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Melting Ice and Strategic Passages: Analyzing the Security Implications in the Arctic

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Abstract

This paper looks at the new relevance of Arctic sea routes, especially, the Northwest Passage and the Northern Sea Route as the global warming shrinks sea ice. It examines the economic, geopolitical and environmental issues of reduced shipping distances, expansion of access and territorial claims, and the environmental issues of maritime activity. The paper has tried to bring to light the urgent equilibrium that must be maintained between economic growth, environmental conservation, and global collaboration to achieve a sustainable and non-violent utilization of the resources and transit routes in the Arctic. Policy suggestions that can be used to improve security in the arctic region are also presented in the paper.

Keywords: Ice melting, NSR, NSW, Arctic Passages, security in the Arctic region, security implications

1. Introduction

Arctic Ice melting is a term used to describe the loss of the ice cover in the arctic region whether in terms of volume[1] or extent[2]. The effect on global climate, sea levels and ecosystems has important implications on this phenomenon. The major factors that have led to melting of the ice in the Arctic are various but the leading factor is global warming due to the emission of various greenhouse gases by human beings. An increase in the global temperature leads to melting of ice at both poles. The ice has a high albedo, i.e. it reflects significant amount of the sun radiation and as it melts, there is more exposure to darker ocean water that absorbs more heat and as a result, more heat is produced resulting in further melting. The thawing of permafrost emits a powerful greenhouse gas methane that contributes to warming.

The consequences of the melting of the arctic ice are severe. Arctic serves as an air-conditioner to the whole world and its melting affects weather patterns, which leads to extreme weather events. Ice melting and glaciers are also increasing the sea levels posing a danger to the coastal settlements across the globe. Arctic animals such as polar bears, seals, and walruses that depend on ice to hunt and procreate are impacted by loss of sea ice (Previdi et al., 2021). It equally affects the indigenous people and their lifestyles. Ice melting can cause changes in salinity and temperature which will interfere with thermohaline circulation and change the global climatic pattern. The ice is receding,

[1]area
[2]thickness

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which has opened up new shipping routes, yet these routes have geopolitical issues and environmental challenges, such as possible oil spills and disruptions of marine life (Wu and Li, 2021).

Since 1979, the extent of the sea ice in the Arctic has decreased on average at the rate of 12.85% per decade (Parkinson and Nicolo, 2021). The ice is even becoming thin with the ice taking several years to become multi-year ice, which is replaced by younger ice. Arctic amplification is the process of the Arctic warming at a rate of about 2 times higher than the global mean temperature (Rantanen et al., 2022). It has been predicted that in next few decades the Arctic would experience a summer with almost no ice, particularly in the case that the global warming continues to remain uncontrolled. The melting of Arctic ice will have to be reduced by all means, including the signing of international agreements by the countries such as the Paris Agreement (Huang and Pan-Mao, 2021), transition to renewable energy sources, and the enhancement of energy efficiency. Two proposed solutions include carbon capture (Lau et al., 2021) and storage and management of solar radiation (Sovacool et al., 2022), which have a high risk and uncertainty. In order to integrate into the shifting reality, indigenous and local communities are developing interventions such as modernization of the infrastructure and a change in the approaches to hunting and fishing (Ford et al., 2021).

1.1 Scope of the Study

This paper is aimed at analyzing the possible consequences of the melting of Arctic ice on security, especially with the opening of important sea routes and the rise in ship traffic.

