Scenarios, Futures and Regional Futures to 2020

Plausible Futures for Arctic Marine Navigation

Marine use of the Arctic Ocean is expanding in unforeseen ways early in the 21st century. The continued depletion of natural resources in the world has led to an increase in interest in developing Arctic natural resources, and this interest has fostered a transformation of marine activity in the Arctic. In addition, regional climate change and the resulting Arctic sea ice retreat are providing for increased marine access in all seasons throughout the Arctic basin and its coastal seas. The AMSA takes a circumpolar view, but has also considered many regional and local issues where the impacts of expanded marine use may be greatest. The AMSA has also sought the views of the Arctic states, indigenous residents of the Arctic and many non-Arctic stakeholders and participants within the global maritime industry, so as to involve multiple perspectives.

The Arctic Climate Impact Assessment (ACIA) documented the recent changes in the Arctic sea ice cover: sea ice thinning, extent reduction and a reduction in the area of multi-year ice in the central Arctic Ocean. In addition, model simulations for the 21st century (using Global Climate Models) indicate increasing ice-free areas in all coastal Arctic seas, suggesting plausible increases in marine access and longer seasons of navigation. The AMSA has used the Arctic sea ice information from the ACIA and the 4th Assessment of the Intergovernmental Panel on Climate Change as guides to what marine access could be in future decades. The key task for the AMSA has been to understand more clearly the uncertainties that might shed light on the determinants of future Arctic marine operations. One way to do this is through the creation of a set of scenarios that are plausible, relevant and diverse.

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AMSA Scenario Workshops

During 2007, scenario workshops were held in San Francisco (April) and Helsinki (July) to create a framework of plausible futures for Arctic marine navigation to 2050. The workshops were facilitated by Global Business Network, a pioneer in the application and evolution of scenario thinking, and drew some 60 maritime experts and stakeholders. The purpose of these strategic conversations was to identify the major uncertainties that would be critical to shaping the future of Arctic marine activity to 2020 and 2050. The use of different stories of future marine activity can indicate how critical uncertainties might play in ways that can challenge the Arctic states to make timely and effective decisions. The scenario narratives provide a rich source of material for strategic discussions about the future of marine safety and marine environmental protection among a diverse group of Arctic and non-Arctic stakeholders and decision makers.

Uncertainties from the Workshops

Participants in the AMSA scenario workshops identified nearly 120 factors and forces that could shape the future of Arctic marine activity by 2050. Among those factors deemed most important were: global trade dynamics and world trade patterns; climate change severity; global oil prices; the marine insurance industry; legal stability (governance) of marine use in the Arctic Ocean; the safety of other global trade routes (for example, the Suez and Panama canals); agreements on Arctic ship construction rules and global operational standards (International Maritime Organization); a major Arctic shipping disaster; limited windows of operation for Arctic shipping (the economics of seasonal versus year-round Arctic operations); the emergence of China, Japan and Korea as Arctic maritime nations; transit fees; conflicts between indigenous and commercial uses of Arctic waterways; new resource discoveries; an escalation of Arctic maritime disputes; a global shift to nuclear energy; and socio-economic impacts of global weather changes. This list of critical factors illustrates the great complexity and range of global connections surrounding future use of the Arctic Ocean (Table 6.1).

Key Uncertainties from the AMSA Scenarios Effort

Influences on the Future of Arctic Navigation

- Stable legal climate
- Radical change in global trade dynamics
- Climate change is more disruptive sooner
- Safety of other routes
- Socio-economic impact of global weather changes
- Oil prices ($US55-60 to $US100-150)
- Major Arctic shipping disaster
- Limited windows of operation (economics)
- Global agreements on construction rules and standards
- Rapid climate change
- China, Japan and Korea become Arctic maritime nations
- Transit fees
- Conflict between indigenous and commercial use
- Arctic maritime enforcement
- Escalation of Arctic maritime disputes
- Shift to nuclear energy
- New resource discoveries
- World trade patterns
- Catastrophic loss of Suez or Panama canals
- Maritime insurance industry engagement

Table 6.1 Key uncertainties from the AMSA scenarios effort. *Source: AMSA*

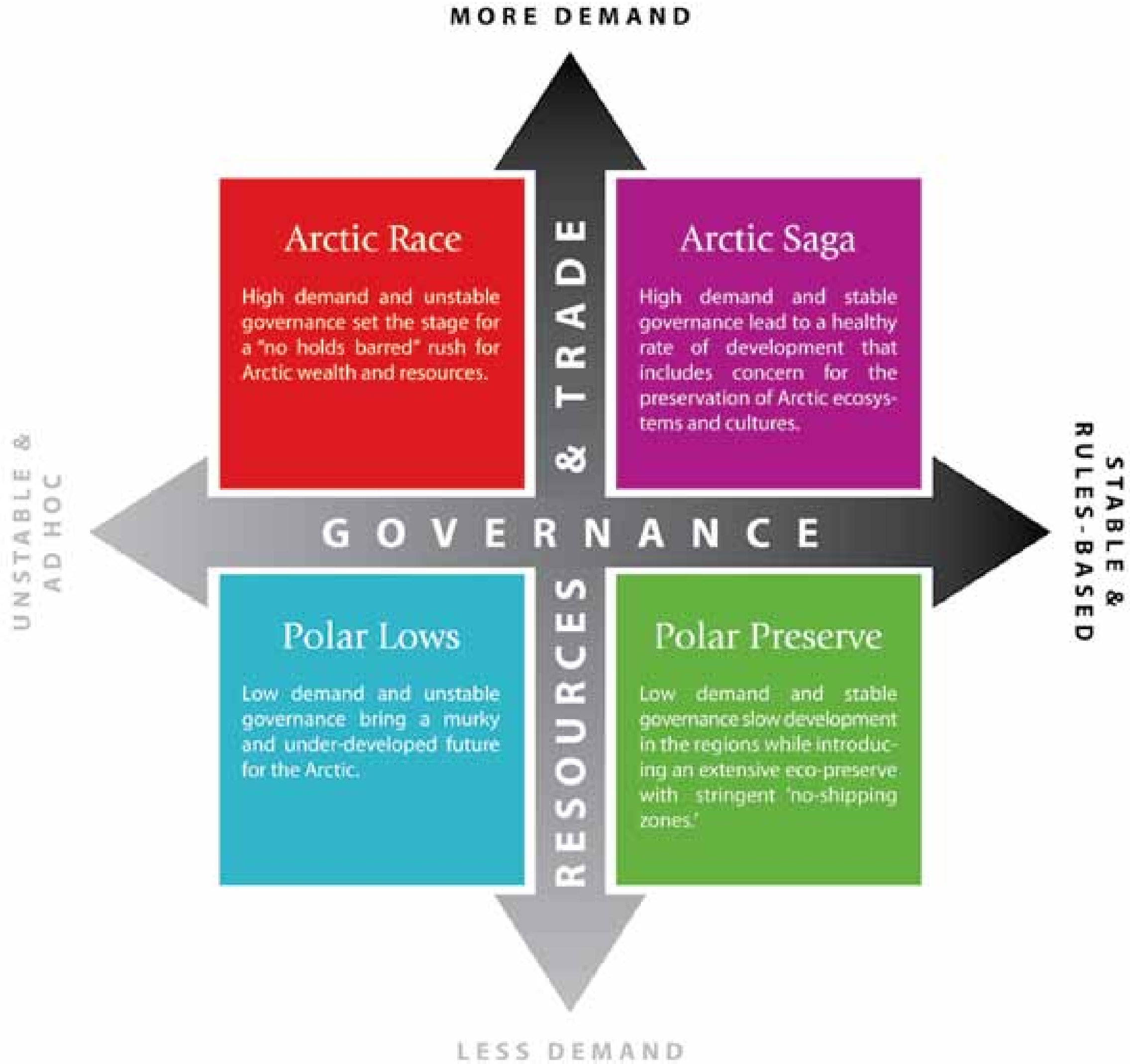


Illustration 6.1 Scenarios matrix. *Source: AMSA*

AMSA Scenarios Framework

The AMSA scenarios work created six potential matrices for framing a set of scenarios. Pairs of critical factors or uncertainties were chosen and crossed to produce candidate frameworks:

- Indigenous Welfare *crossed with* Resource Exploitation
- New Resource Development *crossed with* Maritime Disasters
- Climate Change *crossed with* Level of Trade
- Indigenous People *crossed with* Rise of Asia
- Legal Regime *crossed with* Value of Natural Resources
- New Resource Development *crossed with* Legal Regime

The strengths, weaknesses and applicability to the Arctic of each of these matrices were discussed. Through brainstorming and plenary discussions, two primary drivers and key uncertainties were selected as the axes of uncertainty for the final AMSA matrix:

Resource and Trade: the level of demand for Arctic natural resources and trade. This factor exposes the scenarios to a broad range of potential market developments, such as the rise of Asia or regional political instabilities. More demand implies higher demand from more players and markets around the world for Arctic resources, including increased access for trade in the Arctic Ocean. Less demand implies fewer players interested in fewer resources.

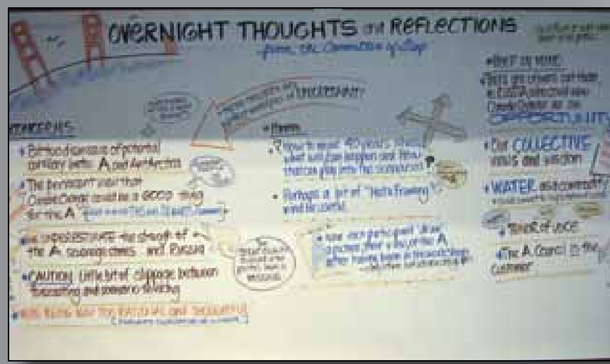
Governance: the degree of relative stability of rules for marine use both within the Arctic and internationally. Less stability implies shortfalls in transparency and a rules-based structure, and an atmosphere where actors and stakeholders tend to work on a unilateral basis. More stability implies a stable, efficiently operating system of legal and regulatory structures, and an atmosphere of international collaboration.

