ARHC2-04C

Analyse&Strategi
Del av MULTICONSULT

Marine Traffic in the Arctic

A Report Commissioned by the Norwegian Mapping Authority

Analyse & Strategi
Postboks 265 Skøyen
0213 Oslo

Contents:

Foreword

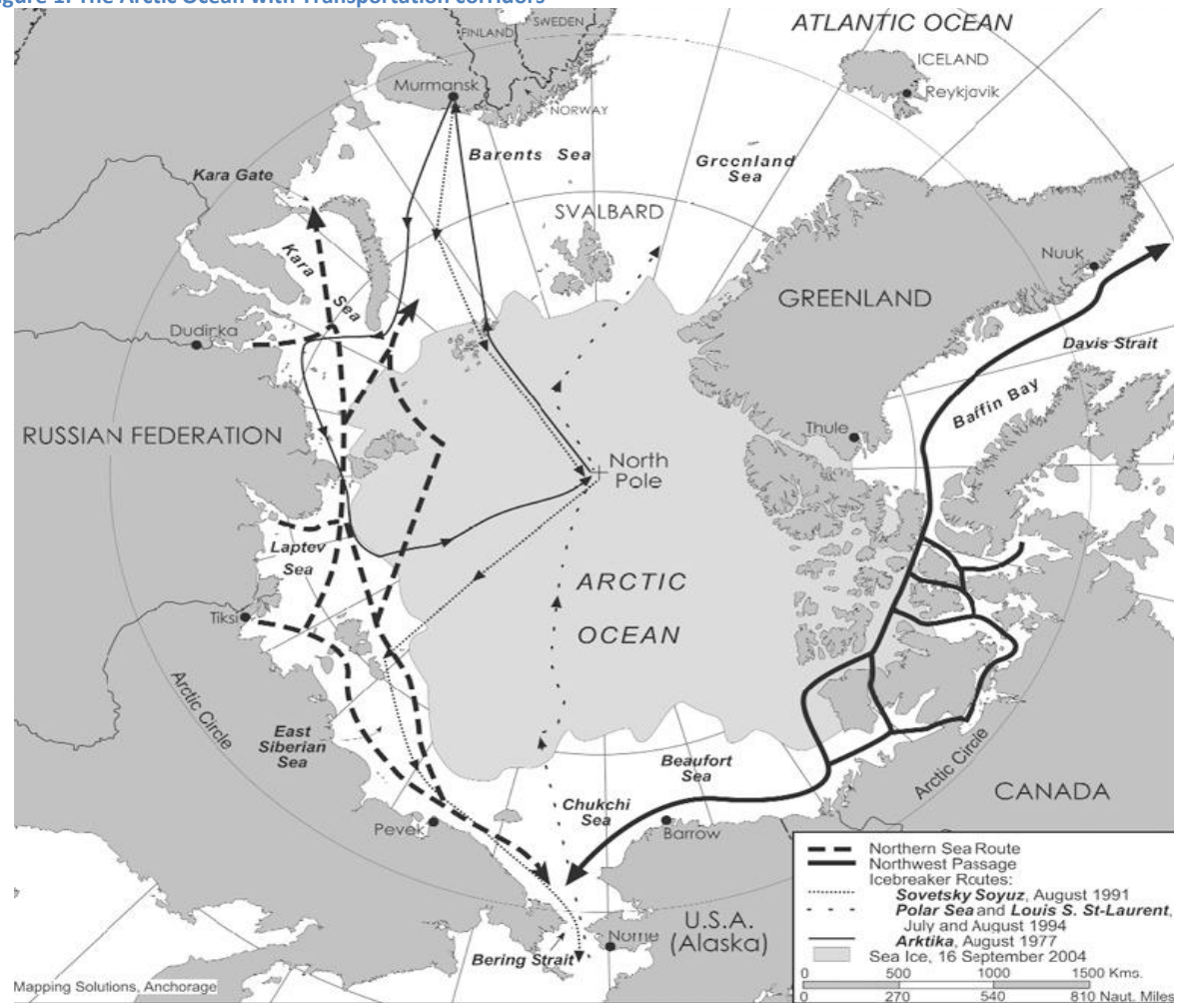
This report is produced by Adviser, Karl Magnus Eger at Analyse & Strategi AS on behalf of the Norwegian Mapping Authority. The study is empirical and highly fact oriented, based on secondary material stemming from INSROP, AMSA, ARCOP etc. All of which have a broad focus on Arctic shipping and the challenges related to transportation in these waters. Further recommendations for in depth studies are presented in chapter 4 of this report.

Oslo, 15. August 2011

1 The Marine Traffic Corridors of the Arctic Ocean[1]

The Northeast Passage (NEP) and the Northwest Passage (NWP) are often perceived as coastal sea lanes, connecting ports in the Pacific and the Atlantic, whereas the Trans Polar Passage is assumed to be a mid-ocean route across the North Pole to and from ports in the Pacific and Atlantic.

Figure 1: The Arctic Ocean with Transportation corridors[2]



Due to the presence of sea ice neither of these transportation passages can offer ships a single set channel to follow. In practice, ships are forced to follow the channel that offers the best ice and navigational conditions at any one time and place. Thus, each and one of them are more like broad transportation corridors stretching out in the North-south direction, containing several alternative navigational channels and fairly huge expanses of ice infested waters. The corridor feature of these passages implies that they occupy broad stretches of waters that under certain specific circumstances and on occasions make them overlap and interact. In sum, the three corridors occupy the whole of the Arctic Ocean, which covers an area of 14.75 million square kilometers and carries a vo-

[1] This report is compiled by Karl Magnus L. Eger, Analyse & Strategi AS, (www.analysestrategi.no)
[2] Mapping solutions, Lawson Btrigham, USARC Anchorage 2006

lume of 18 million cubic kilometers of water.[3] This report will not focus on the Trans Polar Passage. No commercial cargo ship has yet crossed the central Arctic Ocean. There are huge uncertainties as well as variations between different climate models trying to predict the development of ice conditions. In terms of any regular shipping on these routes, however, simulations indicate that the ice will be too heavy and the calculated costs too high for any regular transport. Models indicate that the ice conditions will continue to be heavy during winter and spring seasons, even in 2050, and the route is not expected to be completely ice free in summer.[4]

In terms of operating conditions and shipping opportunities, both the NEP and the NWP faces large water depth variations and complex archipelagos which put constraints on the technical construction and capacity of the vessels operating on these corridors. Moreover, the sea ice conditions vary significantly both between and within each of the three passages presenting different challenges to navigation on the NEP and the NWP. From a navigational point of view, the NWP will be the last area where the multiyear ice will disappear and shipping through this Passage will remain risky even in the summer season. Currently, the NEP seems to offer the best operating conditions for commercial shipping activities during summer season.[5]

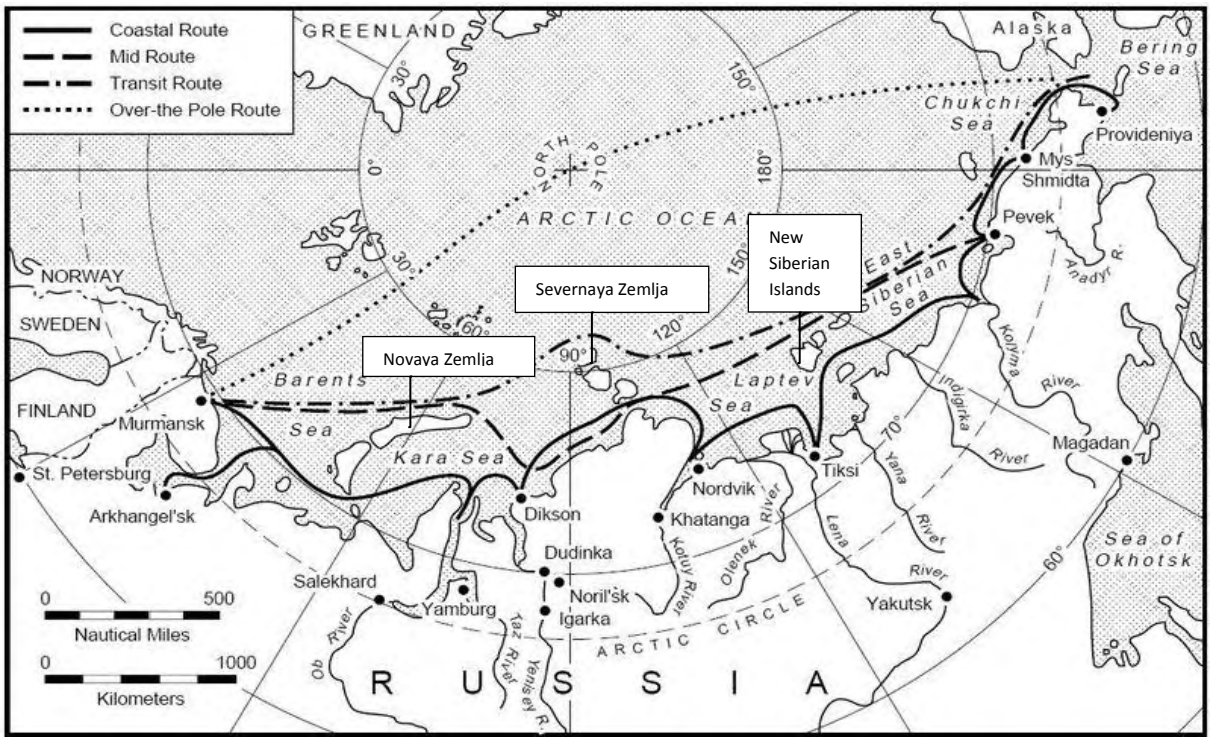
The purpose of the following sections is threefold: Firstly, to examine the NEP, the NWP and connecting corridors on the basis of their geographical features, their interrelations and eventual overlaps. Secondly, to consider the transportation routes in light of climate change and various physical characteristics (i.e. narrow straits, depth restrictions and alternative traffic routes). Thirdly, to give an overview of current and expected traffic patterns on the Arctic sea routes. This section will also add an overview of Arctic Cruise traffic.

