PART I

THE FUTURE OF ARCTIC MARITIME SHIPPING

2. The Future of Arctic Marine Operations and Shipping Logistics

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INTRODUCTION

The natural resource exploitation industries in the Arctic are faced with very challenging operational conditions including: a short drilling season, remoteness, extreme cold temperatures most of the year, storms, icing, darkness in winter, changing sea-ice conditions, heavy fog, offshore operations in deep waters, and increased coastal erosion and permafrost thawing in the summer impacting land-based infrastructure (such as roads and buildings) by destabilizing foundations.

Such destabilization of foundations could alone increase the cost of maintaining needed onshore infrastructure by tens to hundreds of billions of dollars in the decades to come for many of the Arctic countries – Russia, Canada and the United States (Alaska).

In addition to operational challenges in the Arctic, significant logistical, technological and infrastructural problems remain to be resolved both to improve accessibility to natural resources and make extraction and transport of hydrocarbons and minerals a safer operation. Extraction of hydrocarbons in offshore areas of the Arctic Ocean with seasonal sea-ice coverage will require ice-class drill ships, icebreakers and new technology for wells and ice management that increase costs to the point where such areas are currently not viable for development. New technologies and proper infrastructure for safety, logistics and export could change this situation. Balancing commercial activity in the region with environmental protection will remain a significant challenge during the years to come.

Similarly, several deficiencies in the current Arctic marine transport infrastructure have been identified that need to be overcome if the Arctic Ocean is to become widely used in the future as a transportation corridor and trade route between markets in Europe or North America and the Far East.

These include improvements to all the main components of a proper

Arctic marine transportation system, including: a) *physical infrastructure* such as adequate ports and terminals with deep-draft access; cargo handling and passenger/crew facilities; and refuge provided for ships, b) *information infrastructure* such as navigational charts with updated hydrographic and shoreline mapping data; aids to navigation and real-time navigation information; marine weather and sea ice forecasts; proper communication systems; and vessel traffic monitoring and reporting systems, c) *response services* such as services of icebreakers for icebreaking and for vessel escort; search and rescue and emergency response; oil spill prevention, preparedness and response; and available response technologies to clean up oil and other hazardous wastes spilled at sea, and d) *Arctic vessels*, namely a fleet of ice-strengthened cargo ships and specialized vessels operating in the harsh Arctic environment, possibly on a year-round basis.

Hydrocarbon and mining industries and support facilities need to operate on a year-round basis in the Arctic, onshore and offshore. The main shipping activity and transit traffic in Arctic waters now takes place during the summer and early fall (July to November). However, we should also consider the possibility in the near future of year-round shipping in Arctic waters.

The task at hand is to develop infrastructure capable of meeting the safety, security and environmental protection needs of present and future Arctic stakeholders and activities. Our logistics solutions should take advantage of the Arctic resource potential and Arctic shipping opportunities, but at the same time provide the needed safety and reliability of operations and adequate pollution prevention to safeguard the fragile Arctic environment.

FIRST STEP IN ADDRESSING LOGISTICAL CHALLENGES: ASSESSMENT STUDY

A detailed assessment of the existing logistics and transportation infrastructure as well as hydrocarbon and mining infrastructure in the Arctic needs to be done. This includes operational conditions and technical challenges in different parts of the Arctic, existing transport and logistics systems, and currently available support facilities and services of Arctic ports, terminals, and airfields. We need to know what is currently there and the conditions of these facilities. This information is needed to identify the

state of affairs and is a necessary baseline for designing a new, improved transport and logistics system for the Arctic based on predicted future activities.

Two important prior assessments provided a clear picture and overview of our current deficiencies when it comes to Arctic marine transport infrastructure: the Arctic Council's Arctic Marine Shipping Assessment of 2009 and the Canadian Arctic Shipping Assessment of 2007 done for Transport Canada.

A new report by the U.S. Committee on The Marine Transportation System provides a detailed evaluation of the current state of the U.S. Arctic (Alaska) marine infrastructure and describes in detail the five main components and 16 infrastructure elements of a new preferred Arctic Marine Transportation System. For each of the infrastructure elements (e.g., communication, shoreline mapping, places of refuge for ships, etc.) information is provided on the a) status, challenges and current activities, b) case studies to highlight importance, c) federal actions needed and cooperation with non-federal partners, and d) milestones and timeframes for action.

Another important recent effort is the Arctic Council's Arctic Maritime and Aviation Transportation Infrastructure Initiative (AMATII). AMATII is meant to help decision makers evaluate northern infrastructure – ports, airports and response capabilities – by inventorying maritime and aviation assets in the Arctic. What infrastructure is in place and what is lacking? The effort has as deliverables an Arctic Maritime and Aviation Infrastructure Database and an interactive web-based map of current Arctic infrastructure.

SECOND STEP IN ADDRESSING LOGISTICAL CHALLENGES: MODELING AND VISUALIZATION STUDY

Based on the above studies we already know that we currently lack both adequate marine transportation and resource exploitation infrastructure in the Arctic. But more importantly, the question now becomes: what kind of infrastructure would we like to see put in place in the Arctic in the near future, for example by 2030, to satisfy our safety and environmental requirements?

The initial assessment study described above now needs to be followed

by detailed circumpolar Arctic modeling of the needed infrastructure for reliable and safe cargo transport and proposed natural resource extraction along with related support facilities to carry out emergency response and search and rescue activities.

Results should be displayed as interactive GIS maps with effective visualization components, animations and as a series of videos showing the proposed structural and design features of the required physical infrastructure, communication and navigational systems, and response services.

Such detailed graphical visualizations of the whole shipping and natural resource infrastructure system are needed to give all stakeholders a clearer picture of how various components of the logistics chain are tied together and how the whole system should operate and function. Model simulations should be based on various development scenarios and feasibility and sensitivity analyses for different cargo types being shipped, volumes and trade flows, types and sizes of vessels being used, transshipment, seasonal or year-round operations, and other factors.

Full-scale, year-round transit shipping on the Northern Sea Route (NSR), to take a concrete example, requires different physical infrastructure and support services than the current seasonal operation during the five months of summer and early fall, which is taking place in largely ice-free waters. If an Arctic route is only feasible during the current navigation season, will it be economically viable on a large scale to use Arctic ice-class ships in the Baltic during the rest of the year, as currently practiced by the Danish shipping company Nordic Bulk Carriers?

This modeling of a new marine transportation and logistics infrastructure system should be a joint exercise between the industry and the research community (sciences/engineering) based on the safest, the most sensible, cost-effective and environmentally sound solutions – and be circumpolar in nature.

THIRD STEP IN ADDRESSING LOGISTICAL CHALLENGES: COSTS AND FINANCING STUDY

If an agreement is reached on a new marine transportation and logistics system for the whole Arctic, the next step is estimating the costs of the various infrastructure components of the new system and establishing

international cooperation and partnerships for putting the required infrastructure in place.

The build-up of new infrastructure will take many years and will be costly. Is there a way to finance long-term, capital-intensive infrastructure? Some kind of funding mechanism needs to be put in place. Maybe, a transnational "Arctic Development Bank" or "Arctic Bank" along the lines of the European Bank for Reconstruction and Development (EBRD), Nordic Investment Bank (NIB) and others. But a mechanism is needed that can finance projects that cross borders within the Arctic. This could open up the possibility of attracting long-term financing such as the sovereign wealth funds (e.g., those in Norway, Europe and Alaska).

All eight Arctic nations and international shipping and natural resource companies need to be involved, as well as other nations and industries that see benefit in better excess to Arctic resources and shorter trade routes between the markets of the Eurasian Arctic, north and west Europe, the east coast of North America, and Asia (China, Japan, and South Korea). Without cost-sharing, the up-front capital costs of establishing proper infrastructure are prohibitive. Joint funding among interested parties and governments should be a viable solution. Infrastructure maintenance could also be partially funded through user fees.

With energy and mineral exploration currently driving increased marine transportation activities in the Arctic, we need to explore greater use of public-private partnerships (PPPs) with energy and mining companies to finance some parts of the needed infrastructure and/or leverage the infrastructure that directly supports these companies' needs. Also, to make sure that when infrastructure is developed as part of resource extraction projects, all aspects of the new Arctic logistics and transportation system must be considered. Creative approaches to meeting the infrastructure requirements of the private sector will stretch scarce government financial resources and benefit all users of the Arctic logistics and transportation system.

What are some of the key issues to consider for Arctic routes to develop into predictable and commercially viable trade routes that attract large volumes on a recurring basis between markets in Europe, North America and the Far East? The main determinants will always be the availability of cargo, transport safety and reliability, and competitive cost levels compared to other more southerly routes (Suez, Cape and Panama). Some of these factors are discussed below with particular reference to future development of the NSR.

SIGNIFICANCE OF SEA-ICE REDUCTION FOR FUTURE ARCTIC NAVIGATION

The summer ice extent has declined by 40% since satellite observation began in 1979, and over the same period sea ice has thinned considerably, experiencing a decline in volume of 70%. The last six years, 2007-2012, have produced the six lowest sea ice minima since 1979. The 2012 September sea ice minimum was 49% below the average of 1979-2000 and 18% below the previous minimum in 2007. Over only seven years, 2005-2012, multiyear ice experienced a reduction of 50%.

Studies differ widely in their predictions of when summer sea ice (and remaining multiyear ice) will melt completely in the Arctic Ocean – perhaps before the mid-century or possibly before 2030. The sea ice is likely to collect and persist longest along the northern flanks of the Canadian Archipelago and Greenland, while the central and eastern part of the Arctic will see the most significant decline of ice, further promoting shipping on the NSR and along a possible new Transpolar Passage. Some year-to-year variability of sea ice in some coastal seas and straits will likely continue to remain a challenge, at least in the beginning and end of the summer navigational season.

The summer navigational season on the NSR is now five months, from July to November. For the last two years, in late August and the whole of September and October, the NSR has been nearly or completely free of sea ice, so transiting ships such as the 162,000 dwt Suezmax tanker "Vladimir Tikhonov" could keep the same speed as in open waters – an average of 14 knots – and transit the NSR in only eight days. In November the Laptev Sea and the East Siberian Sea are covered with new ice up to 30 cm thick that allows for safe passage of vessels supported by an icebreaker.

Diminishing sea ice and rapid melting of multiyear ice will further promote shipping activity in the Arctic. In fact, all NSR seaways are currently located in the area of one-year ice. In the Arctic, one-year ice grows up to 1.6 m in thickness. With less or no sea ice, the predictability and punctuality of NSR voyages will increase, both of which are important to global shipping operations. This will increase the attractiveness of the NSR as an optional trade route in the future, even for liner services (container shipping). Lack of schedule reliability and variable transit times have been noted as major obstacles to the development of Arctic shipping.

The Arctic Ocean will always refreeze during late autumn and sea ice

cover will be present in the winter and spring, presenting a challenge to future traffic. But this would be relatively thin seasonal ice and navigable by high ice-class carriers and icebreakers. Arktika-class Russian icebreakers can open up water passages through ice that is 2.3 m thick. This fact opens up the possibility of year-round operations on the NSR if proper support infrastructure is put in place.

ENERGY AND MINERAL RESOURCE DEVELOPMENT IN THE ARCTIC

The U.S. Geological Survey (USGS) forecast in 2008 that almost one quarter of the undiscovered, technically recoverable hydrocarbons in the world are located north of the Arctic Circle. This amounts to 90 billion barrels of oil, 1,670 trillion cubic feet of natural gas and 44 billion barrels of natural gas liquids in 25 geologically defined areas thought to have potential for petroleum. According to the USGS, the Arctic accounts for around 13% of the undiscovered oil, 30% of the undiscovered natural gas, and 20% of the undiscovered natural gas liquids in the world.

A substantial part of this hydrocarbon resource potential lies in the Eurasian Arctic – in northwest Russia and offshore in the Barents and Kara seas – at the gateway of the NSR. In addition, an abundance of iron ore and other mineral resources are located in Northern Scandinavia and on the Kola Peninsula in Russia.

Current and future development of this resource base is the main driver for increased Arctic shipping in the coming decades, bringing Arctic natural resources to markets in the Far East via the NSR. This is also the main driver for the urgent need to build up the proper logistics and marine transport infrastructure with the goal of taking full advantage of this resource potential without harmful effects to the fragile Arctic environment.

THE FREIGHT MARKET, PRICE DIFFERENCES, AND TIME SENSITIVITY OF MARKETS AND CARGO

The main factor influencing the short-term usage of the NSR as a trade route is the inherently unpredictable freight market. This is even more difficult to assess because of fluctuations within the different shipping

segments. The main factor is the economic savings achieved by using the NSR relative to traditional routes. Other important factors are price differences of products in Asian and Western markets, the delivery time sensitivity of various cargoes, and the repositioning cost of the vessels.

Overall, high commodity prices and in particular high demand and prices in the Far East are the current drivers of cargo transport along the NSR eastward. Transport of Arctic hydrocarbons and mineral ores from the resource-rich Barents region and Northwest Russia to Asian markets along the much shorter NSR is considered an alternative shipping route with potential savings too large to ignore. Today, as in the near future, we will primarily see dry bulk carriers and tankers transiting the NSR carrying Arctic resource materials to destinations outside the Arctic.

But a prerequisite for increased growth of transit shipping on the NSR is the availability of cargo transport in both east and west directions. Therefore, for further development, a new cargo base needs to be identified for shipment westward along the NSR. This will enable more effective use of Arctic vessels by reducing or even eliminating the costs of in-ballast transits and will thereby significantly increase the overall cost-effectiveness of each vessel's operation.

Global shipping operations are dependent on three key factors: predictability, punctuality and economy of scale, all of which are currently limited in Arctic shipping.

Container ships operate on regular schedules and follow set routes, calling at a number of ports to load and unload cargo. Profitability can only be achieved with large-scale shipping based on stable and predictable year-round operations. The ability to schedule voyages a long time in advance and to guarantee uninterrupted services is considered key for container ship operators.

Full-scale container shipping on the NSR as part of world trade is therefore problematic, as the above conditions cannot be easily met even during the current navigational season. Container shipping occurs on a just-in-time-schedule in order to reduce costs associated with warehousing and storage. During the summer navigational season on the NSR such accurate time scheduling could become a reality in the years to come. Though the NSR will in the future become increasingly ice-free during this season, still, large-scale container transport between the Far East and Europe requires year-round operation. For the NSR this means unpredictable navigational conditions due to the presence of seasonal sea ice covering the whole Arctic

Ocean during more than half of the year in winter and spring.

Dry bulk carriers and tankers, on the other hand, follow less predictable schedules and their routes depend more on changing supply and demand of less time-sensitive items. Bulk metal ores and concentrates can be stockpiled at the mine or destination port, and oil in large storage tanks. Such raw materials could then be shipped along the NSR if spot charters could be arranged on an opportunistic basis.

TIME AND COST SAVINGS BY USING THE NSR VS. THE SUEZ ROUTE

Shipping of ores and hydrocarbons from Murmansk through the NSR shaves 19 days off transport times to Kobe (Japan), 18.5 days to Busan (South Korea), and 16 days to Ningbo (China) compared to the Suez route, providing the average sailing speed is the same on both routes. By using the shorter NSR between Northern Europe and Asia one saves about 40% of travel time and subsequent fuel and freight shipping costs. The reduced number of days at sea allows a ship to make more return trips, resulting in increased revenue and potentially greater profits.

Cost savings can be achieved by simply burning less fuel because of a reduced number of days at sea, or through more energy-efficient slow steaming, or a combination of both. A vessel on slow steaming between China and Kirkenes/Murmansk can reduce its speed by 40% and still arrive at the same time as a ship sailing at full speed traveling the Suez route. Such slow steaming can double a vessel's energy efficiency performance and result in a significant reduction of greenhouse gas emissions. This could become important if future emissions control measures were to include global maritime transport. Reduction of emissions could thus also result in significant cost savings.

Shorter sailing distances allow for considerable fuel cost savings. As an example, a Panamax bulk carrier (about 75,000 dwt) sailing from Kirkenes in north Norway to Shanghai in China burns about 30 metric tons of heavy fuel oil per day at a cost of USD $650/ton. The travel time saved on the NSR compared to Suez one way is 21 days, hence 42 days saved on a round trip, or 1,260 metric tons of burned oil, which is a savings of about USD $820,000. Future price increases in bunker fuel will make the NSR even more competitive compared to the Suez.

Overall cost savings depend on the type of cargo being transported. A shorter shipping route for an expensive LNG tanker can add up to substantial savings. For an LNG tanker with a time-charter rate of USD $120,000 per day going from Statoil's LNG Melkøya Plant near Hammerfest in north Norway to Yokohama in Japan and back the same way in ballast, savings in time-charter alone can add up to USD $5 million. Total savings on a round trip can reach USD $6.8 million compared to the Suez. Russia's Yamal LNG is additional eight days (roundtrip) better positioned within the NSR than the Suez route, representing even more cost savings.

Other cost elements to consider are insurance and the NSR's transit tariffs vs. Suez Canal fees. Marine insurance costs on the NSR are currently higher than on the Suez route but are by no means prohibitive. These costs are expected to go down in line with increased traffic and transport volumes on the NSR, if no major accidents occur. Russian authorities are actively investigating ways to reduce perceived risks to shipping. Future insurance fees also need to consider the changing sea ice conditions, route optimization and more advanced sea ice reconnaissance. In general, as the proper marine infrastructure is put in place on the NSR, insurance costs will subsequently go down. At this time, there seems to be no solution to the piracy threat on the Suez route, leading to increased costs of insurance and protection, and increased risk of non-delivery of cargo.

The official NSR tariffs from June 7, 2011, are much higher than the listed Suez Canal fees, but it is stated clearly that these are maximum rates subject to negotiations between FUSC Atomflot in Murmansk (now the new NSR Administration in Moscow) and the ship owner/operator. At least some of these past negotiations led to agreed rates that were equal to the Suez Canal fees or approximately USD $5 per ton.