	Arctic Race	Polar Lows	Polar Preserve	Arctic Saga
Framing Uncertainties	▲ More Demand for Resources and Trade ◀ Less Stable Governance	▼ Less Demand for Resources and Trade ◀ Less Stable Governance	▼ Less Demand for Resources and Trade ▶ More Stable Governance	▲ More Demand for Resources and Trade ▶ More Stable Governance
High Concept	High demand and unstable governance set the stage for an economic rush for Arctic wealth and resources. This is a world in which many international players anxiously move to outwit competitors and secure tomorrow's resources today. Intense interest in Arctic natural resources.	Low demand and unstable governance bring a murky and underdeveloped future for the Arctic. This is a world in which domestic disturbances divert attention from global issues, and simmering frictions cause prolonged divisiveness. Global financial tensions are prevalent.	Low demand and stable governance slow Arctic development while introducing an extensive eco-preserve with stringent "no-shipping zones." This is a world where concern about the environment, coupled with geopolitical and economic interests elsewhere, drives a movement toward a systematic preservation of the Arctic Ocean.	High demand and stable governance lead to a healthy rate of development that includes concern for the preservation of Arctic ecosystems and cultures. This is a world largely driven by business pragmatism that balances global collaboration and compromise with successful development of the resources of the Arctic.
Primary Drivers of Change	• Global competition among many nations for future rights to resources intensified by rise of Asia; new oil & gas discoveries • Acute demand for water worldwide; continuing Middle East tensions • Climate warms faster than models predicted; tourism expands	• Global economic downturn and increasing national protectionism • Increased domestic troubles worldwide, including regional outbreaks of new-generation Avian flu • Recession of Arctic ice slower than models projected	• Arctic oil and gas reserves disappointing • Alternative energy emerges as viable source for global growth • Public concern about climate change and conservation, especially impacts to the Arctic	• Expanded global economic prosperity • Systematic development of oil, gas and hard mineral resources • Shared economic and political interests of Arctic states • Climate warms as expected
Implications for Arctic Marine Navigation	• Much activity dominated by destinational traffic supporting resource development • Unilateral governance regimes lead to inconsistent infrastructure with incompatible standards • Seasonal trans-Arctic passage possible, but not economical	• Minimal Arctic marine traffic, consisting of government re-supply and research, with periodic disruptions • Market for ice-class ships cools, reducing R&D and shipbuilding • Low attention to regulations, with unenforced and mismatched standards, and no new infrastructure	• Harmonized rules for Arctic ship design and mariner training • Seasonal trans-Arctic shipping possible but proves prohibitively expensive due to environmental restrictions, frequent patrols and aggressive enforcement • Growth of Arctic marine tourism allowed through limited number of "use permits"	• Wide range and variety of marine activity • Navigational infrastructure and aids expanded, making marine transport safer and more efficient • Comprehensive international Arctic ship rules • New technologies make seasonal trans-Arctic shipping a possibility

Table 6.2 Scenarios comparison. *Source: AMSA*

Scenarios

Scenarios are tools for ordering one's perceptions about alternative future environments in which today's decisions might be played out. In practice, scenarios resemble a set of stories, written or spoken, built around carefully constructed plots. Stories are an old way of organizing knowledge; when used as strategic tools, they confront denial by encouraging - in fact, requiring - the willing suspension of disbelief. Stories can express multiple perspectives on complex events; scenarios give meaning to these events.



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Scenarios are powerful planning tools precisely because the future is unpredictable. Unlike traditional forecasting or market research, scenarios present alternative images instead of extrapolating current trends from the present. Scenarios also embrace qualitative perspectives and the potential for sharp discontinuities that econometric models exclude. Consequently, creating scenarios requires decision-makers to question their broadest assumptions about the way the world works so they can foresee decisions that might be missed or denied.

Within an organization, scenarios provide a common vocabulary and an effective basis for communicating complex - and sometimes paradoxical - conditions and options. Good scenarios are plausible and surprising; they have the power to break old stereotypes, and their creators assume ownership and put them to work. Using scenarios is rehearsing the future. By recognizing the warning signs and the drama that is unfolding, one can avoid surprises, adapt and act effectively. Decisions that have been pre-tested against a range of what fate may offer are more likely to stand the test of time, produce robust and resilient strategies and create distinct competitive advantage. Ultimately, the result of scenario planning is not a more accurate picture of tomorrow but better thinking and an ongoing strategic conversation about the future.

The chosen axes met three key criteria: degree of plausibility, relevance to the Arctic and maritime affairs and being at the right level or threshold of external factors. The roles of global climate change and continued Arctic sea ice retreat are fully considered in the AMSA scenarios. Retreating Arctic sea ice acts as a facilitator and is assumed to provide opportunities for improved marine access and potentially longer seasons of navigation. For the AMSA, globalization of the Arctic and development of natural resources are the primary drivers for increased marine use in the region. Greater access facilitates that use, but economic drivers are considered paramount.

Table 6.2 illustrates the crossed uncertainties (Resources & Trade and Governance) and outlines four resulting scenarios central to the message of the AMSA. The Arctic Race scenario, with high commodity prices and demand for Arctic natural resources, implies an "economic rush" for development, based in part on global markets, not a geopolitical "race" for sovereign rights or new territory. This is a region where the international maritime community has moved into the Arctic Ocean for resource extraction and marine tourism at a time when there is lack of an integrated set of maritime rules and regulations, and insufficient infrastructure to support such a high level of marine activity.

Polar Lows is a future of low demand for resources and unstable governance: a murky and undeveloped future for the Arctic. There is minimal marine traffic in the Arctic Ocean in this scenario and low attention is given to regulations and standards that remain weak and undeveloped.

Polar Preserve is a future of low demand, but with a stable and developed governance of marine use. This also is a world where environmental concerns, with geopolitical and economic interests focused elsewhere, drive a movement toward a systematic preservation of the Arctic. In this scenario, Arctic oil and gas reserves are disappointing, and there is strong public concern about climate change (environmental awareness is high) and conservation impacts on Arctic affairs.

Arctic Saga is a future of high demand for resources and trade coupled with a stable governance of marine use. This world leads to a healthy rate of Arctic development that includes concern for the preservation of Arctic ecosystems and cultures, and shared economic and political interests of the Arctic states. There is improved marine infrastructure making marine transportation safer and more efficient, supporting systematic and safe development of oil, gas and hard minerals.

Arctic State Challenges from the Scenarios

A significant challenge facing the Arctic states is to recognize the international nature of shipping in the Arctic Ocean and to effectively engage with a very broad range of non-Arctic actors, stakeholders and decision-makers. Recognition of this global reach of the maritime industry also includes a responsibility to work toward balancing historic navigation rights under UNCLOS with regimes and mechanisms designed to enhance marine safety and to protect the Arctic marine environment. A major task will be for the Arctic states to convince the IMO membership to take into account the uniqueness of marine operations in the Arctic and work within the IMO and other global organizations for international standards. The Arctic states must also recognize there may be a host of new maritime players at the table with a stake in the future use of the Arctic Ocean.

If the retreat of Arctic sea ice continues, marine access should improve throughout the Arctic basin. Complementing this change will be new Arctic ship designs that will also allow greater access and independent operations (without icebreaker escort) during potentially longer seasons of navigation. Such extended marine operations will require greatly expanded search and rescue cooperation and expanded regional environmental response networks. Information and data sharing may also be a key to the future of the maritime Arctic.

Expanded surveillance and monitoring of marine operations, particularly in the central Arctic Ocean, will require agreements among the Arctic states (and other interested parties such as flag states) for the rapid transfer of ship transit information. Monitoring of the environment could be enhanced by the establishment of a Sustainable Arctic Observing Network (SAON), an activity that was promoted during the International Polar Year. Expanded traffic in the central Arctic Ocean will provide new and unique challenges to the Arctic states and the global maritime community, since there will be a lack of communications, salvage and other critical infrastructure.

The AMSA scenarios effort has identified three key issues, among many, for the Arctic states: the ongoing globalization of the Arctic through natural resource development and resulting destinational marine traffic; arrival of the global maritime industry in the Arctic Ocean with Arctic voyages of large tankers, cruise ships and bulk carriers on regional and destinational voyages; and the lack of international policies, until now, in the form of maritime governance to meet this arrival.

The Arctic states will continue to be challenged by a widespread lack of adequate maritime infrastructure to cope with current and future levels of Arctic marine operations. In order to better enhance marine safety and environmental protection, the Arctic states working within the IMO could develop an integrated, or complementary, system of rules and regulations governing Arctic marine activity. The Arctic states must continue to engage non-Arctic states and global institutions that will influence the future of Arctic marine operations. More cooperation in Arctic maritime affairs among the eight Arctic states will be an imperative to address complex marine use issues in an uncertain future.

Future Natural Resource Development

A U.S. Geological Survey report, issued in July 2008, indicates the Arctic may contain as much as one-fifth of the world's undiscovered oil and natural gas. More specifically, the assessment found the Arctic to potentially contain 90 billion barrels of undiscovered oil and 1,670 trillion cubic feet (47 trillion cubic meters) of undiscovered natural gas, representing 13 percent of the undiscovered oil and 30 percent undiscovered natural gas. Of the total for undiscovered oil reserves, more than half are estimated to occur in geologic provinces in the Alaska Arctic (offshore and onshore), the Amerasian Basin (offshore north of the Beaufort Sea) and in West and East Greenland (offshore). More than 70 percent of the undiscovered natural gas is estimated to be located in three areas: the West Siberian Basin (Yamal Peninsula and offshore in the Kara Sea), the East Barents Basin (location of the Russian Federation's giant offshore Shtokman field) and the Alaska Arctic (offshore and onshore). Each of these regions would require vastly expanded Arctic marine operations to

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support future exploration and development. Several regions, such as offshore Greenland, would require fully developed Arctic marine transport systems to carry hydrocarbons to global markets.

Despite the recent global recession, two Arctic nations, Norway and the Russian Federation, have already made significant investments during recent decades in developing Arctic hydrocarbons in offshore Arctic Norway and northwest Russia's offshore systems in the Pechora Sea. Arctic marine transport systems support each of these developments, and oil and LNG tanker traffic from the Barents Sea to world markets is expected to continue for several decades.

For the Russian Federation, future investments in developing the Shtokman gas field west of Novaya Zemlya in the east Barents Sea are evolving. This field, understood to be one of the world's largest gas fields, lies 600 kilometers offshore and in depths of water to 2,000 meters. Exploration and development of this large, offshore region will require extraordinary levels of Arctic marine operations, most conducted in waters that are not ice-covered, but under extreme cold temperatures. Natural gas from Shtokman would be transported by sub-sea pipeline or a marine tanker system, either of which would increase marine operations in this region of the Arctic. For the United States (Alaska) and Canada, where offshore Arctic lease sales were held for the Chukchi (U.S.) and Beaufort (Canada) seas in 2008, the future remains uncertain. The leases represent long-term, strategic investments. Marine exploration of the Arctic offshore should continue during the next decade.

One of the key factors in future Arctic offshore developments is that a majority of the seabed oil and gas resources are located within the Exclusive Economic Zones (EEZs) of the Arctic states (i.e., Arctic offshore regions of Alaska, Canada, Norway, Greenland and the Russian Federation). While there remain several, regional boundary disputes where potential resources may overlap, the general jurisdictional issues are clear and do not appear to be significant obstacles to future Arctic hydrocarbon development.

Hard minerals development in the Arctic will continue to be influenced by global commodities markets and prices. However, the largest zinc mine in the world (Red Dog in the Alaska Arctic) and the largest nickel mine (Norilsk in Siberia) will continue to be solely dependent on marine transport systems - seasonal in the case of Red Dog and year-round operations for Norilsk Nickel. It is plausible that the summer, ice-free season for support to the Red Dog mine could be extended as Arctic sea ice continues to retreat in the Chukchi Sea.

The Mary River iron ore deposits on Baffin Island, Nunavut in the Canadian Arctic represent a highly valuable mineral resource (high grade iron ore of 67 percent iron). Plans have been underway for some time to develop a mining operation and ship to European markets 18 million tons of ore each year, estimated to last for a minimum of 25 years. This is a large Arctic project that would involve a fleet of ice-capable cargo carriers operating on a year-round basis between Baffin Island and Europe. Ice navigation would be required for operations in the winter and early spring.