1.1 The Northeast Passage (NEP) and the Northern Sea Route (NSR)

According to political perception and legal regulations in Russia[6], the NSR stretches from Novaya Zemlya in the west (meridian 168 degrees 58 minutes and 37 seconds west) to the Bering Strait in the east (parallel 66 degree north) (see Figure 1 and 2). The establishment of the NSR as a separate part of the NEP was decided by the Council of People's Commissars of the USSR on 17 December 1932, which marks the beginning of the NSR as an administered, legal entity under full Soviet jurisdiction and control. It comprises the main part of the NEP which, with the addition of the waters of the Barents Sea, connects the Atlantic and Pacific Oceans along the entire length of the northern coast of Eurasia. The NSR is a series of different sailing lanes, and ice conditions at any one time and place will decide the sailing course to be set. The route covers some 2200 to 2900 nautical miles of ice-infested waters. It consists of a series of marginal seas – the Kara Sea, the Laptev Sea, the East Siberian Sea and the Chukchi Sea – which are linked by some 58 straits running through three archipelagos – the Novaya Zemlja, the Severnaja Zemlja and the New Siberian Islands (see Figure 2).[7]

[3] Østreng (2010), p. 25-26
[4] Det Norske Veritas, Arctic Container Project, (2009)
[5] Eger (2010), p. 275
[6] Правила плавания по трассам северного морского пути, утверждены Министерством морского флота СССР 14.09.1990. (Regulations for Navigation of the Sea Ways of the NSR of 1990)
[7] Østreng (2010), p.26-32

Figure 2: Map of the Northern Sea Route[8]



At times, surface vessels operating in convoys are forced to proceed north of the large island masses due to the accumulation of pack ice in the straits[9], which may be clogged with sea ice. Ice conditions are in general more difficult along the eastern extremity of the route than in the west. The eastern sector is also the part of the route with the most shallow shelf areas. The East Siberian Sea has an average depth of 58 meters and the Chukchi Sea of 88 meters. The shallowness of the shelf is the most pronounced in the straits, with minimum depths of 8 meters.[10] This affects the size; volume and draft of ships. The ocean areas west of the Yamal Peninsula are fortunate in having a slightly deeper shelf and lighter ice conditions in average than the eastern sector. This is partly due to the circumstance that the Kara Sea is to the north surrounded by several archipelagos (See figure 2), which usually prevent heavy multi-year ice from the Central Arctic Ocean from penetrating into these waters. Multi-year ice, which is extremely hard and consequently a serious obstacle to navigation, has survived the summer melt season and is typically 1 to 5 meter thick.[11] The eastern sector lacks this kind of land protection and is more open to the influx of multi-year ice from the Central Arctic Basin. However, even in the East ice conditions are changing due to global warming. Here, new extreme minima of summer ice extent have been established repeatedly ever since 1979.[12] However, during the resent summer seasons large tankers, as the Panamax tankers chartered by the Russian gas company Novatek, are now using the route north of the New Siberian Islands. This route makes it possible to use tankers with a draught of over 12 meters [13]

[8] Source: INSROP (1999)
[9] Jørgensen (1991), pp. 77-89
[10] Brubaker and Østreng (1999)
[11] AMSA (2008), p. 178
[12] Weller (2000), p. 43, AMSA (2009), p 23
[13] www.barentsobserver.com (august 2011)

1.2 The Northwest Passage (NWP)

The Northwest Passage is the name given to a set of marine routes between the Atlantic and Pacific Ocean, spanning the straits and sounds of the Canadian Archipelago, the Davis Strait and the Baffin Bay in the east and the Beaufort Sea in the west. Like the Northeast Passage it is a transportation corridor channeled through islands occupying broad expanses of water and land in the north-south direction. The base of the archipelago stretches some 3000 km along the mainland coast, and the tip of Ellesmere Island is less than 900 km from the geographic North Pole. The Archipelago is one of the largest in the world and consists of a labyrinth of islands and headlands of various sizes and shapes. There are 73 major islands of more than 50 square miles in area, and some 18 114 smaller ones.[14] If islets and rocks are included, the Archipelago comprises approximately 36 000 pieces of dry land above sea level, making it one of the most complex geographies on Earth.[15]

The Canadian Archipelago is subdivided into two main parts by the Parry Channel: the northern part consists of the Queen Elisabeth islands, whereas the southern part comprises all islands located north of the Canadian mainland and south of the Parry Channel. Thus, the most troublesome part of the NWP, as seen from a mariner's point of view runs through a continuous archipelago with narrow straits often jammed with impenetrable multi-year sea ice drifting in from the Central Arctic Ocean.

Figure 3: Map of the Canadian Archipelagoes[16]

The NWP consists of seven different routes of which six runs through the southern part of the archipelago (see Figure 4, 9 and 10).[17] Like the NEP, there is no single set channel for ships to follow. The navigation channel used is based on which of them offers the best sea ice conditions at any one time and place. Thus, the NWP is like the NEP a transportation corridor through one massive archipelago until it reaches open, but ice-infested waters in the Baffin Bay (east) and Beaufort Sea (west). From Baffin Island (east side) to Banks Island (west side) it covers a distance of about 2 400 kilometers, and

[14] Pharand (2007), p. 15
[15] AMSA (2009), p. 20
[16] Source: worldatlas.com
[17] For a detailed description of all seven routes see Arctic Marine Transport Workshop (2004), p. A-20

the size of this whole Archipelago is approximately 2,1 million square kilometers, i.e. about the size of Greenland.[18]

In recent summer seasons most of the archipelago was so called ice free, promising to open the NWP to high volumes of intercontinental commercial shipping. However, this warrants a comment on the *concept of ice-free*. Most Arctic shipping experts view this term as meaning ice-infested with icebergs, bergybits and growlers present, even in the summer period (See Appendix A for overview of various ice types). In fact, some believe shipping operations in this environment can be even more dangerous than in ice covered areas. From a mariners point of view it has been assumed that "…with less ice, more icebreaking capacity will be needed."[19] The reasoning goes as follow: "Initially, as first year ice weakens and/or disappears; its ability to keep multi-year ice out of shipping areas will be adversely affected.

This will mean that, even if there is less ice overall, it will be much harder, pose more of a damage risk and be more difficult to break the passage through.

Figure 4: Sailing lanes of the NWP

The inter-annual variability in sea ice conditions within the Canadian Archipelago will continue to be extreme. According to the Canadian Ice Service, "It is quite likely that the latter half of this century will still experience occasional summers with ice conditions as severe as those witnessed in the 1980s. Multi-year ice, particular in low concentrations, will present the major hazard to shipping…. Since the oldest and thickest ice in the Arctic Ocean is that which is driven against the western flank of the Canadian Archipelago, this will likely be the last multi-year ice to remain. As long as this remains a source of multi-year ice in the Arctic Ocean, it will continue to drift through the Canadian Archipelago."[20] M'Clure Strait between Melville and Banks Island (see figure 9 and 10) is one of the

[18] AMSA (2009), p.20
[19] Marr (2001), p. 1
[20] Falkingham (2004)

straits that have a fairly long history of being blocked with multi-year ice drifting in from the Central Arctic Ocean. In addition comes shallow waters and draft restrictions, narrow straits acting like chock points and the combination of the two, making navigation a regular and punctual activity hard to achieve. In the AMSA study the conclusion is clear: "Even during the most recent periods of reduced ice, the location of the ice, its thickness from year to year and the variability of ice-free areas makes it nearly impossible to schedule transit of vessels with any degree of certainty of reaching the desired port on schedule."[21]

1.3 Connecting Corridors

On the Atlantic side of the Arctic Ocean there is one corridor: The *Northern Maritime Corridor*, connecting the Northeast Passage to Europe and North America. On the Pacific side, the three Arctic corridors connect with one joint southern corridor: The "*Northern Pacific Corridor*" going through the Bering Strait connecting to the west coast of North America and North East Asia. These corridors are two-ways corridors made up by re-supply and destination Arctic shipping, and possibly in the long term, transit shipping.

