

Arctic Council Arctic Marine Shipping Assessment 2009 Report



ARCTIC COUNCIL
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PAME
Protection of the Arctic Marine Environment





Arctic Council

**Arctic Marine Shipping
Assessment 2009 Report**



Guide to Acronyms and Abbreviations

<u>ACRONYM</u>	<u>DEFINITION</u>		
ACIA	Arctic Climate Impact Assessment	MF	medium frequency
AIS	Automatic Identification System	MMT	million metric ton
AMAP	Arctic Monitoring and Assessment Programme (Arctic Council working group)	MPA	marine protected area
AMSA	Arctic Marine Shipping Assessment	NEP	Northeast Passage
AMVER	Automated Mutual-Assistance Vessel Rescue System	NGO	non-governmental organization
ARCOP	Arctic Operational Platform	nm	nautical mile
ATON	Aid to Navigation	NOAA	National Oceanic and Atmospheric Administration (U.S.)
AWPPA	<i>Arctic Waters Pollution Prevention Act (Canada)</i>	NOx	nitrogen oxide
CCG	Canadian Coast Guard	NSR	Northern Sea Route
CFC	chlorofluorocarbon	NWP	Northwest Passage
CH4	methane	PAME	Protection of the Arctic Marine Environment (Arctic Council working group)
CNIIMF	Central Marine Research & Design Institute (Russian Federation)	POP	persistent organic pollutant
CO	carbon monoxide	ppm	parts per million
CO2	carbon dioxide	PSSA	Particularly Sensitive Sea Area
COLREG	<i>Convention on the International Regulations for Preventing Collisions at Sea, 1972</i>	RACON	radar beacon
DEW	Distant Early Warning Line	RORO	roll on, roll off (type of cargo ship)
DWT	deadweight tonnage	SAR	search and rescue
ECDIS	Electronic Chart Display and Information System	shp	shaft horsepower
EEZ	Exclusive Economic Zone	SOLAS	<i>International Convention on Safety of Life at Sea, 1974</i>
EPPR	Emergency Prevention, Preparedness and Response (Arctic Council working group)	SOx	sulfur oxide
EU	European Union	STCW	<i>International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978</i>
GCM	Global Climate Model	TDW	tonnage draft weight
GHG	greenhouse gas	TEU	twenty-foot equivalent (measure used in container shipping)
GIS	Geographic Information System	UNCLOS	<i>United Nations Convention on the Law of the Sea, 1982</i>
GPS	Global Positioning System	USCG	United States Coast Guard
HF	high frequency	VHF	very high frequency
IAATO	International Association of Antarctic Tour Operators	VTS	Vessel Traffic Service
IACS	International Association of Classification Societies	WMO	World Meteorological Organization
ICC	Inuit Circumpolar Conference		
IHO	International Hydrographic Organization		
IMO	International Maritime Organization		
INSROP	International Northern Sea Route Programme		
IPCC	Intergovernmental Panel on Climate Change		
kW	kilowatt (1,000 watts)		
LME	Large Marine Ecosystem		
LNG	liquefied natural gas		
LPG	liquefied petroleum gas		
M/V	Motor Vessel		
MARPOL 73/78	<i>International Convention for the Prevention of Pollution from Ships, 1973 as Modified by the Protocol of 1978 Relating Thereto</i>		



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AMSA EXECUTIVE SUMMARY WITH RECOMMENDATIONS

The Arctic is undergoing extraordinary transformations early in the 21st century. Natural resource development, governance challenges, climate change and marine infrastructure issues are influencing current and future marine uses of the Arctic. The Arctic Council, recognizing these critical changes and issues, at the November 2004 Ministerial meeting in Reykjavik, Iceland, called for the Council's Protection of the Arctic Marine Environment (PAME) working group to "conduct a comprehensive Arctic marine shipping assessment as outlined under the Arctic Marine Strategic Plan (AMSP) under the guidance of Canada, Finland and the United States as lead countries and in collaboration with the Emergency Prevention, Preparedness and Response (EPPR) working group and the Permanent Participants as relevant." *The Arctic Marine Shipping Assessment*, or *The AMSA 2009 Report*, is the product of that Arctic Ministerial decision in Reykjavik and was approved at the 2009 Ministerial meeting in Tromsø.

The decision to conduct the AMSA followed the release in 2004 of two relevant Arctic Council reports. First, the Arctic Climate Impact Assessment (ACIA) was a major study that received global attention and reported on the rapid and severe climate change ongoing in the Arctic. One of the key findings of the ACIA was that "reduced sea ice is very likely to increase marine transport and access to resources." The second report, the Arctic Marine Strategic Plan (AMSP), presented the council's strategic goals for protecting the Arctic marine environment. The AMSP called for future application of an ecosystems approach to the Arctic Ocean and for a comprehensive assessment of Arctic marine shipping.

The AMSA is designed to be circumpolar in breadth and also to consider regional and local perspectives. The assessment's central focus is on ships: their uses of the Arctic Ocean, their potential impacts on humans and the Arctic marine environment and their marine infrastructure requirements. The AMSA does not place a

primary focus on determining the operational and economic viabilities of specific marine routes within and across the Arctic Ocean.

The AMSA, led by Canada, Finland and the United States, reached out to a broad community, including the global maritime community consisting of shipping companies, ship designers, shipbuilders, ship classification societies, marine insurers, non-commercial partnerships and shipping associations. With the support of the Permanent Participants (indigenous organizations) of the Arctic Council, town hall meetings were held in selected Arctic communities in Canada, Iceland, Norway and the United States to listen to issues and concerns about future Arctic marine activity. The AMSA linked directly with experts of PAME for marine environmental protection issues and overall guidance and leadership of the AMSA. Two additional Arctic Council working groups were also consulted: the Emergency Prevention, Preparedness and Response (EPPR) working group on spill response and marine infrastructure requirements; and the Sustainable Development Working Group (SDWG) on issues related to the human dimension.

All ship types are considered in the AMSA under the general topic of Arctic shipping: tankers, bulk carriers, offshore supply vessels, passenger ships, tug/barge combinations, fishing vessels, ferries, research vessels and government and commercial icebreakers. The result of the AMSA data survey effort produced a comprehensive estimate of how many ships (less naval vessels) operated in the Arctic for a given year. This survey represents an historic capture of information from the Arctic states that can be used as a long-term database against which to measure future Arctic marine traffic levels. In addition, more than 185 experts participated directly in the work of the AMSA. Thirteen major AMSA workshops were held from July 2006 through October 2008 on a broad range of relevant topics, including scenarios of future Arctic navigation, indigenous marine use, Arctic marine incidents, environmental impacts, marine infrastructure, Arctic marine technology and the future of the Northern Sea Route and adjacent seas. The AMSA workshops provided extensive information for developing the report sections.





Synopsis of the Assessment Findings

The AMSA 2009 Report is focused on current and future Arctic marine activity. The results of this comprehensive assessment are a range of key findings linked to the main topics identified. These findings are listed in full throughout *The AMSA 2009 Report* at the end of each section. Presented here is a synopsis, or review, of the AMSA findings for each section.

Arctic Marine Geography, Climate and Sea Ice: Arctic sea ice has been observed to be decreasing in extent and thickness during the second half of the 20th century and early 21st century. Global Climate Model simulations indicate a continuing retreat of sea ice, but also show that the winter sea ice cover will remain. There is a possibility of an ice-free Arctic Ocean for a short period in summer perhaps as early as 2015. This would mean the disappearance of multi-year ice, as no sea ice would survive the summer melt season. It is highly plausible there will be greater marine access and longer seasons of navigation, except perhaps during winter, but not necessarily less difficult ice conditions for marine operations.

History of Arctic Marine Transport: There is a long history of Arctic marine transport conducted primarily around the ice-free periphery of the Arctic Ocean. Year-round navigation has been maintained since 1978-79 in the ice-covered western regions of the Northern Sea Route (between the port of Dudinka on the Yenisei River and Murmansk). Previous Arctic marine transport studies for the Northern Sea Route, Canadian Arctic, Alaska's coastal seas and other regions have significant relevance to developing any future regulatory framework for the Arctic Ocean. Most of these past studies involved public-private partnerships and close international cooperation.

Governance of Arctic Shipping: The Law of the Sea as reflected in the *United Nations Convention on the Law of the Sea* (UNCLOS) provides a fundamental framework for the governance of Arctic marine navigation and allows coastal states the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction and control of marine pollution from vessels in ice-covered waters (Article 234). The International Maritime Organization (IMO) is the competent UN agency with responsibility for issues related to the global maritime industry. IMO has been proactive in developing voluntary *Guidelines for Ships Operating in Arctic Ice-covered Waters*, which continue to evolve. The International Association of Classification Societies (IACS) has also developed non-mandatory Unified Requirements for their members that address ship construction standards of the *Polar Classes*, which are defined in the IMO Guidelines. There are no uniform, international standards for ice navigators and for Arctic safety and survival for seafarers in polar conditions. And, there are no specifically tailored, mandatory environmental standards developed by IMO for vessels operating in Arctic waters. Mandatory measures, drawn up in accordance with the provisions of customary international law as reflected in UNCLOS, would be an effective way to enhance marine safety and environmental protection in Arctic waters. Expanded Arctic marine traffic increases the possibility of, for example, introducing alien species and pathogens from ballast water discharge and hull fouling.

Current Marine Use and the AMSA Shipping Database: There were approximately 6,000 individual vessels, many making multiple voyages, in the Arctic region during the AMSA survey year; half of these were operating on the Great Circle Route in the North Pacific that crosses the Aleutian Islands. Of the 6,000 vessels reported, approximately 1,600 were fishing vessels. Nearly all shipping in the

Arctic today is destinational, conducted for community re-supply, marine tourism and moving natural resources out of the Arctic. Regions of high concentrations of Arctic marine activity occur along the coasts of northwest Russia, and in the ice-free waters off Norway, Greenland, Iceland and in the U.S. Arctic. Significant increases in cruise ships, a majority not purpose-built for Arctic waters, have been observed in the summer season around Greenland within the past decade. There have been recent marine operations in the ice-covered central Arctic Ocean for scientific exploration and marine tourism.

Scenarios, Futures and Regional Futures to 2020: Arctic natural resource development (hydrocarbons, hard minerals and fisheries) and regional trade are the key drivers of future Arctic marine activity. However, there are many other factors and uncertainties of importance including governance, Arctic state cooperation, oil prices, changes in global trade, climate change variability, new resource discoveries, marine insurance industry roles, multiple use conflicts and Arctic marine technologies. Future Arctic marine activity will include many non-Arctic stakeholders, multiple users in Arctic waterways and potential overlap of new operations with indigenous uses. Arctic voyages through 2020 will be overwhelmingly destinational, not trans-Arctic. A lack of major ports, except for those in northern Norway and northwest Russia, and other critical infrastructure will be significant limitations for future Arctic marine operations. The Bering Strait region, ringed with indigenous communities and a highly productive ecosystem with many species of marine mammals, fish and seabirds, may require formally established vessel routing measures. Offshore hydrocarbon developments may lead to increased marine traffic in the Bering Strait region. For the Canadian Arctic, the Northwest Passage is not expected to become a viable trans-Arctic route through 2020, but destinational shipping is anticipated to increase. Marine transportation of oil from the Pechora Sea to Europe is considered technically and economically feasible; the volume of oil and gas may be as high as 40 million tons per year by 2020 on the western Northern Sea Route.

Human Dimensions: Marine shipping is one of many factors impacting Arctic communities. There may be some positive economic impacts to increased shipping. However, Arctic residents express concern for the social, cultural and environmental effects of such expansion. The possibility of oil spills is a major concern and hunters are especially concerned about the disruption of marine species and their hunting practices. The costs and benefit of Arctic shipping

will likely be unevenly distributed among and within communities and regions. Constructive and early engagement of local residents in planned Arctic marine development projects can help to reduce negative impacts and to increase positive benefits. Importantly, many local Arctic residents today depend heavily on marine resources for subsistence and the local economy; over-the-ice travel and boat transport allow the use of large marine areas during much of the year. Such life in the Arctic is dependent on movement over the ice and ocean and sea ice is integral to this movement.

Environmental Considerations and Impacts: The most significant threat from ships to the Arctic marine environment is the release of oil through accidental or illegal discharge. Additional potential impacts of Arctic ships include ship strikes on marine mammals, the introduction of alien species, disruption of migratory patterns of marine mammals and anthropogenic noise produced from marine shipping activity. Changes in Arctic sea ice will not only provide for possible longer seasons of navigation, but may also result in increased interaction between migrating species and ships. Black carbon emissions from ships operating in the Arctic may have regional impacts by accelerating ice melt. Other ship emissions during Arctic voyages, such as SO_x and NO_x, may have unintended consequences for the Arctic environment and these emissions may require the implementation of additional IMO environmental regulations.

Arctic Marine Infrastructure: There is a general lack of marine infrastructure in the Arctic, except for areas along the Norwegian coast and northwest Russia, compared with other marine regions of the world with high concentrations of ship traffic. Gaps in hydrographic data exist for significant portions of primary shipping routes important to support safe navigation. In addition, for safe operations in the Arctic there is a need for the same suite of meteorological and oceanographic data, products and services as in other oceans, plus comprehensive information on sea ice and icebergs. Except in limited areas of the Arctic, there is a lack of emergency response capacity for saving lives and for pollution mitigation. There are serious limitations to radio and satellite communications and few systems to monitor and control the movement of ships in ice-covered waters. The current lack of marine infrastructure in all but a limited number of areas, coupled with the vastness and harshness of the environment, makes conduct of emergency response significantly more difficult in the Arctic. ☀

The Arctic Marine Shipping Assessment Recommendations

The focus of the AMSA is marine safety and marine environmental protection, which is consistent with the Arctic Council's mandates of environmental protection and sustainable development. Based on the findings of the AMSA, recommendations were developed to provide a guide for future action by the Arctic Council, Arctic states and many others. The AMSA recommendations are presented under three broad, inter-related themes that are fundamental to understanding the AMSA: Enhancing Arctic Marine Safety, Protecting Arctic People and the Environment, and Building Arctic Marine Infrastructure. It is recognized that implementation of these recommendations could come from the Arctic states, industry and/or public-private partnerships.

I. Enhancing Arctic Marine Safety

A. Linking with International Organizations: That the Arctic states decide to, on a case by case basis, identify areas of common interest and develop unified positions and approaches with respect to international organizations such as: the International Maritime Organization (IMO), the International Hydrographic Organization (IHO), the World Meteorological Organization (WMO) and the International Maritime Satellite Organization (IMSO) to advance the safety of Arctic marine shipping; and encourage meetings, as appropriate, of member state national maritime safety organizations to coordinate, harmonize and enhance the implementation of the Arctic maritime regulatory framework.

B. IMO Measures for Arctic Shipping: That the Arctic states, in recognition of the unique environmental and navigational conditions in the Arctic, decide to cooperatively support efforts at the International Maritime Organization to strengthen, harmonize and regularly update international standards for vessels operating in the Arctic. These efforts include:

---Support the updating and the mandatory application of relevant parts of the *Guidelines for Ships Operating in Arctic Ice-covered Waters* (Arctic Guidelines); and,

---Drawing from IMO instruments, in particular the Arctic Guidelines, augment global IMO ship safety and pollution prevention conventions with specific mandatory requirements or other provisions for ship construction, design, equipment, crewing, training and operations, aimed at safety and protection of the Arctic environment.

C. Uniformity of Arctic Shipping Governance: That the Arctic states should explore the possible harmonization of Arctic marine shipping regulatory regimes within their own jurisdiction and uniform Arctic safety and environmental protection regulatory regimes, consistent with UNCLOS, that could provide a basis for protection measures in regions of the central Arctic Ocean beyond coastal state jurisdiction for consideration by the IMO.

D. Strengthening Passenger Ship Safety in Arctic Waters: That the Arctic states should support the application of the IMO's *Enhanced Contingency Planning Guidance for Passenger Ships Operating in Areas Remote from SAR Facilities*, given the extreme challenges associated with rescue operations in the remote and cold Arctic region; and strongly encourage cruise ship operators to develop, implement and share their own best practices for operating in such conditions, including consideration of measures such as timing voyages so that other ships are within rescue distance in case of emergency.

E. Arctic Search and Rescue (SAR) Instrument: That the Arctic states decide to support developing and implementing a comprehensive, multi-national Arctic Search and Rescue (SAR) instrument, including aeronautical and maritime SAR, among the eight Arctic nations and, if appropriate, with other interested parties in recognition of the remoteness and limited resources in the region.

II. Protecting Arctic People and the Environment

A. Survey of Arctic Indigenous Marine Use: That the Arctic states should consider conducting surveys on Arctic marine use by indigenous communities where gaps are identified to collect information for establishing up-to-date baseline data to assess the impacts from Arctic shipping activities.

B. Engagement with Arctic Communities: That the Arctic states decide to determine if effective communication mechanisms exist to ensure engagement of their Arctic coastal communities and, where there are none, to develop their own mechanisms to engage and coordinate with the shipping industry, relevant economic activities and Arctic communities (in particular during the planning phase of a new marine activity) to increase benefits and help reduce the impacts from shipping.

C. Areas of Heightened Ecological and Cultural Significance:

That the Arctic states should identify areas of heightened ecological and cultural significance in light of changing climate conditions and increasing multiple marine use and, where appropriate, should encourage implementation of measures to protect these areas from the impacts of Arctic marine shipping, in coordination with all stakeholders and consistent with international law.

D. Specially Designated Arctic Marine Areas: That the Arctic states should, taking into account the special characteristics of the Arctic marine environment, explore the need for internationally designated areas for the purpose of environmental protection in regions of the Arctic Ocean. This could be done through the use of appropriate tools, such as “Special Areas” or Particularly Sensitive Sea Areas (PSSA) designation through the IMO and consistent with the existing international legal framework in the Arctic.

E. Protection from Invasive Species: That the Arctic states should consider ratification of the IMO *International Convention for the Control and Management of Ships Ballast Water and Sediments*, as soon as practical. Arctic states should also assess the risk of introducing invasive species through ballast water and other means so that adequate prevention measures can be implemented in waters under their jurisdiction.

F. Oil Spill Prevention: That the Arctic states decide to enhance the mutual cooperation in the field of oil spill prevention and, in collaboration with industry, support research and technology transfer to prevent release of oil into Arctic waters, since prevention of oil spills is the highest priority in the Arctic for environmental protection.

G. Addressing Impacts on Marine Mammals: That the Arctic states decide to engage with relevant international organizations to further assess the effects on marine mammals due to ship noise, disturbance and strikes in Arctic waters; and consider, where needed, to work with the IMO in developing and implementing mitigation strategies.


H. Reducing Air Emissions: That the Arctic states decide to support the development of improved practices and innovative technologies for ships in port and at sea to help reduce current and future emissions of greenhouse gases (GHGs), Nitrogen Oxides (NOx), Sulfur Oxides (SOx) and Particulate Matter (PM), taking into account the relevant IMO regulations.

III. Building the Arctic Marine Infrastructure

A. Addressing the Infrastructure Deficit: That the Arctic states should recognize that improvements in Arctic marine infrastructure are needed to enhance safety and environmental protection in support of sustainable development. Examples of infrastructure where critical improvements are needed include: ice navigation training; navigational charts; communications systems; port services, including reception facilities for ship-generated waste; accurate and timely ice information (ice centers); places of refuge; and icebreakers to assist in response.

B. Arctic Marine Traffic System: That the Arctic states should support continued development of a comprehensive Arctic marine traffic awareness system to improve monitoring and tracking of marine activity, to enhance data sharing in near real-time, and to augment vessel management service in order to reduce the risk of incidents, facilitate response and provide awareness of potential user conflict. The Arctic states should encourage shipping companies to cooperate in the improvement and development of national monitoring systems.

C. Circumpolar Environmental Response Capacity: That the Arctic states decide to continue to develop circumpolar environmental pollution response capabilities that are critical to protecting the unique Arctic ecosystem. This can be accomplished, for example, through circumpolar cooperation and agreement(s), as well as regional bilateral capacity agreements.

D. Investing in Hydrographic, Meteorological and Oceanographic Data: That the Arctic states should significantly improve, where appropriate, the level of and access to data and information in support of safe navigation and voyage planning in Arctic waters. This would entail increased efforts for: hydrographic surveys to bring Arctic navigation charts up to a level acceptable to support current and future safe navigation; and systems to support real-time acquisition, analysis and transfer of meteorological, oceanographic, sea ice and iceberg information. 



INTRODUCTION

The Arctic is regarded as containing some of the last physically undisturbed marine spaces on earth. Early in the 21st century, the Arctic has also been undergoing extraordinary environmental and developmental changes. Long known as a storehouse of untapped natural resources, high commodity prices and a growing worldwide demand in recent years have the Arctic poised as a significant contributor to the global economy. Increasing regional and coastal marine transport to support the exploration and extraction of oil, gas and hard minerals, coupled with the increasing presence of the global marine tourism industry, have brought a complex set of users to the maritime Arctic. The potential impacts of these new marine uses - social, environmental, cultural and economic - are unknown, but will be significant for Arctic indigenous people and the marine environment already undergoing significant changes due to climate change.

Simultaneous with the globalization of the Arctic, marine access in the Arctic Ocean has been changing in unprecedented ways driven by global climate change. Arctic sea ice is undergoing an historic transformation - thinning, extent reduction in all seasons and substantial reductions in the area of multi-year ice in the central Arctic Ocean - which has significant implications for longer seasons of navigation and new access to previously difficult to reach coastal regions. The international scientific community has already taken advantage of these changes through pioneering voyages in the central Arctic Ocean. The same sea ice retreat also has important influences on the regional, Arctic marine ecosystems and future fisheries. Taken together, these changes present increased demands on the existing legal and regulatory structures challenged to meet the needs for enhanced marine safety and environmental protection in the face of increasing Arctic marine activity. Such challenges will

require unprecedented levels of cooperation among the eight Arctic states and broad engagement with many non-Arctic stakeholders within the global maritime industry.

Actions Leading to a Shipping Assessment

The Arctic Council anticipated the need to evaluate current and future increasing use of the Arctic Ocean. In 2002 at the Council's third Ministerial meeting in Inari, Finland, the ministers recognized "that existing and emerging activities in the Arctic warrant a more coordinated and integrated strategic approach to address the challenges of the Arctic coastal marine environment." The ministers agreed to "develop a strategic plan for the protection of the Arctic marine environment under leadership by Protection of the Arctic Marine Environment (PAME) working group." The Arctic Marine Strategic Plan (AMSP) was developed by PAME and approved by the Arctic Council in 2004. Four strategic goals were outlined in the AMSP: reduce and prevent pollution in the Arctic marine environment; conserve Arctic marine diversity and ecosystem functions; promote the health and prosperity of all Arctic inhabitants; and advance sustainable Arctic marine resource use. The AMSP addressed the need for future application of an ecosystem approach to management of the Arctic marine environment and also called for a comprehensive assessment of Arctic marine shipping.