Greenland geology records more than four billion years of earth history, preserving significant mineral deposits. For example, the Kvanefjeld Project near the southwest tip of Greenland represents a multi-element deposit containing rare elements, uranium and sodium fluoride. Potentially world class and multi-commodity ore deposits exist in other regions of coastal Greenland. The exploration and development of these mines will require Arctic marine transport systems to carry these scarce commodities to global markets.

Future Arctic Marine Tourism

Tourists now represent the single largest human presence in the Arctic and the overwhelming majority of these visitors travel aboard ships. The Arctic's once forbidding marine environment now attracts growing numbers of tourists aboard more and larger ships to a greater diversity of Arctic destinations. The future of Arctic marine tourism represents serious challenges to public authorities and businesses seeking to address the issues of safe passage and resource management.

Managing Future Marine Tourism

The growing popularity of polar marine tourism and the cruise industry's intentions to expand and diversify its polar market are creating significant management challenges. Foremost among those challenges are ice and weather conditions, lack of reliable hydrographic information, insufficient capacity of infrastructure to respond to emergencies, remoteness of tourist transits and destinations and the sheer size of vessels serving the polar cruise market. The legal and regulatory context defining appropriate ship and tourism operations consists of international treaty conventions, national laws, adopted regulations, industry guidelines and consensus-based guidelines brokered by non-governmental organizations. Governments, the tourism industry and non-governmental organizations are all determining the operational parameters for polar marine tourism through a variety of mechanisms.

National Laws and Regulations

The eight Arctic nations have enacted and enforce numerous laws and regulations governing marine operations and pollution. Based on international regulations, the national laws provide a framework to protect the Arctic environment, promote human safety and provide for a coordinated response to marine incidents, as well as enabling cooperation among the Arctic states. National attempts to regulate marine tourism extend from exceedingly stringent controls to considerably more flexible management techniques. Norway's government, for example, plans to significantly restrict cruise ship traffic around the Arctic archipelago of Svalbard and prohibit the use of heavy fuel oil. The new rules will limit to 200 the number of passengers allowed on board each ship that enters nature preserves on East Svalbard, and those tourists who are allowed entry are paying a special environmental tax. Another approach to the management of marine tourism, currently implemented by the U.S. government and the State of Alaska, is the use of onboard rangers who perform monitoring and pollution enforcement responsibilities. Some Arctic governments find themselves with the challenge of simultaneously trying to protect the environment while also promoting tourism.

Self-Imposed Industry Guidelines and NGO Codes of Conduct

Expedition cruise ship companies operating in both the Arctic and Antarctic are utilizing self-imposed guidelines to enhance marine operations, visitor safety and provide environmental and cultural resource protection. The creation and application of self-imposed industry guidelines for the conduct of environmentally responsible and safe polar tourism began with the formation of the International Association of Antarctic Tour Operators (IAATO) in 1990. The guidelines specifically address the management issues of ship operations, visitor behavior ashore, emergency response plans, the protection of Antarctica's marine and land resources and the preservation of

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the southern continent's heritage resources. IAATO's *Emergency Contingency Plan* has been successfully implemented on several occasions and is constantly updated to improve emergency response capabilities. Given the fact that these guidelines are directly relevant to polar conditions, marine tourism operations and the management of tourists when ashore, Arctic governments, communities and tour operators should benefit from their application to Arctic tourism.

The Association of Arctic Expedition Cruise Operators (AECO) was founded in 2003 for the purpose of "managing respectable, environmentally friendly and safe expeditions in the Arctic. The members agree that expedition cruises and tourism in the Arctic must be carried out with the utmost consideration for the vulnerable natural environment, local cultures and cultural remains, as well as the challenging safety hazards at sea and on land. AECO members are obligated to operate in accordance with national and international laws and regulations and agreed upon AECO by-laws and guidelines." AECO's offices are located in Longyearbyen, Svalbard, Norway and its geographical range in 2008 was Svalbard, Jan Mayen and Greenland. AECO developed its guidelines with considerable input from the Governor of Svalbard, Norwegian Polar Institute, World Wildlife Fund for Nature's Arctic Program, as well as Greenland Tourism, Greenland Home Rule, The Environmental and Nature Agency, and others. Participation by all Arctic coastal states would strengthen the association and its goals.

The WWF's program, in cooperation with tour operators, conservation organizations, managers, researchers and representatives from indigenous communities, has created the *Principles and Codes for Arctic Tourism*. The 10 principles encourage tourism development that protects the environment as much as possible, educates tourists about the Arctic's environment and peoples, respects the rights and cultures of Arctic residents and increases the share of tourism revenues that go to northern communities.

The Importance of Infrastructure

Infrastructure, defined for the purpose of marine tourism management, includes both the physical and human resources needed to prevent harm potentially arising from ship operations. Polar tourism currently operates in regions of the world that have either few or no infrastructure resources (See page 154). In many regions of the Arctic, the capacity to prevent loss of human life, protect property, contain environmental contamination, monitor sensitive resources and enforce laws is greatly diminished by remoteness, lack of capacity and severe environmental conditions.

Arctic nations, both individually and collectively, are legally responsible for providing infrastructure in order to prevent loss of life, property and environmental damage. These responsibilities are clearly within their sovereign domain of providing for the health, safety and welfare of their citizens, visitors and their environmental resources. The amount of information, facilities, equipment and human resources is not sufficient to meet the Arctic's current and anticipated volume of vessel traffic. For example, the number of passengers aboard polar cruise ships far exceeds the capacity of search and rescue assets, medical facilities and shelters needed to protect evacuees from the cold.

Factors Influencing the Future

A plausible future for Arctic marine tourism is that it will continue to grow, diversify and geographically expand as current obstacles are overcome. The most significant barriers influencing Arctic tourism include physical access, the ability of tourists to pay, the time and cost associated with traveling to remote destinations, the availability and capacity of infrastructure, environmental conditions and jurisdictional restraints that prohibit or restrict entry.

Arctic marine tourism's most likely future is that larger numbers of tourists, traveling aboard increased numbers of ships of all types, will be spending more time at more locations. The Arctic's environment, community infrastructure, social institutions and cultural values will be increasingly vulnerable to tourism-caused

Trans-Arctic Container Vessel Shuttle Option

Using the most modern container vessel design for the Arctic, it is technically feasible to establish a container traffic link between North America and Europe via the Northern Sea Route, a 2005 study concluded.

The evaluation, funded by the Institute of the North and executed by Finnish-based Aker Arctic Technology, used ice operational simulations and only evaluated the feasibility of vessel design, not the economic feasibility of the concept. Such economic analysis is still needed before a trans-Arctic shuttle operation can be considered as a serious alternative to today's route via the Panama Canal.

Assuming twin trans-shipment ports in Alaska and Iceland, the study evaluated vessels that were 750 TEU and 5,000 TEU. The simulations were based on two different kinds of years, average winter ice conditions and severe winter ice conditions, for both vessels. The evaluation used the double-acting operation design which allows the vessel to travel the traditional bow ahead in open water and, by using a propeller system that turns 180 degrees, to go stern ahead in ice-covered waters.

The 750 TEU Arctic container vessel for the study was a modified version of the Norlisk Nickel's *Arctic Express,* which moves nickel plate year-round and without icebreaker assistance between the ports of Dudinka and Murmansk in the Russian Federation (See page 82). The theoretical study vessel was modified from carrying nickel plate to container storage both below and above deck. The design also doubled the size of the fuel storage due to the longer sailing required. The ship could ply the shallow waters near the coastline of northern Russia, but simulation runs indicated it would need some traditional icebreaker assistance in severe winter conditions.

The 5,000 TEU vessel used the same icebreaking design, just on a larger scale. While the larger vessel will accommodate more containers, the size and especially the draft of 13.5 meters would prohibit it for use along the traditionally shallow-draft route of the NSR.

While the study does not look at the cost of fairway fees in this scenario, it does note that the current fee structure along the NSR is based on the paradigm of using icebreakers and "paying potential." Therefore, today the movement of natural resources along the NSR pays high fees whether using icebreaker assistance or not. This type of fee policy is not suitable for cargo vessels that are capable of independent operations, as the fee should be paid if the icebreaker assistance is needed, according to the study.

As noted, it is anticipated that the smaller study vessel would need icebreaker support some of the year, while the larger vessel would not. However, if the 5,000 TEU ship needed assistance it would require two icebreakers due to the width of the vessel. Another issue the larger study vessel poses is the ability to travel outside the traditional NSR routes.

Using only economic input related to the cost of the vessel, the operational costs, the amount of cargo that could be delivered and other related issues, the transport cost from the Aleutian Islands in Alaska to a port in Iceland via the NSR for the larger study vessel would be between $US354 TEU and $US526 TEU, and between $US1,244 TEU and $US1,887 TEU for the smaller container ship. It needs to be noted again that these figures do not include all of the economic considerations that are needed to make an accurate evaluation, such as fairway/icebreaker fees, port infrastructure costs, terminal and harbor costs and the cost to offload cargo onto the shuttle vessel, as well as transferring it back to an open-ocean vessel after reaching the twin port.

"All of these factors are unclear, uncertain and difficult to estimate," the study concludes. "Most adverse of them might be the fairway fees, of which a current estimate of $US900 to $US1,000 TEU can be given for traffic" in 2005. "The second could be the cost for building and running the terminals which could be in the same category as the cost of the vessels. Of course, the terminals for the large and effective 5,000 TEU vessel are much more expensive than those for the 750 TEU vessel, but cost per container may be lower for the larger traffic volume. Of less importance and even more difficult to clarify and estimate may be the feeder link cost. Even the existing system using the southern route includes feeder links to the container hub ports and how this picture would be changed for the Arctic Shuttle Container Link remains to be clarified. However, it is expected that extra costs compared to the prevalent system could be created."

impacts. Simultaneously, Arctic governments, communities and businesses increasingly promote tourism and invest their resources to expand this type of economic development. The cruise ship industry, responding to the popularity of polar tourism and clear evidence of profitability, is committed to send more ships with larger passenger capacities to Arctic destinations. All of these significant investments and aggressive promotion by industry, governments and communities insures that Arctic marine tourism will continue to grow and that its management is essential.

Challenges of Trans-Arctic Navigation

For more than three centuries explorers and entrepreneurs have envisioned a direct route across the top of the world between the Pacific and Atlantic oceans. However, the Arctic sea ice cover - more than 2,100 nautical miles of sea ice present except in summer - has always been a significant physical barrier to developing such a global trade route. Although no commercial cargo ship has yet to cross the central Arctic Ocean, there have been trans-Arctic voyages during the summer season along the Russian Federation's Northern Sea Route and the Northwest Passage in the Canadian Arctic. Support was normally required by modern icebreakers leading ice-strengthened merchant ships in convoy. This system of transport was particularly the norm during the era of the Soviet Union when cargoes were carried during a short summer navigation season across the length of the NSR. In recent years, there were no cargo ships undertaking trans-Arctic voyages along either the NSR or NWP. Several ice-strengthened cruise ships and icebreakers have carried tourists on recent trans-Arctic voyages in summer. The fact remains that only six, high-powered polar icebreakers (nuclear and diesel-powered) have successfully navigated across the central Arctic Ocean and each of these voyages was conducted in summer.

