inuit people of the Canadian Arctic and Alaska are embedded in Canadian domestic law, providing a stronger formal basis for community engagement than exists on the NEP though FPIC as a binding precondition for shipping decisions is not consistently applied in practice.[95]

On the TPR, there are no indigenous communities directly on the route but knock-on changes from a shifting CAO ecosystem may affect communities on adjacent routes. Svalbard sits on the route and already faces growing shipping impacts affecting the local tourism and ecosystem.[xxvii] Svalbard's population consists of researchers and settlers rather than indigenous communities. Norway is already responding with EEZ regulations that go beyond IMO Polar Code requirements: introducing vessel speed limits near wildlife, minimum distances from walrus haul-sites, and passenger caps in protected areas as of January 2025, but indigenous consultation is not yet part of this framework. The BBNJ agreement allows participation in MPA processes but grants no formal decision-making authority, and nobody currently has the mandate to represent indigenous interests in CAO shipping decisions.

[94] Whitney Lackenbauer P, Sidorova E. and Sukhanin S. (2023), *RAIPON, Russian Indigenous Peoples, and the War in Ukraine: Pro-Kremlin Narratives and Voices of Dissent*. https://www.naadsn.ca/wp-content/uploads/2023/07/23jul-RAIPON-Russian-Indigenous-PWL-ES-SS-NAADSN-policy-primer.pdf

[95] For FPIC inconsistency — Saami Council (2025) OHCHR submission: https://www.ohchr.org/sites/default/files/documents/cfi-subm/free-prior-informed-consent/subm-indigenous-free-prior-indi-peop-67-saami-council.pdf

4 EU POLICY RECOMMENDATIONS

KEY MESSAGES

The EU has announced its new Arctic Strategy in October 2026; the geopolitical and economic landscape has shifted fundamentally since the last strategy was set in 2021. The Russian invasion of Ukraine, the subsequent Arctic Council paralysis, increasing Russia-China cooperation and changes in Arctic navigability prompt a structural calibration of Arctic policy in a new geopolitical context.

- The economic opportunity for the EU remains modest at <1% of global shipping for the Arctic and <0.1% for the TPR via the CAO by 2090: shorter routes do not translate into proportionate cost savings, projected volumes remain a fraction of global trade, and capturing the opportunity would require significant investment while risking building new dependencies on Russia.
- The environmental costs are potentially severe and poorly understood: disruption to ecosystems Arctic food security depends on, ice loss, and uncertain but far-reaching 2nd-order effects on European climate. The risks of the TPR in the currently undisturbed CAO are most uncertain and potentially highest. Current governance frameworks are designed for today's shipping, not the Arctic shipping that becomes viable tomorrow.
- The cost-benefit case points clearly toward precaution: the economic gains do not justify incurring known and unknown environmental costs, and the EU has both a strategic interest and a clear role in ensuring proactive governance before commercial pressure makes restrictions harder.
- The TPR is a last-resort corridor whose premature opening needs to be actively resisted before a full baseline ecological assessment of the CAO has been completed needs, response infrastructure capable of managing a major incident exists, and a multilateral governance framework equivalent to the CAOFA model has entered into force for shipping.
- Despite its limited formal role in core Arctic governance institutions, the EU holds meaningful levers: some of these can be pursued unilaterally, such as port state control for market access, science funding. Others will require multilateral coordination, such as leveraging party status in CAOFA, within the IMO and co-leadership of the BBNJ High Ambition Coalition.
- In the short term, the EU can push to keep the TPR via the Central Arctic Ocean closed to commercial shipping until the scientific and operational conditions for responsible governance are in place, building on the CAOFA model and pursuing this through a multilateral environmental agreement built a precautionary approach.
- In the long term, the EU can leverage its position as a destination market of trans-Arctic shipping to make EU market access conditional on environmental compliance (across black carbon and HFO, noise standards and other requirements), and work with insurers and vessel operators as additional pressure points where direct regulatory leverage is limited.
- The EU can position itself as the proponent of Arctic ecosystem science in the window before International Polar Year-5 in 2032–33, directing Horizon Europe and the EPCO to critical gaps: CAO baseline biodiversity, whale migration corridor mapping, and low-disturbance technologies.
- Extensive consultation and participation of Indigenous Peoples in decision making as rights holders and knowledge holders will be critical for relevance and legitimacy of policies.

4.A. CURRENT EU ARCTIC POLICY

The current EU Arctic policy was set out in the 2021 Joint Communication,[96] designed for a geopolitical context that no longer exists. The 2021 policy rests on three pillars: tackling climate change and protecting the environment, promoting sustainable development in Arctic communities, and strengthening international cooperation. These pillars remain relevant but require calibrating in a changed context. It was adopted before Russia's full-scale invasion of Ukraine in 2022, which suspended Arctic Council cooperation and eliminated the EU's access to the NEP. In July 2025 the Commission President announced the EU Arctic strategy will be reviewed in light of new challenges.

Since 2021, several EU member states have strengthened their Arctic engagement individually. Denmark's engagement has intensified in response to renewed US interest in Greenland, with the EU opening a Commission office in Nuuk in 2024, France opening a consulate there, and the EU proposing to more than double financial support to Greenland for 2028–2034. Norway and Iceland, both EEA members but outside the EU, have signed Security and Defence Partnerships with the EU,[97] both explicitly covering Arctic maritime security. Norway has also tightened environmental regulations in Svalbard waters in 2025. Finally, Finland and Sweden's accession to NATO in 2023–2024 leaves Russia as the only Arctic Council member outside the alliance, shifting the EU's collective security posture in the High North and adding two Arctic-present states to NATO.

Despite its limited formal role in core Arctic governance institutions, the EU itself has been actively using its available levers. The EU's influence derives primarily from regulatory leverage and market power, and less from territorial presence. The EU only holds observer candidate status at the Arctic Council and has no sovereign Arctic territory or direct EEZ in the region. Nevertheless, the EU co-led the negotiations of the BBNJ agreement, ratified it in May 2025 as part of the largest joint ratification by any group of countries to date, and co-leads the BBNJ High Ambition Coalition, giving it a direct legal pathway to propose marine protected areas in CAO high seas. The EU is also one of ten parties to the CAOFA, the only binding precautionary governance instrument covering the Central Arctic Ocean, but also the proof point that precautionary governance is politically achievable. The EU's most powerful levers remain regulatory: the standards it sets for vessels calling at EU ports, the science funding it directs, and the multilateral positions it takes at the IMO.

The challenge for the forthcoming Arctic Policy update is how to govern a potentially modest increase in activity that carries disproportionate environmental and geopolitical implications. Additionally, there will be strategic trade-offs to navigate for policymakers: between strengthening geo-economic resilience, safeguarding market access and minimising dependence on Russian-controlled infrastructure.

4.B. PRIORITY ACTIONS

A central challenge for EU Arctic policy is that shipping governance decisions must be taken now, before commercial pressure arrives and the window for precautionary action closes. The risk of waiting for traffic to materialise before acting on regulation would mean that the EU will find itself responding to an established operational reality rather than shaping the governance framework that determines it. This section sets out short, medium, and long-term priorities to secure the EU's geopolitical positioning in the Arctic, protect indigenous and coastal communities from irreversible harm, and prevent the environmental damage and macro-structural risks that unregulated Arctic shipping development would otherwise lock in.

The cost-benefit case of arctic shipping points clearly toward precaution. The economic opportunity of Arctic shipping for the EU is real but modest (see Section 2, while risking new geo-economic dependencies on Russia. The environmental costs are severe and poorly understood (see Section 3). Arctic shipping disrupts ecosystems European food security depends on, and accelerated ice loss could potentially carry uncertain but far-reaching second-order effects.

[96] The 2021 Joint Communication refers to several key policy documents issued by the European Commission and the High Representative of the Union for Foreign Affairs and Security Policy. These communications often aim to enhance the EU's role on the global stage through strategic partnerships and specific regional initiatives.

