Towards a Sustainable Integrated Arctic Shipping Strategy

Ana Teresa Cardoso

Shipping activities in the Arctic region pose a wide range of pressures on its marine environment, including underwater noise, light disturbance, ship strikes with marine mammals, pollution from operations and accidents, and socioeconomic impacts on coastal communities. The IMO has adopted the Polar Code to manage shipping in the Arctic Ocean. Protecting the Arctic marine environment from shipping impacts is essential for all stakeholders, including seafarers. Shipping, including cruise tourism, serves societal drivers such as trade, commerce, and recreation, and global shipping is expected to increase, particularly if climate change continues to result in sea ice losses, potentially opening up new trade routes. Increases in shipping activity in the Arctic region have already been observed, raising concerns about potential impacts on sensitive Arctic marine ecosystems, particularly on marine mammals reliant on sound for communication and navigation. Climate change increases navigational risks in the Arctic due to mobile sea ice and limited hydrographic charting in newly opened areas. The WMO and IMO provide seafarers with weather, wave, and ice warnings and forecasts to mitigate these risks, extending the global maritime distress safety system. HFO has been identified as the most significant pressure exerted by ships in the Arctic, with fishing vessels, general cargo vessels, and service vessels being the top emitters of black carbon. The Arctic states should develop a integrated strategy for navigation in the Arctic to improve this region's sustainability and to guide the non-Arctic states.

Introduction

The exploration and potential utilisation of Arctic shipping routes have emerged as a focal point of global interest, driven by the prospect of shorter transit times, reduced costs, and expanded economic opportunities. The retreat of Arctic sea ice, a consequence of climate change, has opened up new maritime pathways, sparking a surge in maritime activity and heightened attention from nations with Arctic interests (Huntington et al., 2023). Accordig Dawson et al. (2020: 19) "Ship traffic has nearly tripled in the Canadian Arctic over the past decade and additional growth is expected as climate change continues to increase navigability in the region. In response, the Canadian Government is developing Low Impact Shipping Corridors as an adaptation strategy that supports safety and sustainability under rapidly changing environmental conditions." As the allure of these routes grows, so too do the complexities and challenges they present, necessitating comprehensive consideration and global cooperation.

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From an environmental perspective, the impact of shipping activities on the delicate Arctic ecosystem is profound and far-reaching. Concerns about pollution, habitat disruption, and disturbance to marine life loom large as vessels navigate these icy waters. Efforts to mitigate these risks include reducing emissions, minimising noise pollution, and preventing ship strikes with marine mammals (IMO, 2023a; Rojano-Doñate et al., 2023). Moreover, there is a growing consensus on transitioning from heavy fuel oil (HFO) towards cleaner alternatives to safeguard the Arctic environment (Comer et al., 2020; Dalaklis et al., 2023).

International conventions such as the United Nations Convention on the Law of the Sea (UNCLOS) provide a legal framework for addressing these issues, emphasising cooperation, environmental protection, and Indigenous rights (Singh et al., 2020).

Arctic shipping has significantly increased over the past decade, according to the Arctic Council. The council's Working Group on the Protection of the Arctic Marine Environment (PAME) released a report detailing the trends in Arctic shipping from 2013 to 2023. The report revealed a 37% rise in the number of unique ships entering the Arctic Polar Code area, with around 500 more ships compared to previous years. September recorded the highest influx, with 1,122 ships entering the area (Arctic Council, 2024).

The distance travelled by ships in the Arctic Polar Code Area also increased by 111%, from 6.1 million to 12.9 million nautical miles during the same period. Fishing vessels accounted for over one-third of all ships, making them the most common type, closely followed by general cargo ships. These developments in Arctic shipping can be attributed to changes in the marine environment, particularly the reduction in sea ice extent. Longer navigation seasons and access to previously inaccessible areas have resulted. The rise is also driven by increased natural resource extraction projects like the Mary River Mine and Yamal Gas (Arctic Council, 2024).

As shipping traffic increases, so do the risks of accidents and collisions, posing threats to human safety and environmental integrity (Huntington et al., 2023). To address these challenges, the World Meteorological Organisation (WMO) and International Maritime Organization (IMO) have implemented various safety measures, including improved ice forecasting, satellite navigation systems, and enhanced training for seafarers.

This paper examines the environmental concerns arising from Arctic shipping and explores the importance of developing an integrated Arctic shipping strategy. A qualitative method based on documentary analysis of scientific articles and institutional websites of organisations relevant to maritime transport in the Arctic, with a focus on environmental concerns, was used.