2. LITERATURE REVIEW

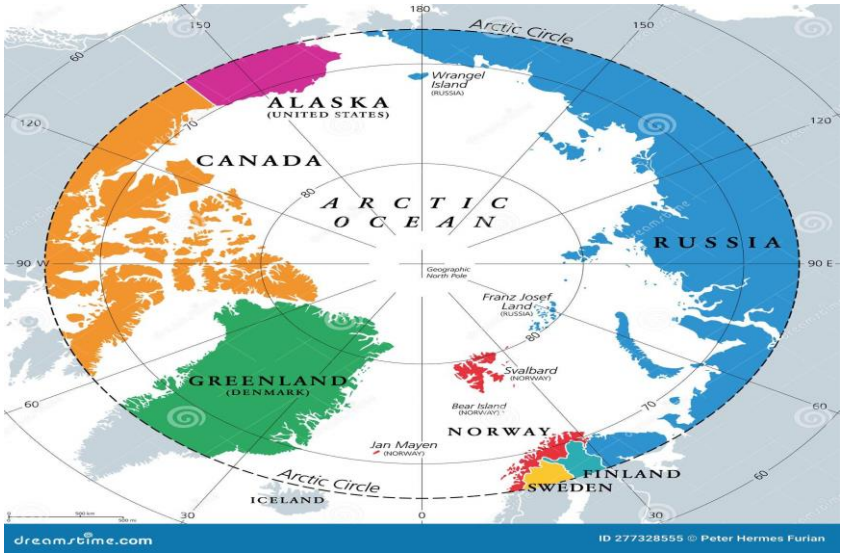
The NSR and the NWP are the two major sea routes in the Arctic, which are getting more and more strategically crucial as the ice melts. The NWP crosses the Canadian Arctic Archipelago and links the Atlantic and Pacific Oceans. With journey times as short as 40% shorter than more traditional routes that go through the Suez or Panama Canal, it offers a shipping shortcut between Europe and Asia. The NSR runs along the northern coast of Russia, from the Kara Sea to the Bering Strait. In a similar vein, it shortens the shipping path between East Asia and Europe (Boylan, 2021). When compared to more conventional routes, Arctic routes also reduce fuel use on shorter routes and therefore result in cheaper transportation costs and greenhouse gas emissions. Shorter journey times also result in quicker product delivery, improving the effectiveness of supply chains and increasing their appeal for moving commodities between important markets in Europe and Asia and the entire cost of moving goods between large markets is considerably decreased by using shorter routes. Minerals, gas, and oil are among the many natural resources found in the Arctic (Romasheva and Diana, 2021). Greater accessibility makes it easier to extract and move these resources, which could strengthen regional and national economies. The tourist industry also is becoming increasingly interested in the Arctic due to its unique environment, resulting in the creation of new cruise lines and adventure travel opportunities (Chen et al., 2021). As a result, to control these vital rivers, nations bordering the Arctic, such as Canada, Russia, the United States, Norway, and Denmark,[3] are extending their borders and claiming new territory (Dal, 2023). Increased activity and territorial claims could heighten geopolitical tensions among Arctic and non-Arctic nations but are also generating new commercial prospects in shipbuilding, logistics, and tourism, as well as stimulating economic growth in Arctic settlements. To control vital waterways, Arctic states are not only reiterating their territorial claims but increasing their forces. This covers things like building infrastructure, setting up military patrols, and setting up scientific

[3]via Greenland

research facilities. Control over recently accessible resources and maritime boundaries are therefore, points of contention. To take advantage of Arctic potential, they are also developing strategic alliances. For instance, China and Russia are working together more on the NSR; China refers to this as the "Polar Silk Road" (Li et al., 2022). The Arctic Council is an inter-governmental organization that promotes cooperation in issues pertaining to the Arctic including the environmental conservation and sustainable development. To regulate environmental protection, search and rescue operations, and navigation rights bilateral agreements are being negotiated between nations.

United Nations Convention on the Law of the Sea (UNCLOS) is a significant framework which is essential in the arbitration of claims, the settlement of these conflicts and the marking of the maritime boundaries but due to the accessibility of the Arctic routes and resources, particularly among the largest powers such as the US, Russia, and China, geopolitical tensions continue to exist. Additionally, since subsistence hunting is a severe problem of Indigenous people whose traditional lifestyle relies on sea ice, there is an increased requirement in adaptation approaches, including the infrastructural adjustments, food security systems, and the economic diversification (Alekseev et al., 2020). The Arctic Code, created by the International Maritime Organization (IMO), establishes environmental and safety guidelines for vessels travelling through arctic waters (Karahalil et al., 2020) but it is not easy to effectively implement and enforce these restrictions.

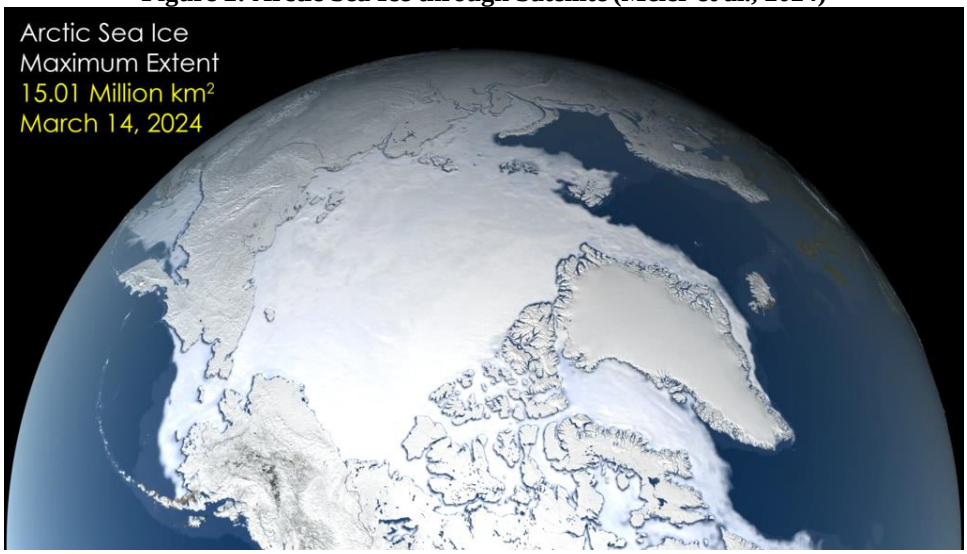
Figure 1: Political Map of the Arctic Circle (Countries within the Arctic Circle, Arctic Region Countries, Political Map Stock Vector - Illustration of Wrangel, Area, n. d.)