1.3.1 The Northern Maritime Corridor

The Northern Maritime Corridor (NMC) stretches from the Whites Sea in the north, with partners in Murmansk, Nenets and Archangel regions, to multiple ports in the North Sea.[22] In our definition of the NEP, the NMC overlaps with the latter in the White and Barents Seas. In this definition, the NMC overlaps with the traditional geographical conception of the NEP, making the Barents Sea a definitional venue of four overlapping routes: the NEP, the NMC, the Kara Sea Route and the functional extension of the NSR (see Figure 5).

Figure 5: The Northern Maritime Corridor (NMC) – The Northeast Passage Connection

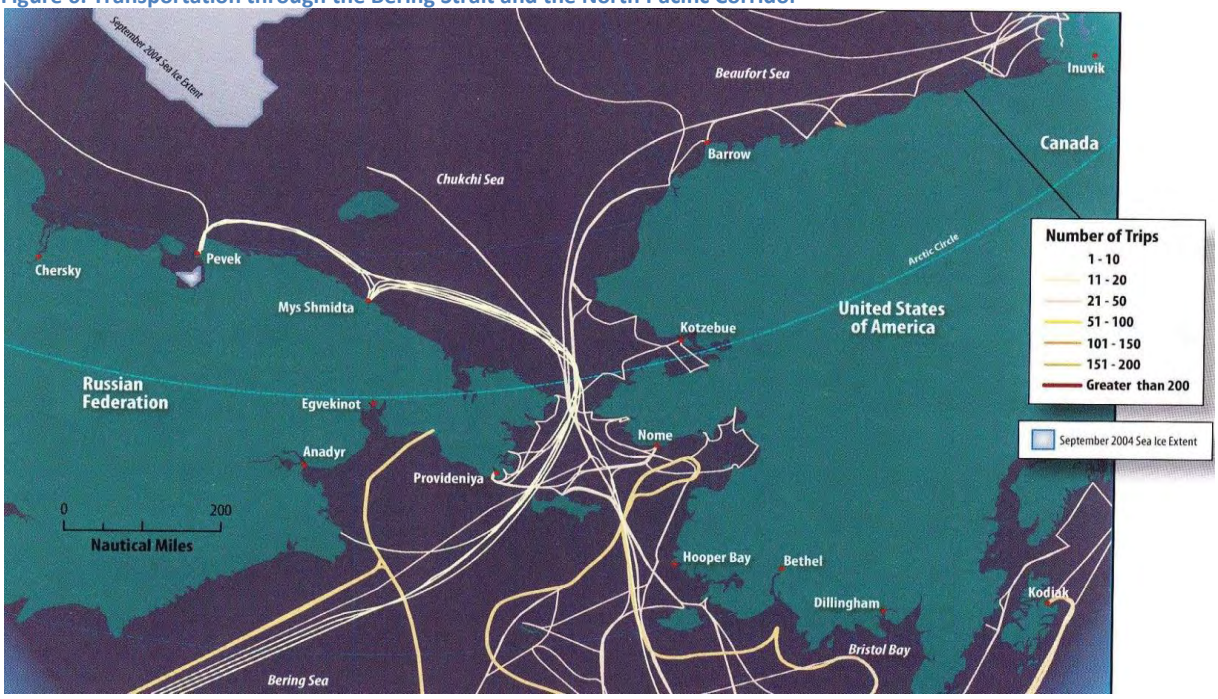
[21] AMSA (2008), p. 139
[22] Solheim, Hauge, Leknes (2004), p. 70

Marine transport of Russian oil through the NMC has been going on for some years, but increased dramatically in 2002. The oil comes from production sites in Western Siberia. As the existing pipeline from Siberia to southern Russia was oversubscribed at the time, oil was instead shipped by train to the White Sea, transferred to tankers and shipped on to the European market through the NMC. Oil production in Russia's Arctic deposits is expected to increase - some suggest a production level by 2021 of 55-65 million tonnes.[23] Crude oil, bunker oil and refined products are shipped out on small ice strengthened tankers from different ports in the White Sea to Murmansk were it is transferred to large tankers for export. The transport capacity was originally about 5,4 million tons a year, but is expected to triple and quadruple over a short period of time.

1.3.2 The Northern Pacific Corridor

The "Northern Pacific Corridor" on the Pacific has not yet been established or for that matter got an official name. For simplicity and for the purpose of this study we call it the *Northern Pacific Corridor* (NPC), which starts out in the Bering Strait, overlapping with the definition of the NEP on the Pacific.

Figure 6: Transportation through the Bering Strait and the North Pacific Corridor[24]



The Bering Strait is a narrow international strait that connects the Arctic Ocean to the North Pacific Ocean. It is the geographical venue of the NWP, NEP and NPC – a choke point through which all vessels have to pass to exit or access the Arctic Ocean on the Pacific (see Figure 6). At the straits narrowest point, the continents of North America and Asia are just 90 km apart. The biggest depth is 60 meters. In the land territory surrounding the strait there are three US ports: Nome, Kotzebue and the Red Dog mine harbour. Also on the Russian side the ports are located to the south of the strait. These are: Providenija, Anadyr and Egvekinot. The water depth in all these ports is less than 10 meter.[25] The closest U.S. harbour with deep water is Dutch Harbour at the Aleutians in the Southern Bering Sea. On the Russian side, the nearest deep water port is Providenija. Thus, the regional shortage of suitable and effective infrastructure is striking and in need of cost-intensive improvements (see Fig-

[23] Peresypkin, Yakovlev (2008), p. 4
[24] AMSA (2009)
[25] AMSA (2008), p. 144

ure 6). Current shipping activity in the area is based on community re-supply and destination Arctic traffic.

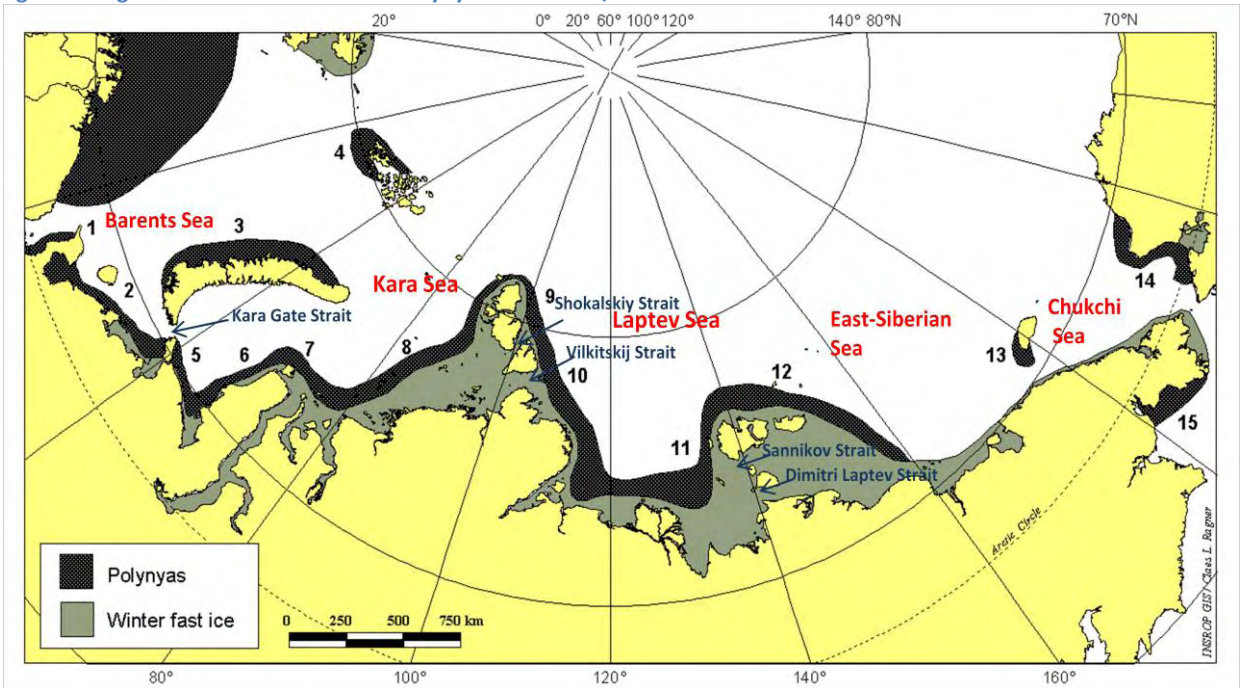
2 Operational Conditions and Marine Traffic in the Arctic Ocean

The two potential transport corridors share some of the same natural challenges. However, a set of detailed natural characteristics makes each corridor unique, as well as more or less favorable in terms of marine shipping operations. As described in the sections below, both the NEP and the NWP faces large water depth variations and complex archipelagos which put constraints on the technical construction and capacity of the vessels operating on these corridors. Moreover, the sea ice conditions vary significantly both between and within each of the two passages presenting different challenges to navigation on the NEP and the NWP.