The new Russian federal law on navigation on the NSR being implemented for the first time during the 2013 navigational season states that the tariff rates on the NSR will depend on the tonnage of the vessel, ice-class of the vessel, distance of needed icebreaker guidance, and the time period of navigation. Previously, discounts were given based on the total volume being transported within a season (in excess of 200,000 tons) and for in-ballast return legs connected to loaded legs. Clearly, for the NSR to be competitive to the Suez route, the NSR tariffs need to be commercially reasonable.

REDUCED GREENHOUSE GAS EMISSIONS ON THE NSR

Shorter transit routes in the Arctic imply lower stack emissions into the lower atmosphere on a global scale. For the case presented above for a Panamax bulk carrier transiting the NSR from Kirkenes to Shanghai and burning 1,260 metric tons less heavy fuel oil compared to the Suez, savings in CO_2 emissions for a round trip are close to 4,000 tons. Additional savings in NOx and SOx emissions are 130 tons and 90 tons, respectively. As stated in the AMSA study, the presence of sea ice in the Arctic may require higher propulsion levels and ultimately similar or greater emissions during voyages compared with southerly routes. But this would only come into play during the winter and spring seasons if the NSR opened up for transit traffic on a year-round basis.

AVAILABILITY OF ICE-CLASS SHIPS IN DIFFERENT SEGMENTS AND SIZES

The numbers of vessels with an adequate ice class (1A or Arc 4) represent a limitation on the utilization of the NSR during the short navigational season. The availability of such vessels varies greatly between different segments and sizes.

The new Rules of Navigation in the NSR Water Area approved by the Ministry of Transport of the Russian Federation on January 17, 2013 allow vessels with lower ice classes (Ice1, Ice2, and Ice3) and even vessels without ice reinforcement to operate along the NSR in the period from July to October if ice conditions are favorable according to official information from Roshydromet, and without icebreaker assistance (and tariff payments) if sailing takes place in essentially open waters. The new navigational rules will further promote the use of the NSR and open up the possibility for less ice-strengthened vessels to use the route when sea ice conditions are favorable.

Still, there is a serious lack of ice-class vessels (Arc 4) in the dry bulk sector. Today only several ice-class Handymax and Panamax vessels can be involved in cargo transport on the NSR, while larger Capesize vessels are not available at all. This is the reason dry bulk transportation is still limited on the NSR, despite significant cost savings due to the shorter travel distance, time and reduced fuel consumption. This makes the NSR

vulnerable to competition from much larger dry bulk vessels going via the Suez or Cape (economy of scale). Because of the depressed market for Capesize bulk vessels, it has been cheaper to transport iron ore from Kirkenes to China via the Cape instead of using Panamax vessels via the much shorter NSR.

Few LNG tankers with proper ice class have been delivered, but some are on order. Recent high demand in the Far East for LNG and positive prospects for increased natural gas development in the Russian Arctic (e.g., Yamal) are the drivers.

There seems to be a sufficient number of oil tankers with proper ice class to service oil production in the Russian Arctic today. Tankers that operate in the Baltic during the winter and early spring could be used on the NSR during summer-autumn navigation.

Also available are specialized ice-class vessels transporting project cargoes. But for these kinds of vessels, which call on Arctic ports, issues like draft and crane capacity are equally important. Oversized project cargoes and modules represent high values and are often critical to project schedules and could in the future be transported by high ice-class barges.

From the above it is clear that large-scale global investment is needed for the construction of a fleet of large, powerful ice-class cargo ships. The question is whether these ships will be icebreaking carriers in their own right and capable of independent ice operations or will require icebreaker support.

THE IMPORTANCE OF ARCTIC ICEBREAKERS

Icebreakers are essential in the Arctic today. Russian icebreakers servicing the NSR not only provide ice pilotage and icebreaking services for vessels but also act as important floating support units or infrastructure to ensure safety of navigation and provide various support to vessel operations as needed. This is important because of limited land-based infrastructure. These services include providing emergency and rescue services if needed, towing of vessels through ice-covered or ice-free waters and salvage support. Subsequently, the risk to the vessel and the corresponding financial risk to owners and insurers are substantially reduced.

With anticipated increased ship traffic on the NSR, these icebreaker services become even more critical. The Russian icebreaking fleet now

consists of five powerful nuclear-powered vessels (in addition to a number of diesel-electric powered ones) which will be gradually decommissioned over the coming 20 years. The renewal process has already started; the construction of the first of three planned nuclear icebreakers of the LK-60 type started in the beginning of 2013 to be delivered at the end of 2017. This icebreaker will be a dual-draft type with the ability to work at a variable draught from 8.5 to 10.5 m, which will permit piloting vessels along the whole NSR, including the estuaries of the Ob and Yenisei Rivers. This will be the world's most powerful icebreaker, with propulsive power of 60 MW, able to break solid sea ice with a thickness of 2.8 m at a speed of 2 knots. The width of the icebreaker will be 34 m, which will allow large Aframax vessels to safely follow the icebreaker through the opened water passage.

The three planned LK-60 nuclear icebreakers are an important investment in future infrastructure development on the NSR, as they provide much-needed navigational support for intra-Arctic winter navigation, including possible commercial destination Arctic and trans-Arctic shipping in the winter. In other words, such powerful icebreakers could collectively keep the NSR open to commercial shipping on a year-round basis, provided other needed infrastructure is in place, and support convoys similar to those in the Baltic Sea during late winter and early spring.

The Russian icebreaking fleet is by far the largest and most powerful. In additon to the three planned LK-60 icebreakers, Russia plans to build new diesel-powered icebreakers, including the largest of them all, a 25 MW diesel icebreaker at the Baltiisky Yard in St. Petersburg for delivery at the end of 2015, designed for operations in Arctic waters. But as AMSA concludes, the world's icebreaker fleets are aging and will require significant investment during the coming years to maintain their effectiveness and capabilities. The average age of these icebreakers is now about 30 years.

INACCESSIBILITY AND POOR CONDITIONS OF EXISTING ARCTIC PORTS

Adequte port infrastructure and support facilities for commercial shipping such as deep water access, places of refuge, marine salvage, port reception facilities for ship-generated waste, and towing services are rarely available in the Arctic.

In recent years, however, Russian Arctic ports in the Barents Sea area, including the deep-water port of Murmansk, have expanded significantly and are providing increased services due to increased ore, coal and oil production and transport. Some other ports in satisfactory condition are located in the Kara Sea, including the port of Dudinka on the Yenisei River, but ports further east – on the shores of the Laptev, the East Siberian, Chukchi, and Bering seas – are in very poor condition and only support the basic needs of local settlements.

Even if Russian Arctic ports did provide better services and facilities, draft limitations make these ports and harbors inaccessible for larger cargo ships sailing on the NSR. These ships cannot sail into these ports for services, to load or unload cargo, or in case of trouble as they would run aground because the harbors are too shallow. This fact should be a reminder that future support facilities for cargo ships and the extraction industries need to include floating units, far removed from the shallow Arctic coastline. Loose infrastructure and mobile assets (vessels that move within the Arctic) need to be considered. Such floating support units give added flexibility since they can be relocated if needed. A floating LNG plant was even considered as one option for gas from Yamal to provide tankers with deep-water access to the plant.

IMPORTANCE OF TRANSSHIPMENT HUBS FOR THE NSR

A future increase in destination Arctic shipping and transit shipping on a year-round basis will require the establishment of transshipment hubs on either side of the NSR in order to fully utilize specialized Arctic vessels in the most economically efficient way, provide storage, and serve industrial purposes.

Shipping activity during the Arctic winter and spring will require a fleet of high ice-class cargo ships and support vessels that are able, with assistance from powerful icebreakers, to plough through winter seasonal ice in large convoys led by icebreakers at an acceptable speed. Because their design features are used to break through thick winter seasonal ice, these cargo ships or "Arctic shuttles" should not sail for long distances in ice-free waters and should deliver their cargo between ice-free transshipment hubs located on the west and east gateways to the NSR. Then, feeder ships that are notice-strengthened can take the cargo from the transshipment

hubs and deliver it to the final destination. The same feeder ships will also deliver cargo to the hubs for transport along the NSR by the Arctic shuttles between markets in Europe and the Far East.

These specialized Arctic shuttles would be fully and solely employed on Arctic voyages. As pointed out in the AMSA study, the addition of transshipment hubs in the northern latitudes could add a new dimension to global trade routes and might add options for select cargoes to be carried from the Pacific to European ports.

One hub could be located in ice-free waters in the Barents Sea – perhaps in the Murmansk-Kirkenes area; the other would need to be located in ice-free waters past the Bering Strait in the North Pacific Ocean, perhaps in the Aleutian Islands.

The location of a Murmansk-Kirkenes hub is quite strategic, as this area is nine days sailing from both the North Pacific (Bering Strait) and the Mediterranean (Gibraltar), and close to major oil and gas deposits in the Barents Sea, as well as to ore mines in northern Sweden and Finland. A suitable location for the eastern hub in the U.S. Aleutian Islands could be Dutch Harbor or Adak. A location favored by the Russians is the port of Petropavlovsk on the coast of Kamchatka.

NAVIGATION AND COMMUNICATION

Improved Arctic charting and greatly enhanced Arctic marine observations are vital to current and future Arctic marine operations. Only an estimated 6-7% of the Arctic marine environment is charted to international navigation standards. This means that the Arctic needs extensive hydrographic surveying, in particular the coastal areas. Also needed is better real-time information concerning the operational environment. This includes ice charts, satellite images of ice-infested waters, text messages describing ice conditions, and accurate marine weather information such as forecasts for sea ice distribution, wave height, wind direction and speed, visability, temperature and superstructure icing. There are also communication difficulties in the high Arctic. Subsequently, improved voice and transmission coverage is needed.

Though conditions are better along the NSR than elsewhere in the Arctic, major improvements are still needed in support of navigation as well as better communication in light of increasing destinational and trans-

Arctic traffic on the NSR.

As mentioned earlier, Russian icebreakers play a major role here. The tariffs for icebreaker guidance on the NSR guarantee the best available navigational information, knowledge and safety of passage from experienced icebreaker captains. If senior navigating officers of international vessels do not have sufficient experience steering a vessel in Arctic conditions, it becomes obligatory by Russian navigation rules to have on board Russian ice pilots. The experience of steering vessels through the NSR has shown that ice pilots (ice navigators) not only are important in providing advice to the captain of the vessel in ice maneuvering, but also in communication with the icebreaker, interpretation of navigational charts and manuals (most of which are in Russian), and on safe speed and distance when following the icebreaker.

The organizations that provide icebreaker services (FUSE Atomflot and Far Eastern Shipping Company Ltd) form a convoy of transiting vessels guided by one or two icebreakers. Radio communication (16-channel VHF) between the icebreaker and the ships in the convoy is established, and the ships need to act in accordance with the icebreaker's instructions and report directly to the icebreaker captain. The arrangement of vessels in the convoy is determined by the icebreaker, including the allowed speed and distance to the vessel ahead.

LIMITED SAR AND OIL SPILL RESPONSE CAPABILITIES

The current search and rescue (SAR) infrastructure in the Arctic is limited. SAR is particularly challenging in the Arctic due to the remoteness and long distances that are involved in responding to emergencies, as well as cold temperatures and sea ice conditions. There is also a lack of adequate shore side infrastructure and communications to support and sustain a SAR response of any significant magnitude. The potential number of people needed to be rescued from, for example, a cruise/passenger ship far exceeds the capacity of SAR response in the Arctic. This includes lack of sufficient food, lodging and medical facilities.

The Arctic Council's 2011 agreement on developing a joint SAR framework for the eight Arctic states is important. In it, all Arctic states commit to coordinated assistance to those in distress and to cooperate with each other in SAR operations. The Arctic states agreed upon their respective

areas of SAR responsibility and on promoting the establishment, operation and maintenance of an adequate and effective SAR capability within their areas of responsibility.

The accidental release of oil into the Arctic marine environment is the most significant threat from offshore oil exploitation and Arctic shipping. Oil spills in ice are more complicated to address than spills in open waters,and oil spilled in ice-covered waters can collect onto the ice, in open pools between ice floes, underthe ice, and drift with ice flows. All available oil spill response methods must be available and considered for each situtation (e.g., mechancial recovery, chemical dispersion, in-situ burning, biological degregation).

As a precaution against future threats of oil spills in Arctic waters, the Arctic Council agreed on another legally binding agreement in May 2013 on oil pollution preparedness and response. The new agreement provides for assistance between the Arctic states in response to oil pollution incidents in the Arctic that are beyond the capacity of a single state to respond to effectively. Such assistance includes provision of human resources, know-how, equipment and technology. The agreement also outlines other actions that are essential to spill response, such as maintaining national spill response systems, notifying other states of spills that may affect their marine areas, conducting monitoring activities to identify spills, and undertaking joint exercises and training. Prior to this, Norway and Russia had a bilateral oil spill response agreement for theBarents Sea and Russia and the U.S. for the Chukchi Sea.

To address the urgent need for improved SAR and oil spill response along the NSR, Russian authorities started designing new Marine Rescue Coordination Centers in 2011 that are also equipped with oil spill response equipment, with the aim that their construction would be complete by 2015. The main centers are in the ports of Murmansk and Dikson, with sub-centers in the ports of Tiksi, Pevek and Provideniya. Additional SAR units are based at the Archangelsk and Naryan-Mar airports. As before, Russian icebreakers will continue to act as “floating” SAR and oil spill response units on the NSR, accompanied in the near future by six new multifunctional rescue vessels of ice-class Arc5.

As pointed out by Tschudi, the develpment of economic activity in the Arctic region might be the best means to improve response capacity in general and emergency preparedness in particular. The more vessels in the area, such as ice-class offshore support vessels equipped with oil recovery

equipment and other emergency features, the sooner assistance will be rendered in case of an emergency.

THE SIGNIFICANCE OF THE IMO POLAR CODE FOR ARCTIC SHIPPING

The International Maritime Organization (IMO), in an attempt to facilitate safer, more secure, and more reliable navigation in polar regions, approved purely voluntary guidelines in 2009 for vessels operating in Arctic and Antarctic ice-covered waters. Driven by increased vessel traffic in the Arctic, a new mandatory IMO Polar Code is currently in development with a target date for completion of 2014. The code will cover both poles and be used to guide polar states in developing legislation on the safety of ships in ice and polar navigation, training of seafarers, requirements for ship construction and polar classification as well as mandatory environmental standards for shipping.

The key environmental risks the IMO Polar Code should address are: a) use of heavy fuel oil, b) black carbon and other emissions, c) ballast water, d) routing measures and speed reductions, e) particularly sensitive areas and places of refuge, f) emergency response, and g) discharge of garbage and pollutants.

When the Polar Code is finalized and approved by IMO member states, its various measures are expected to take legal effect through amendments to existing IMO instruments, such as the Safety of Life at Sea Convention (SOLAS), the international Convention for the Prevention of Pollution from Ships (MARPOL), and others.

Clearly, Arctic marine safety and environmental protection will be greatly enhanced with the adoption and full implementation of a mandatory IMO Polar Code. But defining the risks for various classes of ships in ice-covered and ice-free polar waters has been a challenging process for the IMO's committees. Inclusion of additional environmental protection measures to those already provided under various IMO instruments has also proved to be difficult.

Environmental organizations are lobbying for the Code to include sections on oil spill response plans and black carbon emissions in the Arctic. Commercial shippers have expressed worries that if regulations are imposed that are too strict or costly, such as a full-scale ban on lower-cost

heavy fuel oil (HFO) in the Arctic while more southerly routes can continue to use it, the NSR will be made uncompetitive from the start. Norway has already banned the use of HFO for the east coast of Svalbard. Shippers also ask: at what level will black carbon and other air emissions start to pose a threat to the Arctic environment? They point out that ship traffic on the NSR will always be just a small fraction of the current traffic on the Suez, Panama, and Cape routes. Will strict pollution prevention technologies be required on the NSR and even zero air emissions enforced?

With increased resource development and new shipping opportunities in the Arctic, new environmental challenges will emerge. But what are the true environmental risks in the Arctic from predicted future shipping activity, and what do we need to include in the IMO Polar Code and other instruments to manage these risks effectively? According to Tschudi, to address these new environmental challenges in the Arctic a holistic approach is needed in which environmental and safety concerns and the need for economic development are all included and integrated in a balanced way.

NEW INDUSTRIAL FRONTIER AND ARCTIC SHIPPING

During the next decade, according to a recent Lloyd's risk report, as much as USD $100 billion of investment will take place in the Arctic, mostly in offshore oil and gas. The Russian Arctic is likely to see most of this activity – in the Barents, White, Pechora, and Kara Seas – promoting commercial shipping activity along the NSR to bring these raw materials to resource-hungry markets in the Far East.

It is also likely that increased shipping activity will take place east of the Urals, where most of the Russian onshore oil activity is located together with several mines and heavy industries. Here the large Russian rivers, which all flow north into the Arctic Ocean, act as major transport connections to the NSR, essentially unlocking the large resource potential of Siberia. Siberian rivers also offer logistical possibilities for regional and destinational transportation from the NSR into the inner part of Siberia, promoting further development.

The abundance of energy and mineral/ore resources in the Eurasian Arctic within the same geographical locations – where gas meets ore – opens up the possibility of value-adding industrial processing in situ before

shipment via the NSR. Subsequently, these new sources of industrial raw materials and energy not only offer closer sources of supplies but also the opportunity to develop a new industrial frontier in the Eurasian Arctic.

DESTINATION ARCTIC TRANSPORT ON THE NSR

Destination transport will be the most relevant activity on the NSR in the short to medium term. This includes transport of resource materials between ports inside and outside of the region, such as oil, gas condensate, LNG, coal, and minerals/ores by specialized ice-class shuttle carriers such as oil tankers, LNG carriers, and dry bulkers as well as purpose-built offshore vessels and multipurpose vessels for transport of equipment. This is in addition to NSR traffic supplying Siberian communities with goods and trade during the ice-free season.

Recent examples of such new Arctic shuttles include icebreaking and multipurpose general-cargo vessels serving Norilsk Nickel's industrial activity in Siberia on a year-round basis, and Sovcomflot's 70,000 dwt double-acting ice-breaking crude oil tankers.

It has recently been estimated that the total volume of all types of cargo transported on the NSR could reach 100 million tons annually by 2020 (including transits) and perhaps reach 150 million tons by 2030.