The extent of Arctic ice cover varied seasonally but was mostly consistent from the early 20th century until the 1970s. Climate cycles cause sea ice's thickness and expanse to naturally fluctuate. Although there is not much data from this era, it offers a starting point for evaluating long-term trends. The introduction of satellite monitoring in the late 1970s made it possible to quantify Arctic ice cover with greater accuracy and consistency from the 1970s to the 1990s. Data indicate that there was a gradual decline in the thickness and extent of sea ice over this period but the declines were more intense in the late 1980s. The acceleration of ice losses started in the 1990s up to the

Early 2000s. The extent of summer sea ice experienced great losses in the 1990s. It has been observed that the Arctic was warming faster than the rest of the world by about twice the global average a phenomenon called Arctic amplification (Smedsrud et al., 2022).
A few years later than the 2000s to 2010s, set record lows in terms of summer sea ice cover (Hop et al., 2020). The lowest point was in 2007 and 2012, and the year 2012 is the lowest expansion so far (Solomon et al., 2021). Multi-year ice, which is more resistant and thicker than seasonal ice, significantly decreased. There was an increasing prevalence of younger, thin ice in the Arctic. The decline in the ice extent and thickness continued throughout the 2010s and up to the current time (Mohammadzadeh et al., 2022). The yearly low level is still recording substantial losses relative to the historical average. The area of winter sea ice is as well shrinking, but at a lower pace than summer ice. There is a significant decrease in ice volume and thickness as indicated by satellite measurements and in situ measurements. The rate of melting of the older thicker ice also keeps overtaking the rate of new ice generation. Its sides are approximately 12.85 percent per decade against the average 1981-2010 (Karahalil and Burcu, 2021). Although the most dramatic declines are observed with summer ice, the extent of ice in the winter also declines. Research on satellite altimetry and submarine sonar records indicate that there has been a substantial decrease in both the thickness and volume of the Arctic Sea ice (Wang et al., 2022). The fraction of multi-year ice has declined significantly, with more proportion of thin ice of younger age being more common (Figure 2). The loss of ice cover that reduces the albedo (reflectivity) of the Earth resulting in greater uptake of solar energy, as well as the release of methane, are also causing further warming. By the current trends, it is likely that further decreases in the extent and thickness of sea ice will be observed in the Arctic with significant consequences on global climate, sea levels, and ecosystems (Wu and Li, 2021).

Figure 2: Arctic Sea Ice through Satellite (Meier et al., 2024)



The future of the Arctic ice melting is strongly dependent on the future direction of the global greenhouse gas release and consequent climate change. Depending on the vigorous mitigation measures or the steady high emissions, these situations have different consequences on the ecosystem and the global climate. Without major mitigation efforts, the High Emissions Scenario (RCP8.5) forecasts ongoing high greenhouse gas emissions. It is commonly known as the "business-as-usual" (DGAP, n. d.) scenario. Summers in the Arctic could be almost completely free of ice as early as the 2030s or 2040s (Overland and Muyin, 2013) while the likelihood of ice-

free conditions increases toward the end of the century. Arctic temperatures could rise by more than 7°C (12.6°F) by 2100 (Johannessen and Elena, 2022), significantly higher than the global average increase. Continued thinning of sea ice, with a substantial reduction in multi-year ice, leads to predominantly first-year ice that is thinner and more prone to melting. The Moderate Emissions Scenario (RCP4.5) assumes moderate efforts to reduce emissions, resulting in a stabilization of atmospheric CO2 levels by mid-century (Tachiiri et al., 2013). Ice-free conditions could still occur, but likely later in the century (2050s to 2070s). Arctic warming could be limited to around 3-4°C (5.4-7.2°F) by 2100, reducing the rate of ice loss compared to the high emissions scenario. Some potential for seasonal recovery of sea ice in colder years, but long-term trends still point to significant reductions (Wei et al., 2020).

