The Arctic Sea Routes: Marine environmental impacts on effect of the climate change and opening of its sea passages for international shipping traffic

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Abstract

The Arctic Sea Routes (ASR) can potentially halve the distance between the Far East and Europe. Due to climate change and the related dramatic ice cap melting, the opportunity for the route to be used has potentially increased accordingly, both the shipping industry and the environment will be affected.

Ships’ traffic is expected to increase as both NW European and Far Eastern countries are expected to benefit from using these routes. In addition, the Arctic region would become destination for trade as it is rich in natural resources. Consequently, due to the anticipated transit and the trade boom there will be some environmental consequences, as there will be a need for ships to dispose of oil residuals, garbage, sewage, and to manage its ballast, inter alia.

Actually, unlike Antarctica, the ASR are not well covered by international pollution prevention instruments, or even considered Special Areas (SA) under MARPOL convention. In this paper, an outline of the major threats to the natural environment of the Arctic as a result of the main pollutants causes will be given, and the feasibility of applying pollution combating techniques in such an environment will be overviewed. In conclusion, it is argued that there is a need to organize an international regime to regulate environmental protection in the Arctic.

Key words:
Climate change, Arctic Sea Routes, operation and accidental pollution, environmental protection conventions, oil combating techniques in ice-infested waters.
1. Introduction

Hidden at the top of the world, far away from noise and crowds lies a pristine area, where wilderness and beauty is unique in that it is largely untouched by human beings that has been referred to as the future Mediterranean (Chalecki, n.d.). The Arctic is commonly defined as the area north of the Arctic Circle of latitude 66°32'N that includes the area of the midnight sun (Orheim, 2003) as shown in the political map in Figure 1. The Arctic sea area is one of the most affected areas of climate change; it is warming up significantly nowadays. Melting of the sea ice there has activated the dream of using the ASR in shipping traffic the trip distance between East and West may be significantly reduced (Kitagawa, 2001).

Figure 2 shows a prediction of the shrinking of summer sea ice in the Arctic region up to the year 2095, as per a Canadian prediction model, where it is very obvious that there will be an ice free area allowing shipping to have a better opportunity to navigate through the Arctic without ice breaking assistance.
The focus of this paper on the Northern Sea Route (NSR), formally known as the Northeast passage, as it is the first to be ready for longer periods of navigation on effect of the climate change (Reykjavik, 2004 & Norwegian Atlantic Committee [NAC], 2006). As a result, shipping traffic is expected to increase as Russia, Norway and most of the NW European countries are expected to benefit from using this route in trading with the Far East. Likewise, Japan and most of its neighbouring countries are expected to benefit from the routes in the container and other types of trades. For example, petroleum trade between Norway and Japan is expected to ascend if the route is properly used. Even the passenger traffic is expected to grow, especially in the tourism sector.

The NWP is not anticipated to become a competitive alternative to the Southern routes within the next decade, or even decades, as per the Canadian commercial marine transport industry. However, it was found that the North West Passage (NWP) became accessible to ships without icebreaker escort in August 2007, and there were at least 3 successful crossing in the same year (Kitagawa, 2008).
Figure 3 shows both the NSR and NWP with the summer sea ice extent in 2004 which also proves, at least, the NSR’s readiness for navigation.

2. **Objective of the study**

In particular, the Arctic Ocean is not considered a Particularly Sensitive Sea Area (PSSA) or even as a SA for any Annex of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL); unlike Antarctica, the Arctic has no treaty to regulate the subsequent environmental concerns (Stares, 2008). The anticipated ship traffic boom, will most probably result in significant environmental consequences as there is no rule to prevent ships from disposing their different types of wastes into the sea, except Article 234 of the United Nations Convention on the Law of the Sea (UNCLOS) and the different national laws of the coastal states that may differ from one country to another, which may be based on MARPOL. Accordingly, there is a need to organize unified international rules to regulate environmental protection in the Arctic.

Consequently, this study aims to emphasize the following:

- To identify the effect of climate change on the Arctic routes in the coming decades.
- To show the increased possibility of using the ASR in international shipping.
- To illustrate the vulnerability of the Arctic environment due to increased ship traffic.
- To describe and discuss the lack of international instruments to regulate environmental protection of these routes.
- To make proposals and recommendations for an international regime to monitor and regulate protection of the environment for the Arctic area.