In November 2004, the Arctic Council released a major study, the Arctic Climate Impact Assessment (ACIA), which received global attention. The ACIA found that the Arctic: is extremely vulnerable to observed and projected climate change; is today experiencing some of the most rapid and severe climate change on Earth; and will experience accelerated climate change during the 21st century. Widespread physical, ecological, social and economic changes, many of which have already begun, were projected. Of particular relevance to marine use and Arctic transport, one of ACIA's 10 Key Findings (#6) stated: "Reduced sea ice is very likely to increase marine transport and access to resources."

Consistent with the work of the AMSP and the ACIA, the Arctic Council Ministers in November 2004 in Reykjavik asked PAME to "conduct a comprehensive Arctic marine shipping assessment as outlined in the Arctic Marine Strategic Plan (AMSP) under the guidance of Canada, Finland and the United States as lead countries and in collaboration with the Emergency Prevention, Preparedness and Response (EPPR) working group of the Arctic Council and Permanent Participants as relevant." AMSA data gathering and planning began in summer 2005.



Arctic Council

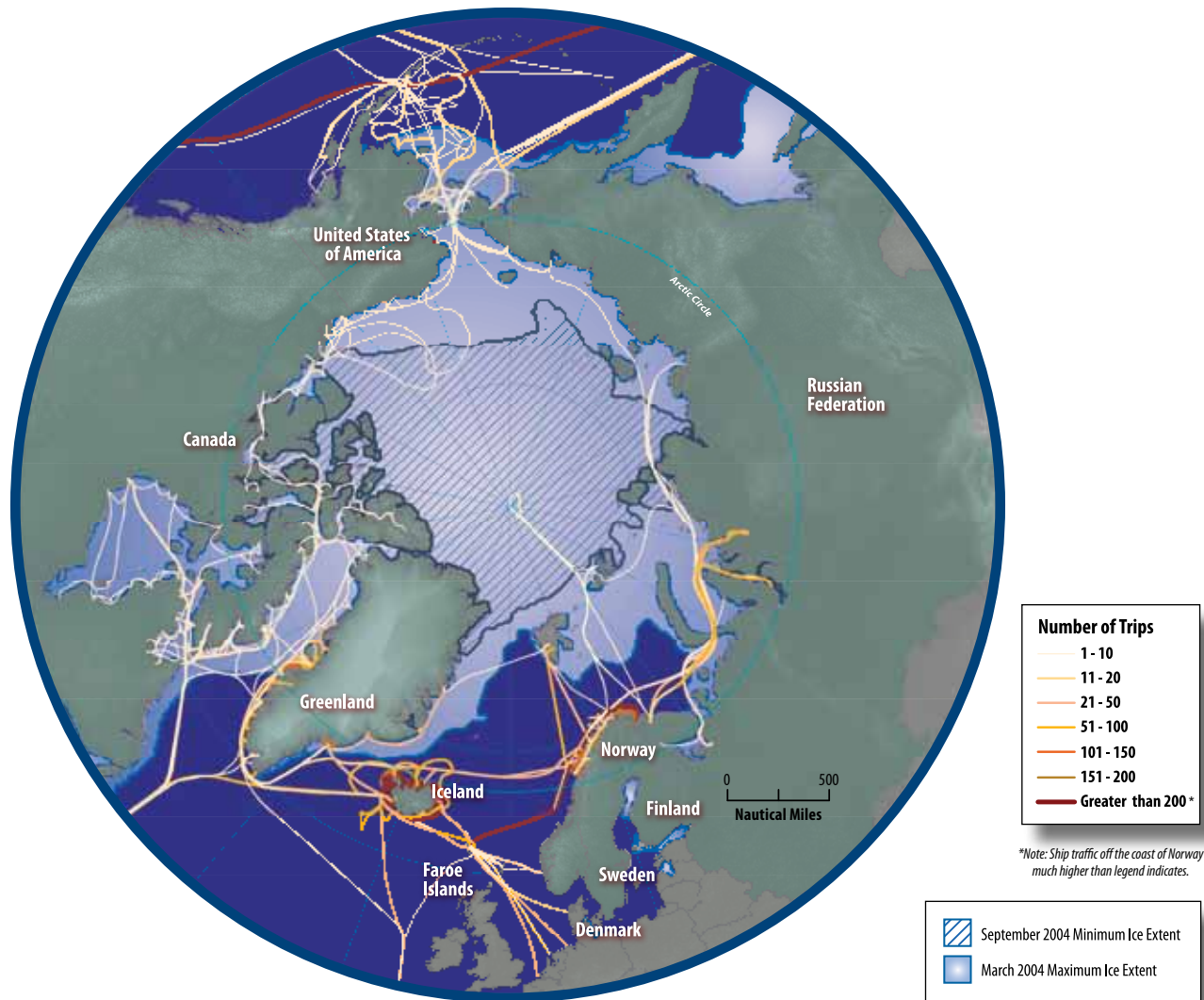
The Ottawa Declaration of 1996 formally established the Arctic Council as a high level intergovernmental forum to provide a means for promoting cooperation, coordination and interaction among the Arctic states, with the express involvement of Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, especially issues of sustainable development and environmental protection in the Arctic.

The Arctic Council is comprised of Canada, Denmark (including Greenland and the Faroe Islands), Finland, Iceland, Norway, the Russian Federation, Sweden and the United States of America.

In addition to the member states, the council created the category of Permanent Participants in order to provide for the active participation of, and full consultations with, Arctic indigenous representatives within the council. Open equally to Arctic organizations of indigenous people with a majority of Arctic indigenous constituency, the Permanent Participants represent a single indigenous people resident in more than one Arctic state; or more than one Arctic indigenous people resident in a single Arctic state. The following organizations are Permanent Participants of the Arctic Council: Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Council, Saami Council and Russian Arctic Indigenous Peoples of the North.

Working groups of the Arctic Council execute the programs and projects mandated by the Arctic Council ministers. Each working group, with its supporting scientific and technical expert groups, holds meetings at regular intervals throughout the year, ahead of the meetings of Senior Arctic Officials and Arctic Council Ministers. The six working groups include: Arctic Contaminants Action Program; Arctic Monitoring and Assessment Programme; Conservation of Arctic Flora and Fauna; Emergency Prevention, Preparedness and Response; Protection of the Arctic Marine Environment; and Sustainable Development Working Group.





Map 1.1 Shipping traffic in the Arctic for survey year 2004. Source: AMSA

Focus and Conduct of the Assessment

The focus of the AMSA is marine safety and marine environmental protection, which is consistent with the Arctic Council’s mandates of environmental protection and sustainable development. The AMSA was designed to be circumpolar in breadth, but also considers regional and local perspectives where impacts, particularly on Arctic communities, are considered to be greatest. However, the overall scope of the AMSA focuses on ships and their infrastructure needs and impacts in the Arctic Ocean.

The AMSA lead countries (Canada, Finland and the United States) recognized early in the planning the importance of contributions from the broader, global maritime community. Therefore, the AMSA reached out to such key stakeholders as non-Arctic states (examples

include the United Kingdom and Germany), shipping companies, ship designers, shipbuilders, ship classification societies, non-commercial partnerships, marine insurers and non-governmental environmental organizations. With the assistance of the Permanent Participants of the Arctic Council, town hall meetings were organized in selected Arctic communities to listen to issues and concerns about future Arctic marine activity. AMSA also linked with the Arctic Council working group experts of the Emergency Prevention, Preparedness and Response (EPPR) working group on issues related to spills, and response infrastructure requirements, and with the Sustainable Development Working Group (SDWG) on issues related to the human dimension.

The AMSA covers all types of marine transport under the general topic of “shipping”: tankers, bulk carriers, offshore supply vessels, passenger ships, tug-barge combinations, fishing vessels, ferries, research vessels and government and commercial icebreakers. Knowing the sum of the voyages completed by these different ships will help to understand the potential environmental impacts (especially from discharges and emissions) of Arctic marine shipping operations. An AMSA Database Survey, requesting these ship types, was sent to the Senior Arctic Officials of the Arctic states in February 2006 to obtain the official shipping statistics of each state for the survey year 2004. The objective was to create the first baseline database of all ships (less naval vessels) operating in the Arctic during a single year. Each Arctic state defined its own Arctic waters for the purpose of the AMSA data collection effort. The AMSA data effort yielded an historic survey that provides a comprehensive estimate for how many ships had operated in the Arctic for the survey year.

More than 180 experts participated directly in AMSA. Twelve major AMSA workshops were held from July 2006 through October 2008; workshop topics included: scenarios of future Arctic navigation;

indigenous marine use; Arctic marine incidents; environmental impacts; Arctic marine infrastructure; and the future of the Russian Federation’s Northern Sea Route. AMSA town hall meetings were held in northern communities in Canada, Norway and the United States. AMSA leads and team members conducted outreach and presented AMSA topics at 56 professional venues throughout the world during 2005-2008.

A large number of source documents were collected from the following activities: the results of the AMSA workshops, reports of the AMSA town hall meetings, the AMSA Data Survey, special reports created by maritime experts, and reviews of AMSA topics drafted by lead and contributing authors. These documents, referred to collectively as the AMSA Research Documents, will be found on the PAME and Arctic Council websites. The AMSA Research Documents represent a significant body of work and, while they have not been reviewed by the Arctic Council, the documents provided the background for drafting the AMSA 2009 Report, which was approved by the Arctic Council Ministers at the 2009 Ministerial meeting in Tromsø, Norway.



Modes of Arctic Marine Transport

In addition to the ship types to be addressed in the assessment, four modes, or types of voyages undertaken in the Arctic Ocean, were identified. They are:

Destinational transport, where a ship sails to the Arctic, performs some activity in the Arctic and sails south. Examples include: large cruise ships sailing from southern ports to the west coast of Greenland in summer; LNG and oil tankers sailing from ports in northern Norway and northwest Russia to world markets; and an ice-breaker from Europe conducting scientific operations in the central Arctic Ocean in summer.

Intra-Arctic transport, a voyage or marine activity that stays within the general Arctic region and links two or more Arctic states. A key example is the marine route between the port of Churchill, Manitoba, Canada on Hudson Bay and Murmansk, Russia, touted as an “Arctic-bridge” between the two continents. Two other examples include an Icelandic fishing vessel working in Greenlandic waters, and tug-barge traffic operating between Canada’s Northwest Territories and the U.S. Beaufort Sea off the Alaskan coast.

Trans-Arctic transport or navigation, voyages which are taken across the Arctic Ocean from Pacific to Atlantic oceans or vice versa. These are full voyages between the major oceans using the Arctic Ocean as a marine link. There are several options for trans-Arctic navigation: directly across the central Arctic Ocean (for example, from the Bering Strait to Fram Strait); using Russia’s Northern Sea Route from the Barents Sea (Kara Gate) to the Bering Strait (for example, from European ports to ports of southeastern Asia); and through the Northwest Passage, which spans the Canadian Archipelago from Baffin Bay to the Bering Strait.

Cabotage, to trade or marine transport in coastal waters between ports within an Arctic state. A prime example is the year-round traffic between the port of Dudinka on the Yenisei River and Murmansk - Russian-flag ships carrying nickel plates processed at the industrial complex in Norilsk to Murmansk for further distribution to Russian and international markets. Other examples are the summer sealift of cargoes to Canadian Arctic communities from southern Canadian ports and the delivery of consumer goods to Russian Arctic communities using the Northern Sea Route.



185+

Number of international experts who worked on the AMSA.

The Origin of the AMSA

The Arctic Council Ministers in November 2004 in Reykjavik asked PAME to “conduct a comprehensive Arctic marine shipping assessment as outlined in the Arctic Marine Strategic Plan (AMSP) under the guidance of Canada, Finland and the United States as lead countries and in collaboration with the Emergency Prevention, Preparedness and Response (EPPR) working group of the Arctic Council and Permanent Participants as relevant.”

Protection of the Arctic Marine Environment: PAME

PAME is an example of the international cooperation that is a hallmark of the Arctic Council: while the PAME Secretariat is based in Akureyri, Iceland, its chairmanship in the spring of 2009 held by Canada.

Increased economic activity and significant changes due to climatic processes are resulting in increased use, opportunities and threats to the Arctic marine and coastal environments. These predicted changes require more integrated approaches to address both existing and emerging challenges of the Arctic marine and coastal environments.

PAME’s mandate is to address policy and non-emergency pollution prevention and control measures related to the protection of the Arctic marine environment from both land and sea-based activities, including coordinated action programs and guidelines complementing existing legal arrangements.

According to the Arctic Marine Strategic Plan, PAME aims to improve knowledge and respond to emerging knowledge of the Arctic Marine Environment. The AMSA is the primary action item for this objective. The plan also calls on PAME to determine the adequacy of applicable international/regional commitments and promote their implementation and compliance; and facilitate partnerships, program and technical cooperation and support communication, reporting and outreach both within and outside the Arctic Council.

At the 2004 Arctic Council ministers meeting in Iceland, the Reykjavik Declaration asked the PAME work group “to conduct a comprehensive Arctic marine shipping assessment as outlined in the Arctic Marine Strategic Plan (AMSP) under the guidance of Canada, Finland and the United States as lead countries and in collaboration with the Emergency Prevention, Preparedness and Response (EPPR) working group of the Arctic Council and Permanent Participants as relevant.”

Emergency Prevention, Preparedness and Response: EPPR

The EPPR Secretariat rotates with the chairmanship of the Arctic Council and as such is located in the spring of 2009 at the Norwegian Coastal Administration, Department for Emergency Response, Norway.

Harsh conditions and lack of infrastructure in much of the Arctic create a higher vulnerability to emergencies than in more temperate climates. Consequently, prevention, preparedness and response must be adapted to Arctic conditions. Accordingly, international cooperation in this area is of major importance.

The mandate of the EPPR working group is to deal with the prevention, preparedness and response to environmental emergencies in the Arctic. Members of the working group exchange information on best practices and conduct projects (for example, development of guidance and risk assessment methodologies, response exercises, training, etc.). EPPR is not a response agency. In 2004, EPPR was directed by the Arctic Ministers to expand its mandate to include natural disasters.

Ongoing EPPR projects address oil pollution spill response in the face of increased Arctic shipping and development; technological support of radiological and other hazard assessments; and natural disaster response, particularly catastrophic river flooding.



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The Assessment Report Structure

The AMSA 2009 Report is designed to educate and inform the Arctic Council, the Arctic community, the global maritime industry and the world at large about the current state of Arctic marine use and future challenges. The topics presented in the report include:

- Arctic Marine Geography, Climate and Sea Ice
- History of Arctic Marine Transport
- Governance of Arctic Shipping
- Current Marine Use and AMSA 2004 Database
- Scenarios, Futures and Regional Futures to 2020
- Human Dimensions
- Environmental Considerations and Impacts
- Arctic Marine Infrastructure

The initial sections on Arctic marine geography and Arctic marine transport history provide background and context for the subsequent sections. The complex geography of the Arctic Ocean and its surrounding coastline influences all aspects of Arctic marine operations. The history section emphasizes that industrial and commercial uses of the Arctic Ocean date back to the 17th century. There is also a rich history of marine operations in the Russian and Canadian Arctic regions, around Svalbard and Greenland, and off Alaska. Governance is identified in the AMSA as one of the key uncertainties and drivers of future Arctic marine navigation, and this section provides a critical overview and current state of international and coastal state governance of Arctic marine activities. The section on current marine use provides a comprehensive and historic baseline of Arctic marine activity early in the 21st century, developed principally from the AMSA Data Survey.

AMSA scenario workshops in 2007 and 2008 identified natural resource development and trade as key drivers and uncertainties. Two regional AMSA studies - for the Bering Strait and Canadian Arctic, as well as outcomes of ARCOP and INSROP - all emphasize oil and gas and hard minerals development as important indicators for future Arctic marine transport requirements.

The human dimension section communicates the results of the AMSA town hall meetings and identifies important concerns and issues of the Arctic indigenous people. Impacts are also highlighted in the environmental considerations section where ship types and their specific impacts are characterized. The final section of the report on Arctic infrastructure identifies the Arctic Ocean as a region with limited infrastructure in most areas, lacking communications, response capability, salvage and other basic services that are readily available to the maritime community in lower latitudes.

The Arctic Marine Shipping Assessment is a comprehensive study and evaluation of Arctic marine activity today and the future. The AMSA 2009 Report highlights a single set of findings and recommendations critical to the future protection of Arctic people and the marine environment. The AMSA team of experts has also provided for each section in the report a list of non-negotiated research opportunities that can be considered by the Arctic research community and organizations such as the International Arctic Science Committee. The AMSA Report is a strategic guide for understanding the complexity and multiple factors that will determine the future of Arctic shipping operations. ☀

Long known as a storehouse of untapped natural resources, high commodity prices and a growing worldwide demand in recent years have the Arctic poised as a significant contributor to the global economy.





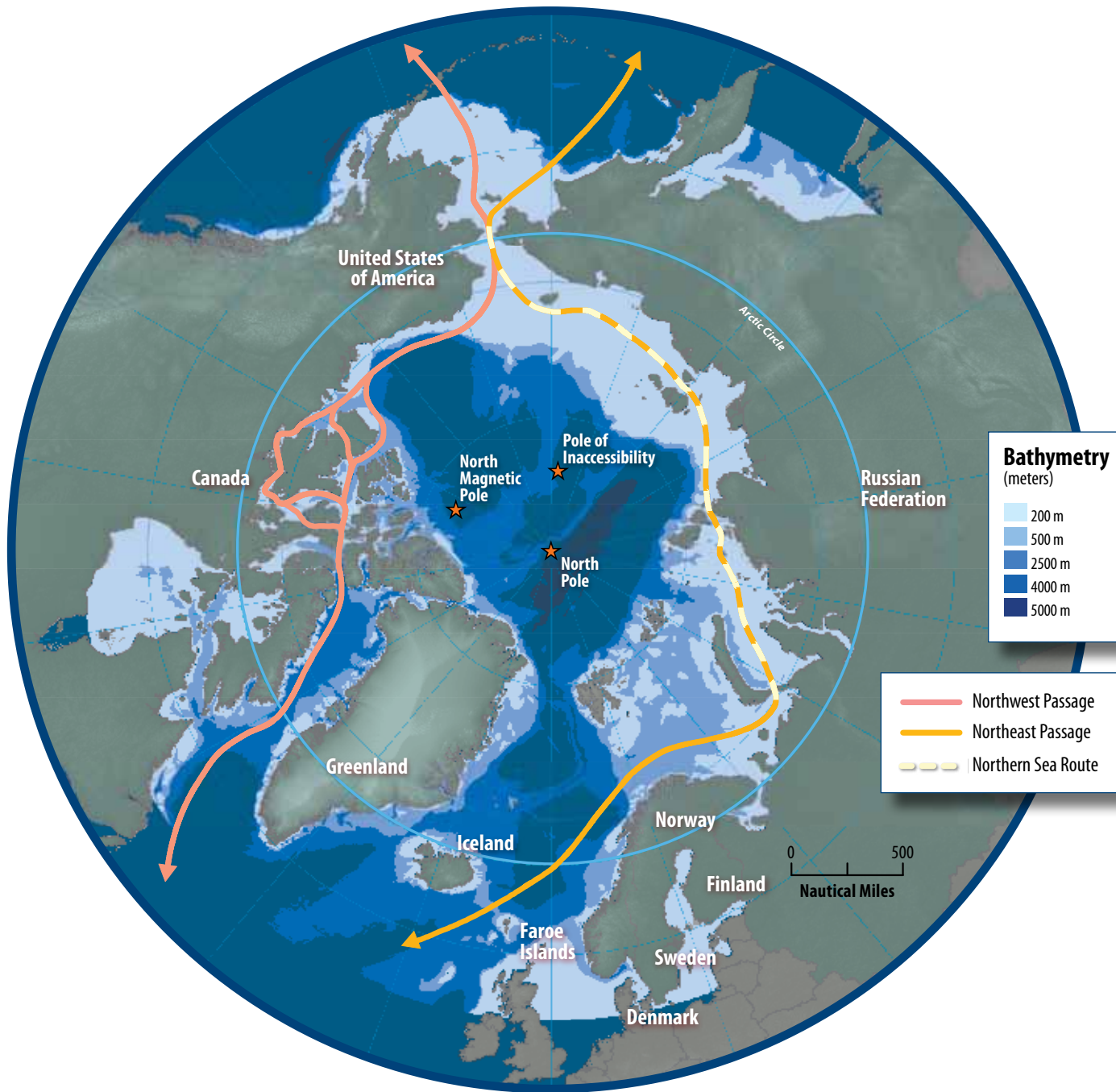
ARCTIC MARINE GEOGRAPHY, CLIMATE AND SEA ICE

Arctic Marine Geography

Our Earth has two polar regions, each with a large marine environment, that are vital to the well-being of the planet: Antarctica and the Arctic. Unlike Antarctica, though, which is a continent surrounded by an ocean, the Arctic is an ocean surrounded by continents. The Arctic Ocean, at 14.056 million km², is the smallest of the world's five oceans (Table 2.1). It is mostly an enclosed sea that has limited exchange of deep water with other oceans. Compared to the Mediterranean Sea, the Arctic has a much greater exchange of water, and it is more than 5.6 times larger. Consequently, the International Hydrographic Organization along with the International Maritime Organization recognizes the Arctic Ocean as one of the five major components of the world ocean that covers almost 71 percent of the Earth's surface. More importantly, the Arctic Ocean is the least sampled of the world's oceans and many areas remain where few, if any, soundings have been recorded. The implications of this lack of basic marine information are profound for charting hydrography and for basic Arctic navigation.

The Arctic is bordered by numerous coastal seas, all of which are seasonally covered with sea ice. Working from Greenland eastwards, the waters adjacent to the Arctic basin itself are Greenland Sea, Norwegian Sea, Barents Sea, White Sea, Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea - all fronting on the Eurasia continental land mass. The Bering Sea, the Beaufort Sea, the waters within the Canadian Archipelago including those of the Northwest Passage, Hudson Bay and Hudson Strait, Lincoln Sea, Baffin Bay, Davis Strait and Labrador Sea are all bordering on the North American continent. Most Arctic marine activity, such as fishing, offshore hydrocarbon development and ship transits, takes place in these coastal seas.

Bathymetrically, the Arctic marine area is relatively shallow (Map 2.1) with broad continental shelves. The shelf extends 100 to 200 kilometers from the United States and Canada, and more than 1,000 kilometers in places extending north from the Russian Federation. Depths over the shelves average between 100 and 200 meters but are variable, especially as the continental landmasses and islands are approached. At the continental slopes, the break between the shelf and the deep ocean basin, depths are between 300 and 500 meters.