The Low Emissions Scenario (RCP2.6) (Huntingford et al., 2015) assumes aggressive mitigation efforts that significantly reduce greenhouse gas emissions, aiming to keep global temperature rise below 2°C (3.6°F) (Gädeke et al., 2021). The likelihood of completely ice-free summers is greatly reduced, with occasional low ice extent periods still possible in the latter part of the century. Arctic temperatures might increase by about 2-3°C (3.6-5.4°F) by 2100, which is closer to the lower end of the projected warming range (Valone, 2021). Greater potential for maintaining a significant amount of multi-year ice, with less severe thinning.

Continued ice melt threatens habitats for polar bears, seals, walruses, and other ice-dependent species. Changes in ice cover alter the distribution and abundance of marine species, with potential shifts in fish populations affecting the entire Arctic food web. Warmer waters and reduced ice cover could allow for the migration of non-native species into the Arctic, potentially disrupting existing ecosystems (Vincent et al., 2001). Melting of the Greenland ice sheet and other Arctic glaciers will also contribute to global sea level rise. Under high emissions scenarios, the contribution from the Greenland ice sheet alone could be significant. The elevation of sea level is dangerous to the low-lying coasts in the world as it poses the danger of floods and erosion. Ongoing depletion of reflective ice cover will further contribute to the increase in heat absorption in the ocean, which will increase regional and global warming (Scambos et al., 2021). Although the ice cover is less, the drifting ice and the abrupt variations in the ice conditions are a significant challenge to navigation. Ships need to be prepared to deal with ice and be able to access real time and accurate ice information. Cold weather, heavy winds, storms and extreme cold are also characteristic of the Arctic and these weather conditions may affect the safety and navigation. Polar darkness during winter months and frequent fog can reduce visibility, increasing the risk of collisions and accidents (Van de Poll et al., 2020).

For generations, NWP was coveted as a possible trading route. Roald Amundsen accomplished the first successful navigation between 1903 and 1906 (Kramskiy et al., 2020). In the past, the Soviet Union used the NSR for local shipping. Russia has made significant investments in port infrastructure and icebreaker fleets. The third option is the Transpolar Sea option, which may go straight across the North Pole (Bennett et al., 2020). Currently unpassable, but if further ice melts, it might become accessible and provide the quickest path between the Pacific and Atlantic oceans. Oil spills are more likely to occur when shipping traffic increases, which might have catastrophic consequences for the delicate Arctic ecosystem. Ships' increased emissions of other pollutants, such as black carbon, hasten the melting of ice in the region. A major worry is the disruption of marine life caused by an increase in vessel traffic, noise pollution, and possible collisions with marine mammals therefore, travelling through the Arctic is dangerous because of drifting ice and severe weather even with less ice cover (Stefansson, 1969). The distinct biodiversity of the Arctic is in danger also due to the introduction of invasive species and modifications to habitat conditions. Because the port infrastructure in the Arctic is limited, it is difficult to accommodate increased shipping traffic. Search and rescue efforts are challenging due to poor infrastructure, vastness, remoteness and difficult terrain. Even those ports that do exist might not have the infrastructure and capacity required for extensive economic activities. The remoteness of the Arctic has an

impact on the dependability of navigation and communication systems. For example, for operations to be both safe and effective, satellite technology advancements are required (Hermann et al., 2022).

In this context, there are some technological and logistical factors to take into account. Using Icebreaker Technology comes first. For commercial vessels to travel safely across ice-covered seas, icebreakers are needed. Russia is the world leader in nuclear-powered icebreaker investments, giving them superior icebreaker capabilities. Other countries are also building up their fleets of icebreakers. Several nations are augmenting their fleets of icebreakers to facilitate enhanced passage through the Arctic. For instance, the US intends to create brand-new polar security cutters (Drewniak et al., 2018). Safe and effective Arctic navigation also depends on the establishment of Arctic ports and logistical hubs to accommodate greater shipping activity as well as sophisticated satellite navigation and communication systems. Modern satellite communication and navigation systems will also be implemented in the Arctic waters to enhance efficiency and safety by tracking vessels and keeping track of the ice in real time (Karahalil et al., 2020).

With the Arctic Sea Ice melting away, the NSR and NWP have become much more accessible. The NSR has been made more available throughout the year, particularly through the application of icebreakers. Summer navigation is becoming a longer season and some places will be navigable deep into the winter with the right assistance. These developments have also given rise to a number of innovations in the field of environmental management, transport, exploitation of resources and geopolitics. The NSR has recorded high levels of transits over the recent years, which implies its increased significance. Large shipping firms are considering the NSR as a way of shortening transit time in between Europe and Asia. As an illustration, trial runs by Maersk and COSCO indicate the potential of the route commercially (Zheng and Chris, 2017).