TRANSITS ON THE NSR

The NSR shortens the distance between the North Atlantic and the North Pacific by about 40% depending on the location of loading and discharging ports. International commercial shipping on the NSR started in 2010 (though the route was officially opened in July 1991), and the number of transits and volume amounts has steadily increased since then.

There were 46 transits on the NSR during the 2012 navigational season, up from 34 in 2011 and four in 2010. The cargo volume grew from 111,000 tons in 2010 to 820,000 tons in 2011, and reached 1.26 million tons in 2012. During the 2012 season, a total of 26 tankers transited the NSR with hydrocarbons (895,000 tons) and six dry bulk carriers with iron ore and coal (360,000 tons).

In 2012, the main loading port to the west of the NSR for both cargo

types was Murmansk, in addition to Archangelsk for a few of the smaller tankers and Hammerfest in Norway for the trial run of the first loaded LNG tanker on the NSR, "Ob River," transporting 66,342 tons of LNG to Tobata (Japan). So in reality, most of the current transits on the NSR are transporting resources within the Eurasian Arctic eastbound to markets in the Far East, and are therefore destinational in character, as described above, though the loading ports in these cases lie outside the Russian-defined boundary for the NSR – Novaja Zemlya in the west to the Bering Strait in the east.

Few transits on the NSR with cargo now take place between loading and destination ports that are both located outside the Arctic, but some examples in 2012 include the tankers "Stena Poseidon," "Marika," and "Palva," all of which departed from Yosu in South Korea going to Porvoo in Finland, with 66,400, 66,550, and 66,280 tons of jet fuel, respectively. Another example of a shipment between markets in 2012 was the NSR transit of the dry bulk carrier "Nordic Odyssey" with 71,790 tons of coal, which went from Vancouver (Canada) to Hamburg (Germany).

Examples in 2013 include the tankers "Propontis" transporting 109,090 tons of diesel from Ulsan (South Korea) to Rotterdam, "Mari Ugland" with 62,115 tons of naphtha from Zeeland (Holland) to Mailiao (Taiwan), "Zaliv Amurskiy" with 96,131 tons of diesel from Onsan (South Korea) to Rotterdam, "Nordic Bothnia" with 41,573 tons of general cargo from Xingang (China) to Amsterdam, "Viktor Bakaev" with 88,024 tons of jet fuel from Yosu to Rotterdam, and "Nordic Odyssey" transporting 73,500 tons of coal from Vancouver to Pori (Finland).

During the 2013 navigational season a total of 71 transits took place with cargo volume reaching 1.35 million tons: 911,867 tons of liquid cargo (31 vessels), 276,939 tons of bulk cargo (4 vessels), 66,868 tons of LNG (one vessel, "Arctic Aurora" sailing from Hammerfest to Futtsu in Japan), and 100,223 tons of general cargo (13 vessels). Vessels in ballast or repositioning were 22 in total, including the LNG tanker Arctic Aurora departing from Vladivostok and sailing to Hammerfest.

Some sources estimate that the transit volume might reach 50 million tons by 2020. This may be a very optimistic figure, but the NSR opens up an interesting market for Arctic LNG, as Asia's appetite for gas has increased after the Fukushima nuclear disaster in Japan in 2011, and as the prices there are significantly higher than in Europe. As mentioned earlier, each large LNG tanker sailing the NSR can save close to USD $7 million

on a round trip compared with vessels going through the Suez. But future pipelines across Eurasia and additional pipelines to central Europe appear to be strong competitors with the oil and LNG carriers sailing eastbound along the NSR.

It is clear that in the short to medium term, the NSR will not revolutionize world trade or be serious competition for the Suez route, which has close to 18,000 ships passing through the Suez Canal each year. But Russia is actively working to capitalize on changing conditions in the Arctic and wants to transform the NSR into a commercial shipping route of global importance, capable of competing with more traditional routes in price, safety and quality.

China, the world's biggest exporter, with 90% of its trade carried by sea, is looking at gaining more economic advantages from the opening of the new Arctic trade routes between China and Europe and facilitating stronger commercial ties with Russia. China is clearly eager to diversify its supply and trade routes, save on shipping costs, and reduce its reliance on the piracy-infested Suez route. One way that China seeks to reduce the carbon intensity of its economy is by increasing the amount of gas in its energy mix, so cooperating with Russia to secure access to Arctic gas resources is a high priority.

The first NSR transit voyage by a Chinese shipping company took place during the 2013 season with Cosco's container vessel "Yong Sheng" transporting 16,740 tons of general cargo (mainly steel and machinery) from Busan to Rotterdam.

CONCLUSION

For the NSR to become an important trade route, large-scale investments are needed in a new NSR marine transportation and logistics infrastructure.

With further development of the NSR the route could become an important transport option for certain cargo types and provide new and additional capacity for a growing transportation volume. The current limited seasonal window for trans-Arctic voyages, however, will be a limitation to the NSR's development and economic viability. Future year-round operation on the NSR will therefore be a prerequisite for the route's full integration into the world's transportation system.

The global maritime industry will decide if and when the potentially

shorter Arctic routes are safe, efficient, reliable and economically viable in comparison with other routes across the world's oceans. The marine insurance industry and ship classification societies will have a significant influence in these route determinations, as will a host of other stakeholders and actors, including investors and shipbuilders.

References

ACIA. 2005. *Arctic Climate Impact Assessment*. New York: Cambridge University Press.

Emmerson, Charles and Glada Lahn. 2012. *Arctic Opening: Opportunity and Risk in the High North*. London: Lloyd's and Chatham House. http://www.lloyds.com/~/media/Files/News%20and%20Insight/360%20Risk%20Insight/Arctic_Risk_Report_20120412.pdf

Arctic Council. April 2009. Arctic Marine Shipping Assessment 2009 Report. Protection of the Arctic Marine Environment (PAME). Ottawa, Canada.

Brigham, Lawson W. and Michael P. Sfraga. eds. 2009. "Considering a Roadmap Forward: The Arctic Marine Shipping Assessment." Workshop Report, October 22-24, 2009. University of Alaska Fairbanks and the University of the Arctic Institute for Applied Circumpolar Policy.

U.S. Committee on the Marine Transportation System (CMTS). February 2013. "U.S. Arctic Marine Transportation System: Overview and Priorities for Action." Draft Document for Public Review.

Canadian Arctic Shipping Assessment. June 2007. Mainport Group Ltd. for Transport Canada.

AMATII Workshop Proceedings. 2012. "Response Capacity and Sustainable Development, Arctic Marine & Aviation Transportation Infrastructure Initiative." Prepared for Arctic Council's Sustainable Development Working Group by the Institute of the North, Anchorage, Alaska, 20 December, 2012.

Perovich, D., Meier, W., Tschudi, M., Gerland, S., and Richter-Menge, J. 2012. "Sea Ice." *Arctic Report Card* 2012. http://www.arctic.noaa.gov/reportcard

Stroeve, J. C., Serreze, M.C., Holland, M.M., Kay, J.E., Malanik, J., and Barrett, A.P. 2011. "The Arctic's Rapid Shrinking Sea Ice Cover: A Research Synthesis." *Climatic Change* 110 (3): 1005-1027. DOI10.1007/s10584-011-0101-1, Springerlink.com

National Snow and Ice Data Center. 2013. www.nsidc.org

Gran, Rani, and Vinas, Maria-Jose. 2012. NASA Finds Thickest Parts of Arctic Ice Cap Melting Faster. NASA Goddard Space Flight Center, Greenbelt, Maryland,

February 29, 2012. www.nasa.gov/topics/earth/features/thick-melt.html

Humpert, Malte and Raspotnik, Andreas. 2012. "The Future of Arctic Shipping." *Port Technology International*, September 2012.http://www.porttechnology.org/images/uploads/technical_papers/The_future_of_Arctic_shipping.pdf

Bird, K.J., Charpentier, R.R., Gautier, D.L., Houseknecht, D.W., Klett, T.R., Pitman, J.K., Moore, T.E., Schenk, C.J., Tennyson, M.E., and Wandrey, C.J. 2008. "Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle." USGS Fact Sheet 2008-3049.

Avershin, V. 2013. "Russian Mining Industry in the Barents Region and Possibilities for Nordic Countries." PP Presentation given at the 9th Barents Industrial Partnership Meeting in Tromsø, Norway, May 13-14, 2013.

Smelror, M.C. 2011. "Mining in the Arctic." PP Presentation at the Arctic Frontiers Conference in Tromsø, Norway, January 23-28, 2011.

Tschudi, Felix H. 2012. "Developing a Profitable Shipping System Using the Northern Sea Route." *The Arctic Herald Information & Analytical Journal* 4: 70-83. http://arctic-herald.ru/

Balmasov, Sergey. 2012. "Prospects of the Development of International Transit Shipping via the Northern Sea Route." *The Arctic Herald Information & Analytical Journal* 2: 44-55. http://arctic-herald.ru/

Belkin, M. 2012. "Results from the 2012 Navigation Season and Future Plans." PP Presentation at the 9th Annual Arctic Shipping Forum in Helsinki, Finland, April 23-25, 2012.

Falck, H. 2013. "Voyage Calculation - Status, Challenges and Opportunities." PP Presentation at the Northern Sea Route (NSR) Conference in St. Petersburg, Russia, April 11, 2013.

NSR Information Office. 2013a. NSR Tariff System. http://www.arctic-lio.com/nsr_tariffsystem

NSR Information Office. 2013b. NSR Current Legislation. http://www.arctic-lio.com/nsr_legislation

NSR Information Office. Rules of Navigation on the Water Area of the Northern Sea Route. http://www.arctic-lio.com/docs/nsr/legislation/20130425185806en-Rules_unof.pdf

Karlsbakk, Jonas. 2012. "Construction Starts for New Giant Icebreaker." *Barents Observer*. February 15, 2012. http://barentsobserver.com/en/business/construction-starts-new-giant-icebreaker

Staalesen, Atle. 2012. "New Icebreaker for Russian Arctic." *Barents Observer*. September 18, 2012. http://barentsobserver.com/en/arctic/new-icebreaker-russian-arctic-18-09

NSR Information Office. 2013d. Port Murmansk. http://www.arctic-lio.com/murmansk

Kirkenes Industrial and Logistics Area (KILA). 2011. PP Presentation by Trond Dahlberg, 9 November 2011. http://www.kystverket.no/PageFiles/8683/Presentasjoner/KILA%20-%20Trond%20%20Dahlberg.pdf

Norterminal - New Oil and Gas Terminal in Finnmark. http://norterminal.no/

PAME. 2013. The Arctic Ocean Review Project, Final Report (Phase II 2011-2013), Kiruna May 2013. Protection of the Arctic Marine Environment (PAME) Secretariat, Akureyri, Iceland.

NSR Information Office. 2013e. Ice Pilot Services. http://www.arctic-lio.com/nsr_icepilotage

Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic. Signed by the Arctic ministers on May 12, 2011 at the 7th Ministerial Meeting of the Arctic Council, Nuuk, Greenland. http://www.ifrc.org/docs/idrl/N813EN.pdf

Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic. 8th Ministerial Meeting of the Arctic Council, Kiruna, Sweden, May 15, 2013. http://www.arctic-council.org/eppr/agreement-on-cooperation-on-marine-oil-pollution-preparedness-and-response-in-the-arctic/

NSR Information Office. Search and Rescue. http://www.arctic-lio.com/nsr_searchandrescue

Guidelines for Ships Operating in Polar Waters. Adopted by the 26th Session of the IMO Assembly, December 2009.http://www.imo.org/Publications/Documents/Attachments/Pages%20from%20E190E.pdf

Logvinovich, Eduard. 2012. Enhancing the Infrastructure of Marine Transportation System in the Russian Arctic. From Lomonosov to Nansen and Beyond. November 2011, Arckangelsk. Joint Norwegian-Russian Seminar devoted to Jubilees of Lomonosov and Nansen. Collection of Reports, Tromsø, 2012.

NSR Information Office. Transit Statistics. http://www.arctic-lio.com/nsr_transits

Deshayes, Pierre-Henry. 2013. "Melting Ice Pulls Norway Closer to Asia." *Agence France-Press (AFP)*, June 22. http://www.google.com/hostednews/afp/article/ALeqM5iiVCnMhIQTXoKrTiYw42DTkBS-8A?docId=CNG.6c583ef5d013cf0b7238f85a329d1052.2b1

Staalesen, Atle. 2013. "First Container Ship on Northern Sea Route." *Barents Observer*, August 21. http://barentsobserver.com/en/arctic/2013/08/first-container-ship-northern-sea-route-21-08

Lee, Sung Woo, Ju-mi Song, and Yeon-seo Oh. 2011. *Benefit of the Northern Sea Route to the North Pacific*. Seoul: Korea Maritime Institute.

Comments on Chapter 2: IMO perspective

Heike Deggim

INTRODUCTION

While Dr. Gunnarsson's paper addresses the challenges of a new marine transport and logistics system and the required infrastructure for the whole of the Arctic, the International Maritime Organization (IMO) only deals with one component of that system: shipping. As Dr. Gunnarsson pointed out, the IMO is currently developing a mandatory International Code of Safety for Ships Operating in Polar Regions, known for short as the Polar Code, which will provide requirements to ensure the safe operation of ships and the protection of the polar environment by addressing risks present in polar waters that are not adequately mitigated by existing IMO instruments. It should be noted that the Code addresses both polar regions, Arctic and Antarctic, and that the requirements in the Code for the two regions are not uniform, given their distinctly different geographical and governance features. This paper provides a brief update on the general progress made so far in the development of the Polar Code and offers additional comments on some of the issues raised by Dr. Gunnarsson from a shipping point of view, in particular regarding environmental protection issues, oil spill response in ice and snow conditions, and availability of hydrographic charts.

STATUS OF THE POLAR CODE'S DEVELOPMENT

Navigation in polar waters was first addressed by the IMO in 2002 with the adoption of the Guidelines for ships operating in Arctic ice-covered waters (MSC/Circ.1056 – MEPC/Circ. 399), later, following a request by the Antarctic Treaty Consultative Meeting (ATCM), revised to include Antarctic areas. The revised Guidelines were adopted by the 26th session of the IMO Assembly in December 2009 as the Guidelines for ships operating in polar waters (Polar Guidelines) (resolution A.1024 (26)).

Immediately following the adoption of these Guidelines by the assembly, the IMO's Maritime Safety Committee (MSC) considered proposals to develop them further and create a mandatory Polar Code,

covering the full range of design, construction, equipment, operational, training, search and rescue, and environmental protection issues for ships operating in polar waters. The Code aims to address the increased interest and traffic in these regions and the unique operational, environmental and search and rescue concerns specific to the areas, taking into account that the consequences of any major safety or pollution incident in polar waters are likely to cause widespread harm to these pristine environments and could in the process also seriously damage the reputation of the shipping community.

The IMO's Subcommittee on Ship Design and Equipment (DE) started its work on the development of the Code at its 53rd session (DE 53) in 2009. From the outset a goal-based approach was followed, consequently developing objectives and functional requirements for each of the chapters of the draft Code,[1] which has been structured to contain two parts: a mandatory part A, including requirements concerning structural integrity, stability, watertight and weather-tight integrity, anchoring arrangements, habitability, fire safety and protection, life-saving appliances and arrangements, navigation, communications, crewing and manning, emergency control and environmental protection together with a recommendatory part B, providing additional guidance with regard to the application of the requirements contained in Part A. The Code will contain only requirements additional to those already set out in existing IMO instruments that in any case apply globally, including for the polar regions. In between the subcommittee's meetings, the work is carried out by an exceptionally active correspondence group under the coordination of Norway.

It is expected that the draft text of the Code will be completed by the subcommittee in January 2014, and will subsequently be approved by the MSC and the Marine Environment Protection Committee (MEPC) for final adoption by the two committees, together with associated amendments to make it mandatory under applicable IMO instruments in line with the respective amendment procedures of these instruments, at the end of 2014.

The subcommittee is currently developing the Code on the premise that its requirements will apply to new passenger and cargo ships as defined in the International Convention for the Safety of Life at Sea (SOLAS) 1974, except for the chapter related to environmental protection, which will apply, as appropriate, to ship types according to the various annexes of the International Convention for the Prevention of Pollution from Ships

(MARPOL) 1973/78. Following adoption of the Code, it is planned to start work on extending its provisions to non-SOLAS ships,[2] such as fishing vessels.

ENVIRONMENTAL PROTECTION MEASURES IN THE POLAR CODE

While the development of the purely technical safety requirements was not controversial and mainly expanded on the existing provisions in the Polar Guidelines, the environmental protection measures to be included posed a much bigger challenge, given the fact that the environmental chapter of the Guidelines was rudimentary, generally just referring to applicable national and international rules and regulations.

The environmental chapter 15 of the draft Code will be of a much more substantial character. A large number of proposals for issues to be addressed were considered by DE 57 and the results of the discussions referred to MEPC 65 in May 2013, which took decisions as described in the following paragraphs.[3]

Discharge of Oil or Oily Mixtures into Arctic Waters

The discharge of oil and oily mixtures into the sea is already prohibited for the Antarctic area under regulation 15.4 of MARPOL Annex I (Regulations for the prevention of pollution by oil). DE 57 prepared two options for additional requirements to those of MARPOL Annex I concerning such discharges by ships operating in the Arctic: either allowing ships to discharge oil and oil mixtures into the sea under certain conditions or prohibiting any discharges into the sea of oil or oily mixtures from ships.

MEPC 65 considered the two options and agreed that any discharge into the sea of oil or oily mixtures from ships in the Arctic area should be prohibited. Consequently, requirements to this effect will be included in the draft Polar Code.

In this connection, the question of the lack of reception facilities in the Arctic region was raised and it was proposed that mandatory provisions for reception facilities should be developed so as to ensure and facilitate the effective implementation of the new requirements. MEPC 65 agreed that this issue needed further consideration and invited member governments

and international organizations to submit relevant proposals and comments to DE 58.[4]

Discharge of Food Waste into Arctic Waters

Keeping in mind the existing requirements for special areas in regulation 5 (disposal of garbage within special areas) of MARPOL Annex V (regulations for the prevention of pollution by garbage from ships) which prohibit (with some exceptions) the disposal into the sea of all plastics and all other garbage, DE 57 prepared two options for requirements additional to those concerning the discharge of garbage into the sea in the Arctic area: either allowing the discharge of food waste into the sea under certain conditions or prohibiting the discharge of all garbage into the sea.