The AMSA is focused on marine safety and environmental protection consistent with the Arctic Council's mandates of environmental protection and sustainable development. Neither the Arctic Council nor this assessment are the appropriate vehicles to determine the economic viability of any potential Arctic trade route, whether destinational or regional, intra-Arctic or trans-Arctic using the NSR, NWP or the central Arctic Ocean. For the purposes of the AMSA, the marine safety and environmental protection measures to be developed and implemented in accordance with international laws are essentially independent of the mode of Arctic marine transport. It is the global maritime industry that will decide if and when the potentially shorter Arctic routes can be safe, efficient, reliable and economically viable in comparison to other routes across the world's oceans. The marine insurance industry and ship classification societies will have significant influence in these route determinations, as will a host of other stakeholders and actors including investors and shipbuilders.

The AMSA has indicated, using a scenario-based strategic approach, that the primary mode of marine transport throughout the Arctic Ocean is destinational traffic related to natural resource development and regional trade. New economic linkages in the Arctic to global markets are influenced by commodities prices for scarce natural resources such as oil and gas, nickel, zinc, palladium, copper, platinum and high grade ore. Current and new Arctic marine transport systems and commercial ship traffic are primarily tied to the global demand for these resources.

The international media and proponents continue to provide broad visibility to the possibility of trans-Arctic navigation, postulating that commercial routes will be viable and fully functional in the near future. This premise is based in large measure on the recent and extraordinary retreat of Arctic sea ice that has garnered worldwide attention. Touted are the large distance savings on global trade routes by using the Arctic Ocean; one example is the nominal 11,200 nautical mile route between Rotterdam and Yokohama (using the Suez Canal), versus a 6,500 nautical route across the top of the world. Many maps are shown promoting these potential marine trade routes without indicating a key factor - that the Arctic's sea ice cover will be present for a majority of the year during the century. Just how plausible is trans-Arctic shipping given that the Arctic sea ice cover remains, but is a less imposing physical barrier?

Arctic nations, both individually and collectively, are legally responsible for providing infrastructure in order to prevent loss of life, property and environmental damage.

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The Presence of Arctic Sea Ice

The observed record of Arctic sea ice noted in Section 2 indicates decreases in both extent and thickness during the past five decades. Global climate model simulations of Arctic sea ice indicate trends of increasing areas of the coastal Arctic Ocean that may be partially ice-covered or even open water. No credible scientific source, though, is arguing that there will be a complete disappearance of the Arctic sea ice cover. The models do indicate a strong possibility of an ice-free Arctic Ocean for a short period of time in September sometime in the future. Again, the significance of this physical change is that multi-year ice would disappear - no sea ice would survive the summer melt season and only new ice would grow through the autumn and winter months during the long polar night. It is uncertain how long the ice-free period will be during the late summer or exactly when it will occur in any given year. It could be a window of time as brief as a few days or several weeks, or nearly ice-free conditions could last longer in the central Arctic Ocean. However, most of the potentially navigable spring, summer and autumn months should remain ice-covered with ice that may be thinner, but more mobile, than in previous decades. The year-to-year variability of sea ice in coastal seas and straits, such as those along the NSR and NWP, will surely remain a challenge in evaluating risk for insurance purposes and determining the overall reliability of Arctic marine routes. The length of the navigation season in all Arctic regions remains uncertain from a sea ice perspective, before other factors such as ship performance and icebreaker support systems are applied.

Key Questions for Trans-Arctic Shipping

The complexity of the trans-Arctic navigation can be viewed through the lens of a range of key questions and issues:

* From the previous discussion, if all or some regions of the Arctic Ocean will remain ice-covered for much of the year, the need for polar ships designed for at least limited ice operations is obvious. The question of whether these ships will be icebreaking carriers in their own right and capable of independent ice operations is important. Will such ships require icebreaker convoy support and who will pay for the escorting icebreakers? Both are significant economic and safety issues. Relevant is the issue of whether polar icebreakers in support of navigation would be funded by commercial interests or Arctic state governments. Such commercial polar ships will also be more expensive to build and operate, and many questions remain as to their utilization beyond the Arctic Ocean on potentially long marine routes in the open ocean. Shorter routes in the Arctic imply that there is a potential for lower stack emissions into the lower Arctic atmosphere during transits. However, the presence of sea ice may require higher propulsion levels and ultimately similar or greater emissions during voyages compared with open ocean routes.

* Can the trans-Arctic routes be used year-round in a reliable and safe manner? This is a significant question as many global fleets would wish to integrate seamlessly the new route with established marine routes. If an Arctic route is only viable for part of the year,

will it be economically viable to use *Polar Class* ships on other routes? How viable and competitive would be a two to three month Arctic navigation season? How will shippers change and adapt their global shipping flows to a potentially seasonal operation along new and shorter Arctic routes? And what might be the response by the Suez and Panama canals to a seasonal route across the Arctic? Might they adjust their fee structures to accommodate this new competition?

✱ Are Arctic routes economically viable today or in the near future? For nearly two decades the NSR has been open for international business under a fee structure. However, a limited navigation season presents the most significant challenge to the global maritime industry. The economic viability of all trans-Arctic options will be based in part on what ship speeds can be maintained in both ice-free and ice-covered waters to take full advantage of the shorter transit distances involved.

✱ What are the risks assumed with using Arctic routes? For the marine insurers the risks could be higher if ships confront voyages of hundreds of nautical miles in ice. Higher risks for ice damage to ships and potential damage to cargoes in extreme cold temperatures, and the insufficient maritime infrastructure in the Arctic (such as salvage, ports and emergency response) will most likely be factors in determining future insurance rates. Navigation risks may also be compounded by operations in the polar night or during the spring/autumn seasons where night operations in ice will be required. Shippers may also face risks with the possibility of schedule disruption and other reliability issues due to the inherent uncertainty of Arctic ship navigation. Many of these risk factors can be mitigated with the use of highly capable polar ships with experienced Arctic mariners.

✱ Trans-shipment of cargoes may be a plausible option for using the Arctic Ocean for trans-Arctic shipments (See page 101). Which ports would be likely termination points at the ends of the Arctic voyages is a key question. The investment in terminals and in a fleet of Arctic ships that would operate year-round across the Arctic Ocean would be sizable. However, a key factor would be that the Arctic ships would be fully and solely employed on Arctic voyages. The addition of trans-shipment ports 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, depending on the time delays associated with cargo transfers.

Potential Operators on Trans-Arctic Trades

The variability of Arctic sea ice and the uncertainties associated with sailing times make predictions for use by marine operators and certain vessel types (and trades) highly speculative. During the assessment's scenarios creation effort, it was identified that large LNG carriers and oil tankers would not likely use trans-Arctic routes for trading. Today, all such ships sail from western Siberian ports and northern Norwegian ports westbound for North America and European ports. Future pipelines across Eurasia and additional pipelines to central Europe appear to be strong competitors to oil and gas carriers potentially sailing eastbound along the NSR.

The challenges for container traffic and carriers using trans-Arctic routes are many, including schedule reliability and the need to satisfy very tight customer supply chains. The potential safety of the ships and cargoes, and the actual fuel costs and time savings (with ice navigation required on portions of the routes) are significant considerations that are not well understood. The investment in ice class ships would also be a major issue since their operation would be sub-optimal in non-Arctic trades if year-round Arctic operations could not be achieved.

It is plausible that several types of dry bulk and break-bulk carriers could conceivably use seasonal trans-Arctic routes. Bulk metal ores and concentrates (many can be stockpiled at the mine or the destination port) could be shipped along the NSR and even across the central Arctic Ocean if spot charters could be arranged on an opportunistic basis. However, suitable ice class ships would have to be built or be readily available for charter. Break-bulk carriers of forest products and pulp might use the Northern Sea Route to trade from northern Europe to Pacific and North American ports. It is reasonable to assume that experimental voyages of a commercial icebreaking carrier could take place within the decade to test the operational and technical challenges associated with trans-Arctic navigation.

The Need for Economic, Comparative and Technical Studies

There is a dearth of rigorous economic studies related to the evaluation of trans-Arctic shipping routes. Comprehensive economic studies using cost-benefit-risk analyses are needed for all three potential routes of trans-Arctic shipping (central Arctic Ocean, NWP and NSR). Such studies need to fully identify the global demands and key economic needs for use of these polar routes. Additional related studies are necessary to determine the economic benchmarks and indicators for viable seasonal and year-round trans-Arctic traffic. What might be the key commodities suitable and economically viable for trading during even a partial or summer navigation season? Further economic research should be conducted on the potential for trans-shipment of cargoes across the Arctic Ocean in icebreaking carriers. An important component of such an analysis would be the economics of trans-shipment terminals/ports in Alaska, Iceland, northwest Russia and northern European sites.

Operational and technical studies are also lacking. A comparative analysis of icebreaker-assisted convoys versus independently-operated, icebreaking carriers for all trans-Arctic options is required as new Arctic ship technologies emerge. Risk assessments related to Arctic ship operational challenges, the general lack of marine infrastructure throughout the Arctic Ocean and the potential for ice damages would be useful to the marine insurance industry and all ship owners contemplating trans-Arctic navigation. Cost effectiveness studies for different icebreaking propulsion systems, including nuclear propulsion, should also include analyses of future emissions controls that are socio-economic responses to global climate change. The increasing size of ships (on global trade routes) may also have significant implications for all modes of Arctic marine transport including the trans-Arctic option. Studies should identify any maximum limitations, technical challenges and operational constraints for these very large ships on Arctic trade routes.

The uncertainties and complex interactions of many driving forces of trans-Arctic navigation require significant research. While it may be technically feasible to cross the Arctic Ocean today by modern icebreaker or even using an advanced icebreaking carrier, the operational, environmental and economic implications and challenges for routine trans-Arctic voyages are not yet fully understood.

Research Opportunities

- Comprehensive economic research including cost-benefit-risk analyses for all potential routes of trans-Arctic shipping.
- Comparative analysis of using Arctic marine transport in *Polar Class* ships versus pipelines for the carriage of Arctic oil and gas to world markets. Summarize the existing regional studies conducted for these comparisons.
- Comprehensive, comparative analysis of ice-assisted convoys versus independently-operated, icebreaking carriers for all modes of Arctic marine transport.
- Continued marine research on the changing nature of Arctic marine ecosystems related to climate change and the retreat of Arctic sea ice to determine the future level and operational impacts of fishing vessels in higher latitudes.
- Research on the socio-economic responses to global climate change (for example, ship emissions controls) and their potential impacts on Arctic natural resource development and Arctic marine transport.

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Regional Futures to 2020: Bering Strait Region

The Bering Strait is a narrow international strait that connects the North Pacific Ocean to the Arctic Ocean and forms the only corridor between northern and east-west transportation routes (Map 6.1). At the strait's narrowest point, the continents of North America and Asia are just 90 km apart. With diminishing summer sea ice in the Arctic Ocean, the Bering Strait region may experience increased destinational traffic to the oil and gas exploration areas in the Beaufort and Chukchi seas, and to the Red Dog Mine in northwest Alaska.

Sea Ice

Seasonally dynamic sea ice conditions are found in this natural bottleneck. Typically, sea ice develops along the coasts in October and November. During May-July the ice edge retreats northward through the region. First-year sea ice can develop to more than 1.2 meters thick during the winter. Except for shorefast ice, sea ice movement in the Bering Strait region is dynamic and forced by winds and currents. Ice has been observed to move through the region at speeds as high as 27 nautical miles per day. The seasonal ice field does not contain icebergs from land-based glaciers; however, multi-year ice from the Arctic ice pack has been observed to flow southward through the strait and into the Bering Sea. The future sea ice extent in the vicinity of the Bering Strait is projected to change only slightly in spring (April and May); however, a significant reduction (later freeze-up) is projected for the future in November and December.