[97] Norway in 2024 and Iceland in March 2026

The recommended policy approach is to establish precautionary stringent regulation in the short term, with potential easing as scientific understanding matures and response infrastructure is built out. Acting now is feasible while the CAOFA precedent remains fresh and commercial activity in the CAO has yet to take hold. Introducing equivalent restrictions at a later stage, against established commercial operators and infrastructure already built, would be considerably more difficult, requiring going against established commercial interests.

SHORT-TERM ACTIONS

The EU can push for cross-national scientific research and knowledge sharing to understand ecosystem risks in the CAO and along the other routes. Baseline data and understanding of the impact of shipping for the CAO does not exist. Furthermore, there are significant knowledge gaps on whale migration and ecosystem connectivity along the other routes as well. A gap analysis of current Arctic scientific initiatives is set out in Section 4.C, pointing out there are existing initiatives, such as Horizon Europe, that could prioritize these topics.

A high-level ambition for Europe could be to propose a temporary restriction of shipping the Central Arctic Ocean, until sufficient scientific understanding and governance infrastructure is in place. The CAOFA model offers the most powerful existing pathway to restrict commercial shipping in the CAO, as it already brings Russia, the US, China, the EU, and six other parties around the same table in a binding precautionary framework for the CAO, making it the only instrument with proven success to govern Arctic high seas effectively. Extending the CAOFA model to shipping would build directly on this precedent, without the limitations of the BBNJ agreement, which Russia has not signed and the US has not yet ratified. France's precedent of calling for a precautionary pause on deep-sea mining, explicitly pending scientific understanding of environmental consequences, offers a complementary model for how the EU could frame this ambition politically.[98] While the BBNJ provides a complementary legal pathway (as the EU and its member states can propose Marine Protected Area designations for CAO high seas areas), the CAOFA extension could be the primary diplomatic objective in the near term, building on the precautionary approach embedded in CAOFA.

In parallel, the EU can advocate at the IMO for the elimination of Arctic HFO ban exemptions accompanied by further research to identify the best alternative fuel and propulsion. This means accelerating the 2029 Arctic state deadline and closing the 2034 flag state waiver mechanism. These exemptions currently render the HFO ban non-meaningful for the route where HFO use and black carbon deposition are highest. The EU and its member states hold significant weight at the IMO[99] and should use this to build a coalition for accelerated implementation, including among climate-vulnerable states with a direct interest in Arctic ice preservation. This should be

The EU can leverage its position as a destination market for trans-Arctic shipping to make EU market access conditional on environmental compliance. By implementing stringent port state control requirements for ships calling at EU ports - making Polar Code compliance, HFO ban adherence, and environmental standards a condition of access - the EU can extend its regulatory reach to vessels operating under non-EU flags. This requires no new international agreement and can be pursued unilaterally, while also being advanced multilaterally through the IMO.

MEDIUM-TO-LONG TERM ACTIONS

Beyond port access, the EU can consider funding maritime infrastructure related to search and rescue capacity, oil pollution response, and Arctic monitoring and surveillance. This would reinforce existing governance frameworks and make them operational in practice. Horizon Europe, InvestEU, and Connecting Europe Facility (CEF) provide potential funding vehicles, and investment can be made conditional on adherence to environmental standards. The priority for this infrastructure would logically be strengthening the NEP and NWP with closer proximity of routes to potential rescue infrastructure and supporting larger commercially viable shipping volumes compared to the TPR.

[98] Assemblée Nationale. (2023, January 17). *Résolution visant à lutter contre l'exploitation minière des fonds marins* [Resolution to combat deep-sea mining]. French National Assembly. https://www.assemblee-nationale.fr

[99] *The EU's 27 member states are all individual IMO members and can coordinate voting positions, giving the EU significant collective influence despite its own observer status. The EU has previously used this position to shape IMO outcomes, including on sulphur emissions standards and vessel energy efficiency requirements.*

Working through insurers and vessel operators provides an additional and potentially more effective pressure point where direct regulatory leverage is limited. EU leverage over the EEZs of other Arctic states is structurally constrained - but the insurance industry represents a powerful non-territorial lever. Deutsche Bank, alongside Goldman Sachs, JPMorgan Chase, and around two dozen other banks globally, have already excluded financing for new Arctic oil and gas projects - demonstrating that financial institutions are willing to apply Arctic-specific exclusions. A comparable approach applied to Arctic shipping - where insurers deny coverage for vessels that do not meet environmental standards or operate on routes without adequate response infrastructure - could effectively make non-compliant operations commercially unviable. Major vessel operators, who depend on EU market access, represent a further pressure point that does not require territorial jurisdiction. The EU should engage both systematically as part of its Arctic shipping governance strategy.

The EU can pursue IMO shipping standards focused on ecosystem disturbance from noise and light, as well as black carbon standards. These are the two risk categories most inadequately governed under current frameworks. The IMO's Expert Group on Underwater Radiated Noise is building an evidence base until 2028 as the basis for possible future mandatory measures - no binding standard yet exists, and the EU should actively support this process and push for mandatory standards to follow. On black carbon, mandatory standards are already under development at IMO MEPC with targeted adoption in 2026 - if not agreed by then, the EU should use its collective IMO position to accelerate adoption.

Finally, the EU can establish and advocate for a precondition principle: commercial shipping in Arctic waters should not be permitted until response infrastructure is operationally in place. The current situation where treaties and regulations formally exist but operational capacity to execute them does not creates a governance illusion that masks the true level of risk. Building on the Arctic SAR Agreement (2011, in force 2013) and the MOSPA oil spill preparedness agreement (2013, in force 2016),[100] the EU should push for response infrastructure readiness as a binding precondition for commercial route development, rather than an aspiration to be addressed after shipping has already begun.

[100] The Arctic SAR Agreement commits all eight Arctic states to cooperation on search and rescue operations in the Arctic. The MOSPA Agreement commits the same states to cooperation on marine oil pollution preparedness and response.

Key Risk	Policy Actions
All	• Use EU port access to enforce environmental compliance on Polar Code and other existing/future rules • Propose a temporary restriction of shipping in the Central Arctic Ocean until sufficient scientific understanding and governance infrastructure is in place
Ecosystem disturbance	• Pursue IMO shipping standards focused on ecosystem disturbance from noise and light, as well as black carbon standards • Push for cross-national scientific research and knowledge sharing to understand ecosystem risks in the CAO and along the other routes
Albedo ice effect	• Pursue IMO shipping standards focused on black carbon standards • Advocate at the IMO for the elimination of Arctic HFO ban exemptions — accompanied by further research to identify the best alternative fuel and propulsion
Water pollution	• Fund maritime infrastructure related to search and rescue capacity, oil pollution response, and Arctic monitoring and surveillance • International diplomatic efforts: commercial shipping in Arctic waters should not be permitted until response infrastructure is operationally in place

TABLE 8: OVERVIEW OF RECOMMENDED KEY EU POLICY ACTIONS BY RISK TYPE

4.C. SCIENTIFIC INITIATIVES

The scientific evidence base for Arctic shipping governance is uneven in ways that matter directly for regulation. Physical oceanography and climate dynamics are relatively well documented, the product of decades of coordinated international monitoring. Ecosystem-level knowledge, particularly for the Central Arctic Ocean high seas where new shipping routes are emerging, is far thinner. Evidence directly relevant to shipping impacts is largely absent: e.g. species distribution along prospective corridors, the effects of underwater noise and black carbon on marine mammals, and the cumulative disturbance effects of traffic at scale.