Arctic Shipping Routes

The Northwest Passage, Northern Sea Route (the Northeast Passage), and Transpolar Sea Route (Figure 1) represent key Arctic shipping routes that have garnered increasing attention and exploration in recent years (IPCC, 2019). These routes offer potential shortcuts for maritime transportation between the Atlantic and Pacific Oceans, presenting opportunities for reduced transit times and costs and potential economic benefits (Huntington et al., 2023). However, they also pose significant challenges due to the harsh Arctic environment and geopolitical complexities.

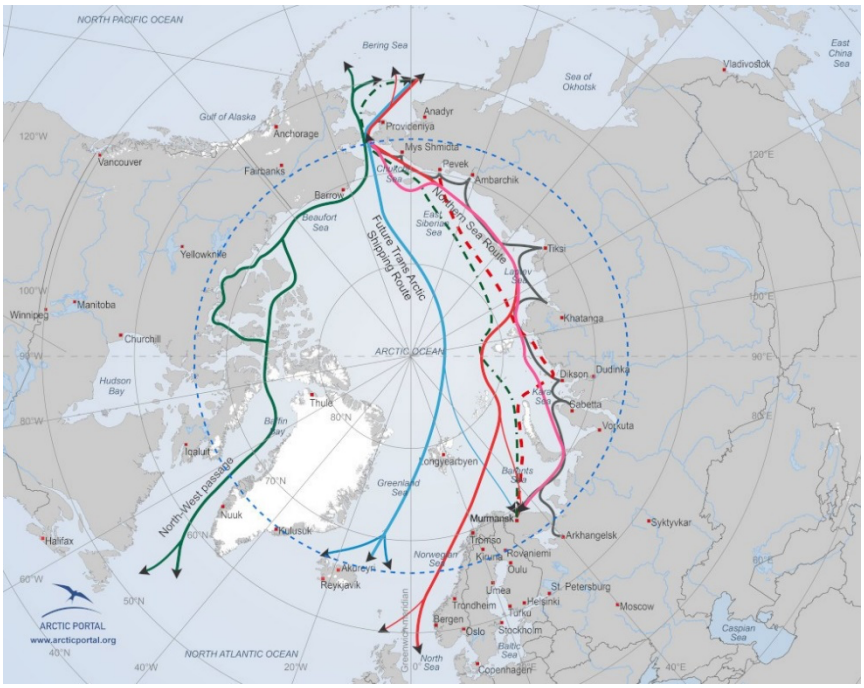

Figure 1. Arctic shipping routes: Northwest Passage, Transpolar Route, Northern Sea Route. (Source: Yercan &. Sogut, 2023)

The Northwest Passage (NWP) traverses the Canadian Arctic Archipelago, offering a potential route connecting the Atlantic and Pacific Oceans through the Canadian Arctic waters. Historically, ice conditions have made this route largely impassable for much of the year. However, with the retreat of Arctic sea ice due to climate change, the NWP has become increasingly navigable during the summer months, attracting interest from shipping companies and governments (Huntington et al., 2023).

The Northeast Passage (NEP), which is also called the Northern Sea Route (NSR) because it encompasses the NSR, extends from northern Norway across Russia to the Bering Strait. Russia defines the Northern Sea Route (NSR) as the waters within its exclusive economic zone between Cape Zhelanie (68°35'E) and the Kara Gates in the west and Cape Dezhnev (168°58'37" W) in the east (Huntington et al., 2023).

Like the Northwest Passage, the Northeast Passage has experienced increased shipping activity in recent years, particularly during the summer when ice coverage is reduced. Russia has been actively promoting the Northern Sea Route as a viable alternative for global shipping, investing in infrastructure and icebreaker fleets to facilitate navigation (Huntington et al., 2023).

The Transpolar Sea Route represents a potential route directly over the North Pole across the central Arctic Ocean. While this route has historically been impractical due to thick ice cover, climate change-induced Arctic ice melt has led to speculation about the future feasibility of a navigable Transpolar Sea Route. However, significant challenges remain, including unpredictable ice conditions and the lack of infrastructure along the route (Bennett et al., 2020; Huntington et al., 2023).

Despite the opportunities presented by these Arctic shipping routes, there are also significant challenges and concerns. Melting sea ice contributes to environmental changes in the region, impacting marine ecosystems and Indigenous communities that rely on the Arctic environment for their livelihoods.

As Arctic ice continues to diminish, the region's shipping future remains uncertain. While Arctic routes offer potential benefits in terms of efficiency and cost savings, they also pose environmental and geopolitical challenges that require careful management and cooperation among states.