2.1 Physical Characteristics of the Northeast Passage

When navigators are considering which shipping lane to sail through the NEP, the choice is strongly affected by the natural conditions. One of the primary factors when selecting a favorable shipping lane on the NSR is the distribution of sea ice. The ice conditions vary greatly between seasons, between years, and between the marginal seas. A major percentage of the recent NEP commercial shipping activities do not involve the NSR. Under normal conditions, winter navigation on the eastern NSR is not beneficial, and commercial operations are restricted to the summer season. Currently, the only year-round transport on the NSR is the Kara Sea Route, between the Port of Murmansk and the port of Dudinka.

Figure 7: Regions of Winter Fast Ice and Polynyas on the NEP/ NSR[26]



Polynyas: 1 – Cheshskaya, 2 – Pechora, 3- West Novaya Zemlya, 4 – Victoria Sea, 5 – Amderma, 6 – Yamal, 7 – Ob-Yenisey, 8 – West Severnaya Zemlya, 9 – East Severnaya Zemlya, 10 – Taymyr, 11 – Lena, 12 – New Siberian, 13 – Wrangel, 14 – Alaska, 15 – Anadyr

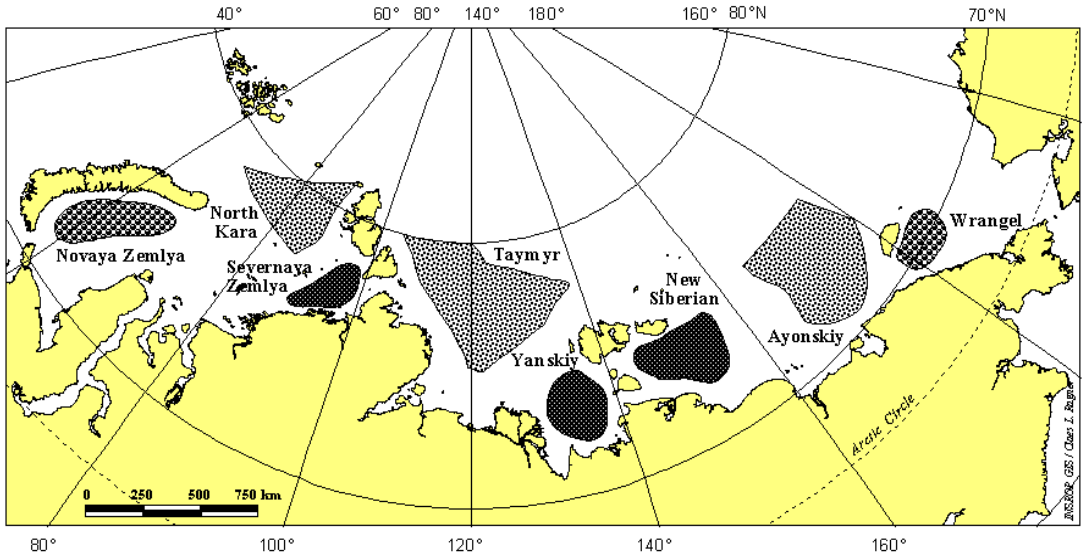
[26] Source: Ragner (2000)

All other transport is carried out only during summer. The summer season has traditionally been defined as June-October, but favorable ice conditions and technological improvements have gradually allowed an extended summer season. Navigation during the winter season (November-May) is generally much more difficult than in the summer season, due to the thicker ice cover. An important feature of winter navigation is the *fast ice* – stable, immovable ice which is fastened to the coastline. Fast ice is very difficult to pass through, and normally it is preferable to avoid it by using northerly routes. Nonetheless, if off-shore winds prevail, one will often during winter find open leads at the edge of the fast ice – so called *polynyas*, which are very suitable for navigation[27]

While the ports of Barents Sea is almost completely ice free even in the winter, no parts of the NSR are completely ice free even during the most favorable summer month (September). Each end of the NSR – the south-western *Kara Sea* and the south-western *Chukchi Sea* – has the lightest ice conditions, with the *East Siberian Sea* having clearly the most difficult ice conditions (see figure 7 and 8). This corresponds with navigational experience, where the East Siberian Sea has been seen as the most difficult sea to navigate, and also being the main bottleneck in terms of navigation. Moreover, the difficult conditions in the East Siberian Sea has to do with the *ice massifs*, consisting of multiyear ice, and which often extends almost to shore even during summer due to currents and winds.

Variations in water depth and narrow straits are other key factors that decide which navigation course to set on the NSR. Since most of the NSR consists of continental shelves, a major part of the corridor and especially the straits are shallow. Shoals depth less than 20m are by no means rare and increases the risk that deep-draft vessels may run aground. However, there are great variations between the marginal seas of the NEP. Although the western and eastern Barents Sea has depths of 100-300m, the *Kara Gate* (the main shipping strait between the Barents and Kara seas) is mere 20-30m deep. Furthermore, the Kara Sea has an average depth of 90m, but some areas, however, are as shallow as only a few meters. Of key importance to shipping on the NSR is that four straits require mandatory icebreaker escort, organized by the Russian Authority, Marine Operation Headquarters. This includes: the *Vilkitskii Strait*, the *Dmitri Laptev Strait*, the *Shokalskiy Strait* and the *Sannikov Strait*.

Figure 8: General Locations of Summer Ice Massifs on the NSR



Noted are three types of summer ice massifs: Multiyear ice from the Arctic Ocean (North Kara, Taymyr and Ayonskiy); local drift ice (Novaya Zemlya and Wrangel); and, fast ice remnants (Severnaya Zemlya, Yanskiy and New Siberian). Source: Ragner (2000)

[27] See Appendix A for an overview of various ice types.

The Vilkitskii Strait is a key NSR Strait between the Kara and Laptev seas. Although it has adequate water depth for deep draft vessels, it is mainly ice covered, except from a short period in the summer season. Thus, Shokalskiy Strait is a second possible route north of Vilkitskii Strait. The Laptev Sea has an average depth of 600m, but as one draws near to the New Siberian Islands the sea becomes shallower than 20m. The route alternatives between the Laptev and the East-Siberian are either through the *Dmitri Laptev Strait* or the Sannikov Strait. Both straits have minimum depths of 12-13m, a limiting factor in terms of maximum ship draught on the NSR. Long Strait links the East Siberian and the Chukchi seas. In this part of the NSR, draught should not be a problem for any ship that keeps well offshore from the mainland.

2.2 Physical Characteristics of the Northwest Passage

Sea ice conditions on the NWP are very complex. Observations of minimum sea-ice extent in the eastern and western regions of the NWP, illustrates the extraordinary inter-annual variability of the ice conditions. Although the trends in sea ice extent are negative in both regions over the period, the year to year variability is extreme and sometimes differs between the two regions. Although climate models for the Arctic, like the ACIA models, indicate a general retreat of sea ice throughout the 21 Century, the designated projection models provide no information on ice thickness (a critical factor for navigation). It is important to note that the horizontal resolution of these models (generally 200 kilometers) is not fine enough to take into account the complexity of the Canadian Archipelago. Hence there is more uncertainty when it comes to predicting future ice conditions in the NWP based solely on the output of climate models. [28]

There are potentially seven routes through the NWP. All of the routes starts out in the eastern part of the Parry Channel heading westward until six of them at different points along the channel breaks off and take a southerly direction to reach the coastal waters of the mainland before making a turn westwards towards the Beaufort Sea. The seventh route employ the Parry Channel in its entirety until it reaches the Beaufort Sea through the often ice clogged M'Clure Strait between Melville and Banks Islands. Of the six southerly routes, the most navigable to be employed by international shipping comprises the Parry Channel until it takes a southerly direction and goes through the Prince of Wales Strait between Banks and Victoria islands, and then west again along the north coast of the Canadian mainland and Alaska to the Bering Strait (see Figure 9).[29]

Of the potentially seven routes through the Canadian Archipelago, three are considered as being practical for routine marine traffic and the fourth which is less so (see figure 10). This includes:

- *M'Clure Strait,* This is the shortest and deepest route with no draft restrictions, but the most difficult way due to the severe ice in the M'Clure Strait (120 kilometers wide at east end, 275 kilometers to the Beaufort Sea and depth at over 400 meters).
- *Prince of Wales Strait:* the passage through the Prince of Wales strait (Minimum width of less than 10 kilometers about half way through the strait, 230 kilometers long) has an average depth of 32 meters which tends to be the limiting factor.
- *Peel Sound*: navigation of this route is more challenging and the route is limited to ships having a draft of less than 10 meters.
- *Fury and Hecla Strait*: This route has a draft limit of 10 meters.