In NWP, the opportunities of ice-free summer days have been on the rise, which makes it easier to access them by commercial vessels. The NWP is receiving more vessels including personal yachts, cargo vessels and cruise lines, although it still receives less traffic than the NSR. As an example, the quantity of transits has been growing at a fast rate, and over the past few years, there have been massive commercial transits. Canada has been investing in upgrading its port infrastructure and other elements of its Arctic infrastructure in order to accommodate more of the maritime traffic. Search and rescue and navigational aids are also being enhanced. In certain sea routes, the NWP offers a potential route avoiding the Atlantic and Pacific Oceans which can significantly lower the passage time. Continued ice melting along the North Pole could result in the possibility of the fastest path between the Pacific and Atlantic (Karahalil et al., 2020).

The melting ice has made it easy to access the sources of Arctic oil and gas. The latter trend is evidenced by such projects as Yamal LNG in Russia which necessitated massive investments in infrastructure such as extraction and transportation. The Arctic has rich mineral resources including gold, diamonds and rare earth elements. Businesses are spending more and more in mining and exploration as the accessibility increases. Accessibility of natural gas and oil resource is on the increase as a result of melting glaciers, which augurs better investment of exploration and exploiting activities. Commercial fisheries in the Arctic are also increasing due to changing ice cover and ocean temperatures which provide new fishing activities (Harsem et al., 2011).

Many types of ships and cargoes do transit through the arctic routes. Arctic routes are used by a variety of ship types and cargoes. Container ships and other commercial cargo ships are used to move manufactured goods, electronics, and other consumer items between major international markets. Bulk commodities like coal, ore, grain, and other raw materials are transported by bulk carriers. Oil tankers carry crude oil and refined petroleum products from extraction sites in the Arctic to global markets. LNG carriers are responsible for transporting LNG from Arctic-producing sites, like Russia's Yamal LNG project, to global consumers (Katysheva, 2019). Then, certain specialist boats, like icebreakers, that are necessary for negotiating ice-covered seas, keep shipping channels open and facilitate the passage of other boats. Scientific study on arctic

conditions, ice patterns, and the effects of climate change is carried out by research vessels (Silber and Jeffrey, 2019) and tourism and cruise ships, as rising demand for Arctic travel is causing an increase in the number of cruise ships visiting Arctic waters and providing travellers with exclusive experiences like seeing wildlife and exploring far-flung areas.

2.1. Security Implications Of Melting Ice

There exists a unique set of security threats and challenges due to more shipping in the Arctic due to the harsh weather, fragile ecosystem, and lack of infrastructure. The unpredictable weather condition, shifting ice patterns, and poorly charted waters in the Arctic increase the risk of collisions and groundings (Fu et al., 2022). These accidents are quite dangerous as the region is isolated. Icebergs and sea ice pose real danger to ships, and the probability of accidents, leading to breaches of the hull and loss of cargo, is increased. Cold weather, especially in those vessels that are shipping hazardous products, may lead to malfunction of machinery and also increase the chances of fire or explosion (Homlong, 2010). The ecological environments of the region, which are conducive to the highly adapted species to the frigid climate, can be disastrously affected by the oil spills in the Arctic (Camus and Smit, 2019). The cold process hinders the natural degradation of oil which makes the damage on the environment worse. This is further enhanced by the challenge and repeated delays of spill response operations due to the distant place, ice coverage and bad weather (Borgerson, 2008). The volume of shipping traffic also has effect on the quality of pure water and air in the Arctic due to the pollutant emissions (Benson, 1987). Black carbon emissions in ships have the potential to accelerate the melting of ice by reducing albedo effect. The release of ballast water may introduce invasive species in the region, threatening the marine biodiversity and disturbing the natural balance (Jing et al., 2012).

The Arctic has a low number of ports, airstrips, and rescue facilities, and is usually poor in terms of infrastructure. SAR[4] activities are thus not easy and time-consuming. The ship crews and rescue personnel are challenged since SAR activities are harder and hazardous due to long periods of darkness, cold weather, and forceful weather conditions (Byers and Covey, 2019). The territorial claims and the international problems that surround the Arctic make the problems of enhancing maritime administration and security difficult. Due to its remoteness and vastness, the Arctic is a potential center of malicious acts such as smuggling, unlawful fishing, and the exploitation of resources without any report (Kraska and Baker, 2022). Ships need specialized ice navigation skills and support of the icebreaker, which are not easily found. Ice flows and poor visibility are causes of difficulty in navigation. Some of the Arctic routes such as the NWP and the NSR have very narrow and shallow sections, which as the number of vehicles increases, pose a greater risk of accidents (Leppala et al., 2019).