Map 2.1 The Arctic marine area. Source: AMSA

4,000 meters +
The depth of the Arctic Ocean at the North Pole.

	Size (million km ²)	Percentage of Earth's Total Surface	Greatest Depth (m)	Average Depth (m)
Pacific	155.557	30.5	10,911	4,300
Atlantic	76.762	20.8	8,605	3,300
Indian	65.556	14.4	7,258	3,900
Southern	20.327	4.0	7,235	4,000-5,000
Arctic	14.056	2.8	5,160	1,050

■ **Table 2.1** Arctic Ocean compared to other oceans. *Source: AMSA*

Country	Closest Point to the North Pole	Distance to Pole (km)
Greenland (Denmark)	Kaffeklubben Island, Perry Land	707
Iceland	Kolbeinsey, Eyjafjorour	2552
Norway	Rossoya Sjuoyane, Svalbard	1024
Russian Federation	Cape Fligely, Rudolf Island, Franz Josef Land	911
USA	Point Barrow, Alaska	2078
Canada	Cape Columbia, Ellesmere Island	769

■ **Table 2.2** Distances from nearest land of Arctic states to the North Pole. *Source: AMSA*

There are two major deep basins - the Eurasia and Amerasia - separated by the Lomonosov Ridge stretching from the East Siberian Sea to the Lincoln Sea. The ridge is an underwater mountain chain rising, on average, 3,000 meters above the abyssal plain. On the Eurasian side of the Lomonosov Ridge, the basin is again split into two by the Nansen-Gakkel Arctic Mid-Ocean Ridge. Between the Lomonosov and Nansen-Gakkel Ridges lies the Pole Abyssal Plain in which is found the geographical North Pole at 90 degrees north. The depth of water at the pole is well over 4,000 meters. On the Amerasia side of the Lomonosov Ridge there are also two basins - the Makarov and Canada - separated by the Alpha and Mendeleev ridges. Of the two basins, the Canada Basin is the largest.

Major islands and island archipelagos fringe the Arctic marine area and they help frame the marine routes, legal regimes and navigational options in the Arctic Ocean. The largest island is Greenland at 2,166,086 km². The largest archipelago is the Canadian Archipelago with more than 36,000 islands including Baffin (507,451 km²), Victoria (217,291 km²) and Ellesmere (196,236 km²), which are among

the world's largest 10 islands. The next largest single island fringing on the Arctic marine area is Iceland (103,000 km²). On the west, the Arctic Ocean is bounded by Svalbard (Norway) of which Spitsbergen is the largest island; Franz Josef Land (Russian Federation) with 191 islands; Novaya Zemlya (Russian Federation) with two major islands (Severny at 47,079 km² and Yuzhny at 33,246 km²); Severnaya Zemlya (Russian Federation) consisting of four major islands and 70 smaller ones; and New Siberian Islands (Russian Federation) with the Anzhu Islands and the Lyakhovskiy Islands. Between the New Siberian Islands group and the Bering Strait lies Wrangel Island (7,300 km²). Given these fringing islands, the distance from the nearest land to the North Pole is as little as 707 kilometers (382 nautical miles) (Table 2.2), but this distance is different for each Arctic nation. Of interest to the marine world is the approximate 2,100 nautical mile (1134 kilometer) distance (direct) from the Bering Strait to the North Pole to Fram Strait (between Greenland and Svalbard). All other distances along the coastal routes within the Arctic basin are longer.

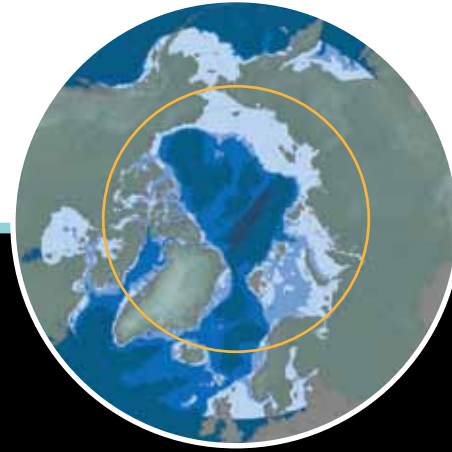
Although technically not on the edge of the Arctic Ocean, the Aleutian Islands in the Pacific Ocean provide the southern limit of the Bering Sea, which links through the Bering Strait into the Chukchi Sea and the Arctic Ocean. A global maritime trade route - the North Pacific's Great Circle Route - intersects with the Aleutian Islands and thousands of large ships pass north and south of these islands on voyages between the west coast of North America and Asian ports each year.

The water connections linking the Arctic and the Pacific and Atlantic oceans are limited. The narrow and shallow Bering Strait (85 kilometer width; 30-50 meter depth) is the only link between the Arctic and the Pacific. There are more and wider passages between the Arctic and the Atlantic. Davis Strait between Canada and Greenland links Baffin Bay with the Labrador Sea and the North Atlantic. At its narrowest point Davis Strait is about 300 kilometers wide; at its widest it is over 950 kilometers. Between Greenland and Iceland lies Denmark Strait (290 kilometers wide at its narrowest). The widest passage is the Norwegian Sea at about 1,100 kilometers separating Iceland from Norway.

These water passages between the Arctic Ocean and its northern coastal seas allow exchanges of water vital to the Arctic's climate and marine ecosystems. By far the greatest exchange of water takes place between the Arctic and the Atlantic. Relatively warm dense salty water, as part of the North Atlantic Current originating in the Gulf of Mexico and Caribbean Sea, enters the Norwegian Sea continuing into the Barents Sea. This warmer water means that the Southern Barents Sea is not generally ice-covered, a significant factor in the regulation and control of marine traffic in this northwest

corner of Europe that is by latitude located in the Arctic region. After much mixing and cyclonic (counter-clockwise) circulation, cold, less salty water exits between Svalbard and Greenland and Greenland and Iceland. This exiting water consists not only of the modified North Atlantic waters but, more importantly, continental river water from Eurasia, especially from the Ob', Yenisei and Lena rivers of the Russian Federation; freshwater from the Mackenzie River in Canada; and Pacific water which entered through the Bering Strait. The driving engine conveying the Pacific water and the river waters eastward is the Beaufort Gyre north of Alaska and western Canada. This gyre - a clockwise circulation of relatively fresh, less dense water - is driven by prevailing winds. When winds shift and the current lessens some water escapes and is caught up in the Trans Polar current, eventually linking with the outflow water into the Atlantic Ocean. Cold waters also exit from the Arctic to the Atlantic through Baffin Bay, Davis Strait and Hudson Strait.

An important geographical limit and a defining line is the Arctic Circle (66 degrees 33 minutes north). At this latitude places receive continuous light for 24 hours per day once a year and as one moves poleward the number of days of continuous light increases until at the North Pole continuous light is experienced for six months



Arctic Circle

The Arctic Circle is the circle of latitude at 66 degrees 33 minutes N (2606 kilometers/1619 miles from the North Pole) that encloses a northern area about 8 percent of Earth's surface. The Arctic Circle is the southern limit of the midnight sun, where north of the circle there is at least one day each year when the sun does not set.



between the Vernal (March 21) and Autumnal equinoxes (September 21). Conversely, continuous dark is experienced at the pole for the other six months and decreasingly in time as one moves south. Significant for marine operations is that much of the central Arctic Ocean is shrouded in winter darkness with very low temperatures for half the year. This seasonal or diurnal cycle in the polar environment, while highly influential in the rhythmic behavior and adaptation of Arctic communities and animal populations, has broad implications for maritime use throughout the Arctic Ocean and its coastal seas.

The Canadian Maritime Arctic and Northwest Passage

The Canadian maritime Arctic is located across the north of Canada from the Beaufort Sea in the west to Baffin Bay in the east, and south to 60 degrees north latitude. The Canadian Arctic Archipelago stretches longitudinally about 1,900 kilometers from mainland Canada to the northern tip of Ellesmere Island. From west to east, it covers a distance of about 2,400 kilometers from Banks Island (west side) to Baffin Island (east side). The size of this roughly triangular area, including land and ocean, is approximately 2.1 million km², about the size of Greenland. As mentioned previously, it comprises approximately 36,000 islands, making it one of the most complex geographies on Earth. The area is sparsely populated along the coastline. The largest settlement is Iqaluit, Baffin Island, at 6,100 people; the entire Baffin region includes most of the eastern and northern portion of the Archipelago including all of Baffin Island. The most northern settlement is Grise Fjord on Ellesmere Island. Resolute on Cornwallis Island and the shores of Barrow Strait are an important staging area for air and marine traffic.

The Archipelago serves as a major impediment to shippers seeking a link between the Atlantic and Pacific oceans or for internal shipment of resources or community supplies. There are five recognized routes or passages, with variations, through the Archipelago (Table 2.3). They make up the much searched for Northwest Passage, which occupied European adventurers for more than 400 years. The NWP is the name given to the various marine routes between the Atlantic and Pacific oceans along the northern coast of North America that span the Canadian Arctic Archipelago. The



Northwest Passage (NWP)

The NWP is the name given to the various marine routes between the Atlantic and Pacific oceans along the northern coast of North America that span the Canadian Arctic Archipelago.

first complete ship transit of the NWP took place from 1903-06 by Norwegian explorer Roald Amundsen following Route 3b (Table 2.3). In 1940-42 the first eastward passage, using Route 4, was made by the *St. Roch* commanded by RCMP Sergeant Henry Larsen. This trip was followed in 1944 by a westward passage following Route 1, marking the first time the Northwest Passage had been navigated in a single season.

All passages have common eastern and western approaches. In the east, ships must proceed through the Labrador Sea, Davis Strait and Baffin Bay - the exception is for Route 5, which requires a transit through Hudson Strait. In the western approaches ships proceed through the Bering Sea, Bering Strait, the Chukchi Sea and the Beaufort Sea before deciding which route to follow. In general, the operating season is short - from late July to mid-October - depending on the route and year. Of the various passages, routes 1 and 2 are considered deep water ones, while the others have limiting shoals and rocks restricting the draft of vessels to less than 10 meters.

The Arctic Ocean is the least sampled of the world's oceans and many areas remain where few, if any, soundings have been recorded.


Water Routes of the Northwest Passage

Route	Routing (East to West)	Physical Description	Of Note
1	Lancaster Sound – Barrow Strait – Viscount Melville Sound – Prince of Wales Strait – Amundsen Gulf.	<p>Lancaster Sound: 80 km wide, 250 km long, deep at over 500 m.</p> <p>Barrow Strait: 50 km wide, 180 km long, deep, string of islands west of Resolute disrupts clear navigation.</p> <p>Viscount Melville Sound: 100 km wide, 350 km long, experiences multi-year ice from M'Clure Strait.</p> <p>Prince of Wales Strait: minimum width of less than 10 km about half way through the Strait, 230 km long, limiting depth of 32 m.</p> <p>Amundsen Gulf: irregular shape, 90 km wide entrance, approximately 300 km long.</p>	Suitable for deep draft navigation; the route followed by <i>St. Roch</i> in 1944 on westerly transit and the <i>SS Manhattan</i> in 1969.
2	Same as 1 but substitute M'Clure Strait for Prince of Wales Strait and Amundsen Gulf. Collectively Lancaster Sound – Barrow Strait – Viscount Melville Sound is known as Parry Channel.	<p>M'Clure Strait: 120 km wide at east end, 275 km long to Beaufort Sea, deep at over 400 m, experiences multi-year ice from Arctic Ocean.</p>	<p><i>SS Manhattan</i> attempted this route in 1969 but was turned back.</p> <p>Russian icebreaker <i>Kapitan Klebnikov</i> succeeded in a passage in 2001.</p> <p>In September 2007 was clear of Arctic pack ice for a limited time since satellite photos have been available; there was more ice in 2008.</p>
3A	Lancaster Sound – Barrow Strait – Peel Sound – Franklin Strait – Larsen Sound – Victoria Strait – Queen Maud Gulf – Dease Strait – Coronation Gulf – Dolphin and Union Strait – Amundsen Gulf.	<p>Lancaster Sound and Barrow Strait: see Route 1.</p> <p>Peel Sound: 25 km wide, deep at over 400 m at south end.</p> <p>Franklin Strait: 30 km wide.</p> <p>Larsen Sound: depths vary between 30 and 200 meters.</p> <p>Victoria Strait: 120 km wide, at southern end is blocked by Royal Geographical Society Islands, worst ice conditions along the mainland coast of Canada.</p> <p>Queen Maud Gulf: eastern entrance 14 km wide, but widens into an irregular area with width of up to 280 km before narrowing to 14 km at entrance to Dease Strait; numerous islands, reefs and shoals.</p> <p>Dease Strait: 14 – 60 km wide, 160 km long.</p> <p>Coronation Gulf: over 160 km long, many islands.</p> <p>Dolphin and Union Strait: 80 km wide at Amundsen Gulf, 150 km long, caution should be exercised in passage, several soundings of less than 10 m have been recorded.</p> <p>Amundsen Gulf: see Route 1.</p>	Of the 3A, 3B and 4 routes, this is considered the best option but with a draft limit of 10 m.
3B	A variation of 3A. Rather than following Victoria Strait on the west side of King William Island, the route passes to the east of the island following James Ross Strait – Rae Strait – Simpson Strait.	<p>James Ross Strait: 50 km wide, but restricted by islands, extensive shoaling.</p> <p>Rae Strait: 20 km wide, with limiting depths of between 5-18 m in mid channel.</p> <p>Simpson Strait: about 3 km wide at narrowest point, most hazardous navigation area in 3B route.</p>	<p>The route of Roald Amundsen.</p> <p>Also route of the <i>MS Explorer</i>, in 1984, the first cruise ship to navigate the Northwest Passage.</p>
4	Similar to 3A. Rather than following Peel Sound on the west side of Somerset Island, the route passes to the east of the island through Prince Regent Inlet and Bellot Strait.	<p>Prince Regent Inlet: 80 km wide, free of islands, deep.</p> <p>Bellot Strait: short and very narrow, strong currents, limiting depth of 22 m.</p>	Route of <i>St. Roch</i> in 1940-42 on easterly transit.
5	Hudson Strait – Foxe Channel – Foxe Basin – Fury and Hecla Strait – Gulf of Boothia – Bellot Strait – remainder via routes 3A, 3B or 4.	<p>Hudson Strait: 100 km wide, 650 km long, deep, also serves as entrance to Hudson Bay and Churchill port.</p> <p>Foxe Channel: 130 km wide, deep, with limiting shoal in the middle that can be avoided.</p> <p>Foxe Basin: very large, many islands in northern end.</p> <p>Fury and Hecla Strait: 160 km long, very narrow with fast current.</p> <p>Gulf of Boothia: very large waterway connecting to Prince Regent Inlet to the north (see route 4). No problems for navigation except at exit of Fury and Hecla Strait where Crown Prince Frederick Island is to be avoided.</p>	Not generally considered a viable commercial passage for moderate to deep draft ships.

■ **Table 2.3** Adopted from Pharand (1988) with additional material from Sailing Directions, Arctic Canada, Vol. 3, 5th edition, 1994 and Canadian Arctic Shipping Assessment, Transport Canada, 2007.

The Nature of Ice at Sea

Several forms of floating ice may be encountered at sea. The most extensive is that which results from the freezing of the sea surface, namely sea ice; but mariners must also be concerned with "ice of land origin" - icebergs, ice islands, bergy bits and growlers. Both icebergs and sea ice can be dangerous to shipping and always have an effect on navigation.

- Young ice: newly formed sea ice less than 30 centimeters thick. It forms extensively in the autumn as ocean surface temperatures fall below freezing and on leads that open in mid-winter due to shifts in the pack ice. It is not a significant safety hazard for most Arctic vessels although, when placed under pressure by winds or currents, it can impede progress.
- First-year ice: can easily attain a thickness of 1 meter but rarely grows beyond 2 meters by the end of the winter. It is relatively soft due to inclusions of brine cells and air pockets and will not generally hole an ice-strengthened ship operated with due caution. Under pressure from winds or currents, first-year ice can impede progress to the point where even powerful vessels can become beset for hours or even days.
- Old ice: If first-year ice survives the summer melt season, it is then classified as old ice (subdivided into second-year and multi-year ice). It is typically 1 to 5 meters thick and is extremely hard. During the summer melt process, the brine cells and air pockets that characterize first-year ice drain out the bottom of the ice, leaving a clear, solid ice mass that is harder than concrete. Even ice-strengthened vessels are at risk of being holed by old ice. When under pressure, old ice can stop the most powerful icebreakers.
- Icebergs: are large masses of floating ice originating from glaciers. They are very hard and can cause considerable damage to a ship in a collision. Ice islands are vast tabular icebergs originating from floating ice shelves. Smaller pieces of icebergs are called bergy bits and growlers and are especially dangerous to ships because they are extremely difficult to detect. 

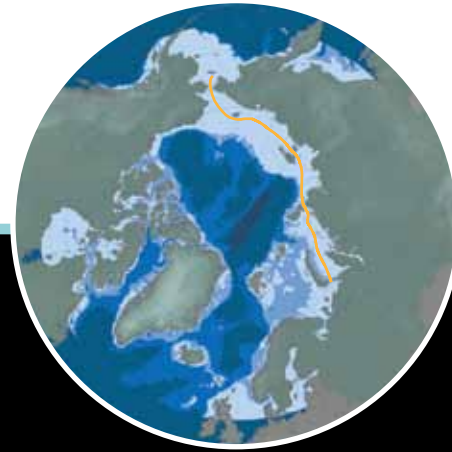


The Russian Maritime Arctic and Northern Sea Route

The physical environment of the northern coast of Eurasia - the Russian maritime Arctic - presents unique challenges to the mariner and to modern ship technology and systems. Shallow waters generally characterize the length of the coastline from the Norwegian-Russian border in the west (in the Barents Sea) to the Bering Strait. The average depths of the East Siberian and Chukchi seas are 58 meters and 88 meters respectively, making the entire coastal region in the east quite shallow for all marine operations. The average depth of the Laptev Sea is 578 meters (its northern limit extends into the Arctic Ocean basin); however, 66 percent of its area along the coast is in depths of 100 meters or less. The Kara Sea has an average depth of 90 meters and the Barents Sea is relatively shallow along the coast (10-100 meters) in the southeastern region and slopes to depths of 200-300 meters to the northwest. From the early years of exploration in the 17th century to today's offshore development and use of shipping routes, the consistently shallow bathymetry of this broad Arctic coast has been a key facet in all maritime affairs.

The Northern Sea Route is defined in Russian law as the set of Arctic marine routes between Kara Gate in the west and the Bering Strait. A number of narrow straits represent a significant constraint to navigation along the NSR. Yugorskiy Shar Strait is located along the south coast of Vaygach Island and is the southernmost entrance from the Barents to Kara seas (21 nautical miles long, 13-30 meters deep). Kara Gate is the main shipping strait between the Barents and Kara seas (18 nautical miles long, minimum depth of 21 meters) and shipping uses an established traffic separation scheme. Vilkitskiy Strait separates Severnaya Zemlya from the northernmost extremity of the Eurasian land mass, Cape Chelyuskin. This is a key NSR strait between the Kara and Laptev seas (60 nautical mile length, 100-200 meter depths), but it is ice-covered except for a short period in some summer seasons. Shokalskiy Strait is located in Severnaya Zemlya north of Vilkitskiy Strait and is a second possible shipping route between the Kara and Laptev seas (80 nautical miles long, minimum depth of 37 meters).

In the eastern reaches of the NSR, Dmitry Laptev Strait, oriented east-west, is the southernmost passage between the New Siberian Islands and the Russian mainland, linking the Laptev and East Siberian seas. This strait is 63 nautical miles long and has depths of 12-15 meters; however, the eastern approach has only depths of 10 meters or less, restricting traffic to ships with less than a 6.7 meter draft. Sannikov Strait is a second passage through the New Siberian Islands linking the Laptev and East Siberian seas (160 nautical miles long, minimum depths of 13 meters). From a navigation



Northern Sea Route (NSR)

The NSR is defined in Russian Federation law as a set of marine routes from Kara Gate (south of Novaya Zemlya) in the west to the Bering Strait in the east. Several of the routes are along the coast, making use of the main straits through the islands of the Russian Arctic; other potential routes run north of the island groups.

perspective, the low surrounding New Siberian Islands make visual and radar observations difficult to obtain, especially during long periods of reduced visibility. Long Strait separates Wrangel Island from the Russian mainland and links the East Siberian and Chukchi seas (a 120-nautical mile southern route along the coast with 20 meter minimum depths; a 160-nautical mile northern route with 33 meter minimum depths).

Several marine route distances are notable: from Murmansk to the Bering Strait is 3,074 nautical miles; and the Northern Sea Route from Kara Gate to the Bering Strait is 2,551 nautical miles. The Dudinka to Murmansk marine route that is maintained year-round is 1,343 nautical miles, while it is approximately 500 nautical miles between the offshore region of the Pechora Sea (site of new oil terminals) in the southeast corner of the Barents Sea and Murmansk. Compared with the Canadian Arctic, the Russian maritime Arctic has many more viable ports located along the length of the NSR. Primary NSR ports from west to east include: Amderma, Dikson, Yamburg (Ob' Gulf), Dudinka (north Yenisei River), Igarka (south Yenisei River), Khatanga (Khatanga River on the Laptev Sea), Tiksi (Tiksi Gulf near the Lena River), Zeleny Mys (Kolyma River) and Pevek.



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Arctic Climatology

One defining threshold of the Arctic environment that is often used is set by the 10°C July isotherm. This isotherm marks the southern Arctic boundary where the monthly mean temperature in July is below 10°C. This limit also closely corresponds to the northern limit of the treeline. Because of the mix of landmasses, water and ice in the northern latitudes the isotherm pushes north above the Arctic Circle in all of Eurasia, but is south of the Arctic Circle in much of central and eastern Canada, southern Greenland and the Aleutian Islands. For example, the mean monthly July temperature at Honningsvåg, Norway (latitude 70° 58' N) is 10.3°C; at Murmansk, Russia (latitude 68° 58' N) it is 13.4°C. However, at Inukjuak, Quebec, Canada on the east side of Hudson Bay (58° 27' N) the average July temperature is only 9.4°C; at Paamiut, Greenland on the south west coast (62° 00' N) it is 5.5°C.



Geographic North Pole

The Geographic North Pole, the Earth's northernmost point, is located at the northern end of the Earth's axis of rotation. The latitude of the Geographic North Pole is 90 degrees N and it is the point where all the meridians of longitude and all 24 of the world's time zones converge.

In January, mean temperatures everywhere within the Arctic Circle are all below 0°C, varying from about -5°C along the north coast of Norway to greater than -35°C in central Greenland, the northern part of the Canadian Archipelago and in northern Siberia. The average January temperature at the North Pole is estimated at between -30 and -35° C; however, this is difficult to know given that no permanent recording station exists at the pole. Over virtually all of the Arctic Ocean mean winter air temperatures are not as cold as they are in fringing continental land masses in Siberia, Alaska and Canada.