[28] ACIA (2005), p. 924
[29] Pharand (1973), pp. 50-54 and Brigham (06), p.138

Figure 9: Seven Possible marine traffic Routes through the NWP[30]

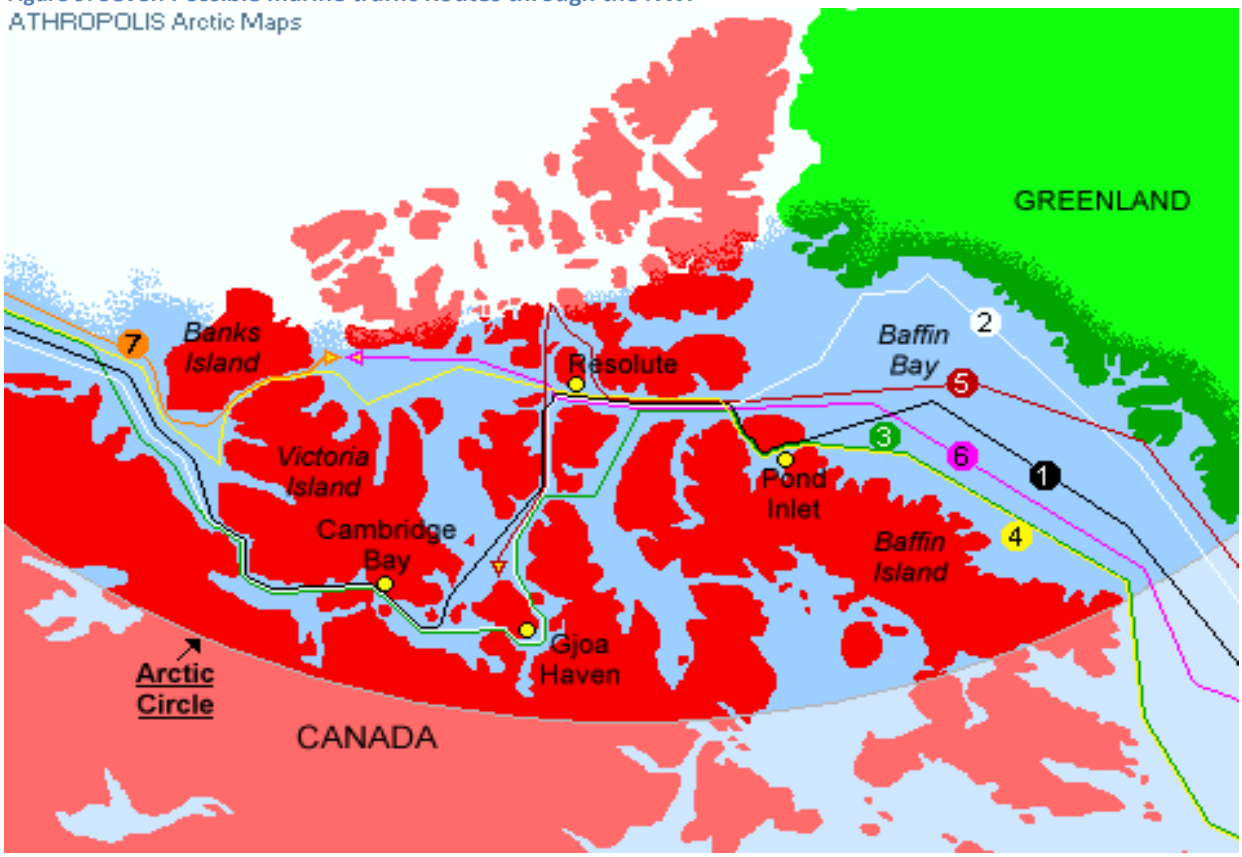
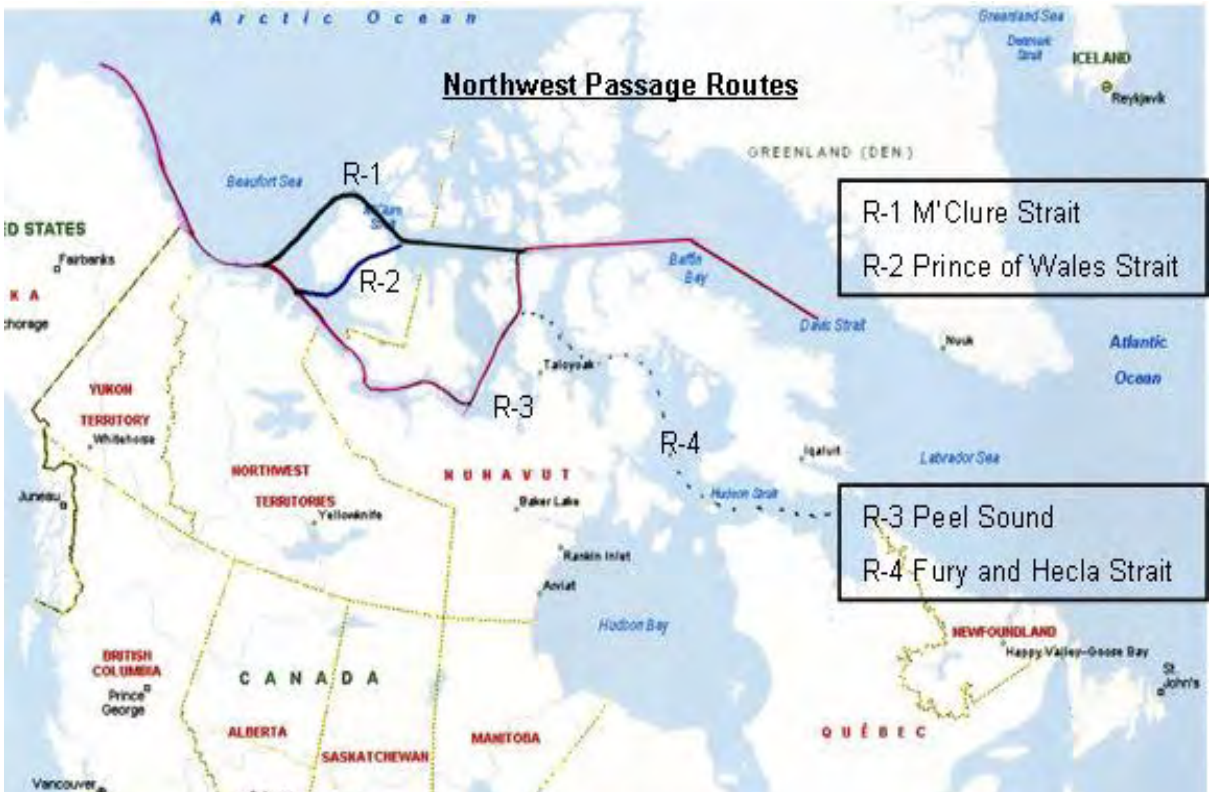


Figure 10: Navigation Route Alternatives on the NWP[31]