A holistic strategy is required so as to curb these threats and challenges. This strategy involves the construction of additional ports (Pahl and Brooks, 2018) and emergency and response centres (Andreassen et al., 2019), development of SAR resources (Byers and Covey, 2019), stricter regulatory measures on emissions (Narita and Kazuki, 2024), discharge of the ballast water (Jing et al., 2012) and readiness in case of oil spill situations (Knol and Peter, 2014), and the establishment of closer collaboration Through such a proactive response, any possible adverse impact of the increased shipping traffic in the Arctic will be reduced, and safer and more sustainable marine activities in this sensitive area will be achieved.

The escalating maritime activities in the arctic present a host of security risks and concerns which are reduced through various methods by the national and international entities, with the use of legislation, regulatory frameworks, infrastructural development, and cooperative arrangements.

[4]Stands for Search And Rescue

The National Strategy of the Arctic Region worked out by the United States promotes the development of maritime infrastructure, of safe sea navigation, of knowledge of the Arctic territory (Heininen, 2012). In Canada Northern Strategy, sovereignty, environmental protection, and economic prosperity are given priority. It also requests the empowerment of search and rescue as well as surveillance in the Arctic (Medalye and Ryan, 2012). Russia has already made a serious presence in the Arctic by constructing new ports, expanding the number of its icebreakers, and creating the NS). The Arctic Strategy of Russia is devoted to increasing the level of economic activity and maintaining security (Kluge and Paul, 2020).

A number of the Arctic countries are investing in port infrastructure to accommodate more traffic. To take an example, Canada is refurbishing the Port of Churchill, and Russia is building ports along the NSR (Pahl and Brooks, 2018). Countries are enhancing their SAR capabilities by placing more icebreakers, helicopters and SAR stations. The United States as well as Canada have made investments to improve SAR operations in the Arctic (Byers and Covey, 2019). To promote safe navigation and aid in rescue efforts, nations are developing and deploying cutting-edge icebreakers. While Russia already has the greatest fleet

of nuclear-powered icebreakers, the US Coast Guard is purchasing new heavy icebreakers (Drewniak, et al., 2021). Countries such as the United States and Canada are putting into practice enhanced satellite surveillance systems for weather forecasting, maritime traffic management, and real-time ice monitoring (Wilentz, 2024).

The Arctic Council encourages communication, coordination, and cooperation between indigenous populations and Arctic states. It covers topics like environmental preservation and sustainable development. The Polar Code,[5] which establishes mandatory safety and environmental protection criteria for ships operating in Arctic and Antarctic waters, was adopted by the IMO. The Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic outlines SAR responsibilities and areas and has been signed by the member governments of the Arctic Council.

Another consensus reached by the Arctic Council is on the cooperation with managing the situations of oil pollution, which contributes to the resource sharing and provides support to each other by the states in the area. In order to conserve the fragile ecosystems and biodiversity, a number of countries and international bodies are trying to establish marine protected areas in the Arctic. The IMO came up with emission control zones (ECAs) to reduce air pollution by the ships. Talks to extend the laws to the Arctic area are underway (Gossling et al., 2021). To comprehend the Arctic ecology and the consequences of growing shipping, there is a need to cooperate internationally in science researches. International Arctic Science Committee (IASC), and other programs are used to coordinate research. More and more weather, marine traffic, and ice conditions information are shared among the arctic countries as a way of enhancing security and protecting the environment (Rees and Ulf, 2024). The example is the Arctic Data Committee that promotes collaboration and the sharing of data between researchers and decision-makers in the area (Pulsifer et al., 2013).

3. METHODOLOGY

The goal of the study is to attain an exhaustive examination of the multidimensional meaning of the crossings of the Arctic sea without biasing it towards either regulation systems or environmental protection, economic possibilities or geopolitical processes. Through this strategy, the study aims at advancing a profound understanding of the advantages and limitations related to the changing Arctic environment. The main area of study will be the Arctic area but specifically in Northwest Passage (NWP henceforth) and the Northern Sea Route (NSR henceforth).

[5]The International Code for Ships Operating in Polar Waters

The neighboring countries of the Arctic will be addressed, and the history of the shipping channels and the meltdown of Arctic ice since the end of the 20 th century until nowadays will be discussed. The financial benefits of using the shorter shipping routes through the Arctic will also be analyzed.