Environmental Concerns

Shipping activities in the Arctic region have garnered increasing attention in recent years due to the changing climate and the opening of new maritime routes. While this presents economic opportunities, it also raises concerns about the environmental impacts on the Arctic ecosystem.

Underwater Noise

Underwater noise from shipping activities in the Arctic can significantly impact marine life, particularly marine mammals that rely on sound for communication, navigation, and foraging. The noise from ships can disrupt essential behaviours such as mating, feeding, and migration, leading to habitat displacement and population declines (Erbe et al., 2019).

Light Disturbance

Light pollution from ships, particularly from artificial lighting used for navigation and operations, can disrupt natural light cycles and adversely affect Arctic wildlife, including seabirds, marine mammals, and fish. Light disturbance can disorient animals, interfere with their feeding and breeding behaviours, and contribute to habitat fragmentation (Qi et al., 2024).

Ship Strikes with Marine Mammals

The increase in shipping traffic in the Arctic raises the risk of ship strikes with marine mammals, including whales, seals, and walruses. Collisions can result in injury or mortality for these animals, impacting their populations and ecological roles in Arctic ecosystems. Implementing speed restrictions in known whale habitats, establishing whale avoidance zones, and using acoustic monitoring systems to detect marine mammals can help reduce the risk of ship strikes and protect vulnerable species (Vincent et al., 2023).

Cleaner Fuels and Scrubber Ban

Among the foremost environmental hazards associated with Arctic shipping is the pollution stemming from the combustion of HFO. HFO, a residual fuel derived from crude oil refining processes, is extensively utilised as a primary fuel source for marine vessels owing to its cost-effectiveness compared to cleaner alternatives like marine gas oil (MGO) or liquefied natural gas (LNG) (Comer et al., 2020). However, the incineration of HFO emits substantial quantities of pollutants, including sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter (PM), and black carbon (BC), which contribute to air pollution, acid rain, and climate change (Comer et al., 2017).

The use of scrubbers in Arctic shipping has raised concerns due to their potential environmental harm, prompting calls for their prohibition in the region. Scrubbers discharge pollutants directly into Arctic waters, threatening marine life and ecosystem health (Clean Arctic Alliance, 2024a).

Transitioning to cleaner fuels, such as low-sulphur marine diesel or LNG, offers a more sustainable alternative, reducing emissions and minimising environmental impact (Al-Enazi et al., 2021).

Furthermore, recent studies have emphasised the environmental benefits of alternative fuels, such as biofuels and hydrogen, in reducing greenhouse gas emissions and air pollutants (Islam Rony et al., 2023). These fuels present promising alternatives for Arctic shipping, offering lower carbon footprints and fewer environmental repercussions.

Creation of Emission Control Areas (ECAs)

Emission Control Areas (ECAs) regulate shipping emissions and protect marine environments. Establishing an ECA in the Arctic would require stringent fuel sulphur content and emissions regulations, promoting cleaner and more sustainable shipping practices (Kontovas, 2020). Collaborative efforts among Arctic states and international organisations are essential for effectively implementing and enforcing ECA regulations.

Recent research has highlighted the positive impact of ECAs on air quality and human health, demonstrating their effectiveness in reducing emissions of sulphur oxides (SOx) and nitrogen oxides (NOx) (Merico et al., 2021; Clean Arctic Alliance, 2023a, 2023b). Additionally, addressing black carbon emissions within ECAs is critical, as black carbon deposition on snow and ice accelerates melting and contributes to climate change (Clean Arctic Alliance, 2024b).

Addressing Black Carbon Emissions

Black carbon emissions from shipping in the Arctic significantly contribute to climate change and ecosystem disruption. Black carbon, primarily emitted from the combustion of fossil fuels, has a warming effect on the climate and contributes to the accelerated melting of Arctic ice (EUA-BCA, 2021; Qi et al., 2024). Implementing measures to reduce black carbon emissions, such as using cleaner fuels and improving engine efficiency, is essential for mitigating its impact on the Arctic environment (Clean Arctic Alliance, 2024b).

Recent studies have underscored the urgency of addressing black carbon emissions in the Arctic, highlighting its detrimental effects on local communities, wildlife, and the global climate system (Zhang et al., 2024).

The Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) has highlighted the significance of close-to and within Arctic sources of BC, concluding BC emissions above 60 degrees North were more significant than those at lower latitudes and mitigating measures should recognise this (IMO, 2013).