MEPC 65 considered the two options and agreed to option one, i.e., allowing the discharge of food waste in the Arctic area under certain conditions. Consequently, requirements to this effect will be included in the Polar Code.

Exemption of Independently Operating Cargo Ships with Ice-Breaking Capability from the EEDI Requirements

DE 57 considered submissions[5] providing the results of an analysis showing that recent higher ice-class cargo ships operating independently, i.e., without icebreaker assistance, in heavy ice conditions have and need considerably more installed power than will be permissible in the future under the EEDI (Energy Efficiency Design Index) regulations. The analysis further showed that even ice-strengthened ships designed to navigate with icebreaker escort in ice conditions may need some additional power in order to be able to follow icebreakers at an adequate speed. Recognizing the need to consider the possible development of correction coefficients or the possible exemption of category A ships[6] from the EEDI requirements and taking into account the relatively small number of such ships, the subcommittee asked the MEPC for advice on the issue.

Following discussion, MEPC 65 agreed that independently operating cargo ships having ice-breaking capabilities should be exempted from the EEDI requirements and approved relevant draft amendments to chapter 4 (regulations on energy efficiency for ships) of MARPOL Annex VI (regulations for the prevention of air pollution from ships) with a view

to adoption at MEPC 66 in spring 2014. The amendments state that regulations 20 (Attained EEDI) and 21 (Required EEDI) shall not apply to cargo ships having ice-breaking capability. A pertinent definition of "cargo ship having ice-breaking capability" was included in regulation 2 (Definitions).

Use of Heavy Fuel Oil (HFO) on Ships Operating in Arctic Waters

In March 2011 the MEPC adopted a new chapter 9 (special requirements for the use or carriage of oils in the Antarctic area) of MARPOL Annex I, establishing a ban on the use and carriage of heavy grade oils in the Antarctic area.[7] MARPOL does not contain any such requirements for the Arctic.

DE 57 received a proposal[8] to include in the Polar Code a requirement banning the use of HFO also on ships operating in Arctic waters, referring to the ban on HFO use and carriage already in force for Antarctic waters (MARPOL Annex I, regulation 43). Noting views that the proposal contained too many policy aspects and was outside its remit, the subcommittee referred it to MEPC 65 for consideration and advice.

MEPC 65, after some discussion, endorsed the view of the majority that it is premature to regulate the use of HFO on ships operating in Arctic waters but noted the view of some IMO members that it might be desirable and possible to develop such regulations at some point in the future.

Grey Water Discharge in Arctic Waters

DE 57 also considered a proposal for the inclusion in the Code of alternative requirements for the discharge of sewage and grey water in polar areas[9] and agreed that the introduction of requirements concerning grey water discharge should be considered first by the MEPC since grey water is currently not regulated under MARPOL.

Impact on the Arctic of Emissions of Black Carbon

MEPC 65 considered a proposal for the inclusion of requirements in the Polar Code that recognize the importance of mitigating black carbon emissions from shipping in all polar waters to the maximum extent feasible,[10] having noted the view of DE 57 that the proposal went beyond

the scope of the work on emissions of black carbon from international shipping currently being carried out by the BLG Subcommittee (target completion year is 2014) but that, in any case, the outcome of that work should be awaited before considering the issue further. Consequently, MEPC 65 agreed that the DE Subcommittee should await the outcome of the BLG Subcommittee's[11] work on the matter.

Shipboard Incineration in Polar Regions

MEPC 65 also considered a proposal[12] to include requirements in the Code prohibiting shipboard incineration in polar regions within 12 nautical miles from the nearest land, ice shelf, land-fast ice, or area of ice concentration in excess of 10% ice coverage. However, the proposal did not receive sufficient support to be carried forward.

Temperature Testing Requirements for Ballast Water Management Systems

MEPC 65 further instructed the DE Subcommittee, when considering relevant recommendations on ballast water management (BWM) systems to be included in the recommendatory Part B of the Polar Code, to take into account the temperature testing requirements for BWM systems, as contained in the revised methodology for information gathering and conduct of work of the GESAMP[13] -Ballast Water Working Group (BWM.2/Circ.13/Rev.1).

OIL SPILL RESONSE IN ICE AND SNOW CONDITIONS

The specific problems of an effective response to oil spills in ice and snow conditions are well known. The matter has been under consideration at the IMO for a number of years and is being addressed by the OPRC-HNS[14] Technical Group (TG), which operates under the auspices of the MEPC.

At its last meeting in May 2013, the TG considered a summary[15] of a newly launched oil industry initiative on Arctic Oil Spill Response Technology, together with other initiatives being undertaken by the International Association of Oil and Gas Producers (OGP), as part of a Joint Industry Project (JIP). Having noted the considerable volume

of work undertaken by OGP through the Arctic JIP project, the group recognized that the resulting information, together with the results of the 2012 Spill Response in the Arctic Offshore document published by the American Petroleum Institute (API) also referred to by OGP, would serve as important information resources in the development of a guide on oil spill response in ice and snow conditions. In discussing how to advance this work, the group noted an offer from Norway to lead the development of the guide and to take the matter forward to the next session of the Arctic Council's Emergency Prevention, Preparedness and Response Working Group (EPPR WG) in June 2013 and agreed that the guide should initially be developed in that forum, on the basis of an initial draft of the proposed guide prepared by the United States,[16] together with the OGP/IPIECA (International Petroleum Industry Environmental Conservation Association) JIP project results and the API publication, referred to above. Once the Guide has been sufficiently developed by the EPPR WG, it will be referred back to the OPRC-HNS TG for its review and agreement and ultimately to the MEPC for approval.

AVAILABILITY OF HYDROGRAPHIC CHARTS FOR THE POLAR REGIONS

Regulation 9 (Hydrographical services) of chapter V (Safety of navigation) of the 1974 SOLAS Convention requires contracting governments (currently 162 countries covering 99.2% of world tonnage) to arrange for the collection and compilation of hydrographical data and the publication, dissemination and updating of all nautical information necessary for safe navigation.

However, according to the International Hydrographic Organization (IHO),[17] systematic and complete hydrographic surveys have not been carried out in many polar areas due to their extensive, remote, and inhospitable nature. While the presence of ice throughout much of the year limits the ability to conduct hydrographic surveys, growing un-surveyed areas may be becoming available for navigation due to the melting of glaciers and sea ice. The IHO estimates that 95% of the Antarctic is un-surveyed and estimates that the situation is similar in the Arctic. The chart coverage of polar regions at an appropriate scale is generally inadequate for coastal navigation. Where charts do exist, they have limited usefulness due

to the lack of any reliable depth or hazard information.

The IHO has been leading an effort to prioritize, encourage and monitor the conduct of hydrographic surveys in the polar regions through its Hydrographic Commission on Antarctica (HCA) and through the Arctic Regional Hydrographic Commission (ARHC). However, it will take many years for the situation to improve, as national priorities generally focus on charting deficiencies at lower latitudes.

The grounding and even loss of ships in uncharted polar waters is not uncommon. To make the situation worse, national hydrographic authorities active in both polar regions are reporting that government-sponsored surveying activity is actually decreasing due to financial pressures and competing priorities in territorial waters. Meanwhile, the level of maritime activity in the polar regions continues to increase significantly. For things to improve dramatically, a major change in the priorities being set by governments and stakeholders for gathering hydrographic data around the world and particularly in the polar regions is necessary.

The IMO's Maritime Safety Committee, at its 92nd session (June 2013), stressed the utmost importance of adequate charting, not only for the polar regions, but also for all other areas. Recognizing that a collective effort is necessary to improve the situation, the committee encouraged IMO member states to collect relevant information, especially for remote areas, in support of the IHO activities in this regard and also instructed its Subcommittee on Navigation (NAV) to consider the matter and advise the committee on a suitable course of action to address the situation.

Notes

1. For the most recent version of the draft Code refer to IMO document DE 57/WP.6/Add.1.
2. SOLAS 1974 applies to ships of 500 gross tonnage and above engaged in international voyages. Fishing vessels are explicitly excluded from the requirements of the Convention (except for chapter V requirements).
3. A more detailed description of the decisions taken at MEPC 65 is contained in the report of that meeting (IMO document MEPC 65/22).
4. Following the restructuring of the IMO subcommittees in 2013, this will be the first session of the new Subcommittee on Ship Design and Construction (SDC 1), scheduled to take place in January 2014.

5. IMO documents DE 57/11/8 (Finland and Sweden) and DE 57/11/16 (Canada).
6. Current definition in the draft Polar Code: "Category A ship means a ship capable to operate at least in medium first-year ice which may include old ice inclusions in accordance with an ice class at least equivalent to those acceptable to the Organization."
7. MARPOL defines in Annexes I (Prevention of pollution by oil) and V (Prevention of pollution by garbage from ships) certain sea areas as "special areas" in which the adoption of special mandatory methods for the prevention of sea pollution is required. Under the Convention, these special areas are provided with a higher level of protection than other areas of the sea. The Antarctic area has been designated a special area under MARPOL Annexes I and V.
8. IMO document DE 57/11/11 (FOEI, CSC, IFAW, WWF and Pacific Environment).
9. IMO document DE 57/11/14 (FOEI, WWF and Pacific Environment).
10. IMO document DE 57/11/20 (CSC, FOEI, WWF and Pacific Environment).
11. Following the restructuring of the IMO Subcommittees in 2013, the BLG Subcommittee has now been replaced by the Subcommittee on Pollution Prevention and Response (PPR).
12. IMO document MEPC 65/11/5 (FOEI, CSC, Pacific Environment and WWF).
13. IMO/FAO/UNESCO-IOC/WMO/IAEA/UN/UNEP/UNIDO Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.
14. Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances.
15. IMO document OPRC-HNS/TG 15/3/1 (OGP).
16. IMO document MEPC 57/6 (United States).
17. IMO document DE 57/11/4 (IHO).

Comments on Chapter 2: Russian perspective

Arild Moe

As described in the introduction to this session, as well in the other comments, there is considerable international interest in using the Arctic waterway connecting the Atlantic with the Pacific – the Northeast Passage. Sometimes, the underlying assumption seems to be that this is an international waterway where it is up to the international community to define the terms of its use. However, this perspective is far from the Russian position.

In Russia, the prevailing understanding is that the waterways north of Russia are a part of the national transport infrastructure holding the country together. Indeed, if one looks at the map, it clearly shows that the route between the northeast and northwest of Russia is much shorter than connections over land. Moreover, this sea route has been developed over decades by the Russian and Soviet states.

Traditionally Russia's legal argument for control and management of the sea route rested on its de facto control over the area and its historical role in developing shipping lanes. But with the USSR's signing of the UN Convention on the Law of the Sea (UNCLOS), the argumentation changed, bringing Soviet and later Russian claims more in line with international law.

As a general rule, UNCLOS mandates free navigation within a coastal state's 200 nm exclusive economic zone. There is, however, an important exception, the so-called "ice paragraph" Article 234. This paragraph stipulates that "Coastal States have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance." This paragraph is crucial in Russia's argument today for management and control of traffic through the sea route.

Nevertheless, a certain ambiguity can be detected in Russian declarations. The 2012 "Law on the Northern Sea Route (NSR)" (in reality a "change" law detailing alterations in several relevant laws) says that "Navigation in the water area of the NSR, a historically formed

communication lane of the Russian Federation, is conducted in accordance with generally accepted principles and norms of international law, international agreements of the Russian Federation, the present Federal law, other federal laws, and other normative legal acts issued in accordance with them." Although convoluted, this clearly refers to UNCLOS and Article 234. But it also retains a reference to the specific historical circumstances. Clearly, there is some uneasiness in Russia over the prospects of diminishing ice, which at some point would make Article 234 irrelevant. If such a situation occurs, I would expect that the emphasis on the historical formation of the NSR would become stronger again.

Even if *internationalization* of the route itself has never been an issue, much has happened with regard to international use of the sea route. With the easing of international tensions in the late 1980s, the USSR changed its policy in the Arctic and declared that it should be open for international cooperation and trade. The NSR was officially opened for international shipping on January 1, 1991. Russia has since encouraged international use of the sea route – unsuccessfully in the 1990s, more successfully in the last four years.

Transit traffic on the NSR was for a long time held back by exorbitant transit, or icebreaker, escort fees. The fees, which were last fixed in a "price list" from 2005, were meant to secure enough revenue to finance the icebreaker fleet. The problem was that few were willing to pay the fees, and the financial challenge only grew worse.

The reason for the increased interest in transit that has been observed in recent years has much to do with changing ice conditions. But clearly, improvement in conditions offered by Russia played a big part. Special deals that had been offered in 2009 and 2010 became the norm when one word was changed in the price list in 2011. What had been compulsory rates now became maximum rates; the fees had become officially negotiable.

Also, the practical administrative handling changed: it was simplified and became more transparent. Whereas shipping companies previously had to arrange transit a long time in advance, starting in 2012 a 15-day minimum notice system was introduced. The conditions were further elaborated in the new "Rules for Navigation on the Northern Sea Route" adopted in January 2013. Applications can now be sent electronically, containing standard information about the ship and cargo and documentation of insurance. The applications are processed by the

newly established Northern Sea Route Administration. The administration determines whether an icebreaker escort is required, based on an assessment of the ice situation in combination with the ice class of the relevant vessel.

The Law on the NSR from 2012, which is the legal basis for the new regulations, also introduces a new principle for the determination of fees. The fees should no longer be a general payment for going through the sea route, but payment for services rendered. This was seen as an important step forward by shipping companies that do not expect to be dependent on Russian icebreakers.

Uncertainties remain, however, over how the principles will be implemented. Icebreaker services are treated as a natural monopoly, and the icebreaking companies cannot charge higher rates. The maximum rate is fixed by the Federal Tariff Service, but the actual rate is negotiated with one of the Russian icebreaker companies, Atomflot and five others operating long-distance diesel icebreakers or port icebreakers, which together are given a monopoly position in icebreaker escort on the NSR.

The most complicated question is what should be included in the "services rendered." It can be argued that services rendered to vessels navigating the sea route consist not only of an actual icebreaker escort. Navigational assistance, for instance, could be termed as a service. But most importantly, the presence of icebreaker back-up capacity is a vital element in safe NSR shipping. Icebreakers amount to floating rescue stations in areas with no other relevant infrastructure. And the cost of maintaining nuclear icebreakers in a back-up mode is almost the same as running them. If the back-up and rescue operations are taken into account as services, the difference in fees between vessels enjoying icebreaker escort and those sailing independently is not so great. For the time being, it seems that a narrow definition of services is applied (i.e., only icebreaker escort), but the new tariff system is not settled, and strong voices argue for reintroduction of a general transit fee for all ships using the sea route.

The underlying problem is whether the income collected from fees will be substantial enough to cover the running costs of infrastructure and icebreakers along with some investments. It has been claimed that the fees negotiated over the last few years, and which have been competitive enough to attract vessels, have been so low that they cover no more than direct operational costs. But if competitive rates are not sufficient to cover costs, how long can this continue? Will competitive rates attract so much traffic that revenues reach a decent level, or can and will the Russian government

step in with increased subsidies?

The number of commercial transits with cargo, with destinations or ports of departure outside Russia, (19 in 2012) is still very limited. (The total number of 46 voyages also includes ballasts, repositioning and transits between western and eastern Russia.) It is difficult to draw clear conclusions regarding interest in NSR transit based on these numbers alone – how much is a reflection of a long-term trend toward increased usage of this Arctic transport corridor and willingness to invest and how much is about companies availing themselves of short-term opportunities in the freight markets? Obviously, companies who see the NSR as an important option in the years ahead will be concerned about how conditions will develop over time, whereas actors in the second group just relate to existing conditions at any point in time. Thus, it is important to look for companies and projects that have a long-term stake in the NSR.

The Yamal LNG project is seen as crucial for the further development of the NSR since it depends on extensive use of the NSR year round. The plan is to build an LNG factory on the eastern side of the Yamal Peninsula, construct the port of Sabetta and ship out the product via the NSR, eastward in the summer and westward in the winter. This project was owned 80% by the independent Russian gas company Novatek and 20% by Total. In September 2013, CNPC of China bought a 20% stake in the project from Novatek coupled with contracts for gas deliveries.

Daewoo of South Korea won an option to build 16 ice-strengthened carriers in 2013. The LNG carriers ordered are designed to cut through 1.5 meters of ice with a continuous speed of 5 knots. They also can go through thicker ice, with less speed. Yamal LNG argues that this will make it possible to operate without the escort of nuclear icebreakers. This position contrasts with statements from Atomflot, which maintains that escorting LNG carriers from Yamal will form a stable demand for icebreaker services and thus produce revenues in the years ahead.

A final investment decision for the project has yet to be made (as of September 2013). The decision – positive or negative – will have large implications. But in any case, it is reasonable to expect that the debate regarding how much icebreaker capacity will be needed along the sea route will heat up in the years ahead. Could diesel-powered icebreakers stationed in the most critical passages do more of the job, and will the melting of ice altogether make icebreaking less of a constraint? These discussions are complicated by a widespread scientific disagreement in Russia on the pace,

and even the direction, of climate change.

Meanwhile, the official Russian position is that there will be a continued need for nuclear icebreakers. The fleet is aging, however. In 2013, there is a total of six, but only four are in operating condition. One new nuclear icebreaker has been completed since soviet times. According to the latest assessments from Atomflot, five of the icebreakers will have reached the end of their service life by 2022, but two will, with renewal of their nuclear fuel, be able to operate for some additional years. Only one will be operational after 2026. The diesel icebreakers are also ageing and in need of replacement. Thus, the overall picture is that Russia is in need of rapid renewal of its icebreaker fleet if it wants to continue to provide the present level of icebreaker services.