4. DISCUSSION ON SINGLE INSTANCES/ACCIDENTS IN THE ARCTIC SHIPPING ROUTES AND THE IMPLICATION TO SECURITY

Although a mix of technology investments, legal regimes, and cross-border collaboration is common in successful undertaking, the mix of the three is often applied in an unsuccessful endeavor. There are still issues, though, mainly with incorporating the knowledge and demands of indigenous groups and striking a balance between environmental preservation and economic development. The following individual instances in the Arctic are analyzed, security measures are examined, and various techniques are compared to emphasize how difficult it is to provide maritime security in the area:

i. MV Arctic Grounding (1996): (Yu et al., 2024) In Nunavik, northern Quebec, the Canadian bulk carrier MV Arctic grounded close to the town of Kangirsuk. This incident highlighted the risks of travelling through the Arctic when the territory was poorly charted and the need to improve mapping and navigation instruments. It placed more emphasis on the importance of possessing emergency response skills in remote regions.

ii. Nordic Orion (2013): (Laurent et al., 2024) Nordic Orion was the first commercial bulk carrier to pass the Northwest Passage. The trip proved the logistical and environmental difficulties of such activities despite the fact that the expedition was successful. This trip also showed that there might be the economic benefits of using ship routes along the Arctic, however it also showed that there had to be strict ecological laws and reliable SAR resources as there is the potential of accidents in such remote locations.

iii. Kulluk Drillship Incident (2012): (Necci et al., 2019) Shell drillship Kulluk grounded out off Alaska coast after being separated by a huge storm. This tragedy highlighted the extreme weather conditions and technological barriers in Arctic and there were calls to tighten the guidelines of safety and emergence planning measures in oil and gas operations in the area.

Canada has developed the NMTC[6] to determine the specific shipping routes that are more frequently utilized and possess more information. SAR resources, navigational aids, and charting are also given priority funding as far as these corridors are concerned (Chenier et al., 2017). The NMTC project by focusing on the most significant areas has led to a higher level of navigational security and reduced the chances of accidents in the sea. Russia has invested heavily on its fleet of icebreakers to enhance the NSR. Even with the biggest fleet of icebreakers, there have been difficulties keeping up with the growing volume of traffic and guaranteeing prompt icebreaking services. Operations have occasionally been hindered by delays and logistical problems, proving that icebreaker investment alone is insufficient without matching advancements in port infrastructure and marine traffic management systems. The United States has placed a strong emphasis on boosting satellite monitoring, increasing SAR capabilities, and growing its fleet of icebreakers. The U.S. Coast Guard plays a significant role, in such undertakings, in the prioritization of international cooperation and operational readiness (Drewniak et al., 2021). The Northern Strategy that has already been noted is comprehensive in Canada in such a way that it

[6]Stands for Northern Marine Transportation Corridors

incorporates economic development, environmental protection and sovereignty enforcement. It has invested in Arctic-specific SAR and prioritized the development of the NMTC highly. The strategy of Russia is pegged on transforming the NSR into a major trade route. It has greatly invested in icebreaker capacity, port infrastructure, and regulatory systems to attract foreign trade and reinforce the military to ensure security (Petrov et al., 2021).

In their pursuit of legislation protecting their natural resources and livelihoods, Arctic native peoples, such as the ICC[7], pressurize the government. They emphasize that it is important to incorporate traditional knowledge in the environmental assessment and in maritime planning (Shadian, 2006). Some native communities have created their own SAR, taking advantage of their knowledge of the region and its conditions to aid in rescue operations. Such efforts ensure quicker response times in isolated areas and additional national SAR plans (Kao et al., 2012). Through the help of the Arctic Council, the Native American groups collaborate with the Arctic governments. Some of the major examples of successful international initiatives aimed at improving security and environmental safeguarding in the Arctic are its SAR and oil spill response agreements (Robards et al., 2018). Vessels sailing in the Arctic waters have to comply with obligatory requirements of safety and environmental standards as presented in the Polar Code of the IMO. This international regulatory framework helps to lessen the risks associated with the growth of maritime activity.

4.1 Anticipated Trends in Arctic Ice Melting and Shipping Activity, and Their Implications for Security:

Climate change is causing the ice of the Arctic to melt faster. It is projected that by 2050, the Arctic can have nearly no ice during summer. This will enhance accessibility of the Arctic and an extension of shipping season. There will be increased traffic in shipping lanes such as the NWP and the NSR due to the recession of ice, resulting in increased accessibility to the various resources and improved opportunities to conduct tourism and trade in the area with the amount of ice melt. Though reduced ice would mean reduced difficulty of navigation, it would also imply increased and unpredictable frequency and approach of icebergs. Real-time monitoring systems and advanced ice navigation are going to become more significant. More transportation makes the ecology of the Arctic more susceptible to pollution, accidents, and oil spills. The necessity of proper environmental protection will continue to increase.

The strategic relevance of the Arctic will escalate and, perhaps, it will result in the growth of military presence and geopolitical tensions between Arctic and non-Arctic states that are interested in the control of shipping routes and resources. The increased amount of ships will probably lead to more incidents that need SAR operation. Thus, to cope with these risks, it will be necessary to improve the capabilities of SAR and the infrastructure.