AMAP defined the Arctic as all regions north of 60 degrees North. It has previously been proposed that at a minimum the geographic scope of measures cover the maritime waters of the Arctic Human Development Report area or those defined by AMAP, or alternatively, all waters above 60 degrees North (excluding the Baltic Sea) may be a simpler definition for navigational purposes (IMO, 2023b).

The International Council on Clean Transportation (ICCT) has conducted four studies on CO emissions from ships in the Arctic region (2015, 2017, 2019, and 2021). In 2021, the study focussed on the Arctic area, defined in Annexes I, II, IV, and V of SOLAS and MARPOL, and referred to as IMO Arctic waters in Figure 2, as well as the wider geographical area of the Arctic, which covers all waters north of 78.95°N (excluding the Baltic Sea) (IMO, 2023b).

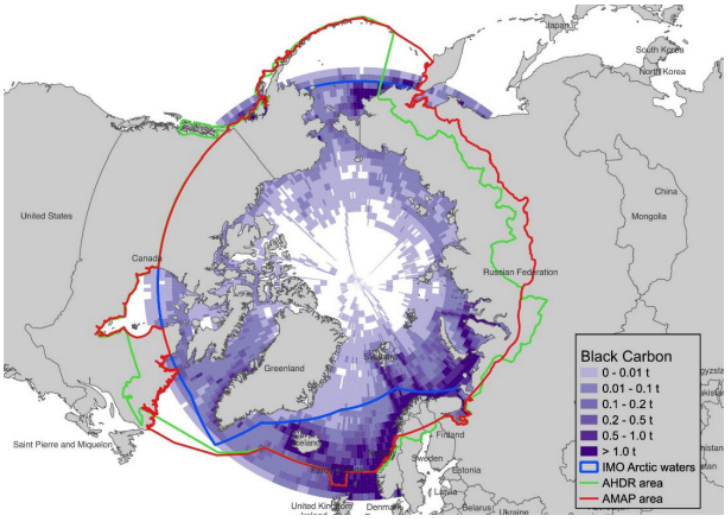

Figure 2. Arctic intensity of ship BC emissions (north of 78.95°N) based on 2021 data (IMO, 2023b)

According to the ICCT on the IMO (2023b: 3-4):

> Several findings bear directly on the question of geographic scope of BC emission control measures. A comparison of 2021 BC emission data with 2015 data shows that in six years BC emissions from ships operating within IMO Arctic waters have doubled from 193t to 413t. The analysis of BC emission data also compared the numbers of ships operating in the IMO Arctic waters area with the number of ships operating north of 78.95°N (excluding the Baltic Sea) in 2021. This analysis shows that 8,577 vessels operated in Arctic sea areas north of 78.95°N and were responsible for emitting 1,500 tonnes of BC in 2021, while only 1,866 vessels operated in the IMO Arctic waters area emitting 413 tonnes of BC. The numbers of ships operating in the IMO Arctic waters represented 22% of ships operating throughout the wider Arctic and they were responsible for only 27% of the total of BC emitted in the Arctic. The analysis also shows that the volume of residual fuel used throughout the wider Arctic area is less than a quarter of that needing to be replaced to comply with the recently adopted Mediterranean Sea SOx ECA. The blue boundary marks the delineation of Arctic waters as used for purposes of the IMO's Polar Code, the green boundary the delineation of the Arctic Human Development Report and the red boundary the Arctic Monitoring and Assessment Programme boundary.

Measures to reduce BC emissions must applied to all ships emitting this pollutant, which impacts the Arctic. A definition of 'Arctic' is needed in MARPOL Annex VI. The geographical scope of measures to reduce the effects of BC emissions from ships in the Arctic should cover, as a minimum, the maritime waters of the AHDR area or the AMAP area (see Figure 2) or a more feasible definition of the Arctic for shipping purposes could include all waters, for example, North of 60 degrees North (excluding the Baltic Sea) (IMO, 2023b).

Sustainable Practices and Environmental Stewardship

Adopting sustainable practices is imperative for minimising the environmental footprint of Arctic shipping. Preventing oil spills, managing waste responsibly, and reducing underwater noise pollution contribute to preserving Arctic ecosystems (Pavlov, 2023). Indigenous communities play a vital role in environmental stewardship, offering traditional ecological knowledge that informs conservation efforts and sustainable resource management (Huntington et al., 2023).

Unique Challenges Posed by Arctic Shipping

Arctic shipping presents distinctive challenges that exacerbate its environmental impact and complicate risk mitigation efforts. The extreme cold, harsh weather conditions, and sea ice pose significant operational hurdles for vessels navigating Arctic waters, heightening the risk of accidents, spills, and pollution incidents (Albrechtsen et al., 2021; Uryupova, 2024). Moreover, the remoteness of Arctic regions and the dearth of infrastructure and emergency response capabilities further compound the challenges associated with Arctic shipping (Brigham, 2018).