Significant scientific effort is underway to understand Arctic ecosystems, and the EU is an active contributor. The MOSAiC expedition (2019–2020), in which the German icebreaker Polarstern drifted frozen in the Central Arctic for a full year, produced the most complete picture of Central Arctic ecology ever assembled with over 200 peer-reviewed publications to date and the EcoOmics project now building on this data to benchmark Arctic Ocean biodiversity at the molecular level for the first time. The EU funds Arctic research through Horizon Europe, contributing 163 mln EUR to Arctic research and 17 mln EUR to polar research under the 2021–2027 programme.[101] The CAOFA's Joint Programme of Scientific Research and Monitoring provides a multilateral framework for coordinated ecosystem research in the CAO. Looking ahead, the 5th International Polar Year (IPY-5) in 2032–33 - co-led by IASC, SCAR, the World Meteorological Organization, and the International Science Council - will be the largest coordinated polar research effort ever mounted, with an explicit commitment to integrating indigenous knowledge alongside science. A full overview of current and completed Arctic scientific initiatives, including their route and risk coverage, is provided in Appendix E.

The broader international research landscape is substantial but increasingly fragmented. The Arctic Council's CAFF and AMAP working groups run the most systematic pan-Arctic monitoring programmes in existence, but both are operating at reduced capacity since Russia's effective exclusion in 2022, removing AARI, one of the oldest Arctic research institution in the world, from international collaboration. China is the most active non-Arctic research nation in the region: it has conducted 13 national expeditions, deployed five research vessels in 2025, and built research infrastructure on Svalbard and in Iceland, while its share of global Arctic scientific publications has increased fivefold since 2000 - with particular growth in the Central Arctic Ocean.[102] China's research serves both environmental and strategic objectives, and findings are not always openly shared with international partners.

The priority research areas for closing these gaps are Central Arctic Ocean species distribution baselines, whale migration corridor mapping, ice-ecosystem interaction data, and quantification of shipping-attributable albedo loss. Four datasets are most urgently needed.

1. Comprehensive species distribution mapping for the Central Arctic Ocean high seas, covering the marine mammals, migratory fish, and seabird populations most exposed to shipping traffic.
2. Systematic whale migration corridor mapping across the main prospective shipping routes, without which routing decisions cannot account for collision risk or noise impacts.
3. Ice-ecosystem interaction data sufficient to model how accelerating sea-ice loss will alter habitat boundaries and species behaviour over the timescales relevant to route planning.
4. Quantification of the albedo loss attributable to shipping through black carbon deposition and the mechanical breaking of reflective ice, including the potential for non-linear effects as icebreaking and emissions interact with an already-thinning ice pack.

Without this evidence base, no governance framework can credibly claim to permit Arctic shipping in an environmentally responsible way.

The EU is well positioned to lead this effort and the window before IPY-5 in 2032–33 is the critical moment to act.

- The 5th International Polar Year (IPY-5) in 2032–33, co-led by IASC, SCAR, the World Meteorological Organization, and the International Science Council, will be the largest coordinated polar research effort

[101] European External Action Service. (2024). *The EU in the Arctic*. https://www.eeas.europa.eu/eeas/eu-arctic_en

[102] Clean Arctic Alliance. (2025). *The Expanding Footprint of China in the Arctic Region*. https://cleanarctic.org/wp-content/uploads/2025/07/The-Expanding-Footprints-of-China-in-the-Arctic-Region_.pdf

ever mounted. Its explicit commitment to integrating indigenous knowledge alongside scientific programmes is a significant advance.[103]

- The newly established European Polar Coordination Office (EPCO) could be tasked with commissioning a baseline ecological assessment of the Central Arctic Ocean high seas, modelled on the scientific precondition the CAOFA required before commercial fishing could proceed.[104]
- Horizon Europe's polar research portfolio should be rebalanced to include dedicated funding for Arctic ecosystem ecology and shipping-specific impact assessment.[105]
- The 10,000 Ships for the Ocean initiative, launched at UNOC3[2] in 2025 to equip commercial vessels with oceanographic sensors, offers a scalable platform on which Arctic-specific monitoring programmes could build.[106]

Indigenous knowledge must be treated as a co-equal source of evidence, not a supplement to scientific programmes. Communities across the Arctic hold centuries of direct observation of ecosystem change from whale migration corridors to seasonal ice patterns that no expedition can replicate or replace. Scientists must partner with indigenous communities in designing research from the outset. A co-designed research effort between the EU and Arctic indigenous communities would produce a more complete evidence base and, importantly, a more legitimate basis for governance.

A full overview of current and completed Arctic scientific initiatives, including their route and risk coverage, is provided in Appendix E.

[103] International Polar Year 2032–33. https://ipy5.info/

[104] European Polar Coordination Office (EPCO). https://www.europeanpolarboard.org/epco/

[105] Horizon Europe (2021–2027). https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[106] 10,000 Ships for the Ocean. https://www.10000ships.org

APPENDIX

A. OVERVIEW OF ARCTIC, SUBARCTIC AND BALTIC PORT INFRASTRUCTURE

Port	Ice-Free?	Deep-Water?	Region Type	Key Information
RUSSIA				
Murmansk	✓	✓	Arctic	Largest Arctic port in the world; ice-free year-round due to North Atlantic Current; primary NEP gateway; home to Rosatom nuclear icebreaker fleet; major LNG and container hub
Arkhangelsk	Seasonal	✓	Subarctic	Historic northern port; freezes Nov–Apr; deep-water capable; key timber, mineral, and military logistics hub; White Sea access
Sabetta	Seasonal	✓	Arctic	Purpose-built LNG terminal on Yamal Peninsula (Yamal LNG / Arctic LNG 2); requires icebreaker escort Oct–Jun; largest LNG export facility in the Arctic
Dudinka	Seasonal	✗	Arctic	River port on Yenisei; serves Norilsk Nickel metals exports; icebreaker-assisted May–Jun and Oct–Nov; limited draught
Dikson	Seasonal	✗	Arctic	NEP administrative waypoint; very limited commercial capacity; used for logistics resupply and emergencies
Tiksi	Seasonal	✗	Arctic	Remote Laptev Sea port; limited capacity and infrastructure; primarily military and scientific use
Pevek	Seasonal	✗	Arctic	Easternmost NEP port; hosts world's first floating nuclear power station (Akademik Lomonosov); limited commercial handling; growing strategic significance
NORWAY (EEA MEMBER) ICELAND (EEA MEMBER)				
Tromsø	✓	✓	Arctic	Major Arctic logistics, research and supply hub; ice-free year-round; well-connected road/rail hinterland; de facto capital of Arctic Norway
Narvik	✓	✓	Subarctic	Deep-water iron ore export port; TEN-T listed; ice-free year-round; direct rail connection to Kiruna iron ore mines (Sweden)
Hammerfest	✓	✓	Arctic	LNG terminal (Equinor Melkøya); TEN-T listed; ice-free year-round; closest European port to the NEP western entry point
Kirkenes	✓	✗	Arctic	Closest Norwegian port to Russia and NEP entry; ice-free; limited depth/capacity but highly strategic; Barents Sea gateway; proximity to Murmansk
Longyearbyen	✓	✗	Arctic	Svalbard; research and supply hub; ice-free; limited commercial capacity; governed under Svalbard Treaty (demilitarised)
Bodø	✓	✓	Subarctic	New deep-water port under development; TEN-T listed; ice-free year-round; planned as a major Arctic logistics hub for northern Norway
ICELAND (EEA MEMBER)				
Reykjavik	✓	✓	Subarctic	Capital and main commercial port; ice-free year-round; potential transatlantic waypoint for CAO/Transpolar routes
Akureyri	✓	✓	Subarctic	North coast port; ice-free; growing Arctic cruise and supply logistics role
Finnafjörður	✓	✓	Subarctic	Deep-water greenfield port in northeast Iceland; under development; explicitly designed as an NEP/Transpolar waypoint; ice-free year-round