Ecosystem and Bio-resource Considerations

The Bering Strait region is a highly productive area extensively used by many species, including several species listed under the U.S. Endangered Species Act. The prolific continental shelf seasonally supports a rich array of benthic feeders, such as gray whales, Pacific walruses and seabirds. Ice-dependent marine mammals seasonally move through the region as sea ice retreats in the summer and advances in the fall.

Many species depend upon primary productivity associated with sea ice, and the juxtaposition of the seasonal ice, shallow depth and productive benthos serves to support a unique diversity and high density of marine life. It is a dynamic region, and the physical constraints of the Bering Strait serve to seasonally concentrate species associated with the ice edge. The region is the only migration corridor for many species of fish, birds and marine mammals. Potential conflicts between increased ship traffic and large marine pinnipeds and cetaceans in the region are associated with increases in ambient and underwater ship noise, ship strikes, entanglement in marine debris and pollution (including oil spills).

Indigenous Marine Use

The Bering Strait region is home to three distinct linguistic and cultural groups of Eskimo people in Alaska: the Inupiaq, Central Yupik and Siberian Yupik on Saint Lawrence Island. The coastline of the Bering Strait region has been continually occupied by indigenous people for several thousand years. Human populations in this region have been dependent on marine resources, including mammals, fish, birds, macro algae, shellfish and other invertebrates. The hunting of large marine mammals has been the primary adaptive subsistence strategy of Bering Strait human populations for more than 1,000 years.

Currently, the population of the Bering Strait region is greater than 10,000 people, with Alaska Natives comprising more than three-fourths of the population. There are 15 year-round villages along the U.S. coast that range in population from approximately 150 to more than 750 residents.

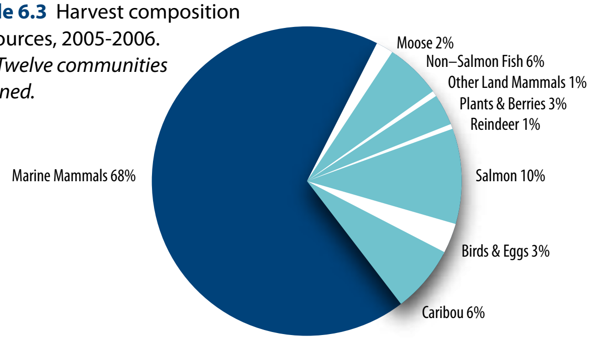
The use of different marine resources occurs throughout the year. However, use strategies change seasonally with the animal migrations and life history stages. Regions where marine resources are gathered include beaches, coastal waters and/or nearshore waters, and may include offshore waters. For example, to adapt to the rapidly changing accessibility and availability of sea ice, hunting of large marine mammals (i.e., walruses) can take place up to 50 to 80 nautical miles offshore. Travel to these offshore locations is typically conducted in small open boats and a hunt can span several days before a vessel returns to its port of origin.

Map 6.1 Vessel traffic in the Bering Strait during the summer of 2004. *Source: AMSA*

Marine resources are of vital importance to peoples of this region. Not surprisingly, today's U.S. communities in this region, except White Mountain, are situated on the shores of the Bering or Chukchi seas and are strongly tied to subsistence lifestyles. This maritime reliance for subsistence in the Bering Strait region is very significant and, for marine mammal species such as walruses, whales and seals, comprises a significant portion of the total U.S. harvest. Additional marine-based resources are obtained through beachcombing, clamming, gathering seabird eggs, fishing, birding, gathering greens and other activities.

While Bering Strait region communities exhibit unique socio-economic, cultural and political differences, they all use the marine resources for nutritional reliance, cultural customs and economic dependence (for example, clothing, equipment, handicrafts, commercial fishing and hunting and limited ecotourism). The general patterns of large marine mammal hunting and reliance on other marine resources (i.e., fish, crabs, birds, beachcast invertebrates, macro algae) persist to the present time, despite technological changes.

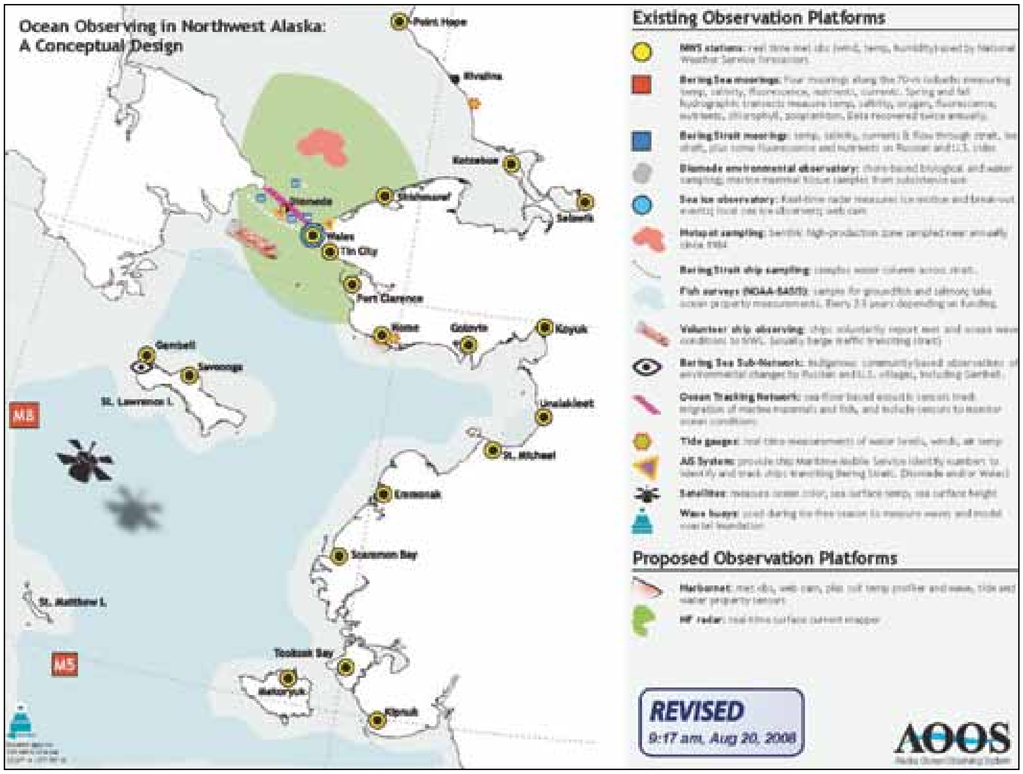
Table 6.3 Harvest composition of resources, 2005-2006. *Note: Twelve communities combined.*



Source: Kawerak, Inc., North Pacific Research Board, Alaska Department of Fish and Game, 2005-2006 Comprehensive Subsistence Harvest Survey, Bering Strait/Norton Sound Region

Table 6.3 graphically demonstrates the maritime reliance for subsistence in the Bering Strait region with more than 85 percent of the harvested resources being marine-derived. The regional reliance on marine mammals is very significant.

The communities closest to proposed vessel traffic in the Bering Strait region (Gambell, Savoonga, Shishmaref and Wales) have a high reliance on ocean-based resources. The St. Lawrence Island communities of Gambell and Savoonga are most dependent on marine resources, with the marine mammal harvest totaling over one million kilograms. More than 95 percent of their total subsistence harvests are marine-based resources (i.e., seabirds, eggs, fish and marine mammals). Shishmaref, on Sarichef Island, and Wales, on the mainland, demonstrate a high reliance on marine resources with more than 75 percent of their total harvest derived from the sea. In contrast, the coastal communities of southern Norton Sound, especially Stebbins and Unalakleet, demonstrate a higher reliance on fish, especially salmon, which is indicative of the highly productive river influences.



Map 6.2 A potential observing system for the Bering Strait region. *Source: Alaska Ocean Observing System (AOOS)*

Though current environmental patterns and predictions indicate a profound and long-term ecosystem change to the Bering Strait region, human reliance on marine resources for subsistence remains essential. The importance of the cooperative hunting of large marine mammals and the use of all available marine resources for nutritional, cultural and economic needs will persist in the region.

In 2001, Russia and the U.S. signed the *Agreement between Government of the Russian Federation and United States of America on Cooperation in Combating Pollution in the Bering and Chukchi Seas in Emergency Situations*. This agreement establishes cooperation in oil spill preparedness and response in the Bering Strait region.

Potential conflicts between increased ship traffic and indigenous marine resource use in the Bering Strait region include but are not limited to an increased amount of:

- Ambient and underwater ship noise - recognized as one of the primary concerns to marine mammal populations, especially within the narrow and shallow migration corridor;
- Ship strikes on large marine mammals;
- Entanglement of large marine mammals in commercial fishing gear;
- Potential for collision between coastal and offshore large ship traffic and small open boats using marine resources;
- Pollution affecting the availability and quality of offshore, coastal and beachcast marine resources, due in part, but not limited to:
  - lack of navigational and rescue infrastructure in an extremely challenging physical and marine environment;
  - concern for infrastructure to secure a large vessel in distress;
  - concern for infrastructure to assess and respond to an oil and/or chemical spill; and
  - language (for example, English, Russian, Siberian Yupik) and cultural communication barriers.

In spite of the intensive subsistence use of resources, dynamic ice conditions and biological richness, there are currently no operational ocean-observing platforms in this region. Map 6.2 describes a potential observing system for the Bering Strait region, building upon existing (mostly research) assets.

Commercial Marine Uses: Fishing, Oil and Gas, Minerals, Tourism and Shipping

In the Bering Strait region, there are three primary U.S. ports: Nome, Kotzebue and the DeLong Mountain Transportation System (DMTS) port serving the Red Dog mine. The main ports on the Russian side are just south of the Bering Strait, as they are on the U.S. side. The three largest ports are Provideniya, Anadyr and Egvekinot. The water depth in most U.S. and Russian ports in this region is about 10 meters or less.

Overall, approximately 150 large commercial vessels pass through the Bering Strait during the July-October open water period, with transits of these vessels most frequent at the beginning (spring) and end of the period (autumn). This estimate excludes fishing vessels, which are generally smaller, as well as fuel barges serving coastal mining activities and coastal communities.

Potential offshore development north of the Bering Strait region in the Chukchi and Beaufort lease sale areas could plausibly increase the numbers of support and supply ships transiting the region. There is no indication or information in support of ships transiting the Bering Strait on trans-Arctic voyages by 2020.

Infrastructure, Navigation and Communication

There are currently no established vessel routing measures in the Bering Strait region. A Traffic Separation Scheme (TSS) may need to be established in the region as vessel traffic increases. There is currently no active Vessel Traffic Service (VTS) or other traffic management system in place in the waters of the Bering Strait. Shipboard Automated Identification System (AIS) capability is currently limited. Presently the Marine Exchange of Alaska has established and is expanding AIS reception capability throughout portions of the Bering Sea.