[30] Athropolis Arctic Maps

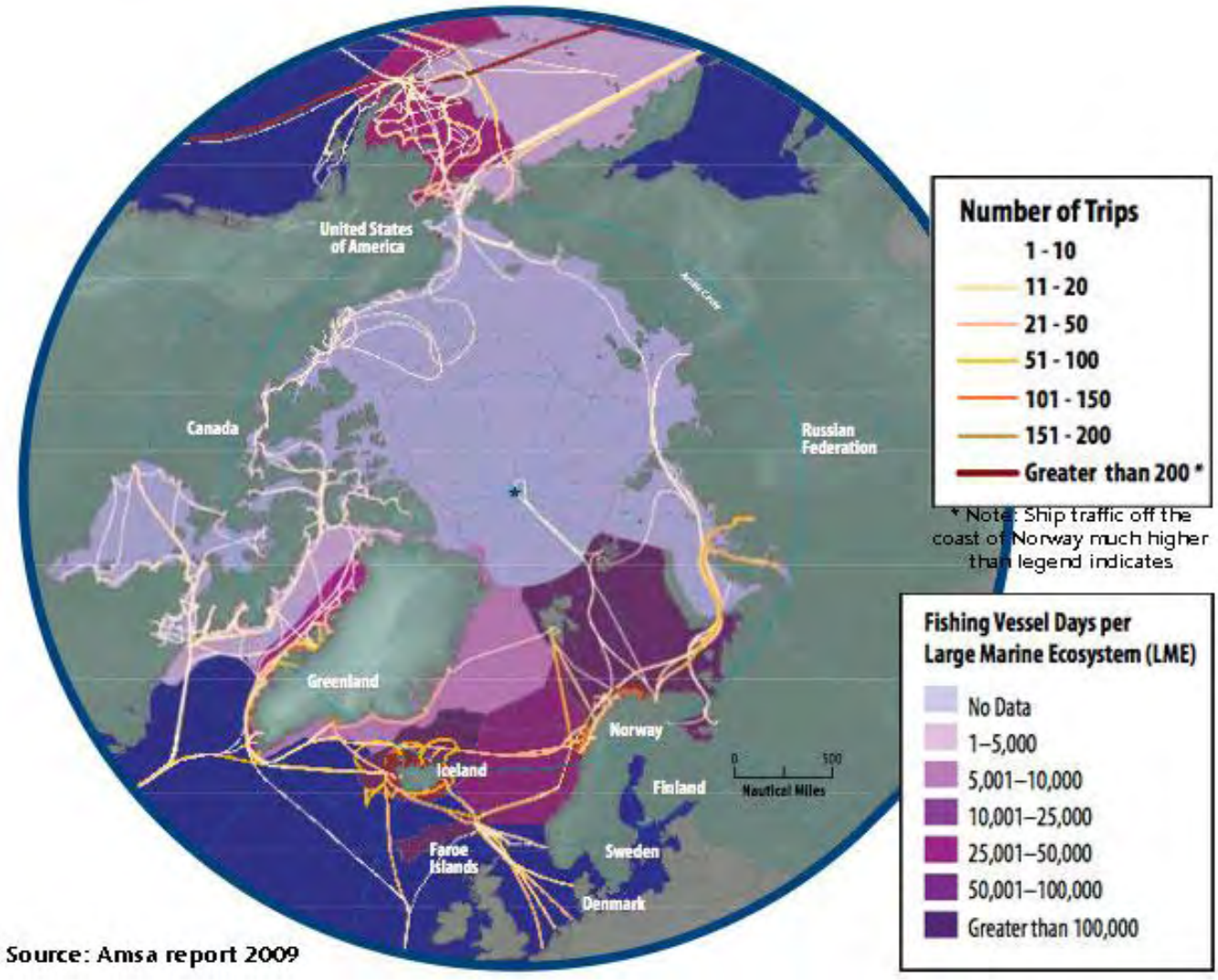
[31] CASA (2007)

3 Marine Traffic Patterns in the Arctic – Three Types of Traffic Concepts

When considering marine traffic patterns in the Arctic, a distinction between three types of traffic concepts or sailing routes are being addressed:

1) ***Intra-Arctic routes,*** i.e. sailing lanes between locations (ports) within the Arctic region. As an example, shipments between the port of Kirkenes and the port of Murmansk.
2) ***Destination-Arctic routes***, i.e. sailing lanes from locations (ports) inside the Arctic region to destinations outside of the Arctic region. As an example, shipments from the port of Murmansk to the European markets.
3) ***Transit routes***, i.e. sailing lanes between ports in the Pacific and the Atlantic via the Arctic Ocean. As an example, shipments between ports in Germany and ports in China via the Northeast Passage or Northwest Passage.

Figure 11: Overview of all vessel activity in Arctic Waters of 2004



As shown in Figure 11, the most busy 'Arctic waters' of vessel activity in 2004 were primarily, according to the AMSA, along the Norwegian and Bering Seas - followed by the traffic around Iceland near the Faroe Islands and southwest Greenland. Fishing vessels were responsible for an important part of this total. Ships plying these waters also include: bulk cargo carriers, oil tankers, LNG carriers, coastal ferries, cruise ships and other smaller vessels.

3.1 Current and Expected Marine Traffic on the Northeast Passage

Most recent ship traffic on the NEP includes *Intra-Arctic routes* and *Destination- Arctic routes* (See description above).

Community re-supply represents a significant portion of the Intra-arctic ship traffic between destinations within the NEP. Furthermore, in areas such as the eastern part of the NEP, this activity is the basis for most ship traffic. Re-supply activities provide a lifeline to many communities that have no or very limited road access and no or limited capacity to handle heavy aircraft.

Since 1978 and up to the present, the Russian Icebreaker fleet has succeeded in keeping the stretch from Murmansk to Dudinka on the banks of the Yenisei River (231 nautical miles from the river's mouth) open for sailings 12 months a year. This means that more than 1000 nautical miles, or some 30 percent of the NEP between Murmansk and the Bering Strait, is now kept open for shipping all year round. This stretch is what throughout history has been labelled the *Kara Sea Route*. The driving force behind this achievement has been the prospects of increased revenues stemming from year-round shipments of nickel from Igarka. Furthermore, a large percentage of today's intra-Arctic and destination-Arctic shipping activity using the NEP, involves transportation through the Barents Sea. Development of port capacities in the Russian part of the Barents Region is directly connected to the increase of petroleum exports. In 2008, the ports/terminals of Varandey, Arkhangelsk, Vitino and Murmansk, directly or through the offshore terminals in the open areas of the Barents Sea, exported about 10 million tons of crude oil and petroleum products. In 2009, the volume of oil exported to the western market through the Barents Sea was estimated approximately 15 million tons.

The NSR never got the intended significance as a *Transit-Arctic route* between the two world oceans. Transit traffic reached a maximum cargo volume in 1993 with 208,600 tonnes brought in by 30 voyages of multi-purpose ships of the Norilsk type (SA-15).[32] In recent years there has been an increased focus from international ship owners on the possibilities of transit, through the NEP. 2009 was a kind of a test year for vessels sailing through the entire route from Asia to Europe, via the NEP and 2010 was a breakthrough for commercial shipping along the NEP (See figure 12). So far, by august 2011, the first supertanker (suezmax class) has made a transit through the NSR. This is the first time in the history a ship of such dimension (280 m long, 50 m wide and with a draft of 13 m.) has sailed through the entire NSR.[33]

[32] Peresypkin and Yakovlev (2008). P. 1
[33] http://barentsobserver.com/first-supertanker-along-northern-sea-route.4951370-116320.html

Figure 12: Transit routes along the NEP, 2009 to (August) 2011

Ship owner	Name of the ship	Dwt	Destinations (Dates)	Cargo	Comments
Beluga Shipping Group	MV Foresight	12 000	Vladivostok (21.08.09) Novy Port (07.09.09) – Murmansk	Heavy lift modules	First foreign ships in transit through the NSR Passage
	MV Fraternity	12 000			
Beluga Shipping Group	MV Houston	12 000	Norrkoping - Novy Port (26.07.10)	Heavy lift modules	Not a complete transit. Only parts of the NSR was ued
	MV Fortitude	20 000			
Murmansk Shipping Company	Indiga	16 000	Murmansk (14.07.10) - Pevek (22.07.10)	Diesel fuel	First ship to transit the NSR in 2010
	Varzuga	16 000			
Sovcomflot	Baltica	100 000	Murmansk (14.08.10) - Pevek (25.08.10) - Ningbo (China) (06.09.10)	LNG	The largest tanker ever to cross the NSR
Nordic Bulk Carriers	MV Nordic Barents	41 000	Kirkenes (04.09.10) - China (30.09.10)	Iron ore	First foreign bulk ship ever to cross the NSR
Norilsk Nikkel	Monchegorsk	18 000	Murmansk (15.09.10) - Dudinka - Shanghai (17.10.10)	Iron ore	First ship ever to transit he the entire NSR without icebreaker assistance
Russian state owned	Georg Ots	12 600	Murmansk (09.09.10) - Anadyr (26.09.10) - Petropavlovsk - Vladivostok (10.10.10)	Passanger ship	First passanger ship ever to transitt the NSR
Belgian Owned	Perseverance	70 000	Murmansk (27.06.11)- China (15.07.11)	Oil condensate	Currently, the first and the only oil shipment in 2011.
STI Heritage Shipping Co.	STI Heritage	73 000	Murmansk (19.07.11) – Map Ta Put in Thailand (16.08.11)	Gas condensate	Fastest transit through the NSR with an average speed of 14 knots. Only 8 days.
Sovcomflot	Vladimr Thikonov	162 000	Murmansk (20.08.11) -	Gas condensate	First Supertanker (Suezmax) through the NSR.