Precipitation, generally, is light within the Arctic at less than 250 millimeters per annum. Only along exposed coastal regions in southern Baffin Island, western Greenland and northern Scandinavia are amounts greater than this regularly experienced. The main component of the precipitation in the central and high Arctic is snow, but it too is light, at less than 25 centimeters per annum. Although light, snow tends to be blown in all regions and accumulates in drifts and around structures; in marine environments drifting snow accumulates along ice edges and other features on the sea ice creating considerable additional barriers to normal navigation. Almost all snow disappears nearly everywhere in the summer, except in glacier areas.

One of the factors explaining the climatic patterns and annual weather events in the Arctic is the distribution of high and low pressure systems through the year. In winter two semi-permanent low pressure areas set up in the region: one over Iceland and the

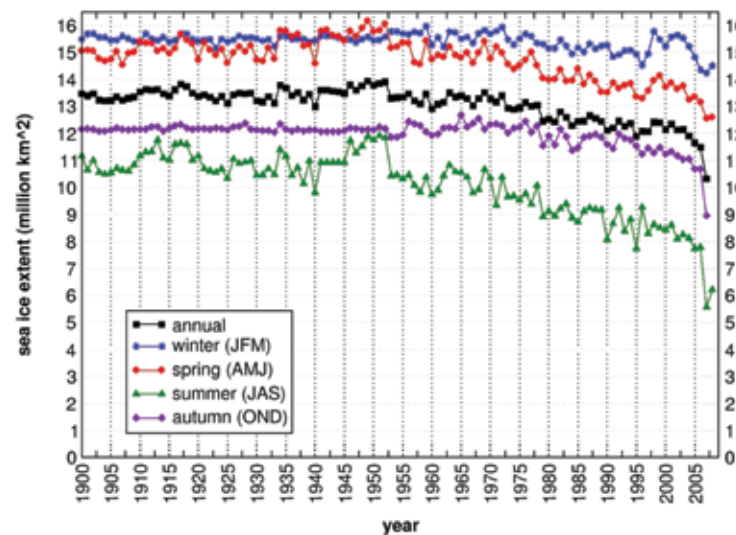
North Atlantic extending into the Barents Sea, the other over the Gulf of Alaska in the North Pacific. In contrast, high pressure areas are established over Siberia and the Yukon in Canada. The pressure differences bring about frequent and intense cyclonic storms moving generally from west to east. In summer, the lows weaken, the Siberian high disappears and the Canadian high shifts north over the Canadian Archipelago. As a result, pressure gradients are less and cyclonic activity declines, providing a fairly benign Arctic marine environment for voyages and regional operations. By October, the winter configuration begins to take effect and storminess increases with declining temperatures. Again, the seasonality of the polar environment, in this case the overall annual weather patterns over the Arctic Ocean, is a critical, strategic aspect for planning current and future marine transport systems throughout the Arctic basin.

Arctic Sea Ice: Changing Operating Conditions in the Arctic Ocean

Introduction

The Arctic sea ice cover is undergoing an extraordinary transformation that has significant implications for marine access and shipping throughout the Arctic basin. The Arctic Climate Impact Assessment, released by the Arctic Council at the Iceland Ministerial meeting in November 2004, documented that Arctic sea ice extent has been declining for the past five decades. Research has also

■ **Graph 2.1** Northern Hemisphere sea ice extent. *Source: J. Walsh, W. Chapman*



Future Arctic navigation and all marine activity will depend on more frequent, reliable and near real-time sea ice thickness measurements.

indicated that sea ice thickness has been decreasing during the same period, and the area of multi-year ice has also been declining in the central Arctic Ocean.

Global Climate Models used in the ACIA and the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4 released in 2007) simulate a continuous decline in sea ice coverage through the 21st century. One ACIA model showed it is plausible that during mid-century, the entire Arctic Ocean could be ice-free for a short period in the summer, a finding that garnered significant media attention.

Recent research (2006-2008) has indicated this plausible ice-free state of the Arctic sea ice cover may occur as early as 2040, if not sooner. It is important to note that despite the remarkable, ongoing changes in Arctic sea ice and some uncertainty surrounding the output of the GCMs, no research and none of the GCM simulations have indicated that the winter sea ice cover of the Arctic Ocean will disappear during this century.

This fact alone - that there will always be an Arctic sea ice cover to contend with - has important implications for all future Arctic marine activity and for the development of ship standards and measures to enhance Arctic marine safety and environmental protection. The resulting sea ice conditions for future Arctic marine operations will be challenging and will require substantial monitoring and improved regional observations. This new Arctic Ocean of increasing marine access, potentially longer seasons of navigation and increasing ship traffic requires greater attention and stewardship by the Arctic states and all marine users.

In assessments of ongoing and projected climate change, Arctic sea ice is a critical and highly visible element. Observed sea ice extents derived from satellite passive microwave data for 1979-2006 indicate a decrease or annual loss of 45,000 km² of ice (3.7 percent decrease per decade). The same data analysis shows negative ice extent trends for each of the four seasons and each of the 12 months; the decline in summer extent (6.2 percent decrease per decade) is larger than in winter (2.6 percent decrease per decade).

Interestingly, the five smallest September ice-covered areas for the Arctic Ocean during the modern satellite record (1979-2008) have occurred in the five most recent seasons (2004-2008). Map 2.2 shows the sea ice coverage derived from satellite at the time of minimum extent of Arctic sea ice on September 16, 2007.

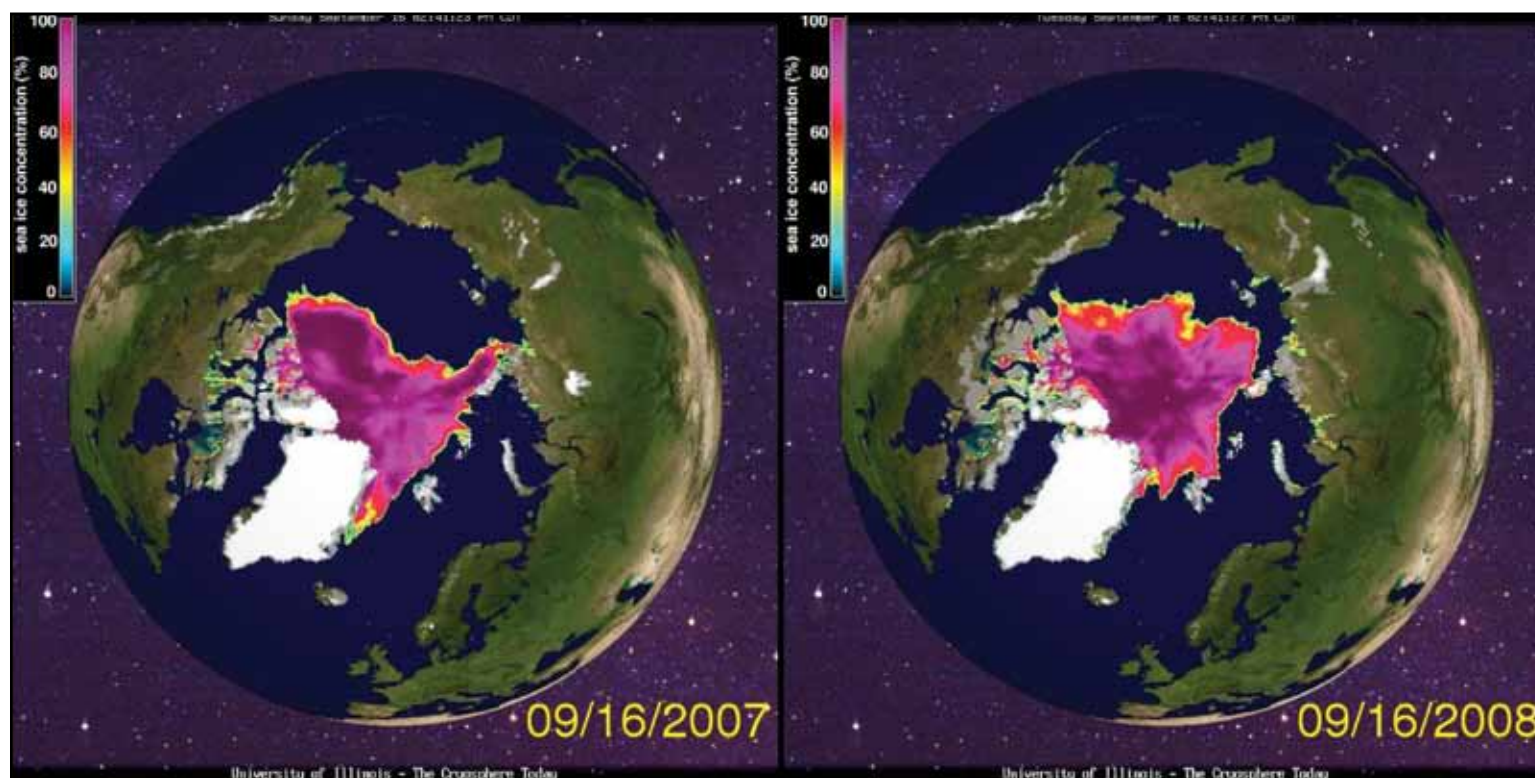
This snapshot represents the minimum coverage of Arctic sea ice in the satellite era of observations. Striking are several notable features: the largely ice-free areas across the Russian Arctic coastal seas (north of the Eurasian coast), except for a small region in the western Laptev Sea; an ice edge that has retreated north of Svalbard and well north in the Beaufort and Chukchi seas; several ice-free passages through the Canadian Archipelago; and a large area of the central Arctic Ocean that previously has not been observed open or without even a thin ice cover.

These extraordinary changes in the summer ice cover of the Arctic Ocean, represented by a single, iconic satellite image for September 16, 2007, are major factors in the potential lengthening of the navigation season in regional Arctic seas, particularly in the summer. It should be noted though that during the same timeframe, the Fram Strait contained more ice than normal, underscoring the regional variability of sea ice extent.

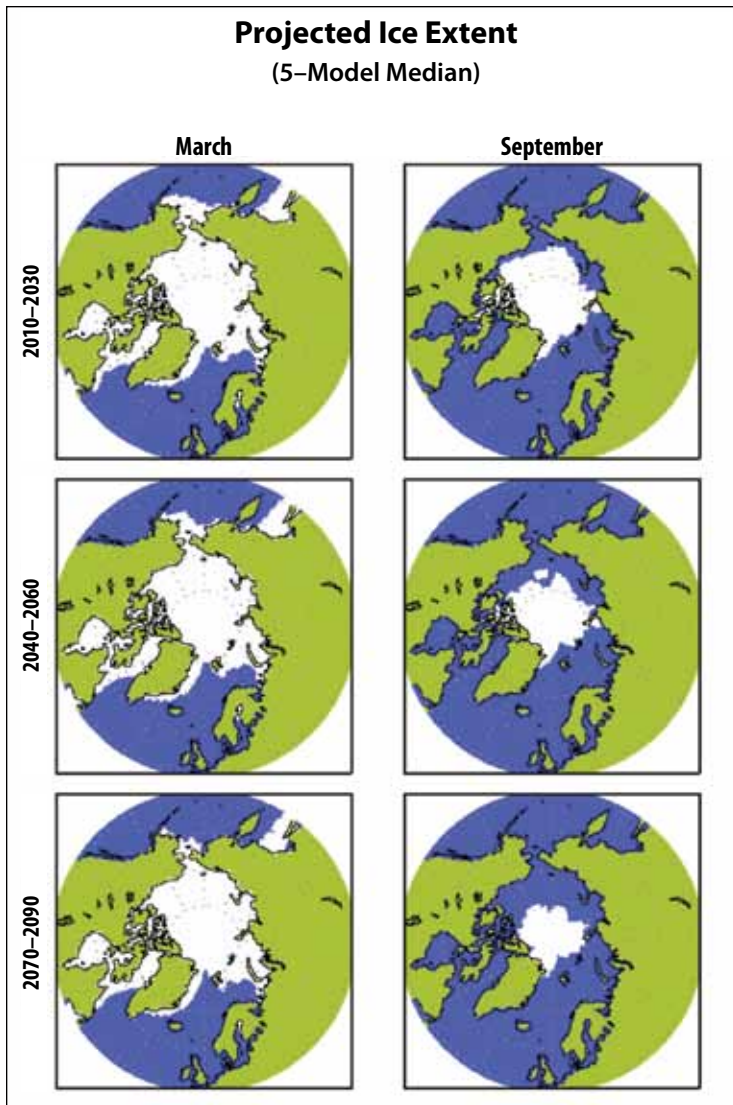
Arctic Climate Impact Assessment

The ACIA, approved by the eight Arctic countries, was called for by the Arctic Council and the International Arctic Science Committee. The assessment found that the Arctic is extremely vulnerable to observed and projected climate change and its impacts. The Arctic is now experiencing some of the most rapid and severe climate change on earth. During the 21st century, climate change is expected to accelerate, contributing to major physical, ecological, social and economic changes, many of which have already begun. Changes in Arctic climate will also affect the rest of the planet through increased global warming and rising sea levels. Of direct relevance to future Arctic marine activity, and to the AMSA, is that potentially accelerating Arctic sea ice retreat improves marine access throughout the Arctic Ocean.

The assessment confirmed, using a wealth of current Arctic research, that declining Arctic sea ice is a key climate change indicator. During the past five decades the observed extent of Arctic sea ice has declined in all seasons, with the most prominent retreat in summer. While the ACIA models have now been surpassed by more capable GCMs, each of the five GCMs used in the ACIA did project a continuous decline in Arctic sea ice coverage throughout the 21st



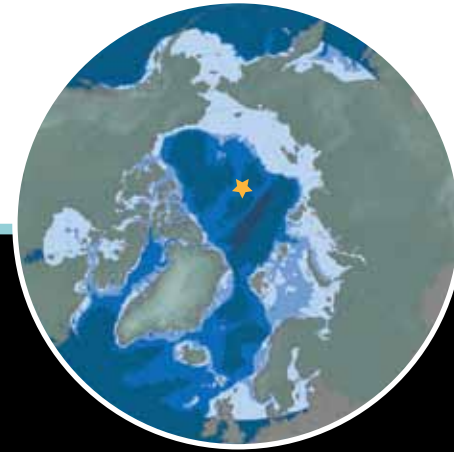
Map 2.2 Satellite images of summer sea ice cover. Source: University of Illinois – The Cryosphere Today



Map 2.3 Arctic sea ice simulations for the 21st century.
Source: Arctic Climate Impact Assessment

century (Map 2.3). From a strategic planning perspective, this is a key factor for evaluating future Arctic marine transport systems. As noted previously, one of the models simulates a summer ice-free Arctic Ocean by 2050, a future scenario of great significance for Arctic shipping and offshore development. Such a physical occurrence would mean that multi-year ice could possibly disappear in the Arctic Ocean. All of the next winter's ice would be first-year: no ice will have survived a winter season (and be able to gain strength and thickness).

GCM projections to 2100 suggest that in the summer the Arctic sea ice will retreat further and further away from most Arctic coasts, potentially increasing marine access and extending the season of



Northern Pole of Inaccessibility

Located at 84 degrees 3 minutes N, 174 degrees fifty-one minutes W, the Pole of Inaccessibility is the point farthest from any Arctic coastline, making it the most difficult to attain.

navigation in nearly all Arctic regional seas. One critical limitation of the GCMs is that they are not useful for determining the state of sea ice in the Northwest Passage region. Their spatial resolution is much too coarse to be applied to the complicated geography of the Canadian Arctic Archipelago.

In the ACIA, the only reliable observed data for the region comes from the Canadian Ice Service and this information, archived since the late 1960s, shows a mean negative trend of sea ice coverage in the Canadian Arctic, but very high year-to-year variability. The ACIA models, however, could be applied very crudely to the more open coastal seas of the Russian Arctic. The ACIA sea ice projections for Russia's Northern Sea Route indicated longer periods of ice-free conditions which could translate into a longer navigation season throughout the 21st century.

The ACIA confirms that the observed retreat of Arctic sea ice is a real phenomenon. The GCM projections to 2100 show extensive open water areas during the summer around the Arctic basin. Thus, it is highly plausible there will be increasing regional marine access in all the Arctic coastal seas. However, the projections show only a modest decrease in winter Arctic sea ice coverage; there will always be an ice-covered Arctic Ocean in winter although the ice may be thinner and may contain a smaller fraction of multi-year ice. The very high, inter-annual variability of observed sea ice in the Northwest Passage and non-applicability of the GCMs to the region prevent an adequate assessment of this complex region.

It is important to note that despite the remarkable, ongoing changes in Arctic sea ice and some uncertainty surrounding the output of the GCMs, no research and none of the GCM simulations have indicated that the winter sea ice cover of the Arctic Ocean will disappear during this century.

Although the ACIA projections indicate an increasing length of the navigation season for the Northern Sea Route (20-30 days per year in 2004, to 90-100 days by 2080), detailed quantification of this changing marine access also tested the limitations of the ACIA GCMs. Since the work of the ACIA, advances and refinements in the models may allow them to provide more robust strategic information on the length of time regions remain ice-free and year-to-year regional sea ice variabilities. There is a definite need for improved Arctic regional models to adequately assess future changes in sea ice extent and thickness, and their considerable implications for expanded marine use of the Arctic Ocean. And, there is a significant need for more sea ice observations to improve the calibration and validation of the GCMs.

The final ACIA report lists 10 major findings that are essentially the key impacts of climate change on Arctic people and the environment. The ACIA key finding #6 states, "Reduced sea ice is very likely to increase marine transport and access to resources." One of the follow-on Arctic Council activities addressing this ACIA finding is the AMSA.

Intergovernmental Panel on Climate Change Fourth Assessment and Beyond

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization of the United Nations Environment Programme. IPCC is an intergovernmental body



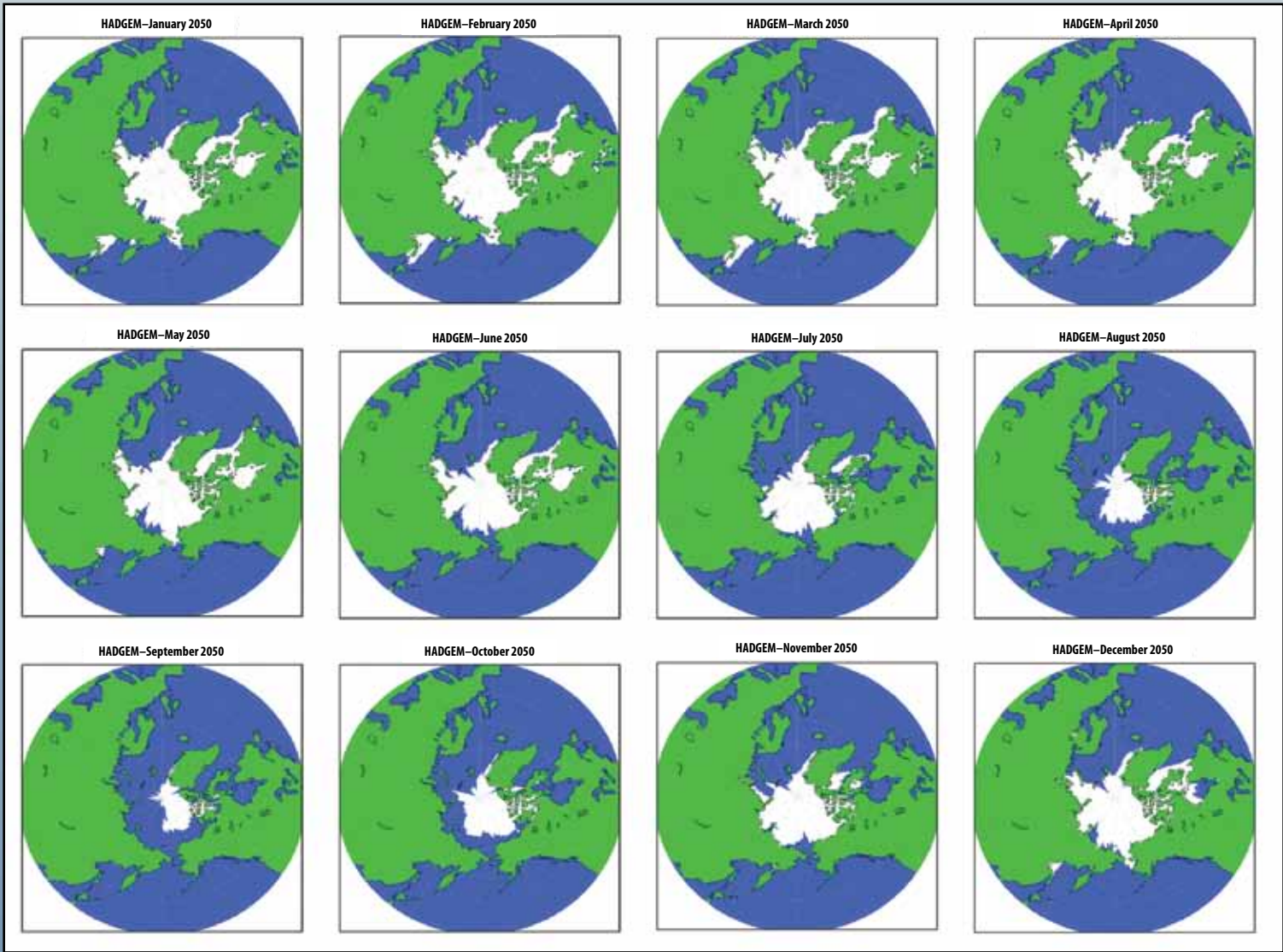
North Magnetic Pole

The North Magnetic Pole is a non-stationary pole in the Arctic to which compass needles point from any direction. The magnetic field at this point points straight down or is at right angles to the Earth's surface. The position of the Pole continues to wander and is currently northwest of the Canadian Arctic.

that provides scientific and technical information to policy makers. The 2007 IPCC 4th Assessment report indicated the lack of comprehensive sea ice data prior to the satellite era. However, observed data analyses have been able to confirm a sustained decline in Arctic sea ice since the early 1970s, notably during the summer melt season. The report also comments that the accuracy of satellite-derived ice concentration is usually 5 percent or better; errors of up to 10-20 percent can occur during the melt season as the passive microwave sensors measure the thin surface layers of melt water on the sea ice surface. Of critical importance to future navigation, the assessment also summarizes the information on the remarkable decrease in multi-year ice throughout the Arctic Ocean.