Port	Ice-Free?	Deep-Water?	Region Type	Key Information
SWEDEN (EEA MEMBER)				
Luleå	Seasonal	✓	Baltic	TEN-T port; freezes Dec–Apr, requiring icebreaker assistance; key iron ore and steel export hub; rail connection to Kiruna
Skellefteå	Seasonal	✗	Baltic	Growing port linked to Northvolt battery gigafactory; freezes in winter; emerging green industry hub
FINLAND (EEA MEMBER)				
Oulu	Seasonal	✗	Baltic	TEN-T port; freezes Nov–May; regional industrial port; limited direct Arctic route relevance
Kemi	Seasonal	✗	Baltic	TEN-T port; freezes Nov–May; forestry and industrial exports
Tornio	Seasonal	✗	Baltic	River port; freezes in winter; steel exports (SSAB); cross-border links to Sweden
GREENLAND (KINGDOM OF DENMARK — EEA ASSOCIATED TERRITORY)				
Nuuk	✓	✓	Arctic	Capital and largest port; ice-free year-round; growing commercial and cruise traffic; deep-water expansion underway; geopolitically significant given recent US interest
Sisimiut	Seasonal	✗	Arctic	Second-largest city; ice-free most of year; fishing industry hub; limited capacity
Ilulissat	Seasonal	✗	Arctic	Near UNESCO Icefjord; primarily fishing and tourism; environmentally sensitive; limited commercial capacity
CANADA				
Oulu	Seasonal	✗	Subarctic	Only Canadian Arctic deep-water port on Hudson Bay; freezes Nov–Jul; limited NWP relevance; primarily grain exports; privately owned (AGT Food & Ingredients)
Kemi	Seasonal	✗	Arctic	Former mining port repurposed as Canadian Navy Arctic Patrol Vessel refuelling facility; very limited commercial use; seasonal only
Tornio	Seasonal	✓	Arctic	New deep-water port opened July 2023; capital of Nunavut; ice-free ~5 months/year; growing commercial and government logistics role
UNITED STATES (ALASKA)				
Dutch Harbor	✓	✓	Subarctic	Unalaska/Dutch Harbor in Aleutian Islands; ice-free year-round; busiest US fishing port; key NWP waypoint and refuelling stop; major Coast Guard base
Nome	Seasonal	✗	Subarctic	Western Alaska; Bering Strait gateway; deep-water port under development (USACE project); strategic for NWP and Bering Strait traffic monitoring

TABLE 9: SUMMARY OF KEY ATTRIBUTES OF MAJOR ARCTIC, SUBARCTIC AND BALTIC PORTS

B. CURRENT JURISDICTION AND LEGAL STATUS OF THE ARCTIC

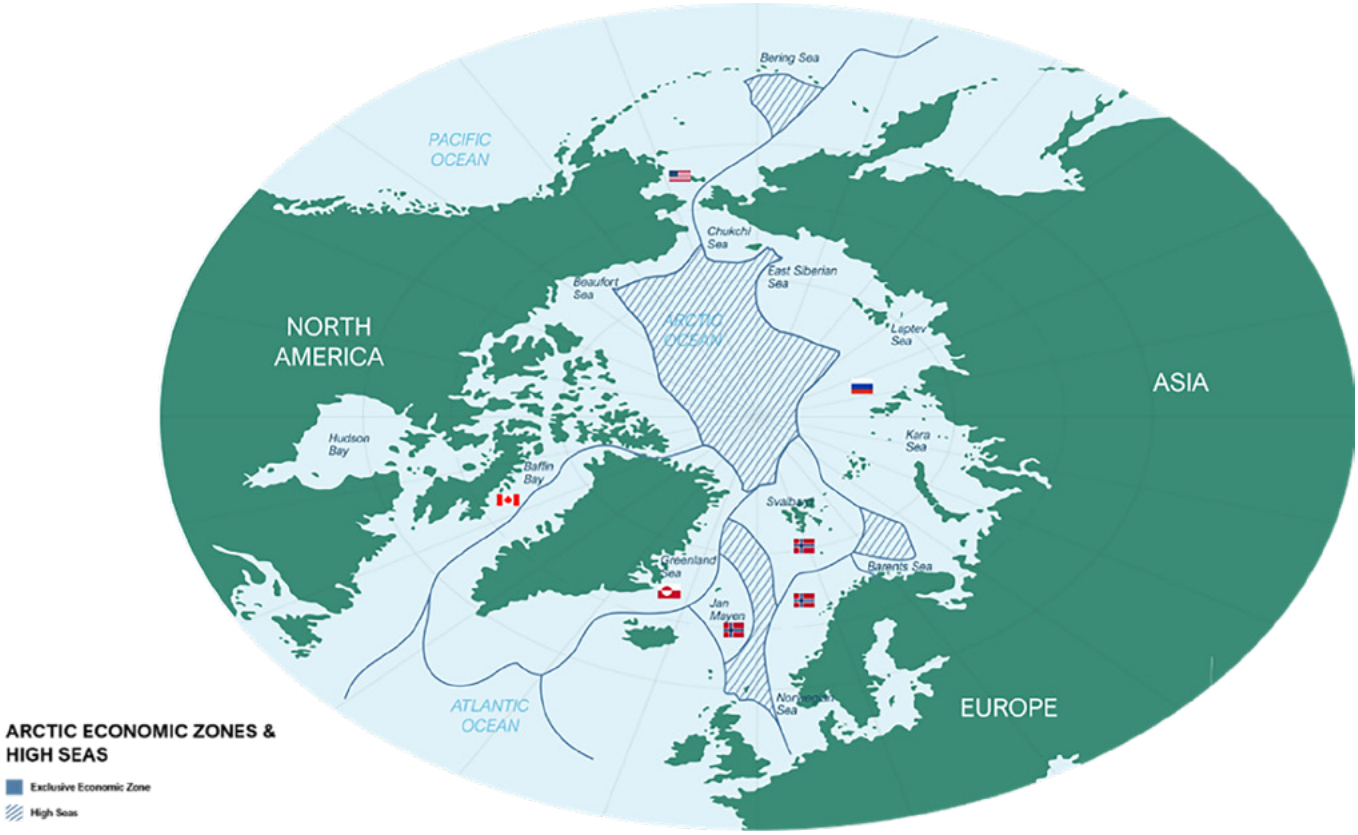


FIGURE 9: ARCTIC SEA ROUTES VS COUNTRY EEZS

International law grants coastal states the right to regulate shipping within their EEZ, including in the Arctic, but not charge fees for transit. The eight countries with Arctic territory can regulate vessel conduct and environmental standards within 200 nautical miles of their coastline under UNCLOS. They may not charge transit fees or require prior authorization for foreign commercial passage.

However, Russia has instituted mandatory fees for escort through their navigation straits. Article 234 of UNCLOS grants coastal states the right to adopt special navigation regulations in EEZ waters ice-covered for most of the year, generally interpreted as more than six months. Russia uses this to justify mandatory icebreaker escorts on the NEP, an interpretation is contested by the US and others. As melting sea ice reduces the months per year where ice cover is present, the 6-month threshold for this clause to apply will be crossed on progressively fewer sections of the NEP, eliminating the legal basis in principle though this may evolve differently in practice.

Russia and Canada claim that stretches of their Arctic routes are internal waters, which would also grant them the right to charge transit fees - although Canada has never asked for one. Russia applies this classification to sections of the NEP passing between its Arctic islands and the mainland coast; Canada claims the passages of its Arctic Archipelago (includes the majority of NWP). Both positions are contested under international law by the US and EU, respectively, and neither has been submitted to the UN for validation. If accepted, internal waters status would give these states the legal basis to impose access conditions and transit fees regardless of ice cover.

Russia, Canada and Denmark (via Greenland), also claim rights to the Arctic seafloor beyond their EEZ. Under the terms of the UNCLOS, a coastal state can claim sovereign rights over the seabed and its subsurface resources if it can demonstrate that the seabed is a geological extension of its landmass. These three states all assert that the Lomonosov

Ridge – an underwater mountain range running across the floor of the central Arctic Ocean - is a natural extension of their respective continental shelves. This would grant them access to large parts of the Arctic seabed, which is estimated the world's largest remaining undiscovered reserves of oil, natural gas, and mineral deposits. However, these rights apply to the seabed only and carry no legal basis for restricting navigation or imposing fees on vessels transiting the waters above.