There are no shore-based very high frequency (VHF) FM communication services available in the Bering Strait region. The U.S. Coast Guard does maintain VHF-FM sites in the Bering Sea, and maintains a HF radio guard for emergency and distress calling, but HF coverage of the Arctic region is poor. There are only three U.S. Coast Guard maintained navigational aids at the Bering Strait along the north side of the Seward Peninsula into Kotzebue Sound. There are no navigational aids north of Kotzebue Sound.

There is 100 percent coverage of the Bering Strait region from the Global Positioning System-Standard Positioning Service (GPS-SPS). However, the GPS constellation is not configured for optimal positioning in high latitudes, resulting in a potential degradation of position accuracy. There is currently no Differential GPS (DGPS) coverage of the area.

In the Bering Strait region, limited capabilities exist to respond to an incident, whether it is for lifesaving or oil recovery. Weather and oceanographic observations necessary to support search and rescue and oil recovery operations are also minimal. Even if a U.S. Coast Guard operating team were seasonally deployed to an Arctic coastal community, weather and distance to an incident site would remain huge challenges. Under present circumstances, vessels in distress must depend on other vessels or local communities in the area for assistance or wait until aid arrives. Few viable salvage vessels are available north of the Aleutian Islands.

Findings

Regional Futures to 2020
Bering Strait Region

1] The Bering Strait region is an international strait for navigation and a natural chokepoint for marine traffic in and out of the Arctic Ocean from the Pacific Ocean.

2] The region, seasonally ice-covered, is a highly productive area extensively used by many species of seabirds, marine mammals and fish. The highly productive continental shelf supports a rich array of benthic feeders; ice-dependent species also move through the region as sea ice retreats and advances. The Bering Strait serves to concentrate species associated with the ice edge and is the only migration corridor for many species.

3] The Bering Strait region is a prolific location for nesting seabird colonies, making it a vulnerable location for ecological disruptions.

4] Indigenous people have continually inhabited the coastline of the Bering Strait region for several thousand years. Marine resources today are of vital importance to coastal American and Russian populations throughout the Bering Strait region. They are dependent on marine resources including marine mammals, fish, birds, macro algae, shellfish and other invertebrates. Hunting of large marine mammals can take place 50-80 nautical miles offshore.

5] Ships related to a spectrum of uses are found in the Bering Strait region: fishing, hard minerals/mining, science and exploration, tourism and offshore oil and gas development. Approximately 25 large commercial ships (bulk carriers) annually sail north through the Bering Strait region (in the ice-free season) to the DeLong Mountain Terminal off Kivalina in northwest Alaska.

6] There are no formally established vessel routing measures in the Bering Strait region and there are very few visual aids to navigation in the region. Any future voluntary set of traffic routes, or a vessel traffic system, could be proposed by the United States and the Russian Federation to the International Maritime Organization.

7] Offshore oil and gas development may lead to increased marine traffic in the Bering Strait region during the next several decades. Multiple use management practices and measures to mitigate potential impacts (noise, emissions, ship strikes, discharges, etc.) from these new uses would be useful.

Breaking the Ice: Arctic Development and Maritime Transportation

Organized by the Icelandic Government, March 2007

Hosted by Iceland's Ministry of Foreign Affairs in March 2007, the "Breaking the Ice: Arctic Development and Maritime Transportation" conference provided the first opportunity under the International Polar Year banner for marine specialists and stakeholders to exchange information on Arctic shipping and the prospects of a trans-Arctic route between the North Atlantic and the Pacific oceans.

Designed as a contribution to the Arctic Marine Shipping Assessment, 90 delegates from all the Arctic countries, the United Kingdom, China and the European Commission discussed and debated issues on three key policy issues: the future of research and monitoring in the Arctic, the status of emergency prevention and response and the viability of trans-Arctic shipping.

The following are some of the observations made at the seminar:

- The extraordinary retreat of Arctic sea ice and the rapid decrease in multi-year ice has increased marine access throughout the Arctic basin and coastal seas.
- The development of "double acting Arctic ships," equally fit for open ocean and navigation through ice without icebreaker assistance, opens the possibility of year-round trans-Arctic container traffic between the North Atlantic and the North Pacific oceans. A number of double acting tankers and containerships are already operating in the Arctic. The economics and ice-breaking capacity of such ships improve with larger size.
- Improved remote sensing technologies will make it possible to provide information on ice thickness and ice ridges. The emergence of ice forecast services can be used for plotting sailing routes through the ice.
- The globalization of world economy and rapid growth in international trade has led to capacity constraints of the Panama and Suez canals, hampering the integration of North Atlantic economies with fast growing economies in East and Southeast Asia. Trans-Arctic shipping would supplement present transportation routes and spur economic development.
- The opening of a trans-Arctic route would enhance economic security of the world. Present transportation links between the North Atlantic and emerging economies in the Far East are precarious. They are subject to delays because of accidents, mechanical breakdowns and maintenance, and they are vulnerable to disruption because of terrorist activities, regional conflicts and piracy.
- The high cost of technical development and infrastructure make it unlikely for private stakeholders to commence regular trans-Arctic transportation without governmental support.
- International cooperation for the development of trans-Arctic shipping should include stakeholders outside of the Arctic. Chinese delegates at the conference expressed a willingness to cooperate with the Arctic states in the research and development of Arctic shipping.
- Changing ice conditions may make it challenging to maintain tight transportation schedules and ensure the punctuality of certain cargoes. Enhanced monitoring, improved sea ice information and more efficient icebreaking carriers would significantly improve the situation.
- A comprehensive feasibility study is needed to estimate the commercial viability of trans-Arctic shipping, taking into account a wide range of economic and natural variables, including vessel cost, ice conditions, sailing speed on different routes, etc. New shipping routes and technologies should be pioneered with experimental voyages in order to gather better information on the shipping conditions and viability of new shipping routes.
- Care must be taken to minimize environmental effects of increased shipping activity in the Arctic. The capacity of the Arctic states for emergency response must be increased with appropriate equipment, materials and sufficient towing capacity, made available for various situations close to development sites and shipping routes. The Arctic Council can play a role in coordinating response to emergencies related to the shipping through the EPPR working group.
- While voluntary or recommended guidelines for Arctic shipping have been adopted by IMO, the movement toward mandatory rules for Arctic shipping must be accelerated.

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- One presenter proposed the use of nuclear ships for trans-Arctic shipping to decrease the release of greenhouse gases and prevent the "graying" of the ice. Furthermore, nuclear ships would be relatively cheaper to operate in view of high and rising fuel costs.
- The participants agreed in general that Iceland could play a role in the opening of a trans-Arctic sea route because of its location in the middle of the Northern Atlantic. The new shipping routes that pass near Iceland (routes of commercial ships from Northwest Russia and northern Norway sailing to North America) could be linked by Iceland serving as a hub for container traffic in the northern Atlantic region.

The participants in the seminar concluded that experimental and limited trans-Arctic commercial voyages through the central Arctic Ocean could start during the summer navigation season within a decade; and that a year-round trans-Arctic marine transportation route between the North Atlantic and the North Pacific oceans could plausibly open in one or two decades, considering security, economic and environmental factors.

Regional Futures to 2020: Canadian Arctic and Northwest Passage

General Description of the Region

The Canadian maritime Arctic is located across the north of Canada from the Beaufort Sea in the west to Hudson Strait in the east, covering approximately 2.1 million km². The Arctic Archipelago comprises approximately 36,000 islands, including three of the world's 10 largest islands. The coastal area is sparsely populated with fewer than 30,000 people. The Canadian Arctic also provides important habitat for a range of permanent and migratory species of marine mammals, seabirds and terrestrial animals such as caribou. Throughout this region there are many ecologically sensitive areas where animals gather in large numbers at certain times and may be vulnerable to impacts from shipping.

The Canadian Arctic has a long and rich history of marine use, beginning with its indigenous residents many thousands of years ago. Shipping in the Canadian Arctic has always been the safest and most economically effective means of moving goods to, from and within the region. It is a vast area with virtually no roads, no rail lines and where air services are both infrequent and very costly. There are also unique geographic and climatic conditions that make the region challenging for maritime navigation, including the presence of ice for most of the year, as well as the many narrow and shallow, often uncharted, areas through the archipelago. Canada has for many years strived to achieve a balance between development and environmental protection in its Arctic areas and for this purpose has a unique and extensive regulatory scheme in place to enhance marine safety and environmental protection in its Arctic waters. This regulatory scheme was ahead of its time when it was first established in the 1970s and is now in need of updating in order to bring it in line with recently developed international standards.

Sea Ice Conditions

Sea ice observations for the past three decades from the Canadian Ice Service show negative trends in coverage for the eastern and western regions of the Canadian maritime Arctic. The observations also show a very high, year-to-year variability of sea ice coverage in all regions, an important factor of uncertainty when considering marine insurance, investment, ship construction standards and other aspects of Arctic marine transport. Due to the unique geographic characteristics of the Canadian Arctic Archipelago (with many channels oriented north-south), the region is also expected to be one of the last areas of the Arctic Ocean to have a significant summer ice cover. It is plausible that if sea ice melt in the central Arctic Ocean continues, as many climate models indicate, there is a potential for more mobile multi-year sea ice to be swept southward through many of the northern passages of the archipelago. For the whole of the Arctic Ocean, including the Canadian maritime Arctic and Northwest

Canadian Arctic Shipping Activity

Expectations to 2020 may be summarized as follows:

- *Dry bulk carriage* stimulated by resource development: definitive forecasts of substantive marine transportation projects are, for now, Mary River and High Lake developments.
- *Liquid bulk carriage* stimulated by resource development: minimal forecasts due to expectations that any substantive products in the Beaufort Sea will move out by pipeline.
- *Supply/resupply:* some important but manageable expansion in shipping activity is forecast, related to growing populations and for movement of supplies and equipment in support of exploration projects.
- *Cruise shipping:* projections of modest but largely unpredictable growth.
- *Container, bulk transit traffic:* no substantive activity seen in this sector in the timeframe under examination.
- *Other:* unknown activity for fishing, seismic, etc.

Table 6.4 Canadian Arctic shipping activity expectations to 2020. *Source: AMSA*

Passage, global climate models indicate that sea ice will be present throughout the winter and for approximately nine months during each year. The Canadian maritime Arctic will have a generally more favorable sea ice situation in a short, summer period, but will be ice-covered for a majority of the year, a significant factor for Arctic transport regulation and protection of the marine environment.

Indigenous Use

The sea is very important to the way of life and culture. Inuit do not distinguish the water from the land in terms of their hunting and culture. All of the communities in the Canadian Arctic are coastal or situated on major waterways. Whether traveling in a boat or over the ice, the water provides a means of transportation, a connection between communities and a source of food. Though their technologies and style of living may have changed dramatically in the past hundred years, the Inuit are still by and large hunters who rely on country foods for a large portion of their diet. Some of the most important country foods are seal, walrus and whale, all of which are harvested on the ice edge or by boat. Any disruption of the ecosystem, such as an oil spill, dumping of waste or noise from machinery or ships could have effects on the animals and, therefore, the health and well-being of the Inuit. Despite the benefits of increased community re-supply, general shipping is a cause for concern to the Inuit. Vessels may scare away mammals needed for subsistence; they break ice tracks, disrupting travel on the ice via snowmobile and ships may affect wildlife in harbors and elsewhere.