3. **The consequences for the shipping industry**

Among some other consequences studied in the original research paper, only economical, demand on ice class ships and new ship design are introduced in this summary paper.
3.1. Economical aspect

Reducing trip distance has always been an attractive practice for the stakeholders of the shipping industry to reduce voyage time and increase profits. Climate change increases the hope of using the ASR for navigation as it can potentially halve the distance between the Far East and Europe, as will be discussed later. The NSR can save 35% to 60% of the distance of commercial voyages between the Far East and Europe, instead of passing through the Suez or Panama Canals (Mulherin, 1996), as shown Figure 4.

In order to show the commercial importance of the NSR, a comparison calculation was done for an imaginary trip between Norway, the oil exporter, and Japan, the major oil importer, using both the ordinary route and the NSR. The saved distance will be 6607 NM. when using the NSR, which means more than a 43.2% savings in distance (Couper, 1983; "Veson Nautical distance 2004," 2004). Table 1 shows the differences in the distances and sailing periods between using the ordinary convenient Suez Canal route and NSR with a presumed speed of 14 knots, which means a saving of about 15 sailing days.

<table>
<thead>
<tr>
<th>Port of departure / destination</th>
<th>Distance in n.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Via Suez canal</td>
</tr>
<tr>
<td>Oslo / Murmansk</td>
<td>-</td>
</tr>
<tr>
<td>Murmansk / Provideniya</td>
<td>-</td>
</tr>
<tr>
<td>Provideniya / Tokyo</td>
<td>-</td>
</tr>
<tr>
<td>Oslo / Tokyo (Total)</td>
<td>11,623</td>
</tr>
<tr>
<td>Sailing days / 14 knots</td>
<td>34.62</td>
</tr>
</tbody>
</table>


3.2. A booming demand for ice class ships

A dramatic increase in the new orders of ice-class ships equivalent to nearly 3 times the world's current fleet in tonnage is expected due to recent development on the NSR. In
In 1992 only 3% of the world’s tanker fleet had some ice class requirements. This is expected to increase to 10% or 18 million tons in 2008. Table 2 shows the orders of ice-class tankers of the year 2006 in respect to the number of ships and their dwt. A dramatic increase of about 63% in class 1A or higher ships carries more than a 28% increase in the dwt. Moreover, the total ice-class fleet will increase in number by about 24% in number and 66% in dwt., while the total tanker fleet will increase by more than 22% in number and 1.5% in dwt. (NAC, 2006).

### Table 2: Ice-class tankers in operation and on order worldwide Deadweight tonnage (DWT)

<table>
<thead>
<tr>
<th></th>
<th>Current fleet</th>
<th>On order</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>dwt</td>
</tr>
<tr>
<td>Class 1A / higher</td>
<td>262</td>
<td>4.2 m</td>
</tr>
<tr>
<td>Class 1B / lower</td>
<td>735</td>
<td>19.3 m</td>
</tr>
<tr>
<td>Total ice class fleet</td>
<td>997</td>
<td>23.5 m</td>
</tr>
<tr>
<td>Total tanker fleet</td>
<td>5825</td>
<td>344.0 m</td>
</tr>
</tbody>
</table>

Source: (NAC, 2006)

### 3.3. Development in of ice-class ships design

A unique new Double Acting Ships (DAS) design that can operate in both open and ice-infested waters depends on the ship’s stern “frame” in breaking the ice (NAC, 2006), as shown in Figure 5-A where a tanker ship is moving astern in 80 cm. ice to break it at 5 knots (Wilkman, n.d.). There are only a few ships already using DAS, such as “The tankers Uikku and Lunni which have made several voyages in the Northern Sea Route” (Juurmaa, Mattsson, & Wilkman, 2001). These ships are propellered with the recently invented AZIPOD propulsion system as shown in Figure 5-B (Wilkman, n.d.).