Most of the Central Arctic Ocean sits beyond any national jurisdiction and has no governance frameworks on shipping. Significant portions of the CAO lie outside of Arctic coastal states' EEZ, in the 'high seas' meaning that it is fully legally accessible to all and entirely ungoverned. In this area, no sovereign permission is required for transiting and transit fees can be levied. Therefore, no framework currently addresses how commercial shipping on the CAO should be managed as a corridor - route designations, area protections, or SAR obligations.

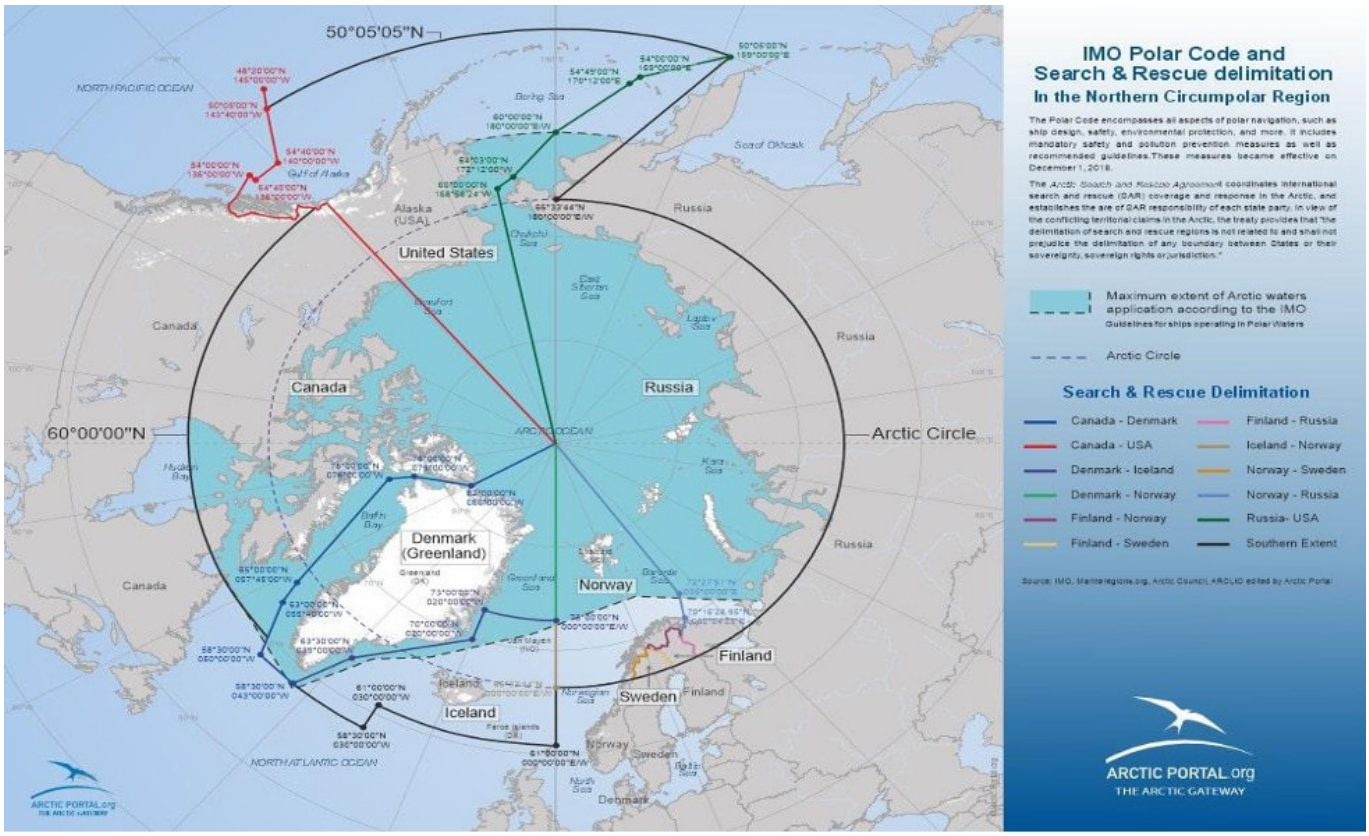


FIGURE 10: IMO POLAR CODE SEARCH & RESCUE DELINEATION

C. ARCTIC STAKEHOLDER POSITIONS RELATED TO ARCTIC SHIPPING

Stance	Stakeholder group	Key examples	Core interest	Description
Strongly oppose	Arctic indigenous communities	• Inuit Circumpolar Council (ICC; Alaska/Canada/Greenland/Russia; 180k people) • Saami Council (Norway/Sweden/Finland/Russia; 90k people)	Environment	These communities demand Free, Prior and Informed Consent (FPIC) under UNDRIP as a legal precondition for any Arctic development. Shipping threatens food security, cultural survival and subsistence livelihoods.
Strongly oppose	Environmental NGOs & governance	• WWF Arctic Programme, Clean Arctic Alliance (22+ NGOs; HFO ban), Greenpeace • IMO, Arctic Council working groups (CAFF, PAME, AMAP)	Environment	Environmental bodies are united in calling for stronger regulation of Arctic shipping — particularly an effective HFO ban, black carbon standards, and precautionary governance of the CAO before commercial activity begins.
Strongly oppose	Planet earth: Arctic ecosystem	• Arctic sea ice, bowhead whales / polar bears, global effects	Environment	The Arctic ecosystem — warming four times faster than the global average — faces existential pressure from HFO spills, black carbon deposition, and underwater noise disruption to wildlife and subsistence species.
Strongly oppose	Fisheries	• Norwegian/Icelandic fleets (Barents Sea cod, capelin) • Russian fishing industry (pollock, crab), EU fleets (Greenland waters)	Economics	Arctic fishing nations are CAOFA signatories committed to a moratorium on CAO high-seas fishing until science-based management is in place, and broadly oppose shipping expansion that risks disrupting fish stocks.
Cautious / conditional	Arctic gov: allied states	• Norway, Canada, Denmark/Greenland, Finland, Sweden	Environment, Economics & Resilience	These allied Arctic states share NATO security commitments and environmental obligations, but diverge on development — Norway and Greenland have resource interests, while Canada, Finland and Sweden prioritise sovereignty, indigenous rights, and climate protection.
Cautious / conditional	Interested state: EU	• European Union, Iceland, Faroe Islands	Environment, Economics & Resilience	EU and allied observer states hold regulatory tools — ETS, port state control, EUR 163M in research funding — and are CAOFA signatories.
Broadly supportive	Arctic gov: Russia	• Russian government, Rosatom/Atomflot (NSR operator), Russian Northern Fleet	Economics & Resilience	Russia treats NSR as a sovereign economic asset and geopolitical lever, opposed to any external governance of its Arctic routes.
Broadly supportive	Interested state: Asia-Pacific	• China (COSCO; Polar Silk Road), Japan (NYK Line; Xuelong icebreakers), South Korea (DSME; Hyundai shipbuilders)	Economics	These have commercial interest in a shorter EU-Asia corridor, and all are CAOFA signatories. China is deepening Russia-Arctic partnership, while Japan and South Korea dominate ice-class shipbuilding and seek assured commercial access.
Broadly supportive	Arctic shipping operators/owners	• Novatek/Yamal LNG, COSCO (China), NewNew Shipping Line • Maersk (trials), NYK Line / MOL (Japan)	Economics	Commercial operators are primarily motivated by route economics — potential savings of 17–33% vs. Suez in favourable conditions.