Current Commercial Use

The types of commercial shipping activity currently taking place in the Canadian Arctic consist of community re-supply; bulk shipments of raw materials, supplies and exploration activity for resource development operations; and tourism. Commercial re-supply activities are serviced by southern points of origin, one in the west and several in the east. In the western Arctic, most cargo is moved by tugs and barges from Hay River down the Mackenzie River to Tuktoyaktuk for transfer and consolidation. Conventional ocean-going general cargo vessels typically handle cargo in the eastern Arctic. Cargo is lightered ashore using small tugs and barges that are carried with the ships. Currently, there are no commercial vessels that regularly transit the Northwest Passage, aside from a few small specialty cruise operators. Other commercial shipping activities in the Canadian Arctic include a single-base metal operation in Deception Bay that ships nickel concentrates to Quebec, and grain shipments from Churchill to international markets. Exploration and resource development is ongoing. Recently, there has been heavy demand for logistics and supplies in both the eastern and western Arctic, particularly in the Beaufort Sea and at the Mary River iron ore mine, which shipped 120,000 tonnes of bulk cargo to European mills during the 2008 season.

Future Use

Destinational shipping is anticipated to increase in the Canadian Arctic. This will be driven largely by the demand for goods by growing communities, expanding resource development projects, as well as increasing tourism. The changing climate will result in increased accessibility and a longer shipping season, which will in turn also affect future activity levels. By 2020, it is projected that annual re-supply demand will increase enough that the current fleet will not be sufficient to meet the needs, despite the likelihood of a longer shipping season. In addition, the current fleet is aging and most ships would likely need to be replaced within that timeframe.

It is anticipated that the primary areas of increased marine activity will be resource driven. The lack of infrastructure and high operational costs have, until recently, made this region uneconomical for large-scale resource development. However, during the next 20 years, new bulk exports are expected to include: Mary River iron ore from a port at Steensby Inlet in the Foxe Basin, with possible commencement in 2010; Roche Bay magnetite from a port near Igloolik in the Foxe Basin, possibly beginning in 2015; and High/Izok Lake lead/zinc/copper concentrate shipping from either Gray's Bay or Bathurst Inlet, possibly starting in the same year. Imports will likely include logistics and fuel for the primary resource operations noted above; logistics and fuel, as well as barge-mounted production modules for the proposed Mackenzie pipeline; and delivery of production modules to the Alberta Oil Sands, among others. High operational costs in the Canadian Arctic are a limiting factor in this region. As a result, it may be many years before the Canadian Arctic matches the volume of resources extracted from Alaska or the Russian Arctic regions.

While the summer climate in the Canadian Arctic region is changing, ice will be present during most of the year and especially during the long, cold polar nights each winter. As a result, access to the Northwest Passage will continue to be controlled by ice conditions. Despite widespread speculation, the uncertainty of conditions in the Northwest Passage due to seasonal variability, changing ice conditions, complexity of routes, depth restrictions, lack of adequate charts and other infrastructure, high insurance and other costs, will diminish the likelihood of regular scheduled services. With the exception of nuclear icebreakers, very few ships have been built that could safely carry out year-round commercial navigation in the Canadian Arctic. The continued presence of ice even in open water will mean that operational costs will continue to be high.

Findings

Regional Futures to 2020 Canadian Arctic & Northwest Passage

1] The Northwest Passage is not expected to become a viable trans-Arctic route through 2020 due to seasonality, ice conditions, a complex archipelago, draft restrictions, chokepoints, lack of adequate charts, insurance limitations and other costs, which diminish the likelihood of regularly scheduled services from the Pacific to the Atlantic.

2] Destinational shipping is anticipated to increase in the Canadian Arctic, driven by increasing demand for seasonal re-supply activity, expanding resource development and tourism.

3] In the Canadian Arctic, ice conditions and high operational costs will continue to be a factor into the future. Irrespective of the warming climate, ice will remain throughout the winter, making viable year-round operations expensive.

4] Canada has a specific regulatory system for shipping in Arctic waters that is in need of an update in line with recently developed international standards.

Regional Futures to 2020: Northern Sea Route and Adjacent Areas

In 2003, participants representing the shipping industry, research community from five EU countries, Russia and Norway began a three-year research project: the Arctic Operational Platform (ARCOP). ARCOP was not to be re-negotiated by PAME, did not have a direct linkage to the AMSA objectives and did not express the views of the Russian Federation.

During the same period "JANSROP Phase II" in 2002 began a three-year program. In conjunction with INSROP (1993-1999), JANSROP II, funded by Japan's Nippon Foundation, emphasized the eastern part of the Northern Sea Route (Siberia, Far East Russia and the Sea of Okhotsk). INSROP (See page 46) was supported by the Russian Federation and funded by a consortium of Norwegian, Japanese and Russian sources. Four hundred and sixty experts participated in INSROP in economics, navigation, meteorology, hydrography, military operations and environmental protection from: Russian Federation, Norway, Japan, United States, United Kingdom, Denmark, Sweden, Germany and Finland. INSROP results included an experimental Arctic voyage from Yokohama to Rotterdam, international conference, three books and 167 peer-reviewed papers.

ARCOP, funded by the EU Commission and European shipping interests, examined the different elements of oil and gas transportation between northwest Russia and Europe. ARCOP included six separate work packages, each concentrating on a specific topic but also using one selected transportation task as a focus of the research. Fifty-seven research reports were produced by ARCOP and all reports can be found on the ARCOP website, www.ARCOP.fi. The contents of this section represent the views of the experts who worked within ARCOP and is presented as one of the assessments in the field.

Work Package 1, *The Ice Information System*, was started in early 2005. The research part of this work package was performed jointly with the Ice Ridging Information for Decision Making in Shipping Operations (IRIS) project, which is a separate EU-funded project coordinated by the Helsinki University of Technology (HUT). It developed methods to acquire online ice information and create accurate ice condition forecasts in a short time span. Kaeverner Masa Yards participated in this project and the results from IRIS were applied to ARCOP. Within ARCOP, the information from IRIS was compared to the experience within the Russian Arctic. The potential of the enhanced ice information system was demonstrated by economic analyses in the NSR conditions.

Work Package 2, *Administrative Measures for Marine Transport*, covered a large number of topics, varying from international law to rules and fees applicable in the Russian Arctic. Within international law, the regime in force in the Russian Arctic is in line with UNCLOS Article 234 and thus the situation regarding commercial shipping is more or less clear. It was also considered that UNCLOS Article 76, dealing with the extended continental shelves, does not really affect commercial shipping, since sailing in the central Arctic Ocean means passing through areas covered by Article 234.

Within the World Trade Organization and the *General Agreement on Trade in Services* (GATS), there are a number of issues that are not yet clear. But since the whole GATS regime covering shipping is still open, this is not a specific Arctic problem. Of interest to the Arctic shipping community is the question of icebreaker services. In some countries, this is considered a service that should be open for competition within the WTO. In the Russian Federation, as well as in Sweden, this is considered to be part of the infrastructure that the coastal state provides. A potential solution to this question will be realized only when large-scale transportation is in place.

The question of ice rules caused much discussion during the ARCOP workshops, and it appears the current system of rules is not consistent. When dealing with hull strength, the IMO recommendations refer to *Polar Classes*. But these *Polar Classes* in fact do not exist, since IACS has not published their Unified Requirements. Additionally, the Unified Requirements do not say anything about propulsion power. Among the national authorities like in Finland and the Russian Federation, there are, and obviously will be, requirements for minimum power. This puts the shipowners and ship designers in a

Non-commercial Partnership of the Coordination of the Northern Sea Route Usages: Facilitated Discussion

Formed in 2001, the Non-commercial Partnership of the Coordination of the Northern Sea Route Usages is a Moscow-based organization comprising federal and regional government officials, Russian shipping companies and international research and/or educational institutions.

Arthur Chilingarov, deputy chairman of the State Duma, is president of the Partnership with Mikhail Nikolaev, deputy chairman of the Council of Federation, as the vice-president. Captain Vladimir Mikhailichenko, former head of the Northern Sea Route Administration, is the managing director.

The organization has 32 members whose aim is to expand the use of the NSR, assist in safe navigation of Russian and international commercial use along the route, ensure adequate environmental protection in the region, stimulate research and development activities associated with the route; as well as addressing issues such as tariffs, taxation, insurance and other economic factors in the Arctic zone and the NSR.

In order to incorporate the thoughts of the partnership members into the AMSA, partnership member Institute of the North, in conjunction with the U.S. Arctic Research Commission, held a facilitated discussion during the organization's quarterly meeting in St. Petersburg, Russia in February 2008.

The participants were asked what opportunities and challenges they anticipated for the Northern Sea Route in the next 20 years, or longer. The following ideas were captured during the 2 ½ hour discussion and placed into seven topic areas: Emerging Routes, Infrastructure, Technological Considerations, Development and Shipping Economics, International Cooperation and Marine Environmental Safety, Training and Education and Arctic Ocean Observing Network/Monitoring.

Concerning emerging routes, participants generally agreed that the intermodal transportation system (rail and shipping) within Russia is poised to make "colossal" changes and that all Arctic shipping will be influenced by the developing intermodal transportation systems. There was agreement that there will be a greater increase in the shipment of oil and gas of western Russia through the Barents and Norwegian seas, and that regional development in the Russian Far East could reasonably tie rail and shipping in the Lena River with Chinese products going into the Russian Far East and possibly natural resources going out. All of the participants agreed that economics, not Arctic climate change, will drive increased shipping in the NSR.

When talking about infrastructure, the group agreed there is a need for better ice forecasting because ice is very difficult to predict. They envisage the icebreaker fleet in the future will be a mixture of a few large federal icebreakers and smaller commercial multi-purpose icebreakers to support offshore oil and gas development. They noted that shallow draft along the NSR coast and inland rivers made access difficult and challenging; however, the European Union ARCOP project indicated winter marine access along the Ob' River. The lack of major ports along NSR is one limiting factor in increased shipping and is compounded by the need for port improvements throughout the North. The members were adamant there is a need for better search and rescue resources deployed, as well as places of refuge identified. In addition, the capability of ships to provide assistance should be considered of prime importance, having due regard to the lack of repair facilities, the limited number of dedicated towing ships available and the response time.

As to technology, the group said the likely future for shipping in the NSR will occur with independent icebreaking cargo ships and a small number of federal icebreakers used to facilitate traffic, if necessary. Some members of the partnership believe there continues to be a need to maintain a federal icebreaker fleet, with the lead icebreakers of 100,000 shaft horsepower; while others see a different role for a smaller icebreaker fleet that are used to assist, when needed, independent icebreaking cargo ships.

Concerning development and shipping economics, some members suggested the NSR tariff structure needs to be evaluated with the goal of making it more competitive within the global maritime industry and economically sustainable. All operations, whether they are from within the Russian Federation or outside the country, should be subject to the same tariff structure. The group said redundancy of critical systems should be incorporated into ships operating in the NSR. Government should work closely with and be supportive of regional commercial icebreaking systems and regional relationships in the Barents Sea region (between nations and regional organizations) are important linkages for the future of the NSR.