The possibility of an ice-free Arctic Ocean, even for a brief period, was advanced as an intriguing outcome of the ACIA. Recent analyses of GCM sea ice simulations using models from the IPCC AR4 (applying global warming scenarios) show near-complete loss of Arctic sea ice in September for 2040 to beyond 2100. However, additional research also indicates abrupt reductions in sea ice coverage during the 21st century are a common feature in many of the GCM simulations. Whether these periods of accelerated summer sea ice retreat might provide windows of opportunity for improved marine navigation is unknown. However, these research results and recent model inter-comparisons show the many uncertainties that remain in simulating the future ice cover of the Arctic Ocean.

Map 2.4 Hadley Centre Arctic Sea Ice Simulations, 2050. Source: IPCC4 - 2050

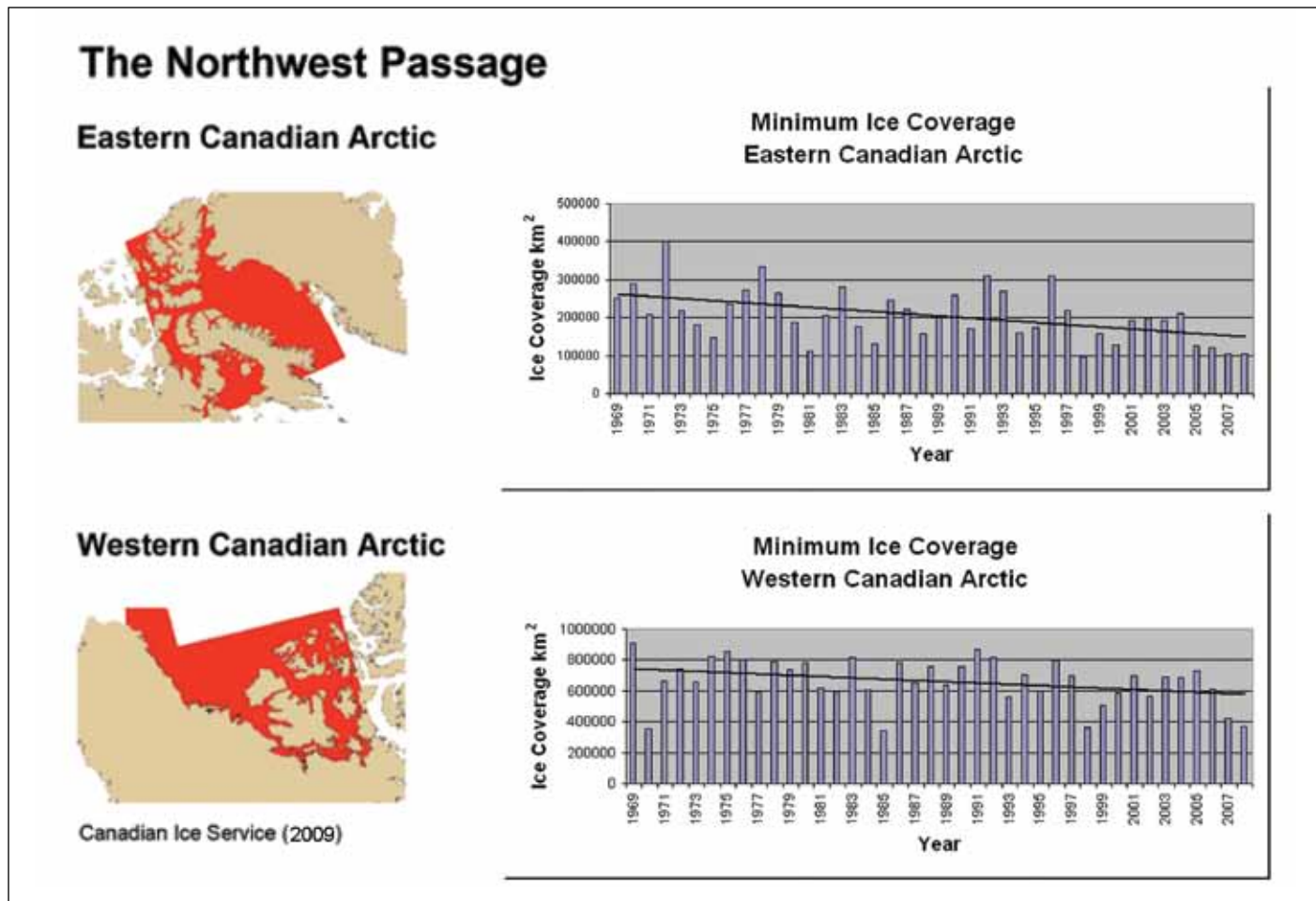


Further research on the performance of the IPCC AR4 models (Map 2.4) reveals that none of the GCMs have negative trends for sea ice as large as the observed sea ice coverage trend for the period 1953-2006 (7.8 percent per decade reduction). The observed trend is three times larger than the multi-model mean of a 2.5 percent per decade loss. This is an extraordinary development that also means the current summer sea ice minima are as much as 30 years ahead of the mean of the model simulations. With continued greenhouse gas emissions, it is highly plausible that the Arctic Ocean could become completely ice-free for a short summer period much earlier than 2040.

Just as important to ship navigation, these simulations indicate large areas of the coastal Arctic seas to be ice-free for longer periods in the spring and autumn months. Arctic marine access continues to increase in nearly all the scenarios posed by the ACIA and the more recent IPCC assessments.

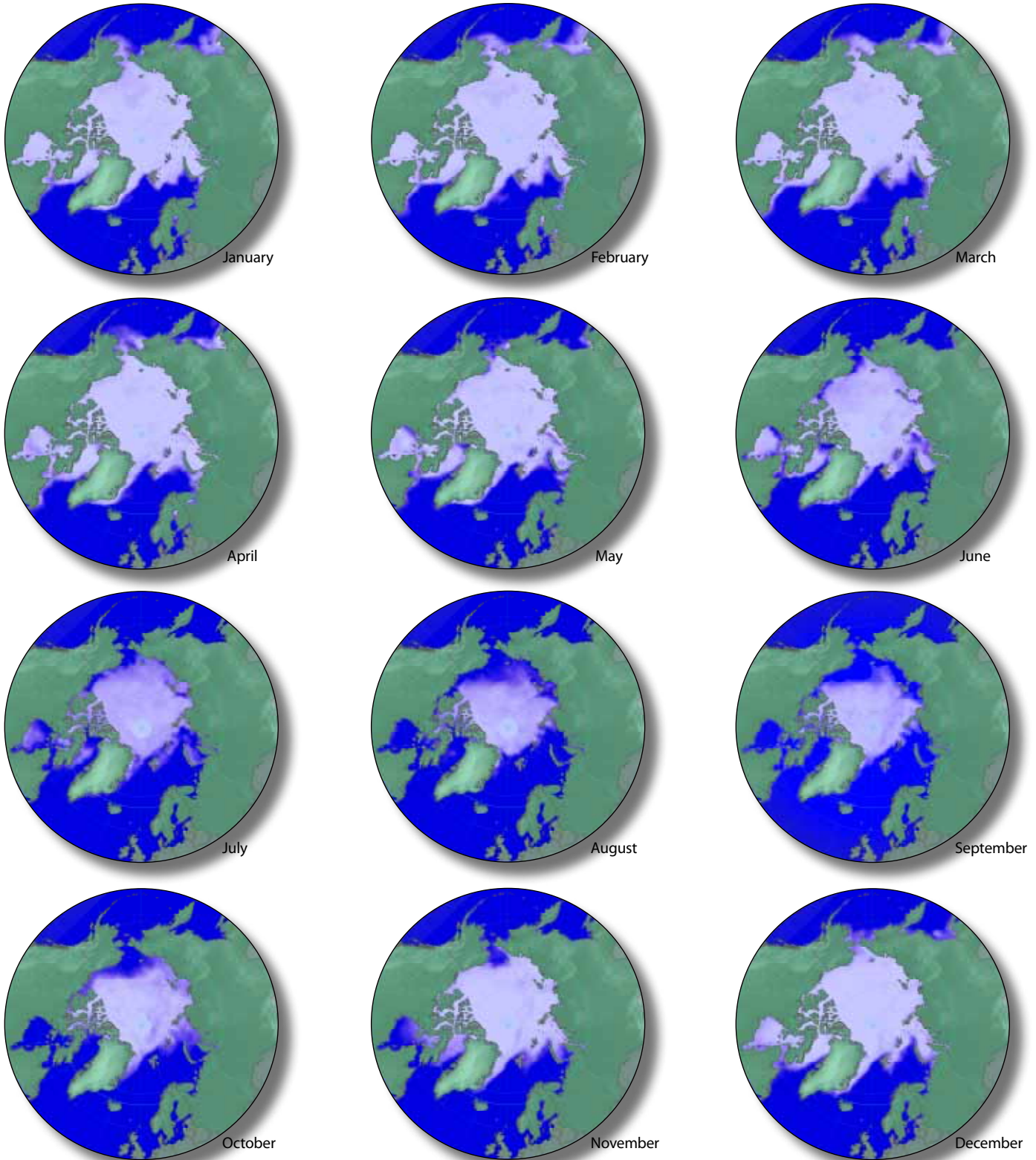
Additional Sea Ice Trends and Research

Earlier observations from aircraft and ships, and three decades of daily satellite observations, suggest that the September 2007 minimum sea ice extent (Map 2.2) was the lowest since the early 1950s; however, the September 2008 minimum extent indicated a slightly larger area of sea ice coverage. The Arctic sea ice cover is at a maximum extent in March and this maximum coverage has also been observed to decrease at approximately 2 percent per decade during the period 1979-2008. These extent reductions have been observed in all seasons of a year, but perhaps more significant have been observations of a rapid decline of thick, multi-year sea ice in the central Arctic Ocean. A study of satellite data for winter during 1978-1998 revealed that the multi-year sea ice cover had declined by 7 percent per decade. A second trend analysis for 25 years of summer ice minima (1978 to 2003) reports a decline of multi-year sea



Graph 2.2 Sea ice variability in the Canadian Arctic and Northwest Passage. Source: Canadian Ice Service

Monthly Arctic Sea Ice Extent and Coverage, 2004



Map 2.5 Sea ice depictions for the AMSA shipping survey year of 2004. Source: AMSA



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ice as high as 9.2 percent per decade. One important result of these trends should be a decrease in the presence of multi-year ice in the Arctic's coastal seas where seasonal navigation and marine activity are highest.

Arctic sea ice thicknesses have been much more difficult to monitor and evaluate during recent decades. Direct measurements of first-year sea ice in the Arctic coastal seas by the Arctic and Antarctic Research Institute in St. Petersburg, the Russian Federation, along the Russian Arctic, generally yield 1-2 meter thicknesses. For the central Arctic Ocean, thicknesses of multi-year sea ice can be as high as 4-5 meters. One pioneering study using sea ice draft data acquired on submarine cruises (data from 1958-1976 compared with cruise data for 1993-1996) indicated a decrease in thickness at the end of the melt season for the central Arctic Ocean from 3.1 to 1.8 meters. This represented a volume decrease of 40 percent and a widespread decrease in sea ice draft. This 40 percent reduction was adjusted to 32 percent in a subsequent study once additional submarine tracks were added.

One key issue is that future sampling of Arctic sea ice thickness requires enhanced monitoring systems for more effective spatial and temporal measurements. Modern measurement systems such as electromagnetics, upward looking sonars and satellites have been developed that are improving thickness observations. Future Arctic navigation and all marine activity will depend on more frequent, reliable and near real-time sea ice thickness measurements.

Sea Ice Regional Trends

Canadian Maritime Arctic and Northwest Passage

The observed record of minimum sea ice extent for the eastern and western regions of the Canadian Arctic is illustrated in Graph 2.2. Although the observations for both regions show negative trends for the period 1969-2008, the year-to-year variability in coverage is quite extreme. Both regions also exhibit large differences for a given year; for example, in 1991 the western Canadian Arctic showed one of the highest or largest ice coverage areas, while in the eastern region a more normal coverage area at the summer minimum was observed. These regional variabilities create a challenge for seasonal operations. While these observations indicate an overall decrease in the ice cover of the waterways that comprise the Northwest Passage, the two key variabilities - year-to-year and spatial - create challenges for planners judging risk and the reliability of an Arctic marine transportation system for the long-term.

The five models used in the ACIA revealed that the last regions of the Arctic Ocean with sea ice coverage in summer would be in the northern waterways of the Canadian Archipelago and along the northern coast of Greenland. The flow of more mobile multi-year ice through these waterways presents another potential challenge to marine operations. Enhanced satellite monitoring (with high resolution imagery) of this complex region will be a necessity if expanded marine operations beyond summer are to be realized.

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Research Opportunities

- ❑ Research to improve regional models for increased understanding and enhanced forecasting of regional Arctic sea ice variability. New regional models should include ice thickness, snow cover and ice ridging, all key parameters of importance to Arctic navigation.
- ❑ Comprehensive analyses of current and future Global Climate Model simulations of Arctic sea ice extent to quantitatively assess the range of plausibly ice-free and partially ice-covered conditions.
- ❑ Considering the ongoing development of the Sustained Arctic Observing Network (SAON), develop and contribute a set of parameters to be observed and more observations that will be relevant to enhancing marine safety and marine environmental protection.
- ❑ Continued data analysis and updating of the International Bathymetric Chart of the Arctic Ocean (IBACO) with a long-term goal to create a comprehensive, integrated digital database of all bathymetric information for the Arctic Ocean.

The physical environment of the northern coast of Eurasia - the Russian maritime Arctic - presents unique challenges to the mariner and to modern ship technology and systems.

Russian Maritime Arctic and Northern Sea Route

Map 2.2 indicates that a nearly ice-free summer passage could have been made in 2007 and 2008 from Kara Gate through to the Bering Strait along the length of the Northern Sea Route except for sea ice in the western Laptev Sea. Passive microwave satellite observations of sea ice in the Russian Arctic seas from 1979 to the present show large reductions in sea ice extent in summer and reductions in winter extent in the Barents Sea. All of the ACIA model simulations and more recent IPCC AR4 model simulations confirm that large summer ice edge retreats should occur in the Laptev, East Siberian and western Chukchi seas. With a continued shrinkage of the fraction of multi-year sea ice in the central Arctic Ocean, it is plausible that fewer multi-year ice floes may be observed along the navigable eastern passages of the Northern Sea Route.

Long-term fast ice thickness measurements of the four Russian marginal seas (Kara, Laptev, East Siberian and Chukchi seas) have been analyzed for trends using 65-year observational records (1930s to 1990s). Long-term trends are small and inconclusive: the trends are small (approximately 1 centimeter per decade); the trends for the Kara and Chukchi seas are positive and the trends for the Laptev and East Siberian seas negative.

A review of recent assessments, observations and studies indicate that there remains much to understand about the present and future trends in Arctic sea ice. The operating conditions for Arctic ships will remain challenging, particularly in winter. It is also highly plausible that Arctic sea ice will be more mobile, particularly in spring, summer and autumn, as the cover continues to retreat from Arctic coastlines. Arctic coastal seas may experience increased ridging of seasonal sea ice, potentially creating more difficult operating conditions for marine navigation. The observed records of sea ice extent in the Canadian and Russian Arctic areas display high inter-annual variabilities. Such year-to-year variability poses a serious challenge to risk and the overall reliability of Arctic marine transport systems. Three key conclusions with direct relevance to Arctic shipping include:

- Arctic sea ice has been observed to be diminishing in extent and thinning for five decades. Also, model simulations indicate a continuing retreat of Arctic sea ice throughout the 21st century. However, no research indicates Arctic sea ice will disappear completely and a substantial winter sea ice cover will remain.
- Even a brief ice-free period in summer for the Arctic Ocean would mean the disappearance of multi-year sea ice in the central Arctic Ocean. Such an occurrence would have significant implications for design, construction and operational standards of all future Arctic marine activities.
- Observed sea ice trends and GCM simulations show coastal Arctic regions to be increasingly ice-free, or nearly ice-free, for longer summer and autumn seasons. Longer open water seasons



Northeast Passage (NEP)

The NEP is defined as the set of sea routes from northwest Europe around North Cape (Norway) and along the north coast of Eurasia and Siberia through the Bering Strait to the Pacific.

increase the potential for greater coastal erosion, which can impact support infrastructure for Arctic development and marine transportation.

Regarding future needs, a key requirement is the development of high resolution, regional sea ice models that can provide more robust and realistic forecasting of marine operating conditions. There is also a critical requirement for more real-time sea ice observations, especially ice thickness measurements, to support all future Arctic marine uses. The national ice centers and ice services are critical providers of such sea ice information and greater international collaboration among the centers will enhance the development of more integrated products. New satellite sensors hold the promise of providing greater, near real-time ice thickness information for Arctic ships that are underway on future voyages. ☀

A global maritime trade route - the North Pacific's Great Circle Route - intersects with the Aleutian Islands and thousands of large ships pass north and south of these islands on voyages between the west coast of North America and Asian ports each year.

Findings

- 1] Arctic sea ice coverage (extent) has been decreasing since the 1950s in all seasons. Observations of sea ice in the central Arctic Ocean have also indicated thinning during the past four decades. However, there remains a significant, year-to-year variability in regional sea ice coverage.
- 2] Global Climate Model simulations indicate a continuing “retreat” of Arctic sea ice through the 21st century. Observed sea ice trends and GCM simulations show coastal Arctic regions to be increasingly ice-free or nearly ice-free for longer summer and autumn seasons. Importantly, all simulations indicate that an Arctic sea ice cover remains in winter.
- 3] Recent sea-ice model simulations indicate the possibility of an ice-free Arctic Ocean for a short period of time in summer by earlier than mid-century. The key implication for this physical change will be the near (or complete) disappearance of multi-year sea ice.
- 4] Future sea ice conditions remain uncertain. It is highly plausible that Arctic sea ice will be more mobile in partially ice-covered coastal seas, particularly in spring, summer and autumn. Coastal seas may experience an increase and greater frequency of ice ridging and shorter periods of coastal fast ice.
- 5] The resolutions of GCM simulations are much too coarse for adequate coverage of the complex geographies of the Canadian and Russian Arctic. GCM Arctic sea ice simulations also lack robustness to provide detailed information on future marine operating conditions such as the length of the navigation season, “residence time” of ice-free conditions, frequency of leads and ridges and more.
- 6] Recent GCM Arctic sea ice simulations have not replicated the observed sea ice reductions from the 1950s to today. For example, the model simulations have not shown the drastic decrease of observed sea ice extent during recent years.
- 7] Climate change as indicated by Arctic sea ice retreat is a facilitator of marine access. It is highly plausible there will be greater marine access and longer seasons of navigation, except perhaps during winter, but not necessarily less difficult ice conditions for marine operations.



HISTORY OF ARCTIC MARINE TRANSPORT

The Arctic Ocean and adjacent seas have been used by mariners since the beginning of time. Historical Arctic marine transport activities reflect continuous indigenous marine use, expeditions and explorations, community supply/re-supply and expanding use by the global shipping community.

The first Arctic explorers were the indigenous people. Though most of their journeys remain undocumented, indigenous people have been traveling and exploring Arctic waters for thousands of years in search of food, supplies and settlement areas. They remain the original explorers and founders of the region.

Early Western marine transport in the Arctic was driven by searches for the Northwest Passage and Northeast Passage (Table

3.1). With the passages discovered, the focus shifted from searching to improving marine routes. Many notable Arctic voyages occurred and the scope of Arctic marine shipping advanced such that vessels even ventured to the then elusive North Pole. Advances in ship design, construction and operation, coupled with advancements in infrastructure, crew training and governance, have led to massive improvements in Arctic shipping.

This section will review briefly the rich history of the search and development of the Northwest Passage through the Canadian Archipelago, the Northeast Passage and later the Northern Sea Route along the northern coastline of Russia, as well as the history of Arctic tourism that can be found throughout the Arctic today.

Northwest Passage

The first European Arctic explorer was the Greek navigator Pytheas who sailed northward in 325 B.C. and is credited with having reached the vicinity of Iceland and perhaps even Greenland. In the late 9th century (aided by a period of worldwide climatic warming), the Norwegians found and colonized Iceland. Later Icelandic explorers found and colonized Greenland, and explored the northeast coast of North America.

It was not until the 1490s that Europeans began to investigate the possibility of a Northwest Passage (NWP) in order to find a more direct route to the Orient and the lucrative trade with India, Southeast Asia and China. In 1497, John Cabot sailed from Bristol in *Matthew* in an unsuccessful search for the passage.

Canadian place names reflect some of the many attempts that followed, with most via Hudson Bay, including Martin Frobisher, John Davis, Henry Hudson and Luke Foxe. In 1778, James Cook made the first attempt at locating the NWP from the west. In the 1800s, the Royal Navy explored the labyrinth of islands and channels that is now the Canadian Arctic Archipelago. In 1845, Sir John Franklin's ships, the *Erebus* and *Terror*, sailed north into Baffin Bay and disappeared. The Royal Navy mounted a massive search during the following decade for Franklin and his 129 men and as a result, the entire archipelago was explored.

It wasn't until 1906 that Norwegian explorer Roald Amundsen in his 47 ton sloop *Gjoa* emerged in the Pacific to become the first vessel to complete the NWP. Amundsen took three winters to complete the voyage and credit for his survival through the harsh Canadian winters goes to the Inuit. The first complete transit from west to east was completed in 1942 by the Canadian ship *St. Roch*. Captain Henry Larsen made the return trip from east to west in only 86 days and became the first vessel to transit the NWP in one season. Transits of the NWP after the *St. Roch* remained fairly sporadic until the 1970s.

In the period from 1945 to 1969, national security was the primary driver for navigation in the passage: the Canadian icebreaker *HMCS Labrador* became the first ship after the *St. Roch*, as well as the first armed Canadian ship to successfully complete transit of the NWP. Three years later, the *Labrador* escorted three U.S. Coast Guard icebreakers - *Storis*, *Spar* and *Bramble* - on part of the journey from west to east through the NWP.