Plans for construction of new nuclear-powered icebreakers have been announced several times and a design worked out for the strongest icebreaker ever seen to secure year-round traffic on the NSR. A shipyard in St. Petersburg finally started construction in 2013. Skepticism about the cost estimate of 37 billion rubles (approximately USD $1.2 billion) has been voiced. The Russian government has declared that it will build and fully finance two more such giants. If all three are delivered on time in 2017, 2019, and 2020, and nothing unexpected happens with the old icebreakers, Russia will avoid the "ice pause" often feared in critical Russian comments. But the time set aside for construction looks very optimistic.

In its policy regarding the NSR, Russia faces paradoxes and trade-offs. Whereas less ice is a major factor in increased use of the sea route, making navigation possible without icebreaker support in longer seasons, uncertainty about the level of icebreaker support needed, is a constraint on long-term plans for use of the route. Whereas Russia maintains its exclusive right to administer traffic on the NSR, it relies on international shipping to help finance maintenance of the route.

As this commentary suggests, much has been improved in the last few years, but the basic financial challenges have not been solved. Russian planners hope that steadily increasing traffic, both transit and commercial destination traffic, will provide a sufficient level of income to sustain and improve infrastructure. The reforms and flexibility seen in recent years indicate a willingness to adapt to the needs of users, which is a prerequisite for a further increase in the attractiveness of the route. Nevertheless, substantial financing from the Russian state also will be needed, and the NSR will have to compete with other priorities for funding.

Comments on Chapter 2: NSR operational perspectives

Lawson W. Brigham

Bjørn Gunnarsson's paper clearly outlines the opportunities and challenges involved in developing the Northern Sea Route (NSR). He makes clear that the primary driver of Russia's NSR initiative is Arctic natural resource development. Development of the Russian Arctic offshore and onshore natural resources is a key component of Russia's economic strategy. Linkages of these resources to global markets, particularly those in the Pacific, are facilitated by the NSR, a challenging waterway across the top of the Russian mainland. Importantly, political support for expanding the NSR as a national waterway has come from President Putin and the highest levels of the Russian government. But how the NSR competes with, or is supplementary to, land bridges as transport corridors across Eurasia is not clear. Transport alternatives to the NSR across Eurasia have not been fully exploited and the possibilities of intermodal options have not yet been adequately explored. However, the strategic driver of Arctic navigation being natural resources development remains paramount. This driver is wholly consistent with the findings of the Arctic Council's *Arctic Marine Shipping Assessment* (AMSA) released in 2009, a study in which Russia was a full contributor and partner.

It is this author's opinion that the NSR (and overall Arctic navigation) will not revolutionize global maritime trade routes. The NSR is seasonal and the sea ice conditions are highly variable, so that achievement of year-round, regular service for its entire length would be difficult. However, marine operations on the western end of the NSR (which has been a year-round operation to the port of Dudinka on the Yenisei River since the 1978-79 navigation seasons) will continue and may witness increasing numbers of westbound voyages of LNG carriers from the Yamal Peninsula throughout the winter period.

Therefore, the NSR cannot be considered a viable replacement for the Suez Canal as a global trade route. *The Moscow Times* (4 June 2013) in an article about the future of the NSR quoted a senior Rosatomflot official who stated that 'the NSR is not a rival to the Suez Canal, but it's a good seasonal complement.' This statement encapsulates what many in the maritime industry believe is the promise of the NSR - linking Arctic natural

resources to global markets, but with significant liabilities related to the viability of regular, trans-Arctic container traffic.

The majority of the ships observed today navigating the length of the NSR in summer are ice-capable tankers, bulk carriers (with Arctic minerals such as iron ore, nickel and zinc), and LNG carriers. These high value bulk cargoes pose significant environmental risks to the Arctic marine environment if accidently released. This current operational picture places urgency on near-term implementation of safety and environmental protection schemes such as the International Maritime Organization's (IMO) mandatory Polar Code. The passage of these large tank vessels and bulk carriers through the Bering Strait region also poses a number of critical challenges, including navigating through waters of coastal indigenous marine use, sensitive marine wildlife areas (with large numbers of marine birds and mammals), and a world class fishery located in the Bering Sea. Navigation across the length of the NSR must be viewed in the context that the Bering Strait region at the eastern end of the Route is one of the most ecologically sensitive marine areas on the planet.

One of the key issues when evaluating future NSR use is determining what the 'navigation season' will be for trans-Arctic voyages. It may be technically possible to move ships in winter convoys led by nuclear icebreakers along the eastern sections of the NSR. But do the slow speeds and higher risks undermine the economic viability of the Route? The answer is probably yes. A six-month navigation season along the length of the NSR may be attainable with significant icebreaker support, and this goal appears more realistic and economically viable. More experimental voyages in early spring and late autumn, likely conducted with commercial ships in icebreaker convoy, are needed to highlight the operational challenges of moving large bulk carriers and tankers through long stretches of the NSR that may be completely ice-covered. In these ice conditions, polar class ships will always be mandatory, and the higher the polar class needed to operate during longer navigation seasons, the more expensive these ships will be. Shipping economics in the Arctic can be altered (perhaps unfavorably) if high ice class ships are required to extend the navigation seasons. One of the challenges for shippers will be the full utilization of these high ice class ships when operating in open water and not during a short, ice navigation season along the NSR.

Gunarsson's paper suggests the use of the NSR for container ship traffic. While there is potential for select trans-Arctic operations, the NSR

presents serious challenges to establishing 'regular' (time sensitive) container traffic. First, any service would be seasonal if using a full trans-Arctic route between Atlantic and Pacific; the Russian regulators would not open the eastern reaches of the NSR for year-round commercial traffic. Second, there are few ports along the NSR where cargoes might be transferred. Further expansion and development of the Russian Arctic could change this situation as goods and services may be purchased from foreign sources throughout the region. New, niche and seasonal opportunities for container ship routing may be possible for Korean, Japanese and Chinese shippers. During a three-month season these shippers might exploit the NSR carrying select cargoes to Europe and to Russian Arctic ports. The challenge will be having sufficient containerized cargoes for return voyages. Multipurpose carriers may be the most effective vessel types to exploit potential markets and provide marine support to the Russian Arctic in limited navigation seasons.

Maritime infrastructure requirements and investment needs are major themes in Gunnarsson's paper. Nearly the entire Arctic lacks fundamental maritime infrastructure. Only the Norwegian coast and Russian northwest coast have adequate infrastructure including ports to support current levels of traffic. Several critical elements of infrastructure that are missing in most of the maritime Arctic include: ports; hydrography and charting; response capacity (for search and rescue, and environmental response); environmental observing systems (for monitoring climate changes and to provide real-time information on weather and sea ice for ship operations); places of refuge; communications; salvage, and polar icebreaking capacity. For the Russian Arctic and NSR, polar icebreakers are deemed essential for convoy escort, especially during extended navigation seasons. New diesel-electric icebreakers are being built in St. Petersburg to replace several of the 1970s/1980s icebreakers built in Finland by the former Wartsila shipyards. Construction of nuclear icebreakers is also underway in Russia to replace the earlier ships of the *Arktika* class. In addition, Russia is building a series of response (search and rescue) stations along the length of the NSR and hydrographic surveys continue so that up-to-date charts are available for select NSR routes.

One operational note for the NSR will be the sailing of ice class ships without icebreaker support or convoy. There may be an increase in such voyages as the regulators respond to the improving ice conditions along sections of the NSR. Several Norilsk class icebreaking carriers have

been allowed to make full voyages without any icebreaker escort during summer voyages to China (carrying cargoes of nickel plates produced at Norilsk). These experimental voyages have shown that these carriers are fully capable of operating the length of the NSR without being escorted in convoy. The future of this mode of commercial ship operations has not been fully evaluated and planned.

The speed of infrastructure improvements and the implementation of additional protection and safety measures developed under IMO auspices will surely influence the use of the NSR. Foreign carriers operating under the mandatory Polar Code will have confidence that international standards are being used to evaluate ship applications for use of the NSR. Increasing investments in coastal marine infrastructure along the Russian Arctic will provide new levels of safety and increase the operational efficiency of the NSR as noted in Gunarrson's paper.

Comments on Chapter 2: Conservation perspective

Martin Robards

In "The Future of Arctic Marine Operations and Shipping Logistics," Dr. Bjørn Gunnarsson focuses on how environmental (i.e., loss of summer sea ice), physical, and economic conditions, as well as infrastructure, are affecting the development of Arctic shipping. In addition, he provides background for the conservation issues that need to be considered and addressed to responsibly manage and steward our natural resources in the face of increased Arctic shipping.

The following quotes highlight some of the considerations Gunnarsson raises related to environmental protection in an era of increased shipping traffic:

> *"Balancing commercial activity in the region with environmental protection will for sure remain a significant challenge for the years to come."*
>
> *"Our logistics solutions should take advantage of the Arctic resource potential and Arctic shipping opportunities, but at the same time provide the needed safety and reliability of operations and adequate pollution prevention to safeguard the fragile Arctic environment."*
>
> *"Accidental release of oil into the Arctic marine environment is the most significant threat from offshore oil exploitation and Arctic shipping."*

Gunnarsson highlights the value of the Polar Code as a means to mitigate some conservation risks through vessel design and operational practices. He also emphasizes the need for other broad efforts to improve navigation, communication, and oil spill response capabilities. In this commentary, I provide more detail about the environment we are trying to conserve, the conservation risks we are concerned about, andthe tools we are/should be considering. I also touch on additional considerations and questions that we must grapple with related to wildlife conservation, subsistence communities, and environmental protection more generally.

This commentary uses the Bering Strait as a case study for issues across the Arctic, but also as an area of profound importance and risk that highlights the need for resolving how to accomplish locally specific measures. Elsewhere in the world, we can find areas of substantially greater concentrations of shipping traffic. However, the Bering Strait has dramatic

seasonal concentrations of wildlife, and its wildlife are of profound importance to the food security of indigenous human communities. A primary message of this commentary is that direct and indirect impacts of shipping on the conservation of wildlife and their habitats are inextricably linked with the health, safety, and cultural continuity of numerous Arctic communities.

WHAT IS THE ENVIRONMENT WE ARE TRYING TO CONSERVE?[1]

The Bering Strait is an 85-kilometer-wide passage that connects the North Pacific Ocean and Bering Sea to the Chukchi Sea and Arctic Ocean. The Anadyr Strait is a 70-kilometer-wide passage separating St. Lawrence Island in Alaska (United States) from Chukotka (Russian Federation). Together, these two straits are globally significant for their marine, avian, and coastal biodiversity.

The International Union for the Conservation of Nature (IUCN) has designated 13 ecologically and biologically sensitive areas in the Arctic, including three in the area that encompasses the Bering and Anadyr straits.[2] Almost the entire global populations of some species, such as the Pacific bowhead whale (about 15,000 animals) and Pacific walrus (more than 150,000 animals) pass through the Bering Strait twice each year over a period of about a month. For other species, such as spectacled eiders, incredible seasonal concentrations may also be found, with large segments of the overall population in one place at one time.

This region is home to a wide array of indigenous subsistence communities dependent upon marine life for their nutritional and cultural survival. For the Bering Strait region as a whole, including the Seward and Chukchi Peninsulas, about 20,000 people directly rely on marine resources as their primary subsistence foods. For some communities, such as those on St. Lawrence Island, these marine resources represent over 95% of all subsistence foods.

Profound reductions and changing patterns of sea-ice cover in recent years as a result of climate change are affecting wildlife distributions and subsistence hunters' ability to hunt. The combination of changing sea ice, strong currents, large seasonal wildlife aggregations, the large number of subsistence communities on the Alaskan and Chukotkan coasts, and a

political boundary makes the Bering and Anadyr straits challenging areas for mitigating the cumulative conservation and food security risks arising from new industrial developments, including shipping.

WHAT ARE THE ENVIRONMENTAL RISKS WE ARE TRYING TO MITIGATE?

Vessel traffic through the Bering and Anadyr straits is expected to significantly increase over the next decade and beyond as the Arctic warms, industrial activities expand, and the Northern Sea Route (NSR) and Northwest Passage become more active transcontinental shipping routes. Already cargo on the NSR has increased by an order of magnitude since 2010, with 1.3 million tonnes of cargo transported by 47 vessels in 2012, up from only two vessels in 2007. While this is a tiny figure compared to the 740 million tonnes of cargo transported through the Suez Canal each year, the rapid rate of increase in vessel numbers on the NSR; expansion of the NSR's sailing season to approximately six months in 2012; general up-tick in port usage by local (including village resupply) and industry (e.g., mining) support vessels, and establishment of new vessel lines such as by FESCO and SASCO, which now sail from Everett, Washington (near Seattle) to Pevek in Chukotka, and China's Cosco Shipping Company, which plies the NSR, all indicate that vessel traffic will continue to grow. It is clear that we have transitioned from what was previously called *experimental* shipping activities[3] to a more routine use of the NSR.

We expect that in the absence of mitigation measures to reduce impacts, the increased vessel traffic will result in a variety of threats to conservation and food security, including:

- Increased risk of vessel accidents (including release of petroleum products)
- An upsurge in legal discharges and emissions (e.g., black carbon)
- Measurable indirect and direct impacts to wildlife and subsistence (e.g., displacement or collisions with whales, and swamping of subsistence vessels)

WHAT ARE THE PRIORITY MITIGATION MEASURES?

Risks of Vessel Accidents

While the voluntary guidelines established in 2002 by the International Maritime Organization (IMO) for ships operating in Arctic ice-covered waters provide a start to ensuring the safety of the Arctic marine environment, environmental protection will be greatly enhanced with the adoption and full implementation of a mandatory IMO Polar Code. Gunnarsson suggests that at a minimum, the mandatory IMO Polar Code should address: a) use of heavy fuel oil, b) black carbon and other emissions, c) ballast water, d) routing measures and speed restrictions, e) Particularly Sensitive Sea Areas, f) places of refuge, g) emergency response, and h) discharge of garbage and pollutants. However, some of these issues, despite their potential value to conservation, will need to be addressed outside of the Polar Code (e.g., speed restrictions to minimize strikes of large cetaceans in areas where they are aggregated).

The IMO's work to develop a mandatory Polar Code started in 2010. In 2012, work on the environmental chapter was set aside to focus on vessel and mariner safety issues and concerns. The IMO Ship Design and Equipment Subcommittee adopted a draft environmental chapter in April 2013, but concerns remain that black carbon emissions and the use and transport of heavy fuel oil by ships operating in the Arctic (despite being outlawed by the Antarctic Treaty in 2005 and by MARPOL Annex I in 2010) are not being addressed adequately. The scope of the IMO Polar Code efforts is currently much more limited than the scope suggested by Gunnarsson, an issue that will need to be resolved in the final Polar Code or elsewhere at the IMO if conservation concerns are to be alleviated.

Given the risk of accidents and associated oil spills in the Arctic, all eight Arctic states have agreed within the Arctic Council to cooperate on search and rescue and oil-spill response. However, necessary technology and infrastructure are currently limited or absent in many areas across the Arctic. The proximity of land to shipping routes, particularly in narrow passes and along the north Chukotka coast, also precludes the timely mobilization of equipment from response hubs to the Bering Strait, emphasizing the need for efforts to both minimize the risk of accidents, and innovative strategies for rapid accident response over the huge area of the Arctic.

In Alaska's Arctic region, oil spill response capacity is primarily linked to the oil and gas industry, which has invested heavily in response and conflict mitigation measures to reduce impacts to the environment and subsistence practices. However, for many of the areas experiencing increases in Arctic maritime traffic, this is not the case, leaving a void between the "responsible party" and the environment at risk. Better connections need to be made between shippers, shipping insurers, and local response organizations to ensure that both safety measures and effective response options are in place when needed. Oiled wildlife (seals and seabirds) from an unknown source in the vicinity of St. Lawrence Island (Alaska) in 2012 emphasized that discharges are already taking place either from sunk or active vessels.

Improved communication systems are being developed to allow the position of large vessels and subsistence vessels to be known to each other, either verbally or through Automatic Identification Systems (AIS). This developing infrastructure has potential for informing captains of large vessels when marine mammals or subsistence vessels are active in an area (as is done on the east coast of North America for Atlantic right whales), reducing the chances of collisions or swamping of subsistence boats. Furthermore, local communities, NGOs, and government agencies are increasingly documenting areas of conservation concern on nautical charts that can inform vessel captains of areas where there is a need for special care (e.g., through voluntary speed restrictions), or that should be avoided entirely (as an Area to be Avoided).

Legal Discharges and Emissions

The IMO has made progress on a number of key safety issues and seems ready to agree to strengthen safeguards on the discharge of sewage and oil in polar waters. However, black carbon emissions, which are the second most important agent of climate change, remain controversial, and routine emissions are currently unregulated. Ballast water has also been identified as a potential issue with respect to invasive species.

Indirect and Direct Impacts on Wildlife and Subsistence

Aggregations of whales in shipping lanes in Alaska and elsewhere have resulted in persistent ship strikes and the death of whales. In the Bering

Strait region, whale strikes by ships could impact whale conservation, food security, and potentially activate responses within political systems, such as the International Whaling Commission, through which subsistence quotas are decided, or the American Marine Mammal Protection Act. Without policies that proactively address the risks associated with large vessels transiting hotspots for marine mammals or areas that support indigenous subsistence practices, negative impacts on marine mammal populations and indigenous food security can be expected.

While direct collisions with subsistence vessels are unlikely, impacts to hunters while involved in hunting, towing of whales, or in/on broken ice as a result of vessel wakes are possible.

Other wildlife aggregations are also vulnerable to the impacts of shipping, although this may be most significant when ice is present, such as the eider duck concentrations in polynyas, walrus concentrations during spring breeding, and pupping of seals, particularly ringed seals.

Tools to mitigate impacts to marine mammals and subsistence hunters include:

- Reduced vessel speed (<10 knots) in areas of whale aggregations to minimize the risk of whale strikes.
- Permanent or seasonal sanctuaries (Areas to be Avoided) to provide safe havens for animals where they concentrate.
- Vessel lanes to provide predictability on location of large transiting vessels.