TABLE 10: SUMMARY OF KEY ARCTIC STAKEHOLDER POSITIONS ON SHIPPING BY GROUP

D. MAJOR ARCTIC RESOURCE EXTRACTION PROJECTS

Project	Location	Sector	Scale	Status	Shipping Implications
HYDROCARBONS					
Johan Castberg	Norway — Barents Sea	Oil	450–650 mn barrels recoverable	Production began Q4 2024; 30-year lifespan	Tanker exports from floating production unit; no new port infrastructure required
Willow Project	Alaska, USA — North Slope	Oil	~600 mn barrels projected	Approved 2023; under construction; first oil ~2029	Pipeline to existing Valdez terminal; limited additional Arctic shipping demand
Arctic	Russia — Gydan Peninsula	LNG	~19.8 mn tonnes/year capacity	First train launched 2024; US sanctions have halted tanker deliveries; future uncertain	Requires Arc7 LNG tankers; eastbound and westbound NEP traffic; no Western tankers currently available
LNG 2	Russia — Yamal Peninsula	LNG	16.5 mn tonnes/year; 287 cargo loadings in 2024	Fully operational; dominant NEP traffic driver	Arc7 tankers year-round; Sabetta terminal; largest single source of current NEP cargo
Yamal LNG	Norway — Barents Sea	LNG / Oil	Snøhvit: 4.2 mn t LNG/ year; Goliat: 175 mn barrels	Operational; Equinor considering Snøhvit expansion to 2040s	LNG tanker exports via Hammerfest; existing NEP-adjacent infrastructure
METALS & MINING					
Norilsk Nickel (expansion)	Russia — Krasnoyarsk Krai	Nickel / palladium / copper	World's largest Ni & Pd producer; ~220,000 t nickel/year	Ongoing expansion; Sulfur Programme 2.0 underway to 2030	Year-round icebreaker-assisted export via Dudinka on NEP; key destinational traffic driver
CRITICAL RAW MATERIALS (CRM)					
Tanbreez	Greenland — SW (Narsarsuaq)	Rare earth elements	~28 mn tonnes — potentially world's largest REE deposit; 27%+ heavy REEs	Exploitation licence held; acquired by Critical Metals Corp (USA) 2024; mining target 2028	Year-round deep-water shipping access via fjord to North Atlantic; port infrastructure in place
Kvanefjeld	Greenland — SW (Narsaq)	REE / uranium	Third-largest known land REE deposit; 11+ mn tonnes	On hold; Greenland uranium ban (2021); legal arbitration ongoing; investment at risk	Year-round direct shipping access; port facilities planned but not built
LKAB Rare Earth / Kiruna	Sweden — Lapland (Kiruna)	Iron ore / REE	World's largest known REE deposit (~1 mn tonnes TREO); largest underground iron ore mine	REE extraction pre-commercial; first production target ~2027–2030	Rail to Narvik (Norway) ice-free port; existing bulk export corridor; no new Arctic shipping infrastructure
Beowulf / Kallak (Gállok)	Sweden — Lapland (Jokkmokk)	Iron ore	~700 mn tonnes indicated resource	Concession denied 2022; legal challenge ongoing; stalled	Proposed rail to Baltic port (Luleå); Gulf of Bothnia shipping; seasonal ice constraints

TABLE 11: LIST OF ACTIVE AND ADVANCED-STAGE EXTRACTION PROJECTS ACROSS HYDROCARBONS AND CRITICAL RAW MATERIALS IN THE ARCTIC REGION

Sources: WWF Arctic (2024); Carnegie Endowment (2025); CSIS (2026); Arctic Economic Council Mining Report (2024); Equinor; ConocoPhillips; Critical Metals Corp.

E. EXISTING SCIENTIFIC INITIATIVES RELATED TO THE ARCTIC

Initiative	Route Coverage	Risk Coverage	Key Focus	Timeline
INTERNATIONAL / MULTILATERAL				
CAFF / Circumpolar Biodiversity Monitoring Arctic Council— pan-Arctic biodiversity tracking	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem – Albedo – Water pollution ✓ Indigenous	• Pan-Arctic biodiversity tracking integrating scientific and indigenous knowledge • Arctic Migratory Birds Initiative (AMBI) • ⚠ Partially suspended since Russia's exclusion (2022)	1996 – ongoing (partial)
AMAP Arctic Council— pollution, climate & ocean acidification	✓ TPR ✓ NEP ✓ NWP	– Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Long-term monitoring of pollution, black carbon, climate, ocean acidification • Annual Arctic Report Card in collaboration with NOAA • ⚠ Partially suspended since Russia's exclusion (2022)	1991 – ongoing (partial)
CAOFA Joint Scientific Research & Monitoring 10-party— Central Arctic Ocean ecosystem baseline	✓ TPR – NEP – NWP	✓ Ecosystem – Albedo – Water pollution – Indigenous	• Scientific basis for CAO fisheries governance decisions • Species distribution and biodiversity surveys in CAO high seas • Multilateral — includes Russia, US, China, EU	2021 – ongoing
Synoptic Arctic Survey IASC— pan-Arctic baseline sampling	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem – Albedo ✓ Water pollution – Indigenous	• Pan-Arctic baseline sampling: water chemistry, biodiversity, ecosystem structure • CAO high seas not yet comprehensively covered	Ongoing
PAME Arctic Council— Protection of the Arctic Marine Environment	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Area-based marine conservation tools for shipping governance • Arctic shipping assessment and black carbon research • ⚠ Partially suspended since Russia's exclusion (2022)	Ongoing (partial)
IMO Expert Group on Underwater Radiated Noise Global shipping noise evidence base	– TPR – NEP – NWP	✓ Ecosystem – Albedo – Water pollution – Indigenous	• Evidence base for future mandatory noise standards • Global scope — Arctic-specific conditions not primary focus • Reporting to IMO MEPC; basis for regulation from 2028+	Ongoing – 2028
WWF Arctic Blue Corridors Programme Whale migration mapping and shipping overlap	– TPR ✓ NEP ✓ NWP	✓ Ecosystem – Albedo – Water pollution ✓ Indigenous	• Maps narwhal, beluga and bowhead migration corridors vs. shipping lanes • Identifies critical knowledge gaps (Kara Strait, Hudson Strait) • Calls for precautionary speed limits in migration corridors	Ongoing
5th International Polar Year (IPY-5) IASC, SCAR, WMO, ISC— largest coordinated polar research effort	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution ✓ Indigenous	• Intensive polar fieldwork, modelling and process studies • Explicit integration of indigenous knowledge • Covers biodiversity, climate, social-ecological systems	Planning now; active 2032–33
EUROPEAN UNION				
Horizon Europe — Arctic Portfolio EUR 163M Arctic + EUR 17M polar research (2021–27)	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Climate change, pollution, biodiversity and connectivity research • Focus on physical climate science — limited ecosystem ecology and shipping impacts • CAO shipping-specific baseline not yet commissioned	2021 – 2027
Arctic PASSION EU Horizon— integrated pan-Arctic observation system	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• EUR 15M project integrating Arctic observations across ocean, atmosphere, ecosystem • Coordinated data infrastructure for Arctic monitoring	2021 – 2025
EcoOmics (MOSAiC follow-on) Alfred Wegener Institute— molecular biodiversity benchmarking	✓ TPR – NEP – NWP	✓ Ecosystem ✓ Albedo – Water pollution – Indigenous	• First molecular-level baseline of Arctic Ocean biodiversity • Genomics and proteomics of marine microorganisms • Reference point for future ecosystem change detection in CAO	Ongoing
EPCO / EU Polar Cluster European Polar Board— EU polar research/policy coordination	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution ✓ Indigenous	• Central contact point: EU polar science community to European Commission • Coordinates EU Polar Cluster and Catalyst Platform • CAO shipping-specific baseline not yet commissioned	2025 – 2029