From the 1969 voyage of the American oil tanker *Manhattan* (discussed later in this section) to the end of the 1980s, more than 30 complete transits of the passage were undertaken by a variety of vessels, as the focus shifted from national security to economic

Date	Event
Since time immemorial	Indigenous people are the original explorers, founders and settlers
325 B.C.	Greek astronomer / geographer / navigator Pytheas sails northward to Iceland
850 A.D.	The Vikings of Scandinavia sail northward and colonize Iceland
981	Viking, Erik 'the Red' Thorvaldson, sails westward and discovers Greenland. Vikings colonize southeastern parts of Greenland
11th century	Russian settlers and traders on the coasts of the White Sea, the Pomors, had been exploring routes in the region
1490	John Cabot first proposes existence of a NWP
1500's	Whalers explore from Baffin Island to Novaya Zemlya
1576	Martin Frobisher lands in what becomes known as Frobisher Bay
1596	William Barents discovers Spitsbergen and seeks NEP
1610-11	Henry Hudson expedition survives Arctic winter
1615	Robert Bylot, with William Baffin as pilot, explores Hudson and Baffin bays
1648	Cossack Semen Dezhnev sailed east from the mouth of Kolyma to the Pacific, thus proving that there was no land connection between Asia and North America
1726	First Northern Expedition, with Vitus Bering in command, discovers Bering Strait while seeking NEP
1733-43	The Great Northern Expedition takes place with Vitus Bering in command
1778	James Cook makes the first serious attempt at locating the NWP from the west
1831	John Ross reaches magnetic North Pole
1845	John Franklin's lost expedition proves existence of NWP
1854	Robert McClure receives the Admiralty's prize for 'discovering' the NWP
1878-79	Nordenskjold in the <i>Vega</i> becomes the first known vessel to achieve a transit of the NEP
1893	Fridtjof Nansen's ship <i>Fram</i> proves the existence of Arctic current
1903-06	Roald Amundsen in the <i>Gjoa</i> successfully completes the first transit of the NWP by ship
1932	Soviet expedition led by Otto Schmitt was the first to sail in one season transit the NSR
1940-42	Henry Larsen in the <i>St. Roch</i> was the second vessel to transit the NWP, the first to do so from west to east
1944	<i>St. Roch</i> is the first vessel to make a one-season transit (in only 86 days going east to west)
1977	<i>Arktika</i> is the first surface vessel to reach the North Pole

■ **Table 3.1** Significant early history of Arctic marine transport. *Source* AMSA

The first European Arctic explorer was the Greek navigator Pytheas who sailed northward in 325 B.C.

development. The bulk of the transits were Canadian vessels involved in the search for hydrocarbon resources offshore in the Canadian shelf in the Beaufort Sea. Also included in the period were tankers carrying fuel for the various explorations and bulk carriers transporting ore from the Nanisivik mine on Strathcona Sound. The year 1993 saw the Government of Canada spearhead an initiative bringing together various international shipping companies and Arctic coastal states in an attempt to develop a shared set of international standards that could govern the operation and construction of vessels that would function in Arctic waters.

Growing population in the 21st century, together with increases in community re-supply and oil and gas development, has led to a greater demand for shipping in the region. The uncertainty of the NWP due to seasonality, ice conditions, complex archipelago, draft

restrictions, choke points, lack of adequate charts, insurance and other costs prohibits the likelihood of regularly scheduled trans-Arctic voyages; yet destination shipping is anticipated to increase incrementally in the Canadian Arctic. Although community growth will drive a steady increase in the demand for seasonal re-supply activity, the primary areas of increased activity will be resource-driven (See page 112).

Cold War Marine Activity: Construction of the DEW Line

The Distant Early Warning (DEW) Line was a linked chain of 63 communication and radar systems, spanning 3,000 miles - from Alaska's northwest coast to Baffin Island's eastern shore opposite Greenland - set up to detect incoming Soviet bombers during the Cold War. It was located entirely within the Arctic Circle, with 42 of the 63 sites situated on Canadian territory.

Between 1954 and 1957, the DEW Line was constructed, and more than 300 ships plied Arctic waters during the two summer navigation seasons carrying more than 300,000 tonnes of cargo. This initiative allowed access into the Canadian Arctic through three major sealifts: the West Coast Sea Lift, the East Coast Sea Lift and the Inland Sea Lift.

Hudson Bay Company Voyages

In terms of commercial shipping, the most impressive record of voyages in ice-infested waters, both in terms of length and its successes, is that of the annual voyages by the ships of the Hudson's Bay Company. For 243 years, from 1670 to 1913, 600 voyages were made from London, England, to trading posts in Hudson Bay, Canada. Of the ships involved in the 600 voyages, 18 were wrecked (the majority of these was not sunk by ice; most either ran aground or foundered in open water). In 1912, the steel-hulled steamer *Nascopie*, which sailed out of Montreal, replaced the ships sailing annually from London. In her first year, the *Nascopie* ran aground in uncharted waters, underlining the achievements of the Hudson's Bay Company's earlier captains who safely made 582 voyages from London through the icy waters of Hudson Strait to its various posts in the Bay, and back.



39,251

Whaling voyages from 1610-1915.

Whaling

Undoubtedly the most massive, sustained activity in terms of Arctic marine shipping was that of whaling. Between 1610-1915, a little more than 39,000 voyages were undertaken in the Arctic in pursuit of the bowhead whale. This activity focused on four main areas: the Svalbard/Greenland Sea area, Davis Strait and Baffin Bay, Hudson Bay, and the Bering, Chukchi and Beaufort seas. The main participating nations were the Netherlands, Germany, Britain and the United States.

This activity was pursued mainly in ice-infested waters and the number of ships and men lost was extremely high. At the same time, the whaling industry resulted in the accumulation of a vast amount of specialized knowledge of patterns of ice distribution and of ship-handling in ice; knowledge upon which the Royal Navy, for example, capitalized by appointing usually two whaling captains as ice-pilots on board each of the vessels engaged in the search for the missing Franklin expedition in 1848-1855.

Table 3.2 Total Arctic Whaling Voyages

1610-19	242
1620-29	149
1630-39	178
1640-49	246
1650-59	487
1660-69	1007
1670-79	1558
1680-89	2522
1690-99	1518
1700-09	2175
1710-19	1944
1720-29	3001
1730-39	2336
1740-49	1996
1750-59	2419
1760-69	2339
1770-79	2341
1780-89	2104
1790-99	1385
1800-09	865
1810-19	1255
1820-29	1155
1830-39	647
1840-49	401
1850-59	1654
1860-69	1532
1870-79	781
1880-89	390
1890-99	351
1900-09	229
1910-15	44
Total	39251

Many of the ships lacked ice-capability, a fact that often resulted in shorn propeller blades and hull punctures. Beyond retroactive measures, such as adding a nickel-aluminum-bronze alloy propeller or steel sheathing, the American Military Sea Transportation Service engaged in a construction program that saw the building of ships designed specifically for operation in an Arctic environment. A new class of tankers included construction features that were standard for Arctic vessels, such as cargo booms and a secondary wheelhouse.

Largely as a result of American interest in the North, Canada was driven to acquire icebreakers and cultivate a greater navigational ability in Arctic waters. Increases to Canada's Arctic vessel capacity, in the early-to-mid 1950s, took the form of the *CGS d'Iberville* (1952) and the *HMCS Labrador* (1954).

The U.S. fleet was split into two task forces. The first - with three icebreakers, a pair of tankers, 27 cargo ships and nearly two-dozen support craft - sailed east and around Point Barrow, bringing with it supplies that would be delivered to the Northern Transportation Company. The second and larger task force comprised seven icebreakers, a dozen tankers, 14 support vessels, four passenger ships and 31 cargo ships. In 1957, the U.S. Coast Guard sent three icebreakers on a complete transit through the passage with partial Canadian icebreaker support, in a successful attempt to gauge whether ships could escape to the east when iced-in on the west.

Cold War operations, especially the creation of the DEW Line, played a unique role in Arctic shipping. Knowledge gained - from design modifications, crew competency, vessel maneuverability in ice, infrastructure and governance concerns - continues to be expanded upon.

Manhattan

The *SS Manhattan* became the first commercial ship to break through the NWP. Even though the *Manhattan* carried no cargo on the initial NWP voyage (the tanks were filled with water to simulate loading), the ship picked up a symbolic barrel of oil in Alaska, returning to New York a merchant hero. The voyage prompted passionate discussions in Canada about sovereignty, followed by the passage of the *Arctic Waters Pollution Prevention Act* (AWPPA). Information gleaned from the two *Manhattan* Arctic voyages - test trials in ice - proved extremely valuable to future icebreaking designs (See page 40).

The discovery of a major new oil field on Alaska's North Slope at Prudhoe Bay in the spring of 1968 signaled the start of a new era of oil transportation technology. Two of the three

The Manhattan was successful as a large model test ship, as the vessel broke thicker ice than any ship in history.

companies involved, ARCO and BP, intended to build a pipeline over Alaska's Brooks Range to deliver the crude to an ice-free port in Valdez for tanker shipment south. But because of traditional tanker "flexibility credits" and the possibility of delivering crude direct to both U.S. west and east coasts, a small group in the third company, Humble Oil and Refining (now ExxonMobil) persuaded parent company Standard Oil of New Jersey, to make a study of icebreaking tankers.

In 1969, four shipyards, an international team of maritime experts and three major oil companies pitted their considerable technical, creative and financial resources together to attain the goal of taking a tanker through the infamous NWP. For this voyage the *Manhattan* had to undergo extensive refit to convert this merchant vessel into an icebreaking tanker. The conversion, lasting eight months (from December 1968 to August 1969) with work being split among four shipyards, cost \$US28 million (the entire experiment, with two test voyages originally estimated at \$US10-15 million, eventually ended up, 21 months later, costing \$US58 million).

The *Manhattan* set sail in August of 1969 with 126 on board (45 crew members, journalists, U.S. politicians, Canadian parliamentarians, scientists, naval architects, marine engineers, etc.) for the 4,400-mile journey. Of key importance and significance were the escorting icebreakers accompanying the *Manhattan*, especially the Canadian icebreakers *John A. MacDonald* and later the *Louis S. St. Laurent*. In this voyage the *Manhattan* was successful as a large model test ship, as the vessel broke thicker ice than any ship in history.

In its second voyage the following April, the multi-year ice was so tough that the ship couldn't enter the passage but went instead to Pond Inlet where further icebreaking tests were carried out. Following the two voyages, a model of the *Manhattan* was built and tested in Wartsilla's new ice model basin in Finland. Built specifically to support the *Manhattan* voyage, the basin opened the door for ice technology exchange between Soviet and Finnish scientists, a lesser-known part of the *Manhattan* legacy.



Map 2.1 The route followed by the SS *Manhattan*. Source: AMSA

Lessons Learned from the *Manhattan* Voyage

What had clearly been learned in the 1969 voyage were several basic Arctic icebreaking truths:

- A large mass moving at decent speed (our "model") could break very tough multi-year ice and ridges, but it would need real backing power to prevent getting stuck, an absolute "must" if un-escorted tankers were to succeed.
- Maneuverability in ice is very difficult for a "parallel body" merchant ship shape even with bow bulges.
- Geared steam turbine machinery with new propellers and shafts could withstand the severe shocks that broken ice floes going through the propellers often caused.
- In near "open" water conditions, growlers and bergy bits were able to cause major structural damage in non-reinforced parts of the ship's hull.
- Success of icebreaking tankers would be very much in the hands of a ship's crew, even with reconnaissance by aircraft and side-looking radar, to find preferable routes through the ice.

Most important was the conclusion supported by all who participated in the *Manhattan* voyage was that it is technically and economically feasible to use non-escorted large icebreaking merchant ships for the routes explored, and most likely also for the Northern Sea Route.



M/V Arctic

Within the same time period as Beaufort Sea activity, another important Arctic marine story, that of *M/V Arctic*, was taking place. The *M/V Arctic* was built in 1978 at a shipyard on the Great Lakes, and subsequently has a relatively narrow maximum allowable beam of 22.9 meters as required for passage through the Great Lakes lock system. Coupled with a required deadweight and draft limitation, this resulted in a 38,500 ton vessel having a rather high length to beam ratio of 9.2. This is far from ideal for an Arctic vessel, since it limits maneuverability in close ice. However, the ship is still a workhorse in the Canadian Arctic, more than 30 years later. The *M/V Arctic's* operations have mostly been stand-alone, with no dedicated icebreaker support, as is the commercial Canadian Arctic marine tradition. The ship was upgraded extensively in 1986 with a new flat Melville bow and increased hull strength. The original geared diesel,

deeply immersed, single ducted CPP propulsion system was unaltered. These modifications allowed *M/V Arctic* to extend its operating field and season. The ship serviced the Nanisivik and Polaris mines in the high Arctic for nearly 20 years until 2002, and then the Raglan mine in northern Quebec and Voisey's Bay mine in Labrador. The ship also transported the first Arctic oil to market from Bent Horn on Cameron Island in 1985 and continued that operation until 1996.

Research and development has been constant through many projects over the years, and for three decades the ship has provided valuable ship performance data on vessel design, hull strength and trafficability. Of particular importance to future Arctic transportation, *M/V Arctic* has always been a test platform for the development of advanced ice navigation systems that have integrated the latest remote sensing technologies with bridge navigation equipment.

The Great Northern Expedition

In Russian history, the Great Northern Expedition refers to a wide enterprise initially conceived by tsar Peter I the Great. The tsar had a vision for the 18th century Russian navy to map the Northern Sea Route to the East. This vast and far-reaching endeavor was sponsored by the Admiralty College in St. Petersburg. In 1725, Russian explorers under the leadership of Captain Vitus Bering, a Dane serving in the Russian navy, made the first expedition voyage on *Sviatoy Gavriil* starting in Kamchatka and going north to the strait that now bears his name.

The major sailing of the Great Northern Expedition was undertaken between 1733 and 1743 through a series of voyages led by Aleksei Chirikov. The goal of the expedition was to find and map the eastern reaches of Siberia, and to hopefully continue on to the western shores of North America to map them as well.

The important achievements of the expedition included the discovery of Alaska, the Aleutian Islands, the Commander Islands and Bering Island; as well as a detailed cartographic assessment of the northern and northeastern coast of Russia and the Kuril Islands. The expedition also refuted definitively the legend of a land mass in the north Pacific. It also included ethnographic, historic and scientific research into Siberia and Kamchatka. When the expedition failed to round the northeast tip of Asia, the dream of finding an economically viable Northeast Passage, alive since the 16th century, was at an end.

With more than 3,000 people directly and indirectly involved, the Second Kamchatka expedition was one of the largest expedition projects in history. The total cost of the undertaking, completely financed by the Russian state, reached the estimated sum of 1.5 million rubles, an enormous amount for the period. This corresponded to one-sixth of the income of the Russian state for the year 1724. Because of its complexity and scale, the voyages became known as the Great Northern Expedition.

Despite the extreme hardships and numerous deaths, mainly from scurvy, the Great Northern Expedition represented a remarkable accomplishment in terms of organization, perseverance and courage. More so, it resulted in an outstanding compilation of knowledge. In tangible terms, the expedition resulted in 62 maps and charts of the Arctic coast and Kamchatka. It is interesting to contrast the general chart of the Russian Arctic resulting from the Great Northern Expedition with what was known of the Arctic coast of North America at the same date (by then William Baffin's voyage round Baffin Bay had largely been forgotten or discredited and the only part of the Arctic coast reliably known and charted was that of the Hudson Bay and Strait).



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The quest for a new route to reach China and India from the Atlantic via north of the Russian coastline spanned more than five centuries, beginning in the 15th century with English, Dutch and Russian navigators.

Northeast Passage

The quest for a new route to reach China and India from the Atlantic via north of the Russian coastline spanned more than five centuries, beginning in the 15th century with English, Dutch and Russian navigators sailing along the northern coast of Russia and far into the Arctic seas.

Early explorers of the area included Willem Barents and Olivier Brunel. Under the auspices of the Russian tsar Peter I the Great, Semyon Dezhnev is likely to have sailed the region in 1648 and Vitus Bering is known to have sailed northward through the Bering Strait in 1728.

In Russia, the idea of a possible seaway connecting the Atlantic and the Pacific was first put forward by the diplomat Gerasimov in 1525. However, Russian settlers and traders on the coasts of the White Sea, the Pomors, had been exploring parts of the route as early as the 11th century. By the 17th century they established a continuous sea route from Arkhangelsk as far east as the mouth of Yenisei.

In 1648, the most famous expedition, led by Fedor Alekseev and Semyon Dezhnev, sailed east from the mouth of Kolyma to the Pacific and doubled the Chukchi Peninsula, thus proving that there was no land connection between Asia and North America.

Eighty years after Dezhnev, in 1725, another Russian explorer, Danish-born Vitus Bering on *Sviatoy Gavriil* made a similar voyage

in reverse, starting in Kamchatka and going north to the strait that now bears his name. It was Bering who gave their current names to the Diomed Islands, discovered and first described by Dezhnev. Bering's explorations in 1725–30 were part of a larger scheme initially devised by Peter the Great and known as the Great Northern (or Kamchatka) expedition. The Second Great Northern Expedition took place between 1735–42. The Northeast Passage (NEP) was not traversed by anyone until Baron Adolf Erik Nordenskjöld of Sweden accomplished the feat in 1878–79 aboard the *Vega*.

Coupled with the ongoing search for a NEP, voyages using the Kara Sea route to Western Siberia played a pivotal role in Arctic marine transport. Two expeditions achieved transits of a substantial part of the NEP, including Fridjof Nansen's *Fram* (1893–1896) and the Baron Eduard Toll expedition on board *Zarya* (1900–1903). *Maud*, commanded by Roald Amundsen (1918–1920), was the fourth ship to complete a transit of the NEP and, as a result, Amundsen achieved the distinction of being the first person to circumnavigate the Arctic Ocean, since he had now linked up with the track of his voyage in the *Gjoa*.

The first one-season transit route was not accomplished until 1934, when Glavsevmorput (Glavnoye Upravleniye Severnogo Morskogo Puti or GUSMP - Chief Administration of the NSR) mounted a successful attempt with the icebreaker *Fedor Litke*.



■ The crew of the *Fram*. Source: The National Library of Norway, Picture Collection

The Northern Sea Route

The Northern Sea Route, or NSR, stretching from the Kara Gate in the west to the Bering Strait in the east, was highly developed by the Soviet Union as an important national waterway, peaking in 1987 with 331 vessels on 1,306 voyages. The western end of the NSR (Kara Sea) has been maintained for year-round navigation since 1978-79 with ships sailing between Murmansk and Dudinka on a regular basis.

The history of commercial use of the NSR can be distinguished by four distinct stages: exploration and settlement (1917-1932); organization of regular navigation coupled with the development of fleet and ports (1932-early 1950s); transformation of the newly developed NSR into a regular operating transportation line during the summer-autumn periods (early 1950s-late 1970s); and finally, efforts to establish year-round shipping (late 1970s-present).

During the first stage, 1917-1932, the NSR was utilized for community re-supply, in addition to sporadic attempts at regional exploitation of resources such as furs, wood, fish, salt, coal, whaling and sealing. In 1932, a Soviet expedition led by Otto Yulievich Schmidt was the first to sail from Arkhangelsk to the Bering Strait in the same summer without wintering en route. The Northern Sea Route was officially open and exploitation began in 1935. Advanced Soviet navigational skills, technological capability and experience in ice navigation were unrivaled and traffic in the Arctic continued to grow. From 1917-1934 there were only two sinkings out of the 178 round-trip voyages across the Kara Sea to import finished goods to, and export timber from Igarka, along the Yenisei River in central Russia.

From 1932-1953, administration of the Russian Arctic marine activity rested with the Chief Administration of the Northern Sea Route (CANSR), a direct arm of the Council of Peoples Commissars of the Soviet Union, with its goal “to develop the NSR from the White Sea to the Bering Strait, to equip it, to keep it in good order, and to secure the safety of shipping along it.” Major additions were made to the Arctic fleet, which carried 100,000 to 300,000 tons of cargo annually and employed 40-150 ships per year.

In 1940, the German vessel *Komet*, an armed raider disguised as a merchant ship, was the first foreign ship in more than 20 years to be granted passage, and it was the last foreign transit for another 50 years. When the Soviet Union entered the war in 1941, the route became important for bringing Allied supplies into the country. In the four seasons of 1942-1945, 120 ships transported approximately 450,000 tons of relief supplies, which amounted to half the freight turnover for the NSR during this period.

In 1953 CANSR became a department under the Ministry of Merchant Marine in Moscow and for 17 years the infrastructure was improved to provide the capability for both summer and autumn shipping. In 1959, the Soviets launched the world’s first nuclear-powered surface ship, the icebreaker *Lenin*, extremely significant as it expanded the range of travel in isolated regions.

After CANSR became the Administration of the Northern Sea Route (ANSR) in 1970, the emphasis became year-round trafficability. By the 1978-79 season, the western end of the NSR achieved year-round navigation with ships sailing between Murmansk and Dudinka on a regular basis. Other landmark voyages during this era of Russian Arctic marine transport history include the 1977 voyage of the *Arktika* to the geographic North Pole and the first complete high latitude passage by the surface vessel *Sibir* in 1978. By the mid-80s, the total volume of traffic passages through the NSR amounted to 6.6 million tons annually.

The NSR was formally opened to non-Russian vessels in the summer of 1991, only a few months before the Soviet Union was dissolved. Several developments have occurred during this modern period of Arctic marine transport history: the creation of the NSR Administration, the commissioning of the International Northern Sea Route Programme, the formation of the Noncommercial Partnership for the Cooperation of the Northern Sea Route Usages, leasing cargo space aboard Soviet SA-15 icebreaker cargo carriers, great strides in developing fleet and port infrastructure, and the establishment of year-round navigation in the western part of the Arctic.

The NSR is a substantially shorter passage (35-60 percent savings in distance) for shipping between northern European ports and those of the Far East and Alaska than routes through the Suez or Panama Canals. The ANSR, responsible for the overall planning, coordination and execution of organizational and regulatory activities for marine operations, is working to strengthen the competitiveness of the NSR. The Russian fleet of the world’s most powerful icebreaking ships and special ice-strengthened ships for moving most types of cargo, highly developed infrastructure along the NSR and specialized ice navigation skills demonstrate that navigation along the NSR is technically feasible and that there is a cargo base for import, export and conceivably transit.

1991
The year the Northern Sea Route
was open to non-Russian ships.

Arctic Tourism


For most of European and American history, the many attempts to explore and occupy high latitudes were characterized by peril and tragedy. From 1576 onwards, numerous ventures into these cold, remote and icy places were conducted to obtain economic benefits and expand empires. All of the expeditions experienced hardships and many ships foundered and men perished in their attempts to penetrate these unknown seas and lands. By the 1800s, newspaper and book publications describing both the heroic and tragic aspects of polar exploits were immensely popular. Given these widely publicized descriptions of a bleak Arctic environment and the fatal demise of Arctic expeditions, it is remarkable that such a place would be attractive to tourists. But, in fact, tourists began visiting the Arctic in the early 1800s and their attraction to this unlikely destination has grown steadily for more than two centuries.

Arctic Tourism for the Masses

By the mid-1850s, the Industrial Revolution was far more than an economic phenomenon; it had transformed societies by creating personal wealth for greater numbers of people, increasing leisure time and improving public education. It introduced new technologies, especially transportation and communication, which facilitated convenient access to the remote parts of the world. One result of these transformations was the extraordinary expansion of tourism. The combination of widely distributed personal wealth, the invention of railroads and steamships with enormous passenger capacities and progressively affordable transport costs suddenly allowed thousands of people to travel for pleasure. By the late 1800s, tourism had become a viable leisure activity for the masses, rather than the indulgence of a privileged few.