In some cases, there are opportunities for win-win solutions. For example, a large proportion of vessels transiting past St. Lawrence Island to the south of the Bering Strait do so on the island's west side (in Anadyr Strait). Despite it being longer for vessels sailing to the United States' west coast, this route is often preferred due to poor hydrographic charting east of the island. For conservation of large cetaceans, it would be better for vessels to travel where possible to the east of the island, and this could be resolved with additional funds allocated to developing better hydrographic charts, an issue common across the Arctic.

Priority Mitigation Activities

Based on what is discussed above, the following five measures are priorities

for protecting the conservation of wildlife and food security:

- Limit/preclude use and carriage of heavy fuel oils in the Arctic through the Polar Code or other international policy tools.
- Limit/preclude black carbon emissions in the Arctic through the Polar Code or other international policy tools.
- Reduce vessel speeds in areas of large cetacean aggregations (e.g., Bering Strait) through the implementation of reporting and speed measures (voluntary or mandatory).
- Divert vessel traffic away from areas of established wildlife conservation or subsistence risk through establishment of Areas to be Avoided.
- Provide and maintain viable spill response capacity in the Arctic through development and support of the necessary institutions that can address the unique challenges posed by Arctic shipping.

CHALLENGES FOR ACCOMPLISHING CONSERVATION OBJECTIVES

Historically, changes in maritime policy are the result of a response to a crisis. International laws such as the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) came about through catastrophic events – the "Titanic" and "Torrey Canyon" disasters, respectively. Currently, the IMO, which balances the principle of "freedom of the seas" with the need to regulate for the safety of people, vessels, and the environment, needs to approve any regulations related to passage through international straits. To accomplish this, the IMO first requires the relevant coastal states (in this case, the Russian Federation and U.S.) to agree on protective measures to address specific environmental needs before the IMO will consider regulation of all international traffic.

Ideally, sound maritime polices can be put into place that avert disasters from happening in the first place. However, as a global community, it will be our continued responsibility to grapple with tough issues and develop durable solutions that balance commerce with ecological, subsistence, and cultural values. Going forward, the following questions must be addressed:

- Given changes in climate, industrial development, and shipping demands, how do we implement policy changes that proactively address the increasing risks to wildlife and indigenous communities while respecting the international desire (and rights) to move more vessels through the Arctic?
- How can national, bilateral, and international institutions work together, perhaps using experience from analogous situations elsewhere, to proactively respond to localized environmental threats before a disaster occurs?
- Can voluntary measures adequately address the threats at hand, or are mandatory policies required to adequately protect ecological, subsistence, and cultural resources?

Notes

1. Based on: Robards, M.D. 2013. Resilience of international policies to changing social-ecological systems: Arctic shipping in the Bering Strait. pp. 99-104 in Arctic Resilience Interim Report 2013. Stockholm Institute and Stockholm Resilience Center, Stockholm. Arctic Council. Stockholm, Sweden.
2. Going forward, the term Bering Strait will be inclusive of both the Bering and Anadyr straits.
3. Brigham, L. W. 2010. The Fast-Changing Maritime Arctic. Proceedings of the U.S. Naval Institute, 136(5), May. pp. 54–59. http://www.usni.org/magazines/proceedings/2010-05/fast-changing-maritime-arctic.

Comments on Chapter 2: Community perspective

Denise Michels

Thank you for allowing me to provide comments on Dr. Bjørn Gunnarsson's paper entitled "The Future of Arctic Marine Operations and Shipping Logistics." I will focus on Arctic marine operations and shipping logistics at the community level, providing an update on shipping activities and recommendations. Dr. Gunnarsson's paper focuses on the Northern Sea Route (NSR) and international relations. What happens here matters to us every day. The majority of Alaska Natives in rural Alaska who live in coastal communities depend on subsistence practices. We need more local control/governance to foster public-private partnerships to finance and build Arctic infrastructure when the budgets of the State of Alaska and the Federal government are tight. Alaska Natives have been the custodians of the Arctic for thousands of years and will be for years to come. The Russian federal government charges for icebreaker-escorted passage within the Russian EEZ, while vessels traversing the Northwest Passage and the Bering Strait are not required to pay fees or comply with the United States' EPA and OPA90 regulations. Alaska Natives bear the most risk but receive no benefits, that is, Outer Continental Shelf (OCS) revenue sharing.

THE BIG PICTURE

The Arctic is the next economic hot spot, with increases in energy and mineral development activities and an increase in tourism. The USGS estimates that there are 90 billion barrels of oil in the Arctic, which at USD $100 a gallon is worth USD $9 trillion. This will make the U.S. energy independent and provide profits for energy companies. The Bureau of Ocean Energy Management (BOME) has plans for additional outer continental shelf (OCS) lease sales in 2017 in their five-year strategy.

These activities in the Arctic are a national security issue, with other countries conducting research on minerals beyond the Exclusive Economic Zone of the US. In 2009, AMSA reported that there were more than 5,000 vessels in Arctic waters. The lates estimate is up to 6,000. For both the NSR and Northwest Passage, the only way in and out of the Arctic on the Pacific

Ocean side is through the chokepoint at the Bering Strait between the Diomede Islands. All vessels and migrating marine mammals go through this 51-mile strait. While the U.S. has not ratified UNCLOS, 164 countries have done so and have a stable regulatory regime along with regulations in place for a stable system for private exploration and production. The lower 48 states receive OCS revenue sharing. But exploration and development have been happening in U.S./Alaskan waters since the 1970s, and Alaska does not receive OCS revenue sharing. The closest US Coast Guard base is in Kodiak, Alaska, over 800 miles away from the Bering Strait region. It takes more than a day of ocean travel by cutter, two hours of flight time by C-130, and five hours by HM-65 helicopter to access the region.

Alaska is a resource-rich state, with coal deposits on the North Slope, the world's largest zinc mine in the Northwest Arctic Borough, and gold and rare earth minerals in the Nome Census Area (the Bering Strait/ Norton Sound), along with opportunities to develop alternative energy. Rural Alaska lacks the infrastructure needed for responsible development. Ports, harbors, barge landings, roads (the Foothills West Transportation Access Project is underway to build a road to Umiat), runways, water and sewer pipes, housing, fiber-optic lines, and cheap energy are needed in rural Alaska for any Arctic exploration and development to happen.

Marine transportation companies have successfully operated in the Arctic, shipping goods during the shipping season. They are used to working in harsh ocean conditions that include rough waters and bad weather (no visibility), and have knowledge of the area theirareas of operation. For example, most villages do not have fuel headers, so a hose is run to shore to deliver fuel. Most villages do not have barge landings and smaller landing craft are used to get close to shore to deliver goods.

The northern Bering Sea, the Norton and Kotzebue sounds, the Chukchi and Beaufort seas and ocean waters along the Kuskokwim and Yukon deltas are very busy, with much ocean vessel traffic.

Fish are migrating farther north. The regional Community Development Quota (CDQ) fishing fleet, numbering 20 or more operate from 20 to 40 miles out in the ocean.

There are 3-10 skiffs for subsistence activities operating from the surrounding villages in the Norton and Kotzebue sounds, the Bering, Chukchi, and Beaufort seas and the Arctic Ocean.

Adventure tourism has increased, with kiteboarders, jet skiers, swimmers, kayakers, and winter ice driving expeditions making attempts to

cross the international border between the Diomede Islands and mainland Russia and Wales, Alaska.

There have been a few near-misses: a fuel barge broke loose in high seas two summers ago. The fuel company was prepared and dispatched a second barge to bring the first barge under control. Gambell lost a whaling crew in rough waters. One of two small skiffs boating from Wales to Diomede was lost in rough waters. The weather in the Arctic is unpredictable. For safer navigation, more weather stations and ice data are required, along with reliable communications (fiber-optic, etc.).

Comparing the lower 48's western coastline to ours, there are numerous bases and stations between Washington and California. We believe the same coverage is needed for Western Alaska's coastline from Kodiak to Barrow and beyond. If we do not include hub communities, there is a huge gap in adequate response time. Nome is a prime location to allow the USCG to respond to emergencies more quickly and to monitor environmental concerns.

With climate change, the shipping season is becoming longer; the Bering Strait in the Norton Sound freezes in late December/early January. The shipping season is predicted to be six months for the NSR,with more use of the Northwest Passage. Even though the passage is shallower than the NSR, there will be more ships passing through the Bering Strait with no regulatory regime in place. The tribes and cities in the Bering Strait region support the USCG's Port Access Route Study with a 4-nautical-mile, two-way traffic lane, speed recommendations, and areas to be avoided. This route needs to be approved by the international community via the IMO. We understand this process may take several years. We recommend voluntary measures be put in place in the meantime, with vessels traveling at a slower speeds and using the proposed shipping lanes.

The Alaska Marine Exchange's data for marine traffic transiting through the Bering Strait showed that there were 262 transits in 2009, 242 in 2010, 239 in 2011, and 316 in 2012. The Barents Observer reported that 46 vessels traversed the NSR in 2012, up from 34 in 2011 and only four in 2010. Canada also saw an increase in transits through the Northwest Passage.

If accidents happen, they will likely occur in the Bering Strait, with its limited visibility, unpredictable weather and lack of infrastructure in place to allow assets staged for SAR, environmental response, and national security enforcement.

The Port of Nome has recorded increased ocean vessel traffic, as documented in port statistical data. In 1990, there were a mere 34 dockings. By 2012, this had increased ten-fold with 436 port calls. Vessels continue to wait in a queue to dock at the port: in 2012, there were 61 (in 2011, 30, in 2010, 49, and in 2009, 53). Destinational traffic includes fuel, bulk cargo, gravel and equipment barges, cruise ships, government ships, and research and exploration vessels. Since 2008, an average of 10 private sailboats and yachts have stopped in Nome after successful transits through the Northwest Passage each year. Adventure cruise ships that transit through the Northwest Passage use Nome as a port of call. In 2009 and 2012, the cruise ship "World" stopped in Nome.

ALASKA DEEP-DRAFT ARCTIC PORT STUDY FOR NOME AND PORT CLARENCE

The Department of the Interior USGS Preliminary Report on the Cape Nome Gold Region in 1900 identified the need for harbor facilities for ocean vessels. It called for necessary public improvements, including constructing a deep-water pier. It also recommended that a lifesaving station be established. Today we are talking about this again, the same issues 112 years later.

In 1980, the Minerals Management Service (MMS) opened up gas lease sales in the Norton Sound. In 1981, a Port Master Plan Phase I identified the need to construct a 3,500 ft-long causeway to support medium-draft ocean vessels to -35 ft MLLW for OCS activities. In 1985, the causeway was constructed to 2,712 ft with a -22 ft depth.

The U.S. Army Corps of Engineers completed the Nome Harbor Improvements Project in 2006 by adding a 3,025 ft breakwater east of the existing causeway and a 270 ft spur on the end of the causeway. This improvement allows vessel operations in a protected marine environment.

The 2013 City of Nome's Port and Harbor Master Plan expands services based on projections of increased vessel traffic with the opening of the Arctic.

The Corps of Engineers and the Department of Transportation identified Nome and Port Clarence as the site for an Arctic Deep-Draft Port System. The Bering Straits Native Corporation is working on acquiring site control from the Federal government where the former USCG station at

Port Clarence is located and is partnering with Crowley to develop the site. Port Clarence has been used as a natural place of refuge for more than 100 years.

U.S. Coast Guard and National Oceanic and Atmospheric Administration vessels continue to use the Port of Nome to conduct crew changes and resupply their vessels with fuel, water and fresh produce. Nome is a medium-draft port, so vessels with drafts over 22 ft have to anchor offshore and use small craft and helicopters to shuttle goods and personnel. The City of Nome has a concept design to extend the causeway to be able to accommodate large vessels.

A gold rush is on, with the price of gold averaging USD $1,200 an ounce and the airing of the shows "Bering Sea Gold" and "Under the Ice, Bering Sea Gold" on the Discovery Channel. Nome is in a unique position in the State of Alaska relative to offshore lease sales in state waters for suction gold dredging. In 2011, Department of Natural Resources lease sales netted the state more than USD $9 million. This was in an area where in 1996 there were only three dredges operating offshore. For the 2012 mining season, there were 80 dredges with 30 support vessels and three mining research vessels specifically for gold mining. The interest in this opportunity is growing rapidly, and we are seeing a massive influx of these dredging vessels. In 2013, DNR approved 204 permits. There continues to be a need for USCG and Department of Environmental Conservation personnel in Nome for boating safety and environmental enforcement.

The City of Nome's efforts to establish an Arctic deep-draft port will allow safer resource development and provide the public with a sense of comfort that resources and assets are close by if needed for environmental response, national security, and search and rescue. Together, all these data show the need to extend the causeway to -35 ft MLLW.

Other regional hubs have plans to develop ports for resource and economic development. Kotzebue has identified a port at Cape Blossom and Arctic Slope Regional Corporation has identified Cape Thompson as a port for the North Slope area, along with Barrow.

If the U.S. wants to be part of the show and not sit on the sidelines, the Senate needs to ratify UNCLOS. One idea is to use the revenue from future lease sales to develop infrastructure in the Arctic to provide for national security, environmental response and search and rescue activities and to move toward energy independence. Waivers to the Jones Act should be considered to allow for the construction of much-needed icebreakers

in a timely manner. We encourage the State of Alaska to work with tribes that have government-to-government status with the Federal government. We recommend that the international community look at utilizing local traditional knowledge for all aspects of developing Arctic infrastructure. Most importantly, Alaska Natives need to be consulted and be at the table when any rules, regulations or laws are being considered. The Marine Mammal Protection Act allows Alaska Natives to hunt marine mammals for subsistence purposes. We depend on these mammals to sustain our way of life.

We continue to encourage the State Department to work with Russia and to improve international relations. We are related to the Chukchi Eskimos and have a long tradition of cultural exchanges before the Iron Curtain sealed the border. The Arctic Council continues to be an important forum for Alaska, with the U.S. taking the chairmanship in 2015. We recommend that all meetings of the council during the US chairmanship be held in Alaska and that there be a U.S. Arctic Ambassador who is from Alaska and lives in Alaska.

We support the AMSA 2009 Report Recommendations and the Northern Waters Task Force Recommendations and continue to work with the Alaska Arctic Policy Commission on Alaska's Arctic Strategy. We will continue to track global events that affect the maritime Arctic, such as climate change, expanding resource exploration, increasing scientific research, changes in biodiversity, non-Arctic nations entering into the Arctic, eco-tourism, and species movements northward. Scientists predict that the Northwest Passage will be open in the future.

The City of Nome and Kawerak, Inc. will continue engage in Arctic issues at all levels of government with the minimal funds we have to advocate on our behalf and to voice concerns to regulatory bodies.

Comments on Chapter 2: Chinese perspective

Xu Hua

I appreciate the invitation to make a comment on Dr. Gunnarsson's paper. His work provides a wide and comprehensive vision on Arctic shipping that considers many factors and sets forth a three-step plan for profitable Arctic shipping in the future. I think these factors fall into three groups:

i) Biophysical factors, such as sea-ice conditions, and Arctic energy and mineral resources.

ii) Freight market factors, such as economic properties of cargo, freight rates, costs occurring in operation, and competition from optional routes.

iii) Infrastructure factors, such as ice-class ships, icebreakers, Arctic ports and transshipment hubs, navigation and communication facilities, and SAR and oil spill response systems.

These three groups of factors interact in a complicated way. For example, the seasonal variations in Arctic sea-ice extent and concentration determine the feasible Arctic shipping lanes, but factors such as icebreaking fees, insurance cost, and transport demand determine the economic lanes. Based on an analysis of the interactions between these factors, we can take three steps toward future Arctic shipping as the author suggests: assessment, modeling, and financing.

As a commentator on Dr. Gunnarsson's paper, I will first integrate the factors and the relations among them into a framework. Second, I will attempt to establish an assessment model for Arctic shipping, combining it with my earlier work. Third, I will identify some available transport routes between Eastern Asia and Northwest Europe other than the Northern Sea Route (NSR) and make comparisons.

FRAMEWORK

I have divided the total cost occurring in shipping into two parts: the shipping cost, which is the prior business cargo carriers' concern, and the cargo cost, which is the focus for shippers. An assessment of Arctic shipping is, to a large extent, a matter of comparing the total cost between the Arctic shipping routes and traditional shipping routes. Dr. Gunnarsson

has presented many relevant factors for the total cost and indicated the relations among them. In this paper I will visualize his work as an explicit framework (see Figure I-1).

As shown in Figure I-1, the shipping cost is divided into: the fuel cost, which is determined by the length of shipping routes, the ship speed, and the bunker price; the operating cost, which includes Protection and Indemnity insurance (P&I), the manning cost, the icebreaking fees, etc., and the capital cost, which is roughly equal to the value depreciation of the ships in service. The cargo cost is divided into: the inventory cost, which is related to the cost occurring during the storage of the cargo; and the time cost, which is the opportunity cost relative to time.

Sea-ice conditions, reflecting seasonal variations in geographic distribution of different thicknesses and concentrations of Arctic sea ice, have an effect on the length of Arctic shipping routes. The position and infrastructure of ports or transshipment hubs also have an effect on the length of Arctic shipping routes. A port with limited infrastructure conditions accommodating lesser ships may become a feeder port, and this can influence the route structure.