Initiative	Route Coverage	Risk Coverage	Key Focus	Timeline
NORDIC / NORWAY				
Nansen Legacy Project Norwegian Research Council— Barents Sea ecosystem transition	– TPR ✓ NEP – NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Studies Barents Sea transitioning from ice-covered to open ocean • Full ecosystem depth — physics to top predators • Results informing Norwegian Arctic management decisions	2018–24; results ongoing
NordForsk Arctic Programme Nordic Council + Canada + USA— ocean health and biodiversity	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution ✓ Indigenous	• 9 projects; 186 researchers across Nordic countries, Canada, US • Ocean health, biodiversity and sustainable marine use	2024 – 2027
UNITED STATES / CANADA				
NOAA Arctic Research Program National Oceanic and Atmospheric Administration	– TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Ocean observations, sea ice monitoring and marine ecosystem studies • Bering and Chukchi Sea ecosystem dynamics • Annual Arctic Report Card (20th edition, 2025)	Ongoing
CINUK Programme UKRI + Inuit Tapiriit Kanatami + Polar Knowledge Canada	– TPR – NEP ✓ NWP	✓ Ecosystem – Albedo – Water pollution ✓ Indigenous	• 13 projects co-designed with Inuit communities • Coastal and marine change, community health and food security • Model for indigenous co-designed research integration	2022 – ongoing
CHINA / RUSSIA				
CHINARE — Chinese National Arctic Expeditions Polar Research Institute of China— Xue Long fleet	✓ TPR ✓ NEP – NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Ocean, sea ice and atmospheric research; 13 expeditions to date • 5 research vessels in Arctic waters in 2025; expanding joint programme with Russia • Data not always openly shared; dual environmental/strategic objectives	1999 – ongoing
AARI North Pole Drifting Station Arctic & Antarctic Research Institute	✓ TPR ✓ NEP – NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution – Indigenous	• Year-round drifting ice station — atmosphere, ocean and ice monitoring • BRICS scientists invited (China, India, Brazil) • ⚠ Closed to Western partners since 2022	Ongoing

TABLE 12: ONGOING ARCTIC RESEARCH AND POLICY INITIATIVES (NON-EXHAUSTIVE)

Risk coverage: ✓ Ecosystem disturbance (noise, light, vibration) ✓ Albedo / black carbon ✓ Water pollution ● ✓ Indigenous communities & governance

Initiative	Route Coverage	Risk Coverage	Key Focus	Timeline
MULTILATERAL				
MOSAiC Expedition (COMPLETED) Alfred Wegener Institute + 20 nations	✓ TPR – NEP – NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution ✓ Indigenous	• Most complete picture of Central Arctic ecology ever assembled • 200+ peer-reviewed publications; data still being analysed • Foundation for EcoOmics biodiversity benchmarking • One-off — no sustained follow-up programme established	2019 – 2020
4th International Polar Year (COMPLETED) IASC / SCAR	✓ TPR ✓ NEP ✓ NWP	✓ Ecosystem ✓ Albedo ✓ Water pollution ✓ Indigenous	• Large-scale coordinated fieldwork across both polar regions • Major advances in Arctic biodiversity and climate science • Baseline data informing current monitoring programmes	2007 – 2008

TABLE 13: OVERVIEW OF PAST ARCTIC RESEARCH AND POLICY INITIATIVES (NON-EXHAUSTIVE)

Risk coverage: ✓ Ecosystem disturbance (noise, light, vibration) ✓ Albedo / black carbon ✓ Water pollution ● ✓ Indigenous communities & governance

F. OXMARTRANS MODEL COST INPUTS AND ASSUMPTIONS

Cost Category	Cost Item	Regular Shipping	Open Water (Arctic)	Ice Class	Open Water + Icebreaker Escort
Fixed costs	Vessel capex (per TEU)	$14k	$14k	$16.8k (+20%)	~$14k + $105m (icebreaker)
	Insurance (% of cargo value)	1.2%	1.7% (+40%)	1.7% (+40%)	1.7% (+40%)
	Maintenance & repairs	Baseline	Baseline	+50%	N/A
Variable costs	Fuel (ice-class hull penalty)	Baseline	Baseline	+40% per day in ice	+40% per day in ice
	Speed	Baseline	Baseline	-30% in ice zones	-30% in ice zones
	Cargo capacity (DWT)	100%	100%	85%	100%
Staff costs	Crew (polar-qualified)	Baseline	+10%	+10%	+10%
Handling costs	Icebreaker escort (NEP)	N/A	$560k (summer) / $1.4m (winter)	None in OW conditions	$560k (summer) / $1.4m (winter)
	Permits & admin (NEP)	$250–285k (Suez)	~$150–300k	~$150–300k	~$150–300k
	Permits & admin (NWP)	$400–500k (Panama)	~$20k	~$20k	~$20k
Dwell & delays	Weather / ice delay	—	+2 days	+2 days	+2 days
	Convoy pacing delay	—	+0.5 days	+0.5 days	+0.5 days

TABLE 14: COST INPUTS OF OXMARTRANS MODEL

COST INPUT ASSUMPTIONS:

- **Vessel capex:** The 20% newbuild premium reflects a mid-point across the literature: Solakivi et al. (2019) find an 8% capital cost differential for IA/IAS container vessels, while Liu & Kronbak (2010) and Lasserre (2014) cite a range of 10–30%. A new open-water Panamax (7,000 TEU) costs approximately $114m in 2024, implying roughly $14k/TEU — IA/IAS vessels sit at $16.8k/TEU on this basis. For the icebreaker escort scenario, an additional ~$105m is added reflecting the 2024 US Polar Fleet Acquisition cost of a new nuclear icebreaker, applied as a fixed escort cost regardless of vessel size.
- **Insurance:** Based on a 2026 Coface report finding that Arctic shipping insurance runs 40% above standard rates. Normal container ship insurance sits at 0.5–2% of cargo value (we use 1.2% as mid-point); the 40% uplift is applied uniformly across all Arctic scenarios without differentiating between H&M and P&I, acknowledging this is a simplification given the wider 25–100% range reported in Lasserre (2014).
- **Maintenance & repairs:** The literature range is 20–100% above conventional costs (Liu & Kronbak, 2010; Lasserre, 2014; Solakivi et al., 2019). We apply a central estimate of 50%, reflecting that our reference

vessel (IA/IAS) sits at the lighter end of the ice-class spectrum where reinforcement costs are proportionally lower than for full Polar Class vessels.

- **Fuel penalty:** Drawn from Solakivi et al. (2019, Fig. 2), which finds that ice-class vessels require approximately 10% more engine power in open water, plus a further 30% fuel uplift in icy conditions — totalling ~40% per day when in ice. For a whole voyage where only part of the route is ice-affected, the effective uplift is closer to 20%; the 40% figure is therefore a conservative upper bound and applies specifically to the ice-zone segments.
- **Speed reduction:** Lasserre (2014) records average NEP transit speeds of 14 knots in ice zones versus 21 knots in open water — a 33% reduction. Solakivi et al. (2019) independently report a 30% speed penalty. We use 30%, noting this is based on winter conditions and may overstate the penalty for summer transits, which we may revise in later iterations.
- **Cargo capacity:** Solakivi et al. (2019) find that PC5/PC6 vessels carry approximately 5% less cargo than conventional vessels due to hull reinforcement. Heikkilä et al. (2024) report larger losses for IA/IAS container ships in their dataset, but this is skewed by small feeder vessels where reinforcement takes up proportionally more displacement. We apply an 85% DWT factor, consistent with the PC5/PC6 bulk vessel findings as a more representative proxy for the vessel types relevant to this analysis.
- **Crew costs:** A 10% uplift is applied across all Arctic scenarios to reflect the higher wages commanded by Arctic-certified officers and the mandatory requirement for Russian-licensed pilots on NEP transits (Liu & Kronbak, 2010, Table 9; Solakivi et al., 2019, Fig. 2). This is treated as uniform across vessel types, though in practice the premium may vary by route and season.
- **Icebreaker escort:** Based on the Rosatomflot cost calculator, applied to a 150,000-tonne open-water container equivalent transiting all 7 NEP zones (~80m RUB in summer). Liu & Kronbak (2010) confirm that vessels of IB class and above may be required to take escort at the discretion of the Northeast passage Administration, though the specific tariff breakdown by ice condition is not publicly disaggregated.
- **Permits & admin:** No public NEP permit fee is available; the administrative fee is treated as 20% of Suez Canal transit costs as a conservative proxy, with the dominant cost being icebreaker escort. For the NWP, no commercial permit structure yet exists; a nominal $20k figure is applied. Panama Canal fees are modelled at $400–500k for a 5,000 TEU vessel based on the fixed fee plus loaded/empty TEU tariff structure.
- **Weather/ice delay:** No systematic empirical dataset exists for Arctic weather delays. The 2-day weather hold is based on the Istanbul Bridge voyage (Reuters, 2025), which experienced a 2-day delay due to adverse conditions off Norway — treated as a representative single-voyage estimate (ShipUniverse, 2025). The 0.5-day convoy pacing delay reflects the speed constraint imposed when a vessel must travel at icebreaker pace (~6–10 knots), drawn from the Maersk High North News transit account.