By the late 1800s, steamship and railroad companies had achieved the capacity to transport large numbers of passengers. Given intense competition between those companies, travel costs were progressively lowered to attract customers and successfully compete. Simultaneously, companies aggressively expanded their transport networks to previously inaccessible regions, including the Arctic. All of those business decisions enabled more people to travel to more destinations.

In 1850, Arctic marine tourism by commercial steamship was initiated in Norway. By the 1880s, Arctic marine tourism was a booming business. Arctic destinations included Norway's fjords and North Cape, transits to Spitsbergen, Alaska's Glacier Bay and the gold rush sites as far north as Homer, riverboat cruises in the Canadian Yukon, and cruises to Greenland, Baffin Bay and Iceland. The tourist experience aboard the steamships was a mixture of exploration and luxury. Little known or recently discovered glaciers, bays, wildlife and indigenous communities attracted curious tourists led by Arctic explorers and naturalists. Shipboard life emphasized lavish meals, concerts

A large, jagged iceberg dominates the right side of the frame. In the background, a white cruise ship with a red stripe is visible. In the foreground, a black zodiac boat with several people in orange gear is moving across the water. The sky is clear and blue.

Given these widely publicized descriptions of a bleak Arctic environment and the fatal demise of Arctic expeditions, it is remarkable that such a place would be attractive to tourists.

468

Researchers and experts from more than 100 institutions in 14 countries – the numbers involved in the International Northern Sea Route Programme.

provided by orchestras, beauty parlors and barbershops, photography studios and lectures presented within library settings. All of the 19th century Arctic destinations were commercially successful and cruise ship companies have continued to operate and expand their itineraries throughout those and other Arctic regions for more than a century. In addition, the combined themes of expedition and luxury cruising have also persisted to the present time.

By 1900, Arctic tourism was a flourishing commercial activity. Its diversity included independent travelers pursuing a variety of adventurous recreation activities in marine and land environments, as well as groups touring natural, wildlife, historical and cultural attractions. All of these Arctic tourism activities were extensively promoted in guidebooks and the popular press. Companies specializing in guidebooks, such as John Murray and Baedeker, came into existence at this time. And travel literature encouraging mass travel regularly appeared in widely distributed periodicals such as Harper's Weekly, The Century Magazine and the National Geographic Society Magazine. From the mid-1800s onward numerous editions of Arctic guidebooks would regale the splendors of the Land of the Midnight Sun.

The economic benefits of the Arctic tourism industry were immediately evident to both private companies and Arctic governments. Tourism provided jobs, personal income, revenues and financial capital for infrastructure. It also represented a new way to use the Arctic's natural resources. It was a departure from the resource extraction and depletion industries such as hydraulic mining, rampant timber harvesting, and the exploitive commercial fishing and whaling practices of the 19th and early 20th centuries.

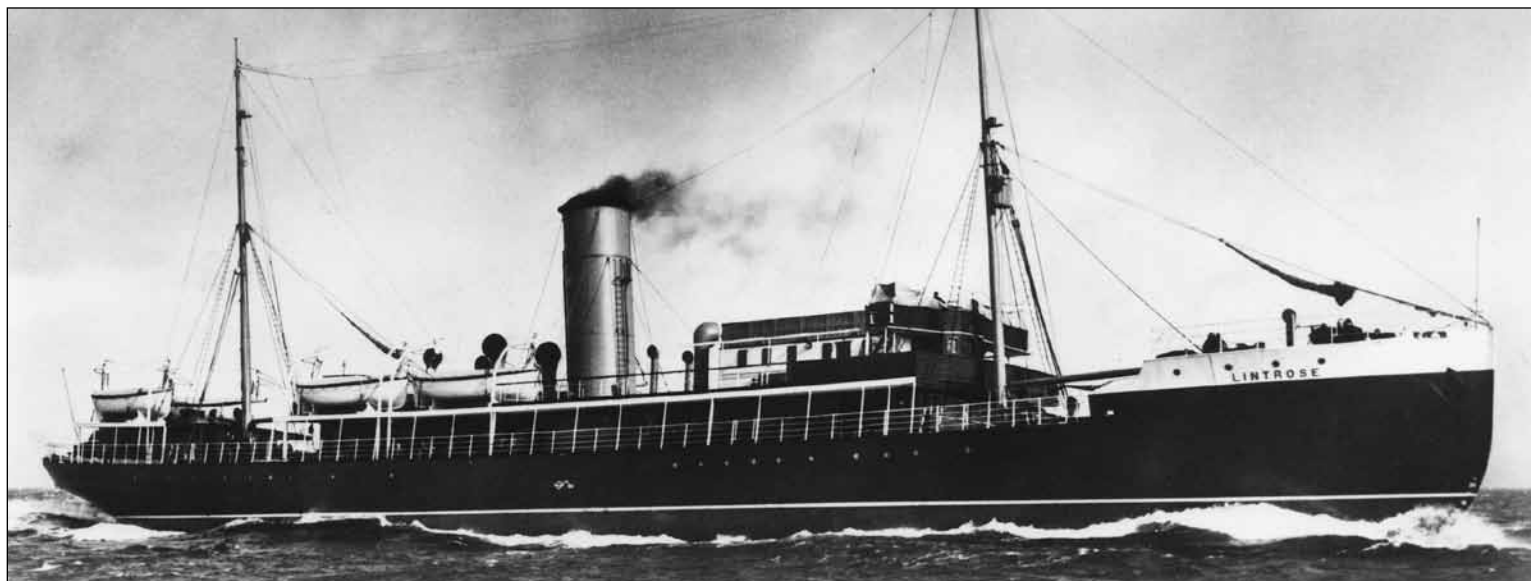
Major Arctic Marine Transport Programs, Studies and Workshops

Previous Arctic marine transport studies, workshops and reports contain a wealth of findings, recommendations and research agendas of significant importance to the AMSA and to any policy and regulatory framework for the future. Broad Arctic navigation studies, such as the 1993-1999 International Northern Sea Route Programme (INSROP), the 2001-2005 Arctic Operational Platform (ARCOP) and the 2002-2005 Japan Northern Sea Route-Geographic Information System (JANSROP-GIS) form a knowledge base on Arctic navigation in addition to localized findings such as the Alaskan trafficability studies. A summary of the 2004 Cambridge Workshop provides an intellectual synthesis of Arctic marine transport.

International Northern Sea Route Programme

The International Northern Sea Route Programme was the most comprehensive marine transport study ever undertaken prior to the AMSA, with the aim to create a research-based knowledge bank of commercial, international shipping on Russia's Northern Sea Route across the top of Eurasia in the Arctic Ocean.

The program was led and coordinated by three principal partners: the Ship and Ocean Foundation (SOF) of Tokyo, Japan; the Central Marine Research and Design Institute (CNIIMF) of St. Petersburg, Russia; and the Fridtjof Nansen Institute (FNI) in Oslo, Norway. The numbers involved are impressive: 468 researchers and experts from more than 100 institutions in 14 countries; 104 projects; an experimental voyage through the NSR; two large international conferences.



Historic photo

Growing population in the 21st century, together with increases in community re-supply and oil and gas development, has led to a greater demand for shipping in the region.

This work produced 167 peer reviewed working papers and a large number of articles and books governing almost every relevant aspect of shipping on the NSR. Funding was provided by the Nippon Foundation, Ship and Ocean Foundation, both from Japan, as well as various Norwegian sponsors and the Soviet Union.

It was acknowledged that the international shipping industry would need information and analysis before committing investments or vessels to the previously unknown route. On the initiative of the Soviet Ministry of Merchant Marine, contact was made with FNI to create an international research project, with St. Petersburg-based CNIIMF coordinating on the Soviet side. A pilot study was produced in 1990-1991. In 1992, SOF joined the partnership, and in May 1993 the three organizations signed an agreement establishing a secretariat at the Fridtjof Nansen Institute in Norway to coordinate the effort.

INSROP was designed as a multi-national, five-year effort, to be executed in two phases with a review conducted after three years. Four sub-programs were identified: 1) Natural conditions and ice navigation; 2) Environmental aspects; 3) Trade and commercial shipping factors; and 4) Political, legal and strategic aspects. In August 1995, a successful experimental transit voyage was conducted from Yokohama, Japan to Kirkenes, Norway onboard the Russian ice-strengthened carrier *Kandalaksha*, demonstrating the NSR's technical feasibility.

In 1999, final findings of INSROP were presented at an NSR user conference in Oslo, Norway, bringing to a close the massive research project. It took years of diplomatic networking, negotiations and lobbying to shape the program and to obtain funding. It was often difficult to bridge language and cultural gaps between the three principal partners - the Japanese, the Norwegians and the Russians - who often maintained different priorities and varying business practices.

INSROP demonstrated that navigation along the NSR was technically feasible, with a cargo base for export, import and conceivably transit. INSROP also noted challenges to overcome. INSROP did not include research on climate change and how ice conditions might eventually enable large scale shipping.

A wealth of new and unique knowledge on the Russian Arctic was produced and made available to the international community. INSROP also pioneered cooperation between Russian and foreign researchers in Arctic-related fields, and created a platform for further Arctic multidisciplinary studies.

Research Opportunities

- ❑ Extraction of sea ice data from historical journals and log books from Arctic exploring and whaling ships.
- ❑ Comprehensive study of the history, design evolution and use of icebreakers.
- ❑ Regional and local studies with mapping of the multiple uses (indigenous, commercial & government) in Arctic waterways.
- ❑ Develop a comprehensive database of damages to ships operating throughout the Arctic Ocean for use in risk assessments; develop, where possible in the historic record, detailed cause & effect reviews of each damage case.
- ❑ Comprehensive review of changes in Arctic marine technology during the past six decades, specifically for Arctic commercial ships, and how these changes may influence the future of Arctic marine transport systems.

U.S. Trafficability Studies of 1979-86

With the advent of offshore oil and gas leases in the 1970s, studies were required to assess the feasibility of year-round marine transportation in ice-covered waters of the Alaska Arctic, yet no amount of analytical modeling or studies without actual field data could provide the information and insight needed. Therefore, the U.S. Maritime Administration (MARAD) embarked on a multi-year program (1979-1986) to:

- Demonstrate the operational feasibility of commercial icebreaking ships along possible future Arctic routes;
- Define environmental conditions along routes in the Bering, Chukchi and Beaufort seas; and,
- Obtain data to improve design criteria for ice-capable ships and offshore structures.

To assess the feasibility of commercial icebreaking ships along possible future Arctic routes, two U.S. Coast Guard *Polar Class* icebreakers, the *Polar Star* and *Polar Sea*, the world's most powerful non-nuclear icebreakers and the only U.S. ships capable of mid-winter Arctic operations, were utilized as data collection platforms. During the eight-year research program, 15 icebreaker deployments occurred aboard the icebreakers and 14 of those were in the Alaska Arctic. General ship performance of trafficability data was continuously collected and summarized in 30-minute increments whenever the icebreakers changed locations.

Two dedicated transits (1981, 1983) from the south Bering Sea to the north Chukchi Sea were designed to simulate, as best as possible, a non-stop transit from the ice edge to northern Alaska. These voyages indicated that routing in the future could be around both ends of St. Lawrence Island and refuted the views of some experts that transit through the Bering Strait was not feasible in winter.

Thousands of ice thickness measurements were made, resulting in the formulation of a representative set of ice conditions for an Alaska route; supplemented with tables that offer suggestions on changes to reflect mild and severe ice conditions and possible voyage delays due to pressured ice conditions. In addition, zones of ice severity for the Bering, Chukchi and Beaufort seas were developed to provide designers and operators with a strategic perspective on year-round Arctic marine transportation systems.

Several major projects were performed onboard the icebreakers to aid in the development of advanced icebreaking hull forms and Arctic commercial vessels capable of year-round operations. The resulting analysis from eight years of data collection made a significant contribution to the knowledge of ice loads and the structural design of all icebreaking ships.

With 15 voyages of data, the U.S. Arctic Marine Transportation Program of 1979-86 was one of the most extensive field tests of icebreakers in history and has provided a valuable knowledge base for future considerations and a model for future cross-border research initiatives. Briefly, key findings from the operational, environmental and technical data can be summarized as follows:

- Field data can provide the at-sea ground truthing of ship modeling/studies, which may help to reduce the perceived risks of year-round marine transportation in the Arctic.
- The offshore Bering, Chukchi and Beaufort seas are extremely dynamic and ship icebreaking activities must be able to cope with the ever-changing ice environment. The most critical elements for successful ice navigation are crew skills and applied technology.

Arctic Marine Transport Workshop: Cambridge University

Amid growing interest and concern over the rapid climate changes occurring in the Arctic, experts in Arctic marine transport and international marine safety, as well as researchers of sea ice and climate change, met at the Scott Polar Research Institute at Cambridge University in October 2004 to create a research agenda and identify critical issues related to the future of Arctic shipping.

Co-sponsored by the Institute of the North, the United States Arctic Research Commission and the International Arctic Science Committee, the international gathering included 54 maritime experts and representatives from 11 countries (United States, Canada, Russian Federation, Sweden, Iceland, Denmark, Norway, the United Kingdom, Finland, Germany and Japan).

The three-day workshop provided the opportunity to study the extraordinary retreat of Arctic sea ice and what that means to the Arctic Ocean as a potential waterway for marine operations. While each area of discussion produced suggested topics for scientific research and questions on policy issues that were incorporated in the conference report, a few crosscutting conclusions emerged:

1. An inter-disciplinary research agenda needs to include economic analysis, assessments, Law of the Sea, indigenous Arctic communities, core issues of conflict, marine safety and environmental protection, and climate change impacts on future marine access.
2. The magnitude of sea ice variability creates difficult challenges for Arctic marine transport planning and adequate risk assessment.
3. Arctic marine charts and aids to navigation need to be updated and airborne ice information enhanced with satellite coverage.
4. Two key factors are needed to expand and develop the use of the Arctic Ocean as a shipping corridor: route reliability and security. Increased Arctic shipping will require an increase in the monitoring and enforcement of national and international laws governing ship security.
5. Multiple economic drivers could fuel expanded use of Arctic marine transportation. Incremental expansion would result in an incremental growth in regional traffic. However, a decision by world shippers to use the Arctic Ocean as an alternate route would require large scale global investments of escort vessels, aids to navigation and staging ports to transfer cargo between ice-strengthened and non ice-strengthened ships.

The workshop identified that the retreat of Arctic sea ice may lead to several plausible futures for the Northern Sea Route, Northwest Passage and central Arctic Ocean, requiring further research, planning and cooperation, as well as consideration of future development of transshipment and port infrastructure. ☀

Findings

- 1] Despite attempts through history to make the Northwest Passage (NWP) a viable route between the east and west, the passage has not become the global trade route it was originally envisioned.
- 2] The Northern Sea Route (NSR) was highly developed during the Soviet Union era as an important national waterway facilitating Arctic marine transport. Notably, year-round navigation on the western NSR (i.e., from the port of Dudinka on the Yenisei River to Kara Gate) has been maintained since the 1978-79 winter season.
- 3] Field data can provide the at-sea ground truthing of ship modeling/studies, which may help to reduce the perceived risks of year-round marine transportation in the Arctic.
- 4] Icebreaking technology has been key to the development of Arctic marine transport in all regions of the Arctic Ocean.
- 5] Previous Arctic marine transport studies, workshops and reports contain a wealth of findings, recommendations and research agendas of significant relevance to AMSA and to any regulatory framework for the future.
- 6] Joint agency/ministerial research, public-private partnerships and international cooperation have been beneficial to tackling the many challenges of future Arctic marine transport systems.





GOVERNANCE OF ARCTIC SHIPPING

The governance of shipping activities in the Arctic might be described as a complicated mosaic. The Law of the Sea, as reflected in the 1982 *United Nations Convention on the Law of the Sea* (UNCLOS), sets out the legal framework for the regulation of shipping according to maritime zones of jurisdiction. Other international agreements address specific elements of shipping such as marine pollution prevention standards, ship safety, seafarer rights and qualifications and liability and compensation for spills. In addition, Canada and the Russian Federation have adopted special national legislation for ships operating in ice-covered waters within their EEZs. Descriptions of international law, including as reflected in the UNCLOS, are included for the benefit of the reader and are not intended to constitute interpretations.

A wide range of actors affect the law, policy and practice applicable to shipping in the Arctic. In addition to governments, ship-owners, cargo owners, insurers, port authorities, trade and labor union associations, among others, may be involved in determining when and where shipping in the Arctic should occur and under what conditions.

Governance of shipping is characterized by efforts to promote safety, security, protection of the environment from damage by accident, as well as harmonization and uniformity in international maritime law and standards. The International Maritime Organization (IMO), a specialized agency in the United Nations system, addresses a broad range of issues pertaining to international shipping, including maritime safety, security and environmental protection. Other intergovernmental organizations work closely with the IMO in the governance of international shipping. For example, the International Labour Organization (ILO) has played a seminal role in the establishment of minimum basic standards for seafarers' rights.

The IMO acts as secretariat for most international maritime conventions and facilitates their implementation through the adoption of numerous codes and guidelines aimed at operationalizing and facilitating the implementation of international rules and standards. International conventions and related protocols become binding only on those states that choose to become parties. Upon ratification of a convention, states must formally implement it into their national maritime regulatory regime. States can, however, legislate

the provisions of a convention or protocol without necessarily becoming a party.

An explanation of the governance of shipping would not be complete without noting the critical role played by standard form contracting and related “good practices” developed by industry. For example, in contracts for carriage by sea the carrier must prepare against foreseeable risks and provide a seaworthy ship for the voyage, which must be pursued without deviation or delay and with due care for the cargo or passengers. These standard forms have been recognized and applied by courts around the world.

Law of the Sea, as reflected in UNCLOS: The Overarching Legal Framework

The Law of the Sea, as reflected in UNCLOS, has struck a balance among the powers of coastal states, flag states and port states to exercise jurisdiction and control over shipping. The jurisdictional status of some Arctic waters, in particular internal waters and straits used (or potentially to be used) for international navigation, remains controversial and could give rise to future disputes concerning the exercise of national jurisdiction over international navigation through those waters.

Coastal State Jurisdiction and Control

For coastal states to claim maritime zones in the Arctic in accordance with UNCLOS, they must have coastal frontage in the region. Of the eight Arctic states, Canada, Denmark (Greenland), Norway, the Russian Federation and the United States have coastal frontage in the Arctic Ocean. Iceland has coastal frontage on the Norwegian Sea and Finland and Sweden in the Baltic Sea.

The extent of legislative and enforcement control over foreign ships by the coastal states of the Arctic Ocean varies according to the different maritime zones set out in UNCLOS, namely: internal waters, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf (Table 4.1).

The seaward limit of the maritime zones and jurisdictions is based primarily on distance from a combination of the low-water marks along the coast, straight baselines and closing lines for bays. With the exception of the United States, the Arctic Ocean states have proclaimed straight baselines along most or all of their Arctic coasts. Table 4.1 sets out the limits of jurisdictional claims by Arctic Ocean coastal states.

For internal waters, coastal states are entitled to exercise full sovereignty and maximum jurisdiction over ships and can, pursuant to that authority, set conditions for entry into its ports. For example,

Arctic States	Territorial Sea		200 nm Zones		
	3 nm	12 nm	EEZ	Extended Fisheries Protection	Fisheries Protection
Canada		√	√		
Denmark (Greenland)	√		√		
Iceland		√	√		
Norway		√	√		
- Jan Mayen		√		√	
- Svalbard		√			√
Russian Federation		√	√		
United States		√	√		

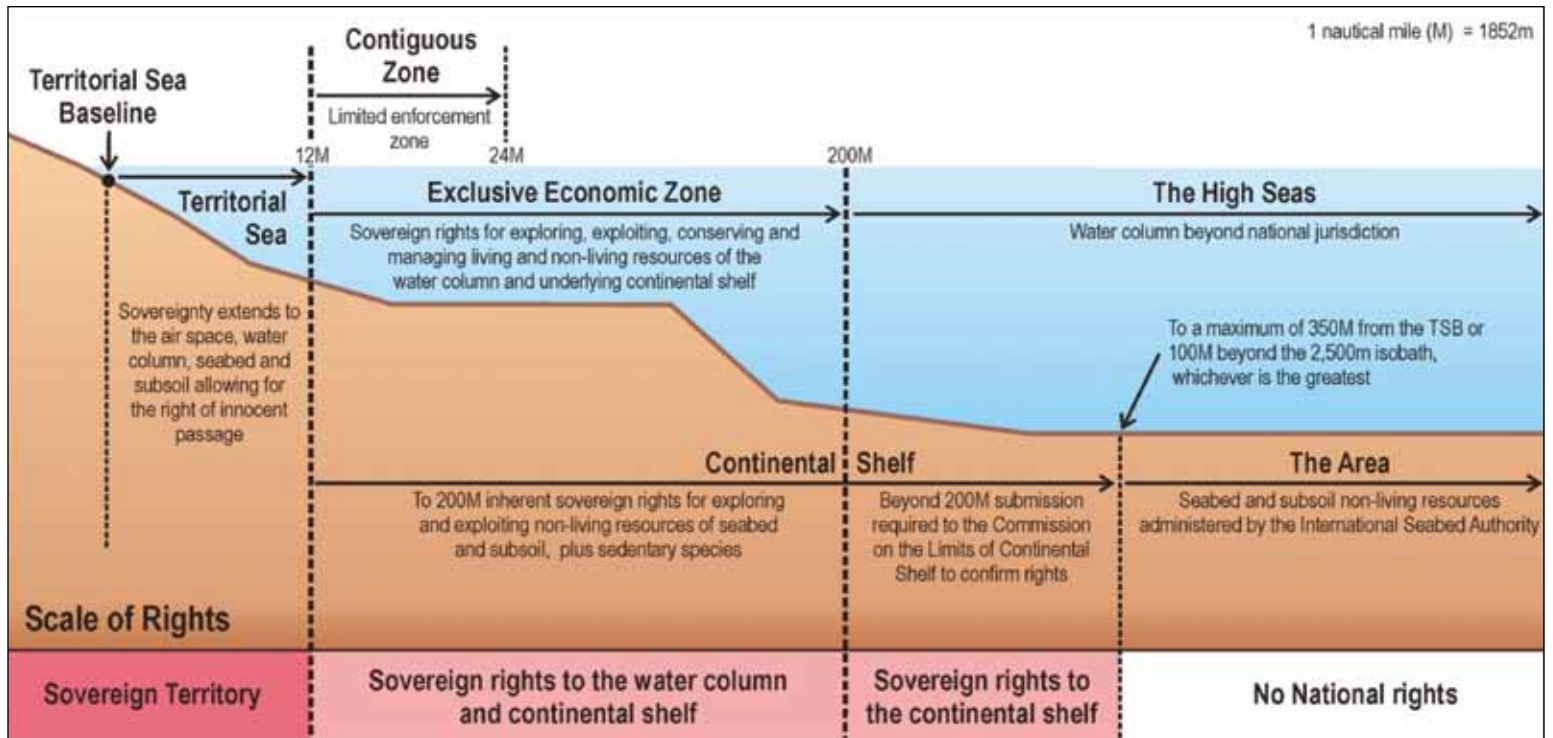
■ **Table 4.1** Arctic coastal state maritime jurisdictional zone claims. *Source: AMSA*

coastal states might prohibit entry of certain “risky ships”, such as substandard ships or those carrying radioactive wastes or other hazardous cargoes, or they might impose “zero discharge” limits on particular ship-source pollutants. The only likely constraint on the exercise of this power is the traditional and customary duty to grant refuge in sheltered waters to a ship in need of assistance.