Combined with IMO regulations, the length of Arctic shipping routes is the most critical determinant in the framework. In the IMO's Guidelines for Vessels Operating in Arctic and Antarctic Ice-covered Waters of 2009, the classification of navigable coverage of Polar Class ships and equivalencies

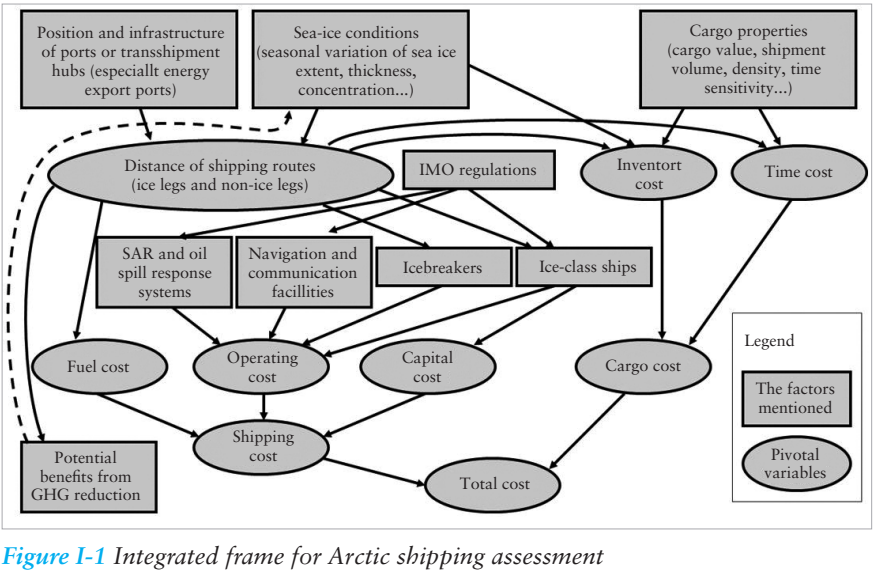

Figure I-1 Integrated frame for Arctic shipping assessment

with other classifications are indicated. An ice-class ship sailing an Arctic shipping route should comply with the coverage of Polar Class from this guideline. If the sea-ice condition is too heavy for an ice-class ship to pass, assistance from icebreakers is needed. Needless to say, the length of Arctic shipping routes also influences the fuel costs from the carrier side, and the inventory and time costs from the shipper side. The reduction of greenhouse gas emissions may result in pecuniary benefits in the future, which can be absorbed into the Clean Development Mechanism (CDM). This reduction may deter or alleviate global warming in the long run, and therefore influence the sea-ice condition. But the extent of this effect has not been clarified yet.

The IMO regulates the standards for navigation and communication facilities, SAR and oil spill response systems, etc. in order to secure navigation safety and protect the maritime environment. These factors will reduce the risk and P&I cost of Arctic shipping, while ships with different ice classes will vary in P&I cost. Assistance from icebreakers will result in icebreaking fees. All of the above factors will influence the operating cost. Moreover, ships with higher ice classes tend to be more expensive to build, leading to higher capital costs.

The properties of cargo are critical for the inventory and time costs. Valuable cargoes require faster and more punctual transportation to avoid high inventory and time costs, so they are usually transported in small shipments. The inventory and time costs, in turn, make up the cargo cost.

MODEL

Using this framework, I have developed a model to make it more maneuverable. The shipping cost and cargo cost for a voyage consist of three and two components, respectively:

$$CS_i = CF_i + CO_i + CK_i,\ CC_i = CT_i + CI_i$$

where the subscript i indicates the voyage number; CS_i is the shipping cost; CF_i is the fuel cost; CO_i is the operating cost; CK_i is the capital cost; CC_i is the cargo cost; CT_i is the time cost; CI_i is the inventory cost. The sea-ice condition on a shipping route varies from season to season, so different voyages may have particular sea-ice conditions.

The annual shipping cost *CS* and the annual cargo cost *CC* are the sum of voyage values:

$$CS = \sum_i CS_i, \quad CC = \sum_i CC_i$$

Each component can be explored in detail as:

$$CF_i = PF \cdot \sum_i \frac{D_{ij}}{SP_{ij}} F_{ij}(SP_{ij}, TH_{ij}, CONC_{ij}, Z_i)$$

$$CO_i = CIB_i + CPAI_i + CMAN_i$$
$$= \sum_i PIB_{ij}(TH_{ij}, CONC_{ij}) \cdot D_{ij} + (ACP\ AI_i(PC_i, Z_i) + ACMAN_i(PC_i, Z_i)) \frac{T_i}{365}$$

$$CK_i = \delta \cdot PIC_i(PC_i, Z_i) \cdot \frac{T_i}{365}$$

$$CT_i = r \cdot CV \cdot V_i \cdot T_i$$

$$CI_i = \frac{1}{2} PI \cdot V_i \cdot T_i$$

where the subscript *j* indicates the sea-ice condition (the combination of the thickness and concentration of sea ice); *PF* is the bunker price; D_{ij} and SP_{ij} are the distance and the ship speed when passing through waters with sea-ice condition jon voyage *i*; F_{ij} is the fuel consumption rate, which is a function of the ship speed, the thickness of sea ice, TH_{ij}, and the concentration of sea ice, $CONC_{ij}$; CIB_i, $CPAI_i$,, $CMAN_i$ are the icebreaking fees, the P&I cost, and the manning costs, respectively; PIB_{ij} is the tariff of the icebreaking service, which is assumed to be a function of the sea-ice condition; $ACPAI_i$, and $ACMAN_i$ are the annual P&I and manning costs respectively, which are both related to the grade of Polar Class applicable for the ship used in voyage i, PC_i; Z_i is the ship size in voyage *i*; T_i is the transit time of voyage *i*;δ is the depreciation rate of a ship; PIC_i is the ship price; *r* is the interest rate; *CV* is the cargo value; V_i is the shipment volume; *PI* is the inventory tariff. The transit time is defined as:

$$T_i = \sum_i \frac{D_{ij}}{SP_{ij}}$$

PC_i is the highest grade of Polar Class applicable in voyage *i*, and is determined by the sea-ice condition.

The constraint conditions are:

$$SP_i \leq SPMAX_{ij}(TH_{ij}, CONC_{ij}, Z_i), \sum_i V_i = TV, \forall Z_i \geq V_i$$

where $SPMAX_{ij}$ is the maximum ship speed under the sea-ice condition and ship size, and TV is the total cargo volume to be shipped.

The objective function is:

$$min(CS+CC)$$

It can be synthesized as:

$$min \sum_i \sum_j k_{ij} \cdot D_{ij}$$

$$k_{ij} = \frac{PF \cdot F_{ij} + \frac{ACPAI_i + ACMAN_i + \delta \cdot PIC_i}{365} + \left(r \cdot \mathrm{CV} + \frac{PI}{2}\right) V_i}{SP_{ij}} + PIB_{ij}$$

Finally, the greenhouse gas emissions in voyage i can be calculated as:

$$GE_i = GER \cdot \sum_j \frac{D_{ij}}{SP_{ij}} F_{ij}(TH_{ij}, CONC_{ij}, Z_i)$$

Where GE_i is the greenhouse gas emission volume, and GER is the emission rate computed as emissions per ton of fuel consumption. The effect from this component needs more detailed study.

These equations compose the model for an Arctic shipping assessment. Each function in the model should be calibrated with historical data. D_{ij}s are the decision variables. That is, given the transport task (TR) and the sea-ice condition, a carrier will select the shipping route which minimizes the total cost. All in all, this model involves a nonlinear programming problem (NLP), and may be solved by computer.

The model can be used to compare different shipping routes, including traditional ice-free routes. For these routes, TH_{ij}s and $CONC_{ij}$s are all set to zero, PIB_{ij}s equals zero, $ACPAIi$,s, $ACMAN_i$s, and PIC_is are much lower than those for ice routes, while $SPMAX_{ij}$s are higher. Of course, the model can also be used to compare multi-modal routes if the costs from land-legs

and transshipment are added.

POTENTIAL ROUTES

There are many potential routes available to ship cargo between the ports of Eastern Asia and Northwestern Europe. I will identify six such routes between Shanghai and Rotterdam for the purpose of demonstration (see Figure I-2):

1) Heavy-ice All-water Route (HIAR): the route via the NSR, which has a very limited navigation season for lower ice-class vessels.
2) Medium-ice Intermodal Route (MIIR): a multimodal route that goes through the Chinese domestic railway - Trans-Mongolian Railway - Trans-Siberian Railway to the Russian city of Krasnoyarsk along the Yenisei River, and then goes northward through the inland waterway of the Yenisei River to Dudinka, and then via seagoing vessels sailing to Rotterdam. This route has a longer ice-free season compared to the above one but is limited by the freezing of the Yenisei River. Three countries are covered on land: China, Mongolia, and Russia.
3) Light-ice Intermodal Route (LIIR): an intermodal route that goes

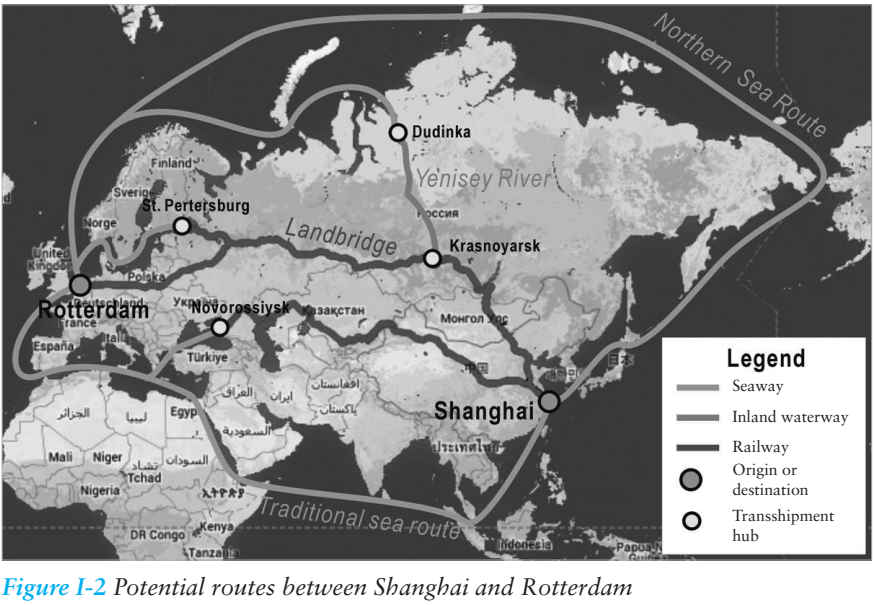

Figure I-2 *Potential routes between Shanghai and Rotterdam*

through the Chinese domestic railway - Trans-Mongolian Railway - Trans-Siberian Railway - Russian domestic railway to the Russian city of St. Petersburg along the Baltic Sea, and then via seagoing vessels sailing to Rotterdam. This route has a very short ice season. Three countries are covered on land: China, Mongolia, and Russia.

4) Warm Intermodal Route (WIR): an intermodal route that goes through the Second Eurasian Land Bridge to the Russian city of Novorossiysk along the Black Sea, and then via seagoing vessels sailing to Rotterdam through the Black Sea and the Mediterranean Sea. This route is totally ice-free. Three countries are covered on land: China, Kazakhstan, and Russia.
5) Warm All-water Route (WAR): the route via the traditional Asia-Europe sea route.
6) Dry Route (DR): the railway route that goes through the Chinese

Table I-1 Details of potential routes between Shanghai and Rotterdam

Route name	Path, distance, and distance ratio of railway leg	Path, distance, and distance ratio of inland waterway leg	Path, distance, and distance ratio of sea leg	Total distance	Recent ice-free season and duration (approx.)	Land border crossed times
HIAR			Shanghai-NSR-Rotterdam; 14,050 km; 100%	14,050 km	From late-Aug. to early-Oct.; 1.33 months	0
MIIR	Shanghai-Beijing-UlanBator-Krasnoyarsk; 5,250 km; 42%	Krasnoyarsk-YeniseyRiver-Dudinka; 2,000 km; 16%	Dudinka-Rotterdam; 5,150 km; 42%	12,400 km	From mid-Jul. to mid-Oct. (sea), from Jun. to Sept. (river); 2.50 months	2
LIIR	Shanghai-Beijing-UlanBator-Perm'-St.Petersburg; 9,600 km; 80%		St.Petersburg-Rotterdam; 2,400 km; 20%	12,000 km	From early-May to late-Nov.; 6.67 months	2
WIR	Shanghai-Urumqi-Almaty-Volgograd-Novorossiysk; 9,600 km; 59%		Novorossiysk-Rotterdam; 6,750 km; 41%	16,350 km	All year; 12 months	2
WAR			Shanghai-Suez Canal-Rotterdam; 19,300 km; 100%	19,300 km	All year; 12 months	0
DR	Shanghai-Beijing-UlanBator-Moscow-Berlin-Rotterdam; 11,900 km; 100%			11,900 km	All year; 12 months	6

domestic railway - Trans-Mongolian Railway - Trans-Siberian Railway - European railway to Rotterdam. Seven countries are covered on land: China, Mongolia, Russia, Belarus, Poland, Germany, and the Netherlands.

These routes are all illustrated in Figure I-2, though this map is somewhat distorted as the areas in high latitudes are exaggerated. The exact distances of the Arctic routes are much shorter than they appear on the map.

The features of these routes are listed in Table I-1. Further analysis would be possible using the model developed in this commentary. However, this step will not be accomplished here.

The shortest of these routes is the DR, while the longest is the WAR (the traditional route via the Suez Canal). Although the former route is much shorter, the transport efficiency of freight trains is far lower than that of ocean-going ships, and it goes through countries with different railway gauges. So, we need further study to find which route is more economical.

The total distances of the MIIR and the LIIR are nearly equal, but the former has a shorter railway leg, so its transport efficiency is higher. However, the ice-free season of MIIR is shorter, and it has a long and slow inland waterway leg. So, which one is more economical requires further

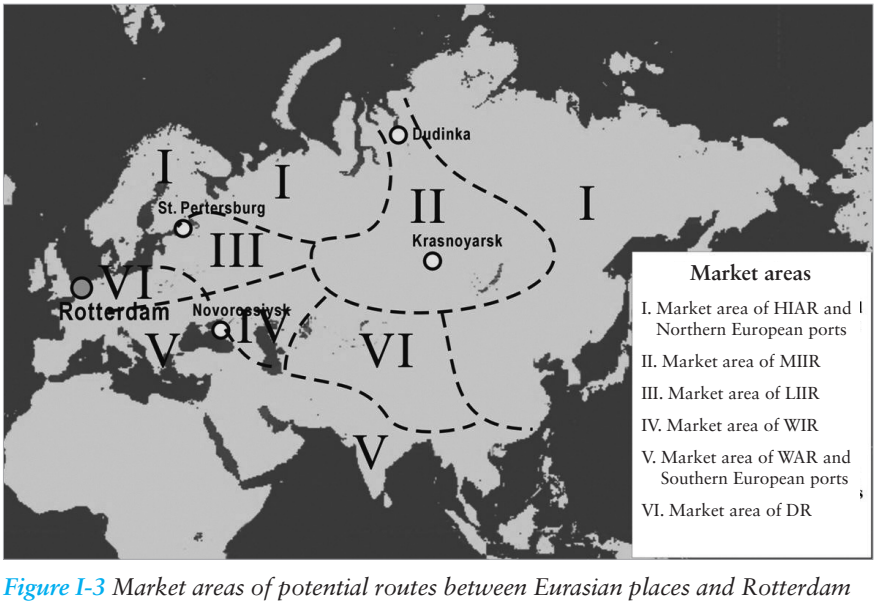

Figure I-3 Market areas of potential routes between Eurasian places and Rotterdam

exploration using the model.

The length of these routes will vary widely due to different origins or destinations. For example, if the destination is an Eastern Mediterranean port, the WIR, which transships at Novorossiysk, will be competitive compared to the upper three routes listed in Table I-1. Moreover, if the origin is chosen among Korean or Japanese rather than Chinese ports, the intermodal routes connecting to the Russian Far East port of Vladivostok for transshipment and going through the Trans-Siberian Railway might be advantageous options. According to this consideration, given the origin (or destination), we can delimitate the destination (or origin) market areas of different routes. The market area of a route is the one in which the route minimizes annual total costs compared to other routes. Based on this step, we can compare each route quantitatively with the cargo volume generated in its market area.

Figure I-3 shows an intuitive delimitation of the origin market areas of the six routes with the destination of Rotterdam, just for demonstration. The actual boundaries should be calculated using the model; this is the next task.

Comments on Chapter 2: Japanese perspective

Toshiyuki Kano and Takahiro Majima

First of all, thanks to Dr. Bjorn Gunnarsson for his paper on "The Future of Arctic Marine Operations and Shipping Logistics." The issues of Arctic marine operations and shipping have been discussed from many points of views.

I will comment on the following points:

- Greenhouse gas emissions on the Northern Shipping Route (NSR)
- Energy efficiency of ice-class ships
- Navigation and transportation

GREENHOUSE GAS EMISSIONS ON THE NSR

The NSR has distance and time advantages compared to the traditional Suez Canal Route (SCR) with regard to shipments between Northeast Asia and Northwest Europe. However, the comparative advantages of the NSR and SCR should be evaluated not only from the perspective of distance and time savings, but also from an environmental conservation perspective. Developing of environmental measures for vessels and applying them to existing rules are under preparation by the IMO, a key organization.

Ice-Class Vessel Energy Efficiency

From the point of view of environmental conservation, the Arctic Sea is vulnerable to environmental burdens.

Mandatory measures to reduce emissions of greenhouse gases (GHGs) from international shipping entered into force on January 1, 2013. The amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships add a new chapter 4 to Annex VI dealing with energy efficiency for ships, making mandatory the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships.

According to the IMO 2012 Guideline[1] on the method of calculation of the attained EEDI for new ships, the attained EEDI of ice-class ships

estimates ship-specific design elements (fj) and capacity factors (fi) as followed:

$$\text{Attained EEDI} = \frac{\text{EEDI}_{Numerator}}{\text{EEDI}_{Denominator}}$$

$$= \frac{f_i \cdot P_{ME} \cdot C_{FME} \cdot SFC_{ME} + P_{AE} \cdot C_{FAE} \cdot SFC_{AE}}{f_i \cdot f_c \cdot \text{Capacity} \cdot f_w \cdot V_{ref}}$$

Technical Innovation Challenges for Ice-Class Vessels

Dr. Matsuzawam, et al.[2] of NMRI made a study calculating the values of attained EEDI of the Guideline and DE 57/11/8[3] by using the principle particulars of 117 existing ice-class tankers. The values of attained and required EEDI are shown in Figure I-4.

The value of EEDI has to be lower than the required EEDI expressed in a straight line for each phase. However, above 20,000 dwt tankers such as 1AS, 1A are expected to have stronger demands according to the Arctic resource development. From phase 0-3 each 12, 38, 75, and 97% vessel's attained EEDI are required to improve. Currently, exemption from EEDI requirement for ice-class vessel is being considered by the IMO.

However, there are still innovation challenges, and ice-class vessels with higher propulsion performance are demanded.