When discussing international cooperation and marine environmental safety, the partnership members agreed there is a need to address the key challenges in combating oil spills in ice-covered waters. They called for the International Maritime Organization to create mandatory, not voluntary, regulations for all ships plying the waters of the Arctic and Antarctica. The partnership plans to work


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with the noncommercial organization, Association Northwest, which includes 11 independent regions. They believe it is important that all ships in the NSR meet or exceed the voluntary *Guidelines for Ships Operating in Arctic Ice-covered Waters*. They also said that the Arctic environment imposes additional demands on ship systems, including navigation, communications, life-saving, main and auxiliary machinery, etc. They emphasize the need to ensure that all ships systems are capable of functioning effectively under anticipated operating conditions and providing adequate levels of safety in accident and emergency situations.

In the training and educational area, they suggested ice navigation simulators are needed to improve ice navigation and enhance marine safety. They emphasized the human factor is very important in all of these issues, but especially true when recruiting and training crew. Such training should include knowledge of cold water survival gear and other unique issues crew may be exposed to while navigating in ice-covered waters.

As to the Arctic monitoring, the partnership urged support for a future Arctic Ocean Observing System, recognizing that a robust and effective Arctic Ocean Observing System is essential to enhancing marine safety and environmental protection in the NSR and throughout the Arctic Ocean. They also supported obtaining reliable and detailed hydrometeorological and sea ice information in the near-real time as necessary for supporting safe ship navigation.

difficult situation since there is no generally approved basis for the requirements. A great deal of work is still required to unify and make the requirements consistent.

The issue of fees seems also to be a difficult one. Generally, it is considered that the current level of fees in the Russian Federation - for example, $US16 per ton of oil cargo - is far too high. The problem is that the fees are set based on the current cargo flow, which is less than two million tons per year. If the cargo flow should increase to 40 million tons or more per year, the fees could decrease to a level of $US1 per ton. This fee would be consistent with fees collected in Finland on the Baltic Sea.

The other issue is that the system defining the fee level in the Russian Arctic is not as transparent as it is in Finland. It is impossible to track how the funds collected as fees are used. Also criticized was that the fee system does not encourage the use of improved ship technology. A simple calculation shows that using a more expensive vessel, which requires less icebreaker assistance, is not beneficial to the shipowner since he is forced to pay for the icebreaker service that is not needed. Hopefully, this issue will be reconsidered in the future.

Work Package 3, *Integrated Transportation System*, was the actual core of the ARCOP project. This work package looked at the different elements that are needed, from tankers and icebreakers to loading systems, traffic management and crew training; and the economics of transportation were analyzed. The scenario for which the development work was done was selected to be realistic, but not yet commercially in operation.

The task was to transport 330,000 barrels per day of oil production from Varandey in northwest Russia to Rotterdam in Europe. Two different operational tanker modes were used, independent and assisted. There were three alternative designs of icebreakers, each capable to assist the tankers up to 120,000 DWT. The route alternatives used were either direct transportation to Rotterdam, or shuttle service to Murmansk and trans-shipment from there to open water tankers to Rotterdam. The result was that assuming a fee level of 1.2 Euros per ton, a cost level can be achieved of 12 Euros per ton. This is considered feasible when compared with the pipeline costs for similar routes that are approximately 20 Euros per ton. What is important to notice is that the difference between the best and worst alternative is nearly 100 percent. This means that with optimization, a savings of more than 100 million Euros per year can be achieved. Over the lifetime of the project, this would amount to more than 2.5 billion Euros.

The work with the Vessel and Traffic Monitoring and Information System (VTMIS) showed that there are a number of information services that could be combined in a system for the Arctic. In the future, ice information must be part of any VTMIS system.

The lack of crew training was an issue that was strongly identified in ARCOP. Although many international codes including IMO recognize the issue, there is no international standard or even training service available. The need for trained crews for ice operations is increasing: an estimated 3,000 positions require Arctic training in future years. The subject of adequate Arctic crew training is also strongly related to the issue of Arctic marine safety.

Work Package 4, *Environmental Issues*, primarily looked at the risk levels of Arctic marine transportation. With the scenarios that were created, it seems that the risk levels were quite low when compared to experience from other sea areas. It must be noted, however, that there is no existing experience with large-scale transportation in the Arctic conditions. The experience on ice damages is mainly based on Baltic conditions. This is an issue that needs to be thoroughly studied in the future. The second issue studied was oil drift after an accident. The several scenarios produced showed that depending on the accident location, either high capacity or quick response time is important. This means that the response strategy must take both of these into account. What was satisfactory was that the different simulation methods gave consistent results and thus at least the experts are confident that the methods are reliable. The third issue was the actual oil spill countermeasures. Knowing that the use of in-situ burning and dispersants is efficient, but their use limited due to other reasons, the project concentrated on bioremediation and mechanical oil recovery. In bioremediation, the problem still exists that the type of bacteria available today is not efficient in temperatures below freezing. This means that the development of more specific PAH-degrading cold-adapted bacteria needs to be continued. Within mechanical oil spill recovery several options were studied. It seems that none of them is proven in a large-scale oil spill. There are efficient methods like the LAMOR Arctic Skimmer, but they have been designed for a limited size of oil spills and need further development.

The original idea within ARCOP was to arrange a large-scale validation voyage with a large-size tanker to the Russian Arctic. Unfortunately, no commercial cargo was available for a large tanker by the time the voyage was planned. What was done instead was that the Russian participants in the project analyzed some of the ongoing

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activities in areas that can be considered relevant. The current cargo operations at the Varandey terminal show that the downtime estimates used in the ARCOP economic analyses were quite close to those that are experienced today. Also, the time that is needed to perform the customs and other administrative formalities were realistic.

The analyses related to the operation of icebreakers with large tankers were done from experience in the Baltic. These analyses show that, at least in Baltic conditions, one icebreaker is often enough to assist one large tanker through the ice. Thus, the assumption that was used in ARCOP calculations may be slightly pessimistic.

During the project, eight workshops were arranged within the Work Package 6. The workshops gathered 401 specialists, representing 89 different organizations from 12 different countries during the whole project.

The workshops were an efficient tool to bring together different interest groups from industry, science and authorities. And although ARCOP was an EU-project, the workshops brought a circumpolar dimension into the work.

In general ARCOP managed to achieve most of its strategic objectives:

- The workshops formed a forum for continuous discussion between the EU and Russia with some circumpolar dimension toward the end.
- The review of the legal aspects resulted in a common understanding of the legal status of the Arctic sea routes, while raising a number of issues that need to be taken into consideration as the GATS regime for shipping is developed.
- The research of the rules, regulations and requirements brought some clarity to the consistency of the regulatory basis of Arctic shipping in the Russian Federation, while noting current IMO and IACS regulations were not fully satisfactory.
- The economic analysis of transportation showed how different factors, such as technology, fees, efficiency of the border formalities and the way of operating the icebreakers, were critical influences in decision-making.
- The studies on environmental issues gave a clear warning that readiness for accidents must be further developed and that all the safety-related factors have to be taken seriously.
- The work between the EU and Russian researchers improved the understanding between the cultures and led to the development of common recommendations on a number of topics.

ARCOP was considered a part of the EU-Russia energy dialogue. The results of the project will be of help when developing energy transportation policies from Arctic Russia to global markets.

Findings

Regional Futures to 2020 Northern Sea Route and Adjacent Areas

1] The marine transportation of oil from the Pechora Sea to Europe is considered to be both technically and economically feasible. Today cargo flow is more than 1.5 million tons per year. With future increases in cargo, the charge for every passing ship along the NSR will be decreased accordingly.

2] Russian rules and requirements are mostly consistent with international law and requirements (for example, UNCLOS and IMO Conventions). However, taking into account Russia's experience with navigation in the Arctic, it has adopted rules pertaining to vessels operating in the NSR that contain certain provisions that go beyond international rules and standards (for example, inspections, requirements for ice pilots and transit fees).

3] The estimated volumes of maritime traffic on the NSR are expected to be about 40 million tons of oil and gas per year by 2020, which may contribute to improved economic effectiveness of cargo transportation via the NSR.

4] New Arctic marine technologies can help solve some of the problems related to transportation economics. With proper technologies, marine transportation costs in the region will be lower than those of pipeline transportation of oil and gas.

5] The probability for major accidents is considered to be low even with the increased traffic volumes; however, the consequences of a major accident would be serious due to the sensitivity of the fragile Arctic environment, remoteness of the area, harsh environmental conditions and difficulties in conducting oil spill cleanup operations.

6] There are several, key infrastructure challenges for the region: the ice information services require support; adequate hydrographic services may become an issue and lack of adequate search and rescue capabilities along the NSR. Regional SAR agreements between Norway and Russia, and the U.S. and Russia, have improved response and coordination in the Barents Sea and Bering Sea accordingly.

Findings

1] Natural resource development and regional trade are the key drivers of increased Arctic marine activity. Global commodities prices for oil, gas, hard minerals, coal, etc., are driving the search for Arctic natural wealth. New Arctic resource discoveries are highly probable and most new developments will require marine transport and operational support.

2] Exploration and development of new Arctic natural resources take place in continually changing and hugely complex physical, economic, social and political environments. Few (if any) predictive/forecast capabilities of this broad scope and magnitude are available to provide quantitative information on these global sectors interacting together (and their relationships to Arctic marine transport requirements).

3] A large number of uncertainties define the future of Arctic marine activity. These uncertainties include: the legal and governance situation, degree of Arctic state cooperation, climate change variability, radical changes in global trade, insurance industry roles, an Arctic maritime disaster, new resource discoveries, oil prices and other resource commodity pricing, multiple use conflict (indigenous and commercial) and future marine technologies.

4] It is anticipated there will be a slow movement of Arctic marine ecosystems northward with retreating seasonal sea ice, which may open new fishing grounds in higher latitudes in the future.

5] Plausible longer seasons of navigation will have significant implications for multiple uses in regional Arctic waterways. The overlap and/or competing indigenous and new marine uses will provide many challenges for the Arctic coastal states.

6] There is anticipation that new Arctic ship technologies will set a norm for more independently operated, icebreaking commercial ships; however, icebreaker assistance will remain the principle element of Arctic infrastructure.

7] Increased marine traffic in the central Arctic Ocean is a reality - for scientific exploration and tourism. The future holds increasing exploration voyages, plausible increases in tourism and fishing and plausible trans-Arctic voyages in summer on an experimental basis.

8] Arctic voyages through 2020 will be overwhelmingly destinational (regional trade), not trans-Arctic. These destinational voyages are driven by natural resource development, marine tourism and supply/import of materials/goods.

9] Most ships built today for Arctic operations are purpose-built, such as bulk ore carriers, tankers and LNG carriers. There is an economic penalty to use these same ships in long, open ocean voyages since their higher construction standards and thicker steel plating for sailing in the Arctic adds considerable weight.

10] Arctic offshore leases in the Beaufort and Chukchi seas and large investments already made in offshore Arctic Norway and northwest Russia (Barents Sea) may stimulate decadal increases in coastal Arctic marine activity.

11] A lack of major ports and other maritime infrastructure, except for those along the Norwegian coast and Northwest Russia, is a significant factor (limitation) in evolving and future Arctic marine operations. There are significant linkages between infrastructure and to most environmental protection and marine safety measures and strategies.

12] Many non-Arctic stakeholders, such as non-Arctic states, marine shippers, insurers, shipbuilders, tour ship operators and more, will become actively involved in the future use of the Arctic Ocean.

13] It is highly probable that socio-economic responses to global climate change (for example, emission controls) will impact all elements of future Arctic marine activity.