One of the most notable environmental risks associated with Arctic shipping is the potential for oil spills in remote and environmentally sensitive areas. Unlike spills in more temperate regions, where swift response and clean-up efforts are feasible, Arctic oil spills present unique challenges due to ice cover, limited daylight, and restricted access to affected areas. The slow pace of natural remediation in cold Arctic waters further complicates clean-up efforts and extends the ecological impacts of spills (Qi et al., 2024).

Furthermore, the melting of Arctic ice and the opening of new shipping routes have led to increased vessel traffic in previously pristine and ecologically sensitive areas, raising concerns about noise pollution, disturbance to marine wildlife, and the potential for ship strikes and habitat degradation (Tiller et al., 2022). Arctic ecosystems, already under pressure from climate change and other anthropogenic stressors, are particularly vulnerable to the impacts of increased shipping activity, underscoring the need for comprehensive risk assessments and mitigation measures to safeguard sensitive habitats and species (Arrigo et al., 2020).

Regulatory Efforts to Address Environmental Concerns

Navigating the complex and ever-changing Arctic region requires a deep understanding of its environmental challenges and the legal frameworks governing maritime activities. As the effects of climate change continue to transform the Arctic landscape, including the melting of sea ice and the opening of new maritime routes, the need for clear and comprehensive regulations to ensure the safety, security, and sustainability of navigation in the region becomes increasingly critical.

UNCLOS provides the primary legal framework for governing maritime affairs, including navigation, environmental protection, and resource management. UNCLOS is often called the "constitution of the oceans" due to its comprehensive scope and its role in establishing the rights and responsibilities of states about the world's oceans and seas.

At the heart of UNCLOS is the principle of freedom of navigation, enshrined in Article 87 of the convention. This principle affirms the right of all states to navigate freely on the high seas, subject only to certain limited exceptions provided for in the convention. The high seas, which encompass the vast majority of the world's oceans, including the Arctic Ocean, are considered international waters where all states enjoy equal rights and freedoms (United Nations, 1982).

The principle of freedom of navigation takes on added significance in the Arctic, where the effects of climate change are most pronounced. As sea ice retreats, previously inaccessible areas are becoming navigable, opening up new opportunities and challenges for maritime activities in the region. UNCLOS provides the legal framework necessary to ensure that navigation in the Arctic is conducted safely, responsibly, and under international law.

One of the key provisions of UNCLOS relevant to Arctic navigation is Article 234, which addresses navigation rights through ice-covered areas. In the Arctic, where ice cover can be extensive for much of the year, navigating through ice-covered waters presents unique challenges and risks. Article 234 ensures that ships, including icebreakers, enjoy the right of innocent passage through ice-covered areas, subject to certain safety measures and regulations established by the coastal state to prevent accidents and environmental damage (United Nations, 1982).

In addition to ensuring freedom of navigation, UNCLOS also imposes obligations on states to protect and preserve the marine environment. Articles 192 to 195 of the convention outline these obligations, emphasising the duty of states to prevent, reduce, and control pollution of the marine environment from various sources, including ships, land-based activities, and exploration and exploitation of marine resources (United Nations, 1982).

In the Arctic, where the impacts of climate change are most pronounced, these environmental obligations take on added significance. The melting of sea ice and the opening of new shipping routes bring opportunities for economic development but also raise concerns about potential environmental degradation. UNCLOS requires states to conduct environmental impact assessments for proposed activities that may have significant adverse effects on the marine environment, ensuring that the environmental risks associated with Arctic navigation are carefully considered and mitigated.

Moreover, UNCLOS establishes principles of international cooperation in addressing marine environmental issues. Article 197 underscores the importance of states cooperating on a global and regional level to protect and preserve the marine environment, including through the exchange of scientific and technical information, capacity-building, and the promotion of international agreements and measures to prevent, reduce, and control pollution (United Nations, 1982).

Cooperation is essential for effective environmental protection in the Arctic region, where multiple states share common environmental concerns. UNCLOS provides a framework for states to work together in addressing shared challenges, such as oil spills, shipping pollution, and habitat degradation. The convention encourages states to develop and implement joint initiatives and regional agreements to protect and preserve the Arctic marine environment (United Nations, 1982). Note that UNCLOS provisions apply during peacetime. Russia's invasion of Ukraine in 2022 jeopardised the cooperation with this Arctic state.