4.2 Recommendations on Policy Improvements to increase security in the Arctic Region:

Hydrographic surveys that would update and enhance the Arctic nautical charts would need to be done with better navigation infrastructure, particularly, more charting and mapping. This involves mapping of sea beds and real time monitoring systems of ice. Similarly, there is need to deploy additional navigational aids like buoys, beacons and GPS augmentation system to enhance safety and accuracy of navigation in the Arctic waters.

More international cooperation particularly needs to be enhanced to strengthen the Arctic Council to enhance its efforts in promoting cooperation and conflict management between the Arctic states as well as ensuring that the non-Arctic stakeholders with interests in the region are included.

In this regard, multilateral agreements to expand and enforce international agreements on SAR, oil

[7]Stands for Inuit Circumpolar Council

spill response, and environmental protection are a must along with developing new treaties addressing emerging security and environmental challenges. Conducting regular multinational SAR and environmental response exercises to improve coordination and preparedness among Arctic nations may also be helpful.

Enhanced environmental protection and stricter emission standards are to be implemented to enforce stringent emission controls for ships operating in the Arctic, similar to those in designated Emission Control Areas.[8] Rapid response teams and equipment may be established and maintained for "Spill Response Preparedness" strategically located along major shipping routes to quickly address oil spills and other environmental emergencies. The "Marine Protected Areas" must be designated to conserve critical habitats and biodiversity hotspots. Ensure that shipping routes avoid ecologically sensitive areas.

Research may be extended to the long-term impacts of climate change on Arctic ice conditions and navigability, including seasonal variations and extreme weather events. As a result, initiatives must be made to create plans for governments and shipping firms to adjust to evolving circumstances, including new ship designs and operational procedures. It is possible to improve the safety and effectiveness of Arctic navigation by investigating icebreaking technology further for innovations and different approaches to managing ice. Analyses of autonomous and remotely operated vessels' potential for Arctic shipping, as well as its consequences for environmental preservation, safety, and security, can also be conducted.

Local and indigenous knowledge promoting research that integrates indigenous knowledge and perspectives on Arctic security and environmental management is also urgently needed. This covers local environmental monitoring as well as conventional navigation techniques. Frameworks for improved participation of indigenous communities in the formulation of Arctic shipping and security policy may be created as part of stakeholder engagement.

The analysis of economic and geopolitical dynamics to explore the geopolitical implications of the resource competition in the Arctic can consider the possibility of conflict along with the chance of cooperation between the Arctic governments and other international powers. The economic impact studies are thus critical in the analysis of the possible consequences of the augmented Arctic shipping on the regional economies, indigenous lifestyles, and the international trade trends.

Such a multinational event is very important in enhancing cooperation and dealing with issues concerning the Arctic governance, environment conservation and sustainable development. The crucial aspect in preserving the Arctic habitats and species is to use sustainable management and conservation laws. In order to address this problem, a multimodal solution that implies international collaboration, local adaptation strategies, legislative flexibility, and scientific research is needed. The future of the Arctic has long term consequences with the world climate action being very urgent.

5. CONCLUSION

Shipping traffic has also risen due to the melting of the Arctic Ice and this has been accompanied by the risk of marine accidents, collisions, groundings and other environmental threats such as as oil spills. As the Arctic ecology is especially vulnerable to pollution and other impacts of the growing shipping, the environmental protection should be gradual. Search and rescue (SAR) operations in the extreme Arctic must address some of the problems which are specific to this area and require increased equipment and skills. The importance of the Arctic region as a strategic factor is also increasing, and it can result in the escalation of geopolitical tensions and the necessity of the international community to collaborate in order to solve security problems. Although there are measures that have enhanced the safety like the use of the icebreaker fleet by Russia, others

[8] Generally abbreviated as ECAs

like the Northern Marine Transportation Corridors plan by Canada indicate that there is need to have extensive measures that consider the infrastructure and management systems. Different stakeholders of the Arctic such as the coastal states, the indigenous communities, and global bodies have their own advantages and disadvantages in terms of approaches to the provision of Arctic security. It is important to deal with the security consequences of shrinking Arctic ice due to a number of reasons, the first being the safety of ships, economic stability, geopolitical stability, and environmental safety. Owing to its strategic value, the Arctic should be worked on through the collaboration and diplomacy in order to secure the sustainable peaceful utilization of the area and to prevent the conflicts. The necessity to implement active and concerted measures related to the safety and sustainability of the Arctic trade routes and marine passages could not be overestimated. Due to the higher accessibility of the Arctic as a result of climate change, infrastructure should be enhanced, the global cooperation should be reinforced, the representatives of local communities should not be excluded, and innovation and research should be promoted. Through these measures, the international community will have succeeded in ensuring that the opening Arctic waters will remain navigable in a safe, sustainable and peaceful process that will protect the region to the generations to come and enjoy its numerous benefits in a responsible manner.

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