GLOSSARY

AARI	Arctic and Antarctic Research Institute. Russia's oldest Arctic research institution, founded in 1920. Effectively closed to Western partners since 2022.
AMAP	Arctic Monitoring and Assessment Programme. An Arctic Council working group responsible for long-term monitoring of pollution, black carbon, and climate change across the Arctic.
AMOC	Atlantic Meridional Overturning Circulation. The ocean current system that drives the Gulf Stream and moderates Northwest European climate. Arctic ice melt contributes to its weakening.
AIS	Automatic Identification System. A tracking system used by ships to broadcast their position, used to generate shipping traffic data.
BBNJ	Agreement on Biodiversity Beyond National Jurisdiction (also known as the High Seas Treaty). Entered into force January 2026; provides legal mechanisms to designate marine protected areas in high seas including the CAO.
BC	Black Carbon. Fine soot particles produced by burning heavy fuel oil and other fuels. When deposited on ice and snow, they reduce reflectivity and accelerate melt.
CAFF	Conservation of Arctic Flora and Fauna. An Arctic Council working group responsible for monitoring pan-Arctic biodiversity.
CAO	Central Arctic Ocean. The high seas area of the Arctic Ocean beyond the 200-nautical-mile EEZs of coastal states.
CAOFA	Central Arctic Ocean Fisheries Agreement. A binding multilateral agreement among 10 parties (including the EU, US, Russia, China, Norway) establishing a precautionary moratorium on commercial fishing in the CAO high seas. In force since 2021.
CINUK	A UK-Canada indigenous co-designed research programme involving Inuit Tapiriit Kanatami and Polar Knowledge Canada, covering coastal and marine ecosystem change.
CRM	Critical Raw Materials. Minerals considered strategically important for the green energy transition, some of which are present in the Arctic seabed.
DWT	Deadweight Tonnage. A measure of how much cargo a ship can carry, expressed in metric tonnes.
EEA	European Economic Area. A free trade and regulatory alignment agreement covering EU member states plus Norway, Iceland, and Liechtenstein. Relevant because Norway is the EU's closest Arctic partner through this framework despite not being an EU member.
EEZ	Exclusive Economic Zone. A maritime zone extending 200 nautical miles from a coastal state's baseline, within which the state has sovereign rights over natural resources and regulatory authority over activities.
EPCO	European Polar Coordination Office. Established January 2025 in Umeå, Sweden; coordinates EU polar research and translates scientific expertise into policy input for the European Commission.
ETS	Emissions Trading System. The EU's carbon pricing mechanism, extended to maritime shipping from 2024.
FPIC	Free, Prior and Informed Consent. A principle under UNDRIP (2007) requiring that indigenous communities are consulted before decisions affecting their lands or livelihoods are taken, with the genuine right to withhold consent.
HFO	Heavy Fuel Oil. The dominant marine fuel used in shipping. Produces significantly more black carbon than cleaner alternatives. Subject to an IMO ban in Arctic waters from 2024, with exemptions until 2034.
IASC	International Arctic Science Committee. The leading international scientific organisation coordinating Arctic research.
IMO	International Maritime Organization. The United Nations agency responsible for regulating international shipping, including through instruments such as the Polar Code and HFO ban.
IPCC	Intergovernmental Panel on Climate Change. The UN body responsible for assessing climate science. Its SSP emissions scenarios form the basis of the navigability projections in this report.
IPY-5	5th International Polar Year. A planned large-scale multilateral polar research effort in 2032–33, co-led by IASC, SCAR, the World Meteorological Organization, and the International Science Council.

LNG	Liquefied Natural Gas. A key cargo on the NSR, primarily from Russian gas fields on the Yamal and Gyda Peninsulas.
MEPC	Marine Environment Protection Committee. The IMO committee responsible for environmental regulation of international shipping, including black carbon standards and the HFO ban.
MOSPA	Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic. Signed 2013, in force 2016; commits Arctic states to cooperation on oil spill response.
MPA	Marine Protected Area. A designated zone where human activities are restricted to protect marine ecosystems. Can be proposed under the BBNJ agreement for CAO high seas.
NOAA	National Oceanic and Atmospheric Administration. The US federal agency responsible for ocean and atmospheric science, including the annual Arctic Report Card.
NEP	Northeast passage. The Arctic shipping corridor running along Russia's northern coastline, currently the only route with meaningful near-term commercial viability.
NSR	Northern sea route. Roughly analogous to NEP, but hugging closer to the Russian coast, between the Kara Gate and EEZ boundary.
NWP	Northwest Passage. The Arctic shipping corridor running through the Canadian Arctic Archipelago. Virtually no commercial cargo transit to date.
OPRC	Oil Pollution Preparedness, Response and Co-operation Convention. The IMO convention underpinning international cooperation on oil spill response; related to but distinct from the Arctic-specific MOSPA agreement.
PC6	Polar Class 6. An IMO vessel classification for ships designed to navigate in medium first-year ice. The most commercially realistic vessel class for near-term Arctic transit.
PAME	Protection of the Arctic Marine Environment. An Arctic Council working group developing area-based marine conservation tools relevant to shipping governance.
RAIPON	Russian Association of Indigenous Peoples of the North. Umbrella organisation representing approximately 300,000 indigenous people across 40 ethnic groups in the Russian Arctic. Holds observer status at the Arctic Council.
REE	Rare Earth Elements. Mineral resources present in the Arctic seabed, relevant to the strategic competition for Arctic resource access.
SAR	Search and Rescue. Emergency response services for vessels and crew in distress. Coverage is sparse across all three Arctic corridors.
SCAR	Scientific Committee on Antarctic Research. Co-leads IPY-5 alongside IASC.
SSP2-4.5	Shared Socioeconomic Pathway 2–4.5. A medium emissions scenario used by the IPCC, treated in this report as the most plausible basis for Arctic shipping projections.
STCW	Standards of Training, Certification and Watchkeeping. The IMO convention governing crew qualifications; amended to require dedicated polar certification for crew operating under the Polar Code.
TEU	Twenty-Foot Equivalent Unit. Standard unit for measuring container shipping volumes. One TEU equals one 20-foot shipping container.
TPR	Transpolar Route. The Arctic shipping corridor crossing the high seas of the Central Arctic Ocean directly. Currently ice-covered year-round; no near-term commercial viability.
UKRI	UK Research and Innovation. The UK research funding body; co-funds the CINUK indigenous research programme.
UNCLOS	United Nations Convention on the Law of the Sea. The international treaty establishing the legal framework for all ocean governance, including jurisdiction over maritime zones and the rights of coastal states in the Arctic.
UNCTAD	United Nations Conference on Trade and Development. Produces key global shipping statistics referenced in this report.
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples. Adopted 2007; establishes minimum standards for indigenous rights including FPIC.
WMO	World Meteorological Organization. Co-leads IPY-5 alongside IASC and SCAR.


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