At the international level, UNCLOS provides a legal framework for addressing these issues, emphasising cooperation, environmental protection, and Indigenous rights (Singh et al., 2020).

Additionally, the IMO's International Code for Ships Operating in Polar Waters (Polar Code), which came into force in 2017, establishes rigorous standards for vessel design, equipment, and operational practices to ensure the safety and sustainability of Arctic shipping. The code encompasses provisions for pollution prevention, emergency preparedness, and environmental risk assessment, striving to minimise the ecological footprint of shipping activities in polar regions.

Polar Code mandates that ships operating in polar waters develop and implement environmental management plans, conduct regular environmental audits, and adhere to stringent discharge limits for pollutants such as oil, sewage, and garbage (Deggim, 2018; IMO, 2024a).

Although the Polar Code is mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL), both Conventions allow flag States to authorise exemptions and waivers for ships flying their flag. The Arctic Ocean cannot wait for these regulations to become mandatory without exemptions and waivers.

In April 2018, the IMO committed to reducing the risks associated with HFO. Canada and the Marshall Islands submitted a proposal to assess economic and other impacts on Arctic communities as a result of a ban on HFO use and carriage in the Arctic because Canadian Arctic communities rely on shipping to bring in essential goods, including fuel, and rely on HFO as a source of energy on land. Approved in 2022, the ban on the use and carriage of by ships of HFO in the Arctic begins in July 2024, although allowed exemptions and waivers (Lloyd's Register Group Limited, 2023) mean that a full ban on HFO for ships in the Arctic will not be enforced until 2029 (Transport Canada, 2021).

IMO's agreement on reducing underwater noise pollution from shipping stops short of prioritising mandatory measures (Humpert, 2023; Clean Arctic Alliance, 2024c; IMO, 2024b). Dr. Sian Prior criticised its failure to make progress toward mandatory rules that would decrease the impact of shipping on Arctic wildlife (Clean Arctic Alliance, 2024c).

The ECAs proposed by Canada and Norway and approved by IMO member states will provide additional protection from air emissions in Canadian Arctic waters and the Norwegian Sea by reducing emissions of sulphur oxides (SOx), particulate matter and nitrogen oxides (NOx) from international shipping (Clean Arctic Alliance, 2024d; IMO, 2024b).

The Canadian Arctic ECA includes Arctic waters under Canadian sovereignty, from the 137º meridian west in the Beaufort Sea to the existing North American ECA boundary in the east (IMO, 2023a). Meanwhile, the Norwegian Sea ECA covers the Norwegian Exclusive Economic Zone north of 62 degrees latitude and includes Norwegian fjords and coastal waters (IMO, 2023b).

During the 82nd session of the Marine Environment Protection Committee (MEPC), IMO has adopted significant amendments to MARPOL Annex VI, establishing those new ECAs. These ECAs will also reduce black carbon emissions, encouraging maritime transport operators to switch to cleaner fuels (Clean Arctic Alliance, 2024e).

According, Sian Prior (2024e) "With the IMO finally looking set to regulate black carbon emissions from black carbon – which will greatly lower the impact of the shipping sector on Arctic sea and glaciers – member states must now agree on which fuels are appropriate for use in the Arctic, so that robust rules can be put in place."

In addition to international instruments, the Arctic States developed and agreed treaties in the 21st century. Among these, two are very relevant for the sustainability of Arctic shipping: the Arctic SAR Treaty and the Arctic Oil Pollution Preparedness and Response Treaty.

The Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic (Arctic Search and Rescue Agreement or SAR) is an international agreement on search and rescue

cooperation in the Arctic, signed by all 8 Arctic States in Nuuk, Greenland, on 12 May 2011, and came into force in January 2013. It is the first ever legally binding document elaborated under the auspices of the Arctic Council and the first multilateral Arctic legal document (Arctic Portal, 2024a).

The Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic, also signed by all 8 Arctic States in Kiruna, Sweden, on 15 May 2013, has "the objective to strengthen cooperation, coordination, and mutual assistance among the Parties on oil pollution preparedness and response in the Arctic in order to protect the marine environment from pollution by oil (art. 1)." Clearly, "each Party shall maintain a national system for responding promptly and effectively to oil pollution incidents. This system shall take into account particular activities and locales most likely to give rise to or suffer an oil pollution incident and anticipated risks to areas of special ecological significance and shall include at a minimum a national contingency plan or plans for preparedness and response to oil pollution incidents. Such contingency plan or plans shall include the organisational relationship of the various bodies involved, whether public or private, taking into account guidelines developed pursuant to this Agreement and other relevant international agreements (art.4.1)" (Arctic Portal, 2024b).