![Figure 5-A: A tanker ship using DAS in breaking the ice and steering astern.](image1)

![Figure 5-B: DAS ship with Azipod moving astern to break an ice layer.](image2)

Source: (Wilkman, n.d.)
4. **Vulnerability and significance of the Arctic area environment**

Arctic organisms and ecosystems are not necessarily more vulnerable than those of other regions. However, their vulnerability lies primary in some particular characteristics, hence, Arctic organisms may be considered as sensitive to certain human impacts. These characteristics are:

- Any damage to a key species in transferring energy to higher food chain animals may lead to significant impact on these animals, as well as the entire ecosystem;
- Storage of energy as fat would be contaminated. Such contaminants enter the food chain with the primary producers, my reach toxic levels amongst predators such as polar bears;
- Effective uptake of nutrition would results in a rapid uptake of fat-soluble substances, including contaminants even in the lower species;
- A concentration of animals in limited areas makes them more vulnerable to pollution of the sea surface such as oil spills;
- Pollution may cause high adult mortality that can result in long lasting impairment of a population as most animals live long and produce few young;
- Pollution in the Arctic regions would result in physical disturbance/fragmentation that may alter or constrain the animals’ natural movement affecting their use of the area because many Arctic species, especially mammals, need large, undisturbed territories and home ranges for food, breeding and shelter demands, *inter alia* (Working Group on the Protection of the Arctic Marine Environment, 1996). Consequently, the NSR may be subject of both operational and accidental pollution that may carry significant consequences to such environment.

4.1. **Continual pollutants impact**

Most factors impacting the marine environment are related to operational and/or accidental pollutants. The anticipated boom in shipping traffic may make the NSR extremely vulnerable to pollution threats such as exhaust, sewage and garbage which will be considered continual pollution sources. Perhaps a vast majority of ships operating in the NSR are already equipped with such pollution prevention requirements. Yet, not all the requirements are implemented, such as water pollution from daily activities such as cooking and showering which are considered a minor threat to the environment and are not included in the national regulation requirements (Kitagawa, 2001). However, it may be necessary to include such regulations on the future. Perhaps it may be necessary to require newly transiting ships to apply international requirements under new rules as
PSSAs do. Table 3 shows the different types of waste according to type of ship and the severity of the pollution with an increase in ship numbers.\(^1\)

**Table 3: Estimated ship waste volumes.**

<table>
<thead>
<tr>
<th>Type of ship</th>
<th>No. of ships</th>
<th>Dw (10^3)t</th>
<th>Size of crew</th>
<th>Ship waste volumes</th>
<th>Source: (Kitagawa, 2001 &amp; Ostreng, 1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oily water</td>
<td>Sewage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Water m(^3)/day</td>
<td>Oil kg/day</td>
</tr>
<tr>
<td>Container carrier</td>
<td>3</td>
<td>5.7</td>
<td>35</td>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>41</td>
<td>4.0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>20</td>
<td>41</td>
<td>4.0</td>
<td>80</td>
</tr>
<tr>
<td>Timber carrier</td>
<td>84</td>
<td>10</td>
<td>21</td>
<td>2.5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>38</td>
<td>21</td>
<td>2.0</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>21</td>
<td></td>
<td>1.3</td>
<td>25</td>
</tr>
<tr>
<td>LASH</td>
<td>2</td>
<td>34</td>
<td>77</td>
<td>6.0</td>
<td>120</td>
</tr>
<tr>
<td>Dry cargo ship</td>
<td>27</td>
<td>20</td>
<td>41</td>
<td>4.0</td>
<td>80</td>
</tr>
<tr>
<td>Reelcr</td>
<td>3</td>
<td>3</td>
<td>31</td>
<td>1.3</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>46</td>
<td></td>
<td>3.6</td>
<td>70</td>
</tr>
<tr>
<td>Tanker</td>
<td>20</td>
<td>6</td>
<td>36</td>
<td>1.9</td>
<td>40</td>
</tr>
<tr>
<td>Multipurpose ship</td>
<td>46</td>
<td>5.0</td>
<td>31</td>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>57</td>
<td>2.5</td>
<td>50</td>
<td>5.7</td>
</tr>
</tbody>
</table>

According to the IMO, the average annual frequency of accidents for ships of 6000 registered tonnes or more is 31% for collisions with ice or other ships, and 41% for groundings. Table 4 estimates the oil spill quantity in the NSR, as an example, assuming that an average of 1/48 of the carried oil quantity is spilled in each accident, based on the upon probabilistic approach.

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\(^1\) The Table excludes the passenger ships which are considered a major waste producer.
### Table 4: Estimated oil Spill Quantity in the NSR².