Simulation Study of Greenhouse Gas Emissions on the NSR and the Traditional SCR

The NSR has apparent distance and time advantages compared to the SCR regarding the shipment of containerized freight between Northeast Asia and Northwest Europe.

While there is a possibility of transiting the NSR with advanced ice-class ships, the economic and operational aspects of this possibility have not yet been fully explored.

Also, the energy efficiency of ice-class ships is inferior to that of conventional ships in Arctic waters as well as in open water. Therefore, reduction of fuel consumption for vessels and GHG emissions due to reduced distance and time savings should be compared and reviewed with an increase in GHG emissions due to the lower energy efficiency of ice-class

ships and ice conditions (ice coverage and thickness of the ice on the route).

Simulation Study on the NSR vs. the SCR

A simulation study of a typical 4,000 TEU container ship traveling from Shanghai to Rotterdam and a crude oil tanker traveling from Murmansk to Shanghai was conducted to analyze the advantages of greenhouse gas emissions on the NSR and SCR. The outlines of the simulation conditions are shown in Figure I-5.

Energy Efficiency of Ice-Class and Conventional Ships

The energy efficiency of ice-class ships has a unique character compared to conventional ships. The EEDI of ice-class and traditional vessels can be compared approximately in ratio correction factor (fi) and (fj). The annex of the DE 57/11/8 provides performance data for ice-class general cargo ships, bulk carriers and crude oil shuttle tankers.

According to these datas, the ratio of (fi) and (fj) shows that an ice-class vessel's CO_2 increases 10% to 50% compared to traditional vessels at the same speed and loadings (Figure I-6).

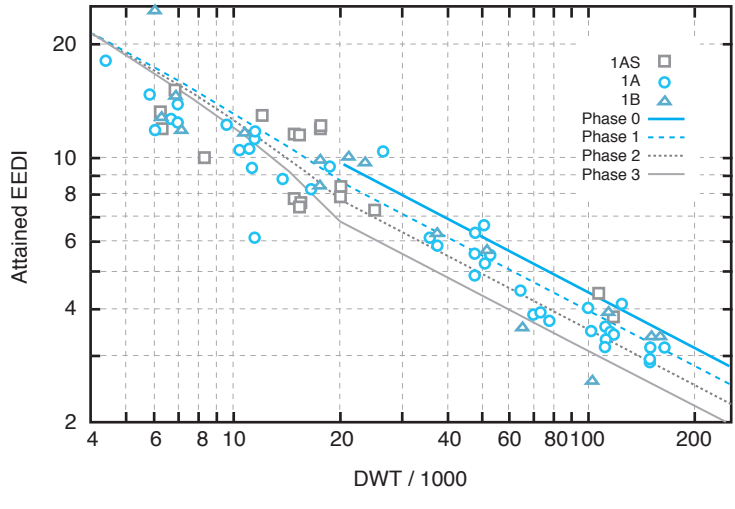

Figure I-4 Values of attained and required EEDI

Typical 4000 TEU container ship

Due to shallow water at sannikov strait (13 m depth)
Route: from Shanghai to Rotterdam

Route	NSR	Suez route
Distance (NM)	7,800	10,500
Capa. Limit. (TUE)	4,000	> 18,000

Distance of NSR is 25%shorter.

Average on 56 ships (3950-4049 TEU)	
Det (ton)	58,000
d (m)	12.9
L_{BP} (m)	260
Poewr (Kw)	38,800
Speed (Kt)	23.8

Crude oil shattle tanker

Route: from Murmansk to Shanghai

Route	NSR	Suez route
Distance (NM)	7,060	11,100

Distance of NSR is 34% shorter.

NMRI Logistics SIMULATOR

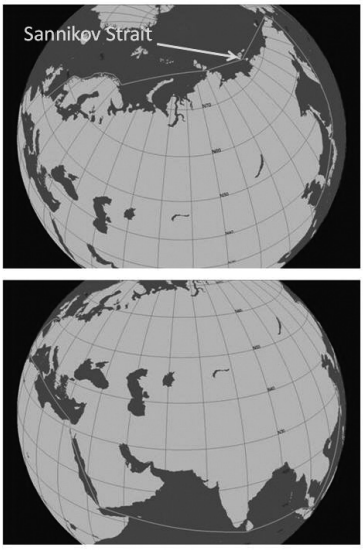

Figure I-5 Outlines of simulation study conditions

Ship Speed Reduction by Ice

An estimation of ship performance in ice from the Annex of the DE shows that a vessel's speed goes down in accordance with the thickness of the ice (Figure I-7).

Amount of CO_2 Emissions on the NSR and Traditional Route

Taking the energy efficiency of the ice-class ships and reduction of ship speed by ice into account, the simulation results are shown below. Figure I-8 shows the variation of CO_2 emissions amount ratio of the NSR and SCR with ice thickness for different ice coverage ratios (ice covered distance/total route distance).

Almost the same results were obtained in these cases. The advantage of greenhouse gas emissions on the NSR declined as the ice coverage ratio and ice thickness increased. The borderline is in the case of almost 20% ice coverage with 0.7 m ice thickness. In the case of 30% ice coverage, it is unable to keep the time schedule.

$$EEDI = \frac{f_j \cdot P_{ME} \cdot C_{FME} \cdot SFC_{ME} + P_{AE} \cdot C_{FAE} \cdot SFC_{AE}}{f_i \cdot DWT \cdot v_{ref}}$$

$$P_{AE} = 0.025 \cdot MCR + 250$$

Omission due to $P_{AE} << P_{ME}$

Factors for ice class ship
f_j: Correction factor ship specific design elements (for container ship; f_j=1)
f_i: Capacity factor

Ice class IA super	Container ship	General cargo ship	Bulk carrier	Crude oil shuttle tanker
f_i / f_j	1.07	1.50	1.35	1.49

Class NK's requirement for NSR

Interpretation: FOC of ice class container ship is about 7% larger

Figure I-6 EEDI of ice-class vessels and traditional ships

Ship name	MV Norilsk	MV Norilsk	MV Norilsk
Ship type	General cargo ship	Bulk carrier	Crude oil shuttle tanker
Lpp (m)	159.6	178.0	234.7
B (m)	24.0	26.6	34.0
T (m)	9.0	11.8	14.0
DWT (t)	14,700 (Arctic draught)	30,902 (Arctic draught)	70,000
MCR (KW)	15,400	21,700	20,000
Vref (knots)	15.0	15.7	15.4

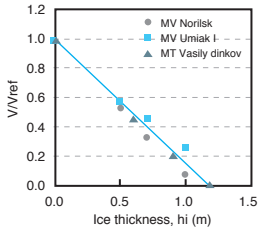

Figure I-7 Ship speed reduction by ice

Monitoring Navigation System

Monitoring navigation information for the NSR can be obtained by a satellite communication system or Automatic Identification System (AIS). The path of the NSR navigation route for a crude oil tanker from May to July is shown in Figure I-9. Satellite radar can provide information on ice properties as well as the extent of ice.

If we can obtain accurate ice information and have access to tools for precisely predicting future ice conditions, we can select the optimum route. A captain can choose the best route, using either the NSR or Suez Canal,

which is called "ice routing," a term corresponding to "weather routing."

CO_2 emission amount ratio(ton) NSR v.s. suez ROUTE

Oil tanker

Route: Murmansk-Shanghai

Ice class	IA super
f_i / f_j	1.49

ICE coverage (%), (Ice covered route dist, / total route dist)	ICE thickness (m)			
	0.0 m	0.1 m	0.5 m	0.7 m
10%	0.38	0.39	0.48	0.59
20%		0.40	0.60	0.96
30%		0.42	0.78	2.25

Container ship

Typical 4000 TEU type

Route: Rotterdam-Shanghai

Ice class	IA super
f_i / f_j	1.07

ICE coverage (%), (Ice covered route dist, / total route dist)	ICE thickness (m)			
	0.0 m	0.1 m	0.5 m	0.7 m
10%	0.44	0.45	0.55	0.67
20%		0.47	0.68	1.10
30%		0.48	0.89	…

Figure I-8 Variation of CO_2 emission amount ratio of the NSR and SCR

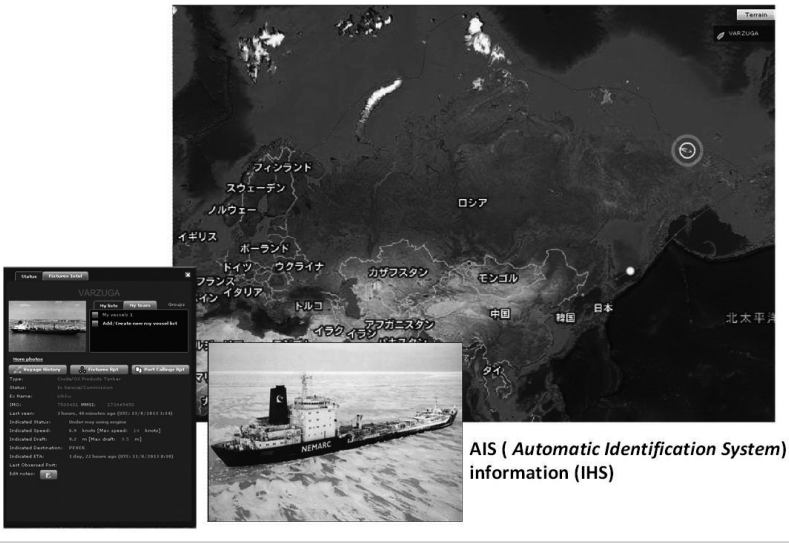

Figure I-9 The path of the navigation route of a crude oil tanker on the NSR

COMMENTS

Greenhouse gas emissions on the NSR

The energy efficiency of an ice-class ship is inferior to that of a conventional ship. Therefore, reduced GHG emissions from distance and time savings should be compared with an increase in GHG emissions due to the lower energy efficiency of ice-class ships, depending on ice conditions (ice coverage and thickness of ice on the route).

The challenge of innovation for ice-class vessel energy efficiency!

Ice-class vessel energy efficiency should be improved.

Monitoring navigation system

A monitoring navigation system that provides information on ice floes and safe routes to ships in the Arctic Sea could help to avoid accidents and make a contribution to safe navigation, leading to environmental conservation.

Notes

1. International Maritime Organization (IMO). Resolution MEPC. 212(63). 2102 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships. 2012.
2. Dr. Matsuzawa et al. "Effect of EEDI Regulations on Engine Power for Ice-Class Ships." The 13th Research Presentation Meeting of the National Maritime Research Institute, Japan.
3. DE 57/11/8 "Development of a Mandatory Code for Ships Operating in Polar Water." (IMO Subcommittee on Ship Design and Equipment), December 14, 2012. Propulsion Power for Ice-Strengthened and Ice-Going Ships.

Reference

Ice-Class Shipping. 2007. Clarkson Research Services Ltd. 2007.

Comments on Chapter 2: Korean perspective

Sung Woo Lee

Dr. Gunnarsson has presented logistical issues linked to Arctic resource development in the past, present and future from the perspective of navigation in the Arctic. Commenting on our preparedness for the commercialization of the Northern Sea Route (NSR), he also talked about the business side of the NSR, in particular the possibilities of the NSR as a route for the shipment of cargo. Lastly, he observed that he did not think that commercialization of the NSR would revolutionize logistics. However, he added that he was positive about the important role of the NSR in resource transportation in the Arctic Ocean and Siberia.

I am in total agreement with Dr. Gunnarsson. Assessments of the use of the NSR should consider environmental factors first. The more active the route becomes, the more closely we should listen to the concerns of environmentalists. In this regard, the way toward using the NSR will be a long and tedious procedure. I would like to add my own opinions on Dr. Gunnarsson's presentation and will discuss the preparedness of East Asian nations to facilitate use of the NSR.

At the North Pacific Arctic Conference 2012, I gave a presentation on the potential use of the East Asia-North Europe route by a container cargo, consuming time, possible cargo volume, and rivalry between the NSR and the TSR. The conclusion was that although the figure could be different depending on the conditions, about 10 million TEU of cargo would use the NSR if navigation time could be cut by 10 days. Of course, there were preconditions and constraints. For example, the active use of the NSR would happen only after tramp ships were increasingly used and more than 10 years of know-how regarding NSR navigation was accumulated. Constraints included cargo balance, possible damages to the environment, route stability, and passage fees imposed by Russia.

Dr. Gunnarsson also dealt with environmental sensitivity, cargo balance and the necessity of passage fees. He added the need for adequate local infrastructure, public funds for development of such infrastructure, the limited economic validity attributable to ship size and a stable logistics system for the entire Arctic Ocean area. On this front, I am on his side. However, I would like to talk about a few possibilities not addressed by his study and what we should do about them.

The first involves possible intermodal transportation through inland areas of Northeast Asia. China and Russia are jointly developing a new intermodal transportation route that starts from the northeastern part of China and passes through the Jena River to link with the port of Tiksi on the Arctic Ocean, as shown in Figure I-10. A good comparison is the rivalry between the Deep Sea Route and the TSR for east-west logistics transportation going through the Suez Canal. Likewise, the NSR and an inland transportation route in Northeast Asia may compete with one another. Cargo owners will choose one route or the other based on its speed, punctuality, stability, volume, and costs. Eventually, these two routes will complement each other, particularly from the cost side. Just as cargo goes back and forth over the Deep Sea Route according to TSR rates, the NSR and inland transportation route in Northeast Asia are likely to give and take cargo with each other.

The second possibility is that excessive fleet size might jeopardize the global shipping market. Falling rates in the global shipping market are pushing shipping companies toward the brink. Many of them have gone bankrupt. Commercialization of the NSR could aggravate the current crisis in the global shipping market. Generally speaking, use of the NSR can save 10 days of transportation time. This means that vessels that were supposed to navigate for these 10 days have to find other business opportunities.

Figure I-10 *Advent of new routes in Eurasia*

Moreover, if East Asian nations bring resource cargo from Russia's Far East, Siberia and the Arctic coasts, instead of Africa, Latin America and Australia, demand for ships will disappear by exactly that saved time. Just as with any other market, the shipping market is governed by supply and demand. More ship supply and less demand herald reduced shipping rates, which can bring in another range of problems. Therefore, shipping companies need to streamline their structure or develop new business models to prepare for "rainy days."

The third possibility is the expected change in port competition in North Europe and East Asia. Ports in East Asia now maintain a loose rivalry. The Busan Port deals with both cargos in the hinterland and transshipment cargo in nearby areas. The Shanghai Port is for cargo from the inland and coastal areas of China. The Kaohsiung Port handles transshipment cargo in the southern part of China and Southeast Asia as well as cargo from Taiwan. Meanwhile, The Hong Kong Port mainly handles transshipment cargo in the southern part of China and Southeast Asia. These ports have maintained a "division of labor" relationship so far. For instance, transshipment cargo that departs from Japan and the three northeast provinces of China bound for Europe uses the ports of Shanghai or Kaohsiung, while cargo bound for the United States uses the Busan Port. However, if the NSR becomes commercialized, cargos bound for Europe and the U.S. will use only one port from among Busan, Shanghai and Kaohsiung for transshipment. In this case, chances are that the current loose rivalry will change into a fierce one. This is why each port authority should prepare for such changes.

Fourth, the IMO Polar Code will toughen the environmental aspects of seaborne transportation. Ships that run on heavy fuel oil, in particular, will be banned from operating in the Arctic Ocean. Therefore, alternative ships and fuel, such as LNG ships and nuclear-powered ships, need to be introduced. Only when technological support and efforts are made simultaneously can the NSR produce economic as well as environmental benefits.

The fifth possibility is that intermediate base areas can develop into cities. Industrial complexes will appear in conjunction with resource development in coastal areas of the Arctic Ocean and Siberia. Such development of resources and relevant industry is destined to induce an influx of people along with subsidiary facilities and commodities. Eventually, a city can be created, acting as a relay base port for ships

navigating in the Arctic Sea. At present, candidates for such urbanization are ports at the end of multimodal transportation routes (mostly on rivers downstream) passing through Siberia from the northern part of China or Central Asia. Accordingly, the necessary cities, logistics and energy infrastructure should be developed. As Dr. Gunnarsson pointed out, financial organizations that are public in nature are necessary, and the Russian government should develop relevant facilities.

Sixth, the development of cargo transportation technology should follow to overcome extreme weather conditions. Bulk cargo transportation for resources does not require special technological support. However, transportation of container cargo is different. For example, cargo inside container boxes should remain safe against temperature changes. For that matter, ships and special containers need to be developed along with other technological logistics advances.

Seventh, an ice-class ship shuttle service in the Arctic Ocean may be possible. One idea is to operate ice-class ships both in the Arctic Ocean and in general seas. In that case, however, costs will go up, while ship effectiveness will decline. Such problems can be solved if a shuttle service with ice-class ships or icebreakers is provided between ports near the Bering Sea and the northern end of North Europe. General ships would transport cargo to those ports, and then ice-class ships would carry them on the Arctic Ocean route (from the Bering Sea to ports at the northern end of North Europe). This exclusive transshipment service may become necessary for cost reduction and stable ship operation.

Last but not least are rates imposed by Russia for the use of the NSR. These rates can be lowered through negotiations if the Russian government makes a serious effort and the market demands this. In the case of the TSR, Russia raises rates if a lot of cargo uses the TSR and lowers them if less cargo uses it. Russia is likely to apply such variable rates to the NSR after the route becomes active. Therefore, the Russian government and user countries need to stabilize the rates through rounds of negotiations.

As I pointed out in my presentation last year, commercialization of the NSR will proceed as follows: First, bulk cargo for early resource development will continue to use the route. Second, logistics and industrial bases will be built at relay ports. Third, route stability and cargo size will be secured. Lastly, liner ships (containerships) will use the NSR. By then, technology for cargo transportation protecting against extreme weather and a logistics system in the Arctic area will be in place. And

urbanization of relay ports will create intermediary cargo, while mid-fueling and shelter facilities will be secured. This means that our main concerns, such as stability of navigation, predictability, economic feasibility and environmental stability will be addressed. Of course, the precondition is that we and the international community cooperate on environmental, economic and technological fronts.