When considering the marine traffic on the NEP during the years ahead, international studies like the Shipping in Arctic Waters (2010) and the AMSA (2009) argues that the most significant increase of marine be Destination-Arctic shipping and resource based. However, there are great uncertainties. Increased shipments of resources form the Norwegian and Russian part of the NEP will be highly dependent on a sufficient infrastructure. Today, there are some 50 Russian ports on the NEP open to foreign vessels. Nevertheless, more than half of the ports are out of operation and only a very few can meet the technical standards required by the international shipping industry. Even if there are adequate accesses to ice-breaker assistance, only a very few have the essential facilities such as adequate water depth, berths and mechanizations needed for increased shipping. Adequate marine communication systems exist in some parts of the NEP, but not in others. Communications using VHF-radio, MF- and HF-systems and satellite are generally adequate for the lower parts of NEP, but data transmission becomes problematic when the high arctic is reached. Russia has currently several ongoing projects developing systems to meet the demand of better communications for ships oper-

ating along the NEP. Several search and rescue centers are located along the NEP, but only a few can give the support needed for ships sailing along the route.

3.2 Current and Expected Marine Traffic on the Northwest Passage

Current shipping demand in the Eastern part of the Canadian Arctic involves up to 22 seasonal trips and occurs during the 100 day navigation season that span from mid-July to the end of October (most communities receive at most two re-supply calls a year). Recently, marine operations averaged 100 voyages by large ships in summer.

Figure 13: The Arctic Bridge (marked with red color)

Churchill is a prime trading port in the east. In 2004, 14 out of 18 foreign voyages to the Canadian Arctic called the port of Churchill, shipping wheat and grain to international markets. The first Russian shipment of fertilizer to the port of Churchill, coupled with perception of an extended sailing season due to global climate change, has renewed planning for establishing an international "Arctic Bridge" between Murmansk and Churchill.

In September 1992, the *Arctic Bridge Agreement* was signed between Canada and Russia. The major goods that might become the basis for significant trade between the two regions are bulk commodities, mainly the export of an estimated 315 000 tonnes of mineral products and lumber from Murmansk, and a minimum of 600 000 tonnes of export grain from Churchill.[34] The Bridge goes through the Barents and Norwegian Seas and proceeds south of Iceland and Greenland before mak-

[34] Arctic Bridge (1994)

ing a northward turn through the Davis Strait to reach Churchill in Hudson Bay. For this bridge to materialize, Churchill will require significant additional port and rail investments, as well as further study by both countries regarding costs, cargos and volumes. The port of Murmansk is in need of similar improvements before this intra-regional traffic scheme – or intra- international route - can be realized.

In the western part of the Canadian Arctic cargo is handled by tugs and barges, with most cargo shipped down the Mackenzie River to Tuktoyaktuk for transfer to ships with deeper ocean drafts. Current shipping demand involves 14-15 seasonal tug-barge trips. These operations take place in what has been labelled the *Mackenzie River route*[35] – a Canadian intra-Arctic route of some regional significance. The western Arctic sailing season is typically 60 days between mid-July and mid-September. These are some of the more important destination Arctic shipping locations within the Canadian Arctic: the port of Churchill, the oil field at Cameron Island, the Nanisivik zinc-lead mine in the vicinity of Arctic Bay, Tuktoyaktuk, Cambridge Bay, Resolute, Pond Inlet, Inuvik and Whitehorse. It is anticipated that by 2020, annual re-supply demand will require up to 30 ship trips, and destination Arctic export shipping will probably include Mary River Iron ore, Port at Steensby Inlet, Roche Bay magnetite, Igloolik, Grays Bay and Bathurst Inlet.[36]

In contrast to the NEP/NSR, there are very few ports along the NWP. There are essentially no adequate deepwater ports along the northern slope of Alaska or throughout the NWP. The lack of major ports and port facilities is also one considerable limiting factor in terms of increased shipping on the NWP. Furthermore, there are several obstacles related to trans-Arctic shipping in the near future (i.e. ice conditions, refuge, seasonality, geographical complexity, draft restrictions, choke points, insurance limitations and other costs). However, most Arctic shipping scenarios indicate an increase in the years ahead, but the shipping will be destination-Arctic and intra-Arctic and mostly resource based. These expectations are also related to a not significant, but nonetheless increasing Arctic population and an increasing demand for consumer goods, community construction and industrial shipments. Based on these expectation it will require significant port improvements.

From a navigational point of view, the NWP will be the last area where the multiyear ice will disappear and shipping through this Passage will remain risky even in the summer season. The ice models indicate that the ice conditions will be too heavy for any commercial shipping.

3.3 Cruise Traffic

In the shorter perspective, specialist operators will continue to offer cruises in all three passages. With powerful icebreakers one can reach the North Pole or circumnavigate the entire Arctic Ocean. With expedition ships and ice classed passenger/cruise vessels, trips are offered into the NWP and in the NSR trips go to Novaja Zemlja and Franz Josef's Land in the west and to the Wrangle Island in the Chukchi Sea in the east. The vessels are fairly small – 50 to 400 passengers – very small compared to the largest cruise vessels of more than 5000 passengers. The larger vessels concentrate on the blue waters around Svalbard and Greenland, which is the target for most Arctic cruises, while the smaller vessels go on expeditions in ice-covered waters. Arctic cruises are a small niche product, indeed, compared to the mass-markets of the Caribbean or the Mediterranean. The cruise vessels used in Arctic operations are very much self-contained units that are not dependent on land infrastructure. This is fine when everything goes smoothly, but is a major problem the day an accident occurs. The

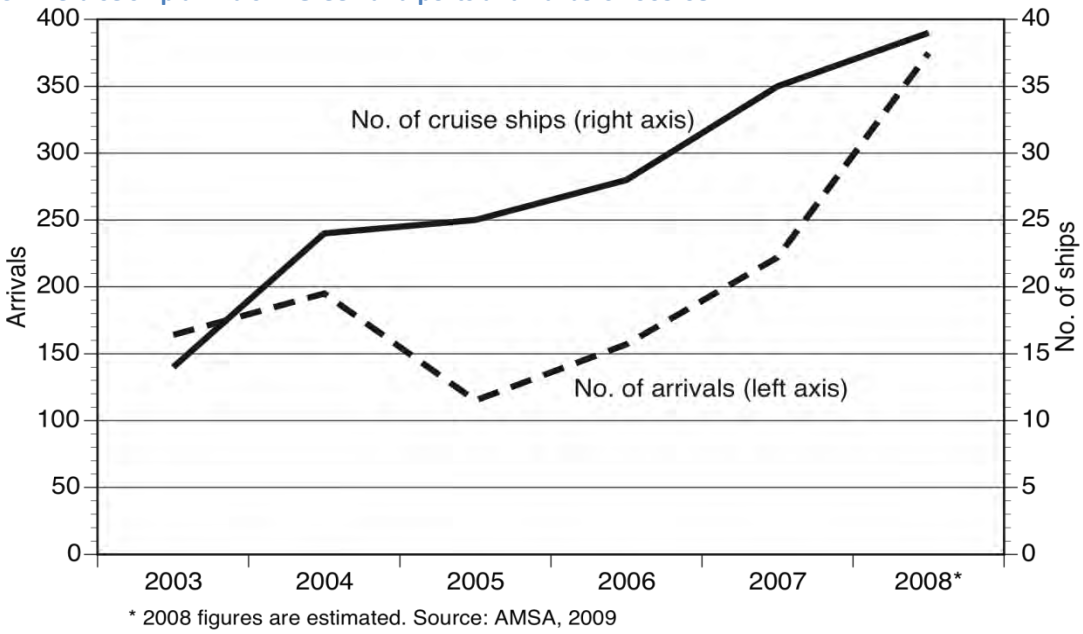
[35] AMSA (2008), p. 79
[36] AMSA (2008), pp.148-149

coastal states face a big challenge when it comes to providing adequate search and rescue service if cruise activities expand in the Arctic.

Complete data for all Arctic cruises are hard to obtain, but some indications of the development in later years can be found in data from Greenland and Svalbard.

Figure 14 shows the development of cruise ship activities in the ports of Greenland. The number of arrivals of cruise ships in Greenland ports has increased by an average of 48,9 % per year from 2005 to 2008.