<table>
<thead>
<tr>
<th>Arctic Region</th>
<th>Transformed quantity per year (1,000 tons)</th>
<th>No. of Journeys per year</th>
<th>Risk 1000 journeys</th>
<th>No. of spill-accidents per year</th>
<th>Spill quantity/year (tons)</th>
<th>Average spill quantity (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of the NSR</td>
<td>392,401</td>
<td>50</td>
<td>0.4</td>
<td>0.02</td>
<td>3.3</td>
<td>163.5</td>
</tr>
<tr>
<td>West Region</td>
<td>166,893</td>
<td>23</td>
<td>0.25</td>
<td>0.006</td>
<td>0.9</td>
<td>151</td>
</tr>
<tr>
<td>East Region</td>
<td>225,508</td>
<td>27</td>
<td>0.25</td>
<td>0.007</td>
<td>1.2</td>
<td>174</td>
</tr>
</tbody>
</table>

Source: (Ostreng, 1999 & Kitagawa, 2001)

#### 4.2.1. Long-term impacts of oil spills

The 1989 Exxon Valdez oil spill (EVOS) in Prince William Sound, Alaska has persisted far beyond initial forecasts that would last long in such environment due to slow biodegradation in the area. In 2005, EVOS oil was found still toxic under beaches across the spill impact area; and scientists predict that this subsurface oil may persist for more decades ahead (World Wide Fund for Nature [WWF], 2007). The EVOS has left oil residues as shown in the photograph in Figure 6. The photo was taken in 2001, 12 years after the EVOS occurred, in an excavated hole on an impacted beach.

In addition, after nearly 40 years an oil spill from a grounded barge in Cape Cod that spilled 1/54.5 of the amount of the EVOS, is still damaging the health of the salt marsh and impacting the crabs and grass beds; the crabs have been observed to show signs of toxic impacts from the 4 decade old oil (Smith, 2007 & WWF, 2007).

![Figure 6: The presence of EVOS oil in an excavated hole on an impacted beach after 12 years from the spill.](image)

Source: (WWF, 2007 as retrieved from Culbertson, et al., 2007)

#### 4.3. Russia radioactive waste in the Arctic

For six decades or more there were environmental breaches such as ‘strip mining, oil spills, forest clearing, overfishing, and the improper disposal of radioactive material’²

² The calculation does not include the extraordinary events that might occur during operation.
which have affected severely the polar areas, to a limit perhaps beyond repair (McCannon, 1998). The Ex-Soviet Union dumping of radioactive waste disclosure in the Barents and Kara Seas is among the main reasons for such environmental breaches. Actually, it is well known now that the Northern Fleet and the Murmansk Shipping Company has carried out such dumping operations for decades\(^3\). It is also known that the total radioactive wastes dumped into the Arctic seas in the Soviet Union era is double the quantity compared to all the previously known worldwide dumping. Such radioactive wastes descend from nuclear vessel reactors which still contain high-level paid out fuel (Stokke, 2000)\(^4\).

5. Feasibility of applying oil spill combating techniques in ice-infested waters

It is not easy to choose which combating technique should to be applied in ice-infested waters. In some instances, ordinary oil spill combating techniques could be applied in the Arctic environment, whereas in others, alternate techniques may be necessary due to the significance and fragility of the area. The Arctic area is extremely fragile to pollution as the cold climate reduces the biodegradation process, therefore, some oil residue may be found under ice layers for decades. In addition, oil spilled in high ice concentration areas may be naturally contained by the ice (WWF, 2007).

Therefore, there is no single perfect oil spill response solution in ice-infested waters. Although, in-situ burning and mechanical recovery technologies have shown some limited effectiveness in ice-infested waters, there are still some drawbacks to be found. However, chemical dispersants are considered promising\(^5\) for treating oil spills in ice-infested waters but further study is needed to establish their applicability (DeCola, Robertson, Fletcher, & Harvey, 2006).

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\(^3\) The Murmansk Shipping Company is company operating 7 nuclear powered icebreakers engaged in keeping the NSR open for navigation particularly the west part of it between Murmansk and Dudinka.

\(^4\) At least it is documented in 1993 that about 16 nuclear reactors have been dumped in the Kara Sea since the 1960s, and due to failure in removal of the spent fuel before dismantling 7 of them are considered dangerous. The northern fleet dumped low and medium level solid waste in flimsy containers which are subject to corrosion. In addition the Barents Sea saw disposal of liquid wastes used in 'cooling, incineration, or deactivation installation’ since the mid 1960s (Stokke, 2000).