The Arctic states have a relevant and dynamic role in protecting the Arctic Ocean from maritime traffic. An example is the Arctic Maritime Transport Assessment (AMSA) report conducted by the Council for the Protection of the Arctic Marine Environment (PAME) working group. This report, with 17 recommendations, was approved by the Arctic Ministers at the 2009 Ministerial meeting in Tromsø. PAME issued four reports (2011, 2013, 2015, 2017) to document and track progress in implementing all recommendations. However, due to the progress and developments, the recommendations had to be updated (2021). These reports present a comprehensive framework and strategy for the Arctic, strengthening maritime safety and environmental protection (PAME, 2024).

PAME's shipping work has evolved into a more project-based approach in recent years. It operates a Shipping Expert Group that collaborates regularly with experts from Arctic States, Permanent Participants, and Observers. PAME focuses on environmental protection and sustainable development, distinct from the regulatory role of the IMO. PAME's role includes data collection, analysis, and policy recommendations to support safe and environmentally sustainable Arctic shipping. This work has influenced decision-making within Arctic States and the IMO, fostering better coordination and cooperation. The strong partnership between IMO and PAME reflects PAME's expertise in providing valuable input to shape maritime actions in the Arctic (PAME, 2024). It can inferred that Arctic states are concerned about the sustainability of Arctic shipping.

Strengthening Arctic Governance Through Integrated Shipping Strategy

Considering the dynamic environmental conditions and the increase in maritime traffic in the Arctic Ocean, the Arctic states should develop an integrated shipping strategy promoting the adoption of regulations without exemptions, among others. This strategy should be the guiding principle for non-Arctic states to develop national strategies for flag vessels operating in the Arctic Ocean.

Ensuring Safe and Secure Navigation

Safety and security are paramount in Arctic navigation, given the challenging environmental factors, including sea ice, extreme weather, and limited infrastructure. (Arctic Council, 2020). An integrated

strategy would prioritise the establishment of standardised procedures for navigation safety, encompassing vessel routing measures, icebreaking assistance, and coordinated search and rescue operations.

Protecting the Marine Environment

The Arctic marine ecosystem is susceptible to pollution, habitat degradation, and biodiversity loss due to shipping activities. (Arctic Council, 2020). An integrated shipping strategy should include measures to minimise environmental impacts, such as emission reduction initiatives, ballast water management protocols, and stringent oil spill prevention measures By promoting sustainable shipping practices, for example, banning the use of HFO and transport for use of HFO and banning scrubbers, Arctic and non-Arctic states are contributing to the Arctic preservation ecosystem and people's health in this region.

Promoting Sustainable Development

Arctic navigation presents economic opportunities for trade and tourism, benefiting Arctic and non-Arctic states (Arctic Economic Council, 2022). An integrated strategy would facilitate the sustainable development of Arctic shipping, infrastructure, and services while ensuring a balance between economic growth, environmental preservation, and community well-being. Howevwer, this strategy would have developed with respect to the Arctic state's jurisdiction and sovereignty.

Strengthening Governance Frameworks

Effective, sustainable governance of shipping requires solid legal and institutional frameworks. An integrated strategy would be the common thread for non-Arctic states developing their Arctic shipping strategies. If the Arctic Council had regulatory status focused on environmental protection and sustainable development, it would reinforce the legal value of this strategy.

Engaging Indigenous Communities

Indigenous communities in the Arctic possess invaluable knowledge, rights, and perspectives that must be integrated into navigation governance processes (Skripnikova et al., 2023). Arctic Shipping Best Practice Information Forum, led by PAME, showcases successful public-private partnerships and is an example of engaging Indigenous Peoples in shaping maritime transport in the Arctic. (Arctic Council, 2020). Another example is the AMSA reports mentioned above, which also involve the relevant participation of Indigenous communities (PAME, 2024). Indigenous knowledge from Arctic communities is so fundamental that the Arctic Corridors and Northern Voices (ACNV) project was created to include this knowledge in the Government of Canada's development of low-impact navigation corridors. Thirteen Canadian Arctic communities in Inuit Nunangat (Inuit homeland) participated in this project, six from the Inuvialuit Settlement region (ISR); Aklavik, Inuvik, Paulatuk, Sachs Harbour, Tuktoyaktuk, and Ulukhaktok; seven from Nunavut (which consists of three different regions – Kivalliq, Kitikmeot, Qikiqtaaluk): Arviat, Cambridge Bay, Coral Harbour, Gjoa Haven, Iqaluit (not finalised at time of submission), Pond Inlet, and Resolute; and one from Nunavik: Salluit (Dawson et al., 2020).