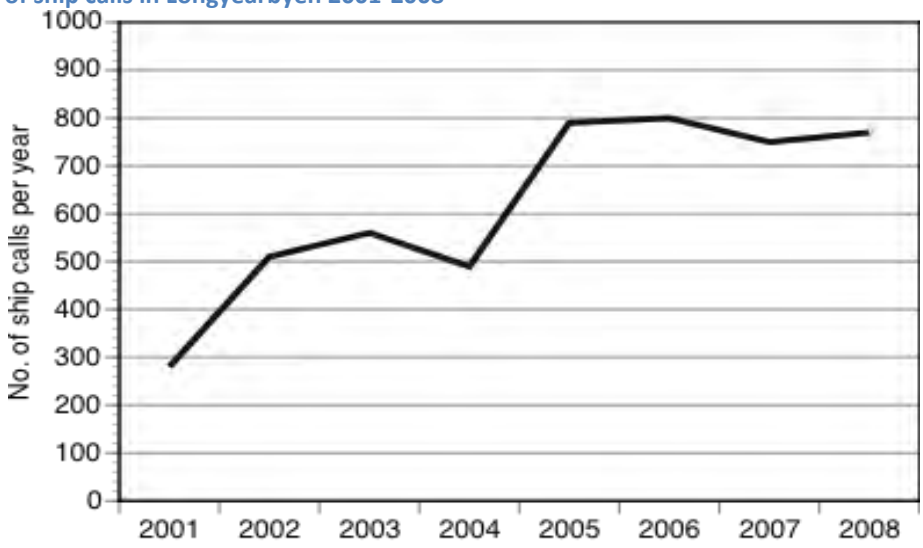
Figure 14: Cruise ship arrivals in Greenland ports and harbors 2003-08



* 2008 figures are estimated. Source: AMSA, 2009

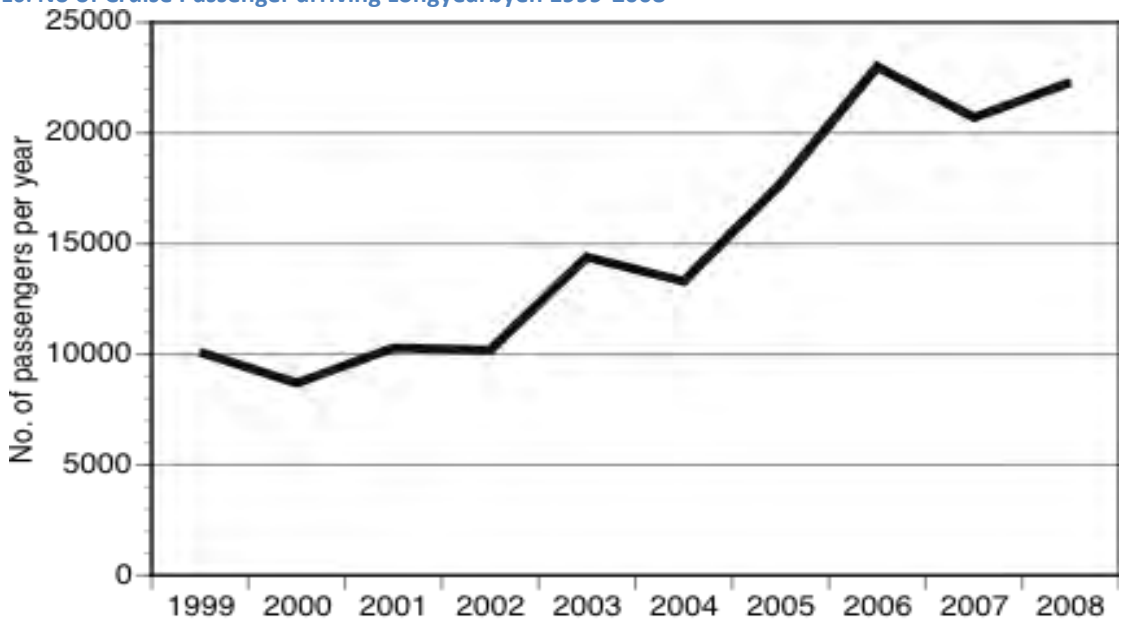
Another indication of an increased interest for sailings in the high north is data from Longyearbyen. Figure 15 shows the number of ship calls, while Figure 16 shows the number of cruise passengers arriving in the port. The average growth rate 2001-2008 of passengers arriving is 14% per year.

Figure 15: No. of ship calls in Longyearbyen 2001-2008[37]



[37] Source: St.meld (White Paper) 22, 2008-09, section 10.4.1

Figure 16: No of Cruise Passenger arriving Longyearbyen 1999-2008[38]



There is a need for further assessments in order to find the number of passengers that go on Arctic cruises. AMSA refers to an independent survey indicating that in 2004, 1.2 mill passengers went on an Arctic cruise and that this number more than doubled in 2007[39]. This implies that more than 15 per cent of all cruise passengers had an Arctic destination, since the world total number of cruisers is estimated at around 15 million. Such a number seems much too high, even if ferry passengers are included. Hurtigruten[40] has 11 ships on daily trips to the north, but in total they carry a little over 100.000 passengers per year, which would be less than 0.5 per cent of all Arctic cruises if this study is to be trusted.

[38] St.meld (White Paper) 22, 2008-09, section 10.4.1

[39] AMSA, 2009, p 79. No source is given for the mentioned independent survey

[40] A Norwegian passenger and freight line with sailings along the Norwegian western and northern coast.

4 Recommendations

In order to get an extensive overview of the transportation passages of the Arctic and the expected transport patterns further in depth studies is needed. Our recommendations are as follows:

- Assess the transport infrastructure (the availability, state of the art and challenges), in order to support efficient ship transportation along the Arctic sea routes.
- Evaluate the current status of ports and port facilities along the Arctic transportation passages.
- Asses the search and rescue availability on the Arctic sea routes, in order to support commercial shipping
- Examine the current status of satellite systems and radio communication on the Arctic sea routes, in order to make an assessment of the safety level of marine transportation.
- Examine the Arctic ice-breaker fleet (Russia, Canada, Norway, US etc.) in order to get an overview of the current availability and the challenges to support increased marine traffic.
- Assess the legal regime of shipping in the Arctic, in order to get an overview of the requirements of transportation in the Arctic.
- An examination of the resource activities in the Arctic, exploration and exploitation, in order to get a more extensive overview of the expected marine traffic patterns.
- A case study of the marine Cruise traffic throughout the Arctic; classifying which routes that is most frequent used etc.

Appendix A:

The diversity of sea ice varies in shapes, thicknesses, ages and hardness, presenting different challenges to navigation. These are some of the more frequent: [41]

- *New Ice*: Recently formed ice composed of ice crystals that are only weakly frozen together (if at all) and have a definite form only while they are afloat.
- *Nilas*: A thin elastic crust of ice (up to 10 cm in thickness), easily bending on waves and swell and under pressure growing in a pattern of interlocking "fingers" (finger rafting).
- *Young Ice*: Sea ice in the transition stage between nilas and first-year ice and 10-30 cm in thickness.
- *First-Year Ice:* Sea ice of not more than one winter's growth, developing from young ice having a thickness of 30 cm or more.
- *Old Ice/multi-year ice:* Sea ice that has survived at least one summer's melt. Its topographic features generally are smoother than first-year ice and can be a few metres thick. Old ice is also much harder than first year ice, and can be much more damaging to ships, if hit at a normal cruise speed.
- *Ice Massifs:* are manifested as extensive accumulations of close or very close ice that are found in the same region every summer.[42]
- *Drift ice:* is ice that floats on the surface of the water in cold regions, as opposed to *fast ice*, which is attached "fastened" to a shore. Usually drift ice is carried along by winds and sea currents, hence its name, "drift ice".[43]
- *Pack ice:* When the drift ice is driven together into a large single mass, it is called pack ice. Wind and currents can pile up ice to form ridges three to four meters high, creating obstacles difficult for powerful icebreakers to penetrate. Typically areas of pack ice are identified by high percentage of surface coverage by ice: e.g., 80-100%.[44]
- *Ice floe:* is a large piece of drift ice that might range from tens of meters to several kilometers in diameter. Wider chunks of ice are called *ice fields*.[45]

[41] Definitions derived from: http://ice.ec.gc.ca/WsvPageDsp.cfm?ID=181&Lang=eng
[42] Johannessen, (2007), p.257
[43] Description taken from: http://en.wikipedia.org/wiki/Drift_ice
[44] Description taken from: http://en.wikipedia.org/wiki/Drift_ice
[45] Description taken from: http://en.wikipedia.org/wiki/Drift_ice