\(^5\) *Alaska decision makers have agreed through pre-approvals that dispersants are a viable response tool* (Morris, 1998, pp. 12, 20).
Dispersants are a group of chemicals sprayed on oil slicks using spray nozzles, pumps and hoses applied and monitored from a vessel or aircraft, as shown in Figure 7 (WWF, 2007).

Table 5 shows the result of a laboratory work done in weathered north slope crude treated with plenty of dispersants at 0°C and 10°C\(^6\) (Ross, 1998). The efficiency of these dispersants seems to be increased; the dispersants products of A, B, D, E showed significant increase varied from 2% to 15% while the efficiency reduction happened only in the products C, F, G and varied from just 1% to 4%.

<table>
<thead>
<tr>
<th>Dispersant type/ temp.</th>
<th>50°F</th>
<th>32°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>60</td>
<td>62</td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>C</td>
<td>64</td>
<td>63</td>
</tr>
<tr>
<td>D</td>
<td>46</td>
<td>49</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>F</td>
<td>35</td>
<td>33</td>
</tr>
<tr>
<td>G</td>
<td>82</td>
<td>78</td>
</tr>
</tbody>
</table>

Source: (Ross, 1998 as retrieved from Byford et al. 1983)

6. Recommendations
There is a real need to build and maintain stable, well functioning navigation service infrastructure along the NSR; for example, Traffic Separation Schemes (TSS), port reception facilities and multiple shipping services.

Adoption of such precautionary measures may include but are not limited to the following:

\(^6\) 0°C (32°F) and 10°C (50°F).
• Extended limit of territorial sea is possible for 20 nm for more surveillance and environmental control;
• Vessel Traffic Service (VTS);
• TSS including, Automatic Identification System (AIS) coverage through stations
• Electronic Chart Display and Information System (ECDIS) to allow better tracking and monitoring of vessels in the vicinities;
• Tow-vessels to be placed at strategic locations;
• Places of refuge and beaching;
• Control of exhaust emissions to air;
• Management of oily wastes, sewage and garbage including reception facilities; and;
• Ballast-water management;
• Measures related to loading and unloading of cargo, and
• Contingency management and planning regime including environmental risk analysis and oil-spill contingency assessment (International News and Analysis Marine Protected Areas [MPA news], 2002).

6.1. A PSSA within the NSR
A PSSA has a broad protection profile offering a comprehensive approach to seeking better monitoring and awareness from the shipping industry, and has been in existence since 1991. It is defined as an area that requires special precautions to be taken because of its significance for recognized ecological, socio-economic, or scientific attributes that may be vulnerable to damage by international shipping activities, in order to prevent, reduce, or eliminate the threat or identified vulnerability (IMO, 2006). ‘For all the reasons mentioned above, the NSR is a prime candidate for consideration as a PAAS, or at least some significant parts of it, such as the proposed Norwegian project for some parts of the Barents Sea shown in Figure 8. The Areas indicated in gray are suggested traffic

Figure 8: A Proposal to Designate a PSSA in the Northern Norwegian Sea and the Barents Sea.
Source: (Igor V. Stepanov, Peter Ørbech, & Brubaker, 2005)
separation scheme areas while the areas hachured in red are of high environmental vulnerability (Igor V. Stepanov et al., 2005).

6.2. The NSR as a SA under MARPOL 73/78
MARPOL defines a SA as an area in which the adoption of special mandatory methods for the prevention of sea pollution are required for technical reasons relating to their oceanographical and ecological condition and to their sea traffic. These SAs are attributed a higher level of protection than other areas of the sea (IMO, 2008). To have the designation of SA would indeed help to protect the vulnerable NSR and the surrounding area.
Although, the Arctic countries have voluntarily agreed to implement MARPOL's SA's requirements for ships sailing in Arctic waters (Ostreng, 1999), this does not mean that there is no need to formally consider the ASR, or at least parts of it a SA under the MARPOL Annexes.

6.3. MPAs in the NSR:
Banning transit and exploration activities in an area is another alternative for protecting sensitive environment. Some of these sensitive environments may be excluded from petroleum activities such as the Lofoten Islands in northern Norway, which were considered petroleum-free in December 2003. Furthermore, the NSR may be treated the same as the Antarctic where it is prohibited to discharge any oil or waste from ships under MARPOL Annexes I and V.


References