An integrated strategy should prioritise meaningful engagement with Indigenous Peoples, respecting their traditional knowledge, cultural practices, and territorial rights.

Conclusions

In conclusion, the exploration of Arctic shipping routes and their potential utilisation represent a pivotal juncture in global maritime affairs, characterised by promise and peril. The opening of these routes, facilitated by the retreat of Arctic sea ice driven by climate change, offers tantalising prospects of shorter transit times, reduced costs, and expanded economic opportunities. However, the allure of Arctic shipping is counterbalanced by a host of environmental, geopolitical, and socio-economic challenges that demand an integrated strategy.

From an environmental perspective, shipping activities' impact on the Arctic ecosystem is profound and far-reaching. Concerns about pollution, habitat disruption, and disturbance to marine life loom large as vessels navigate these icy waters. Efforts to mitigate these risks include reducing emissions, minimising noise pollution, preventing ship strikes with marine mammals, and transitioning away from heavy fuel oil towards cleaner alternatives. However, the unique environmental sensitivity of the Arctic amplifies these challenges, necessitating stringent regulatory measures and proactive environmental stewardship.

Moreover, regulatory efforts at both the international and national levels are crucial for addressing environmental concerns and ensuring compliance with best practices. The IMO's Polar Code establishes rigorous standards for vessel design, equipment, and operational practices to ensure the safety and sustainability of Arctic shipping. Additionally, flag states should not authorise exemptions and derogations for ships flying their flags and operating in the Arctic.

Furthermore, strategic route planning and speed management can help reduce underwater noise pollution and minimise disturbance to marine mammals and other wildlife. Joint work with researchers, Environmental Non-Governmental Organisations, and Indigenous communities will enhance understanding of Arctic ecosystems and their preservation.

Sustainable Arctic shipping requires an approach that integrates technological innovation, regulatory frameworks, and research-based decision-making. By adopting sustainable practices, stakeholders can minimise environmental impact, ensure the safety of Arctic shipping operations, and preserve the region's unique ecological and cultural heritage for future generations.

Arctic shipping needs concerted efforts across multiple sectors and stakeholders. By prioritising sustainable development that balances economic interests with environmental protection, policymakers can navigate the complexities of Arctic shipping that promote long-term prosperity and resilience for the region and its inhabitants. Achieving sustainable shipping in the Arctic requires an integrated strategy that includes shipping sustainable practices and engaging with Indigenous communities.

The fundamental components of such a strategy may include:

- Environmental Regulations: continuously update and strengthen regulatory frameworks to address emerging environmental challenges, including emissions reduction targets (creation of ECAs and increase the geographical scope), pollution prevention measures (ban scrubbers), and habitat conservation.
- Infrastructures: upgrade port facilities to ensure that port operations are carried out as quickly and safely as possible. Raise port fees for non-Arctic flag states vessel. Ensure sufficient port reception facilities for the discharge of ship-generated waste and others.

- Indigenous Engagement: is essential for ensuring that shipping activities in the Arctic region are not only environmentally sustainable but also culturally sensitive, socially responsible, and economically beneficial to local residents. Given the Arctic's unique environment and the rich cultural heritage of Indigenous Peoples, meaningful community engagement is a cornerstone of sustainable development in the region. The Arctic is home to diverse Indigenous groups, including the Inuit, Sami, and various other Indigenous communities. For these groups, the Arctic is more than a landscape; it is central to their way of life, identity, and traditions. Shipping activities, often driven by economic and geopolitical interests, can disrupt these ways of life if not managed thoughtfully. Cultural sensitivity in shipping operations involves respecting and understanding the historical and spiritual significance of the land and sea to Indigenous populations. This requires:
    - involving Indigenous communities in decision-making processes from the very beginning, before key shipping routes or infrastructure projects are finalized.
    - incorporating Indigenous knowledge systems, such as centuries-old navigation and ecological practices, alongside Western scientific approaches. This fosters a more holistic understanding of the Arctic environment and promotes more informed, effective decision-making.
    - shipping activities should be mindful of sacred sites, hunting grounds, and seasonal migration patterns that are essential to Indigenous livelihoods. Any disturbance to these activities can have devastating effects on food security and community well-being.
- Technological Innovation: joint research initiatives focused on green shipping technologies, ice navigation, and satellite monitoring can enhance the resilience of Arctic shipping routes while minimizing environmental harm.

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