Internal waters include marine areas on the landward side of closing lines for bays, ports and harbors and historically recognized internal waters. A coastal state may also choose to draw straight baselines around a deeply indented coastline or where there is a fringe of islands in the immediate vicinity of the coast. Waters enclosed would be internal. UNCLOS sets forth the rules on setting baselines.

Exactly which Arctic waters may be claimed validly as internal has been contentious. For example, Canada enclosed its Arctic archipelago with straight baselines, effective January 1, 1986, but the United States and other states protested against the internal waters status claim.

Within the limit of the 12 nautical miles that may be claimed for the territorial sea, Arctic coastal states have full sovereignty, but foreign ships retain the right to innocent passage; that is, passage which is continuous and expeditious, and is not prejudicial to the peace, good order or security of the coastal state. For example, undertaking research or surveys or fishing without the coastal state’s



■ **Illustration 4.1** Illustration of maritime zones (for illustrative purposes only). Source: Geoscience Australia

consent, or engaging in an act of serious and willful pollution in contravention of UNCLOS would be considered prejudicial to the interests of the coastal state.

UNCLOS allows coastal states the authority to adopt laws and regulations applicable to foreign ships transiting through the territorial sea. Domestic laws can be applied in relation to such things as safety of navigation, preservation of the marine environment and marine pollution control. There are two limits on this authority; namely, that coastal states cannot impose design, construction, crewing or equipment standards on foreign ships unless giving effect to generally accepted international rules or standards; and that such laws may not have the practical effect of denying or impairing the right of innocent passage. Coastal states may also, having regard to the safety of navigation, designate sea lanes and traffic separation schemes for foreign ships. However, the coastal state must take into account IMO recommendations and any channels customarily used for international navigation. They may not impose a charge on the passage itself; only specific fees for services rendered may be charged and without discrimination.

Coastal states may also claim a 12 nautical mile contiguous zone adjacent to the territorial sea (i.e., up to a seaward limit of 24 nautical miles). In this zone, coastal states may exercise necessary control over foreign ships to prevent infringement and to enforce

violations of customs, fiscal, immigration or sanitary laws and regulations in their territory or territorial sea.

In a 200 nautical mile exclusive economic zone (EEZ), measured from the territorial sea baselines, coastal states have sovereign rights to explore, exploit, conserve and manage their natural resources, and jurisdiction over such things as protection of the marine environment. In part XII of UNCLOS, the issue of coastal states' ability to regulate shipping for the purposes of pollution prevention and control laws is addressed, which is that laws and regulations applicable to foreign ships must conform or give effect to international rules and standards established through the IMO.

A coastal state has limited enforcement powers in the EEZ against transiting foreign ships violating applicable international rules and standards for preventing and controlling pollution. A coastal state may only undertake physical inspection of a foreign ship where a violation has resulted in a substantial discharge causing or threatening significant pollution of the marine environment. Actual arrest and detention of a foreign ship is only allowed if a violation causes major damage or a threat of major damage to the coastline, interests or resources of the coastal state. In such a case, the coastal state may only impose monetary penalties.

UNCLOS defines the continental shelf of a coastal state as comprising the seabed and subsoil of the submarine areas beyond the

territorial sea to the outer edge of the continental margin, or to at least 200 nautical miles from coastal baselines where the outer edge of the continental margin does not extend to that distance. A coastal state with a continental shelf extending beyond 200 nautical miles has 10 years from the time the convention enters into force for that state to make a submission to the Commission on the Limits of the Continental Shelf. The limits of the continental shelf established by a coastal state on the basis of the recommendations of the commission shall be final and binding. While the coastal state's rights to the resources of the extended continental shelf are exclusive, the waters above the extended continental shelf are high seas. Therefore, the coastal state has no jurisdiction over foreign ships in those waters with very few exceptions (for example, where a foreign ship is undertaking exploration activities on the continental shelf without its consent.) The coastal state may locate artificial islands, installations or structures on an extended continental shelf and include safety zones that are consistent with international standards. However, it may not establish them where interference may be caused to the use of recognized sea lanes essential to international navigation.

Coastal states bordering a strait used for international navigation retain very limited powers over foreign ships because of their right to transit passage. States bordering straits cannot suspend passage and may only adopt ship-source pollution laws applicable to foreign ships if in accordance with international standards. Sea lanes and traffic separation schemes may be designated, but only with IMO approval. A ship exercising transit passage may do so in its "normal mode," a phrase taken to mean that a submarine may remain submerged, whereas in innocent passage it must navigate on the surface and show its flag.

UNCLOS does not specify the extent of international navigation required to transform navigable waters into a strait used for international navigation. National opinions have differed over the application of the straits used for an international navigation regime in the Arctic.

Article 234 of UNCLOS bolsters coastal state powers to regulate foreign shipping in order to prevent, reduce, and control marine pollution in the Arctic. It recognizes the coastal state's right to adopt and enforce special non-discriminatory pollution prevention, reduction and control laws in areas within the limits of the EEZ that are covered by ice for most of the year, when certain conditions are met. Additionally, the coastal state's laws and regulations must have due regard to navigation, protection and preservation of the marine environment and be based on the best available scientific evidence.

Article 234 raises various questions of interpretation. What is required to meet the litmus of "ice covering such areas for most of the year?" For example, will even partial ice cover suffice if there is



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an exceptional hazard to navigation? What is the significance of giving special coastal state powers only in the EEZ? One interpretation is that coastal states are given no greater powers than those applicable in the territorial sea. Another is that coastal states are granted broader powers, in particular the right to unilaterally adopt special ship construction, crewing and equipment requirements. Application of Article 234 to straits used for international navigation may also be questioned. Since UNCLOS does not exempt straits from the application of Article 234, questions of interpretation may again rise over the geographical scope of coverage and the breadth of coastal state regulatory powers.

Flag State Jurisdiction and Control

Flag states play a vital role in the governance of shipping. UNCLOS permits a state to fix conditions for granting its nationality (i.e., flying its flag) to ships so long as there exists a "genuine link." Ships can only sail under the flag of one state at a time. The flag state's domestic laws, for example, criminal law, apply to those aboard its ships. A flag state must also ensure that its ships conform to international rules and standards concerning matters such as safety at sea, pollution control and communication regulations. On the high seas, the flag state is granted exclusive jurisdiction with only limited exceptions.

It should be noted that the provisions of UNCLOS regarding the protection and preservation of the marine environment do not apply to any warship or other vessel owned or operated by a state and used, for the time being, only on government non-commercial service. However, each state must ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such vessels owned or operated by it, that such vessels act in a manner consistent, so far as is reasonable and practicable, with UNCLOS.

Port State Control

Under general international law, the port state has the authority to impose conditions for the entry of foreign ships into its ports. Under UNCLOS, when foreign ships are voluntarily in the port of another state, the host state has broad inspection and enforcement powers for pollution violations occurring not only in the port and internal waters, but also in the territorial seas and the EEZs of other coastal states when those states request the port state's assistance in enforcement. A flag state may also request the port state's assistance in relation to enforcement of pollution offenses on the high seas. A port state must comply with requests from other states for investigation of discharge violations. If a port state determines that a foreign ship is unseaworthy and threatens marine environmental damage, it may prevent the ship from sailing until the deficiencies are corrected.

Maritime Boundaries in the Arctic

To date, there are eight bilateral agreements delimiting maritime zone and continental shelf boundaries between the five countries that border the Arctic Ocean, in addition to unresolved boundary issues. Lack of clearly delimited maritime boundaries for territorial seas and EEZs is of potential concern for future shipping in the Arctic. Ship operators may face uncertainty over which national

shipping laws are applicable in a disputed zone, particularly with reference to laws and regulations adopted pursuant to Article 234 of UNCLOS and with regard to penalties and compensation for damage caused by ship-source spills. Unresolved maritime boundaries may also reduce opportunities to develop marine resources and expand shipping in the Arctic. This situation is, however, no different than in other maritime areas where maritime boundaries are not agreed.

High Seas

Trans-Arctic shipping across the high seas of the Arctic (i.e., beyond EEZs) raises other governance issues. Because a coastal state's authority to regulate foreign shipping does not extend to the high seas, transiting ships would only be subject to global shipping safety, environmental and security rules and standards adopted through the IMO and as may be applied by the flag states. Thus the adequacy of international shipping standards for Arctic conditions and the need to provide special protective measures for the Arctic high seas must be considered.



International Public Maritime Law Framework

Ships and their crews operating in the Arctic environment face unique risks. A significant body of international public maritime law has established safety, environmental and security rules and standards for international shipping and seafarers. Generally, the contents of IMO safety conventions are not specific to Arctic shipping. Nonetheless, many of the requirements, for example, double hulls for tankers and increased safety and communications equipment systems for passenger ships and cargo ships, will affect ships trading into or transiting Arctic waters. Not all applicable standards are mandatory. Whereas the provisions of the *International Convention on Safety of Life at Sea, 1974* (SOLAS), for example, are mandatory, the *2002 IMO Guidelines for Ships Operating in Arctic Ice-covered Waters* (Arctic Guidelines) only provide internationally accepted recommendatory guidelines. These guidelines, however, are under review by the IMO.

Maritime Safety Rules and Standards

For the most part, international safety standards for merchant shipping are formulated in the rules, codes and procedures adopted within the framework of SOLAS (Table 4.2). The convention specifies minimum safety standards for the construction, machinery, equipment and operation of ships. Flag states are responsible for ensuring compliance of their ships with SOLAS requirements, and certificates are prescribed as proof that this has been done. Using port state control, contracting states can inspect ships of other states on a non-discriminatory basis. Chapter V of SOLAS sets forth provisions of an operational nature including the maintenance of meteorological services for ships, the ice patrol service, routing of ships and the maintenance of search and rescue services. Chapter VII of SOLAS regulates the carriage and care of dangerous goods through the *International Maritime Dangerous Goods (IMDG) Code* and the carriage of liquefied natural gas (LNG) through the *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk Code* (International Gas Carrier Code). The IMDG Code may need to be reviewed for the purpose of identifying any dangerous goods that may be affected by extremely low temperature during transportation in the Arctic.

The American Bureau of Shipping and the Russian Maritime Register of Shipping recently announced they are jointly developing classification rules for Arctic LNG carriers. Ice-strengthening for LNG carriers focuses on hull, containment system, propulsion and propeller requirements.

Arctic States	Safety					
	COLREGS 1972*	SOLAS			SAR 1979*	Load Lines 1966*
		Convention 1974*	Protocol 1978*	Protocol 1988*		
Canada	✓	✓	-	-	✓	✓
Denmark	✓	✓	✓	✓	✓	✓
Finland	✓	✓	✓	✓	✓	✓
Iceland	✓	✓	✓	✓	✓	✓
Norway	✓	✓	✓	✓	✓	✓
Russian Federation	✓	✓	✓	✓	✓	✓
Sweden	✓	✓	✓	✓	✓	✓
United States	✓	✓	✓	✓	✓	✓

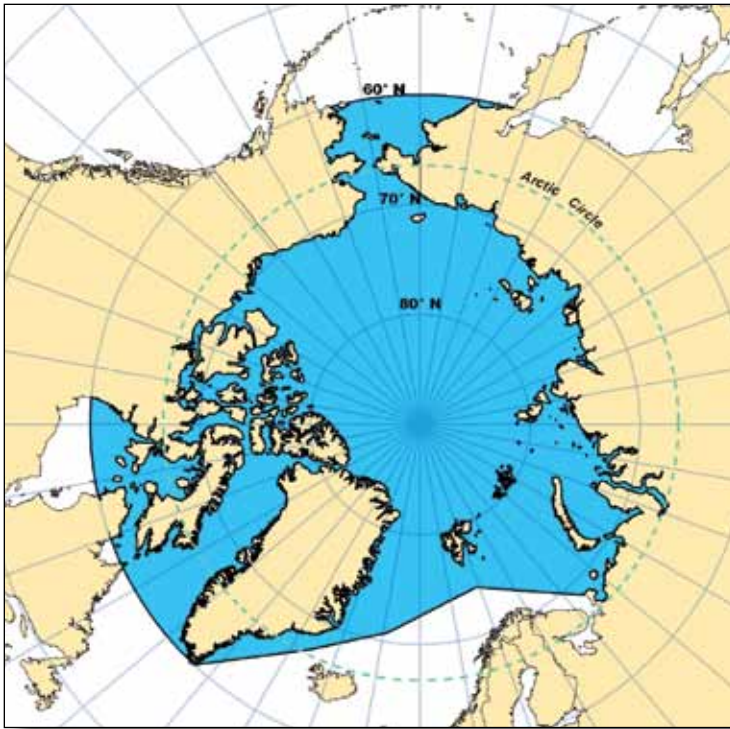
Abbreviations: (✓) = Ratification; (-) = Not Party; * = In Force (data as of October 10, 2008)

Table 4.2 Ratification of International Maritime Safety Agreements and Instruments. Source: AMSA

SOLAS also includes specifications for passenger ships. However, at this time there are no international construction requirements specific for cruise ships in polar operations. Cruise ships, which are not classed as ice-strengthened, may operate in the Arctic at certain times of the year and in areas of open water. The international cruise ship industry has initiated a Cruise Ship Safety Forum to develop design and construction criteria for new vessels and to consider other safety issues.

Additional non-mandatory industry standards for passenger ships have been adopted by the IMO. In January 2008, the IMO adopted *Guidelines on Voyage Planning for Passenger Ships Operating in Remote Areas*, also called the Arctic Guidelines. The Guidelines call for ships to develop detailed voyage and passage plans that include contingency plans for emergencies. Emergency contingency plans should be developed with reference to the IMO MSC/Circular 1184, *Enhanced Contingency Planning Guidance for Passenger Ships Operating in Areas Remote from SAR [Search and Rescue] Facilities*. This guidance document outlines extra steps that should be taken when passenger ships operate remote from SAR facilities, including keeping the appropriate authorities informed of the ship’s position and intentions while the ship is operating in the remote area. Consideration should also be given to voyage “pairing” (i.e., coordinating travel with another vessel

Map 4.1 Geographical scope of the 2002 IMO *Guidelines for Ships Operating in Arctic Ice-covered Waters* (Arctic Guidelines) (shaded area). Source: IMO Arctic Guidelines



to ensure emergency assistance), the carriage of enhanced life-saving appliances and the provision of additional life-saving resources.

The 1994 *International Safety Management Code* (ISM Code), adopted under Chapter IX of SOLAS, provides an international standard for safe management and operation of ships and for pollution prevention. The code calls on shipping companies to establish a safety and environmental protection policy (“safety management system”) that is both ship-based and shore-based. The safety management system should ensure compliance with mandatory rules and regulations, as well as industry standards, and is subject to certification by national maritime authorities and verification by both flag and port states. The ISM Code is applicable to ships operating in Arctic waters although its provisions do not deal with the special circumstances and operational hazards of Arctic navigation. As shipping activity increases in the region, express provision for safety management for ice navigation might need to be considered.

The voluntary Arctic Guidelines apply to ships covered by SOLAS, including passenger ships and cargo ships of 500 gross tonnage or more engaged in international voyages in ice-covered waters (Map 4.1). The Arctic Guidelines are additional provisions deemed necessary for consideration beyond existing SOLAS requirements. They provide the most comprehensive standards for ships in ice-covered waters, including construction, equipment and operational matters.

Polar Class	General Description
PC 1	Year-round operation in all Arctic ice-covered waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multi-year ice inclusions
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

Table 4.3 The Arctic Guidelines and the Unified Requirements, adopted by the International Association of Classification Societies, designate a system of *Polar Classes* for ships with different levels of capability and construction, structural and equipment requirements under various ice conditions. The Unified Requirements apply to ships of member associations constructed on or after March 1, 2008.

Source: IMO Arctic Guidelines

The Arctic Guidelines are structured in four parts. Part A provides construction, subdivision and stability in damaged condition recommendations for new *Polar Class* ships. The guidelines suggest a harmonized classification of *Polar Class* ships into seven categories according to intended ship operations and the level of ice in the area (Table 4.3). Ships should be able to withstand flooding resulting from hull penetration due to ice damage. No pollutants should be carried directly against the hull in areas of significant risk of ice impact. Operational pollution of the environment should be minimized by equipment selection and operational practice. Navigational, communications, safety-related survival and pollution control equipment should be appropriate for Arctic conditions.

Part B applies to *Polar Class* and non-*Polar Class* ships and includes recommendations on fire safety, fire detection and extinguishing systems, life-saving appliances and arrangements and navigation equipment in conformance with SOLAS, Chapter V. All *Polar Class* ships should be provided with an Automatic Identification System. *Polar Class* ships are encouraged to carry fully enclosed lifeboats. Other ships are urged to carry lifeboats having tarpaulins of sufficient size to provide complete coverage from environmental conditions.

Part C concerns ship operations, crewing and emergencies. Ships should carry operating manuals, as well as training manuals with relevant information concerning operations in ice-covered waters, including emergency procedures. Qualifications and training for crew and ice navigators are suggested.

Arctic States	Seafarers									
	ILO								IMO	
	C147 1976*	P147 1996 Protocol*	C163 1987*	C164 1987*	C166 1987*	C180 1996*	C188 2007	Maritime Labour 2006	STWC Convention 1978*	STWC-F Convention 1995
Canada	√	--	--	--	--	--	--	--	√	--
Denmark	√	√	√	--	--	√	--	--	√	√
Finland	√	√	√	√	--	√	--	--	√	--
Iceland	√	--	--	--	--	--	--	--	√	√
Norway	√	√	√	√	--	√	--	--	√	√
Russian Federation	√	--	√	--	--	--	--	--	√	√
Sweden	√	√	√	√	--	√	--	--	√	--
United States	√	--	--	--	--	--	--	--	√	--

Table 4.4 Ratification of International Marine Labor Agreements and Instruments. Source: AMSA

Abbreviations: (√) = Ratification; (--) = Not Party; * = In Force; C188 = Work in Fishing Convention; C180 = Seafarers' Hours of Work and the Manning of Ships Convention; C166 = Repatriation of Seafarers Convention; C164 = Health Protection and Medical Care (Seafarers) Convention; C163 = Seafarers' Welfare Convention; P147 = Protocol of 1996 to the Merchant Shipping (Minimum Standards) Convention; C147 = Merchant Shipping (Minimum Standards) Convention (data as of October 6, 2008)

Part D provides for environmental protection and damage control equipment, recognizing the navigational and environmental hazards and limited response capabilities for assistance in Arctic ice-covered waters. All ships navigating in Arctic ice-covered waters should be adequately equipped and their crews properly trained to provide effective damage control and minor hull repair, as well as containment and cleanup of minor spills.

traffic, COLREGS can be expected to assume greater importance.

The remoteness and harsh conditions present special search and rescue challenges in the Arctic. The *International Convention on Maritime Search and Rescue, 1979* (SAR Convention) provides for rescue coordination centers, ship position reporting systems and expedited entry of rescue units into the territorial waters of other states. Arctic state parties to the SAR convention shall coordinate SAR-incidents in their respective areas of responsibility and cooperate

The Arctic Guidelines have been criticized for various deficiencies. Criticisms include the lack of details or uniform international standards on training, failure to require actual ice navigational experience for ice navigators and limited provisions on prevention and mitigation of sea-spray icing of ships. Guidance about towage in ice-covered waters is also limited. The IMO recently agreed to revise the Arctic Guidelines and to extend their application to the Antarctic.

The *Convention on the International Regulations for Preventing Collisions at Sea, 1972* (COLREGS) sets out technical and seaman-ship rules for ships on the high seas and in all other waters navigable by seagoing vessels connected thereto, including bays, straits, territorial seas and EEZs. COLREGS applies to navigation in the Arctic, but it does not contain specific rules for ships navigating in ice-covered waters. COLREGS covers a situation where a ship is constrained in its ability to maneuver due to size, draft or other reason such as ice. However, the application of some rules may need to be considered with reference to ice navigation. With an extended Arctic shipping season and increased ship

The increased use of Arctic waters for tourism, shipping, research and resource development also increases the risk of accidents and, therefore, the need to further strengthen search and rescue capabilities and capacity around the Arctic Ocean to ensure an appropriate response from states to any accident. Cooperation, including on the sharing of information, is a prerequisite for addressing these challenges. We will work to promote safety of life at sea in the Arctic Ocean, including through bilateral and multilateral arrangements between or among relevant states.

~ Ilulissat Declaration, May 2008



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with each other as required. The IMO has established 13 major search and rescue areas around the world, within which coastal states have designated search and rescue regions.

The Global Maritime Distress and Safety System (GMDSS) facilitates maritime safety communications for merchant and passenger ships. The Arctic is “Sea Area A4” and extends to 90°N for GMDSS purposes. Canada, Norway and the Russian Federation plan to coordinate navigational and related maritime safety information in one or more designated navigational areas (NAVAREAs) by 2011.

Representatives from the five Arctic coastal states meeting in Ilulissat, Greenland, recently adopted a declaration reaffirming their commitment to work together through the IMO to strengthen existing measures and to develop new measures to improve the safety of maritime navigation and prevent or reduce the risk of ship-based pollution in Arctic waters. The Ilulissat Declaration recognizes the need to further strengthen search and rescue capabilities and capacity around the Arctic Ocean.

As international shipping increases in the Arctic, it should be expected that ships will be more frequently in need of assistance. There are, however, practical difficulties in finding and supporting suitable places of refuge for ships in the Arctic, even during the summer navigation months. The 2003 IMO *Guidelines on Places of Refuge for Ships in Need of Assistance* provide a risk assessment and decision-making framework for coastal state decision-makers, masters of ships and salvors when a ship needs refuge in sheltered coastal waters such as a port or a bay. The guidelines are not mandatory.

Many states have adopted places of refuge policies and/or designated such places, with the European Union requiring member states to designate places of refuge.

When a ship becomes a casualty and eventually sinks, it may continue to pose a hazard for navigation. Shipwrecks within and beyond the territorial sea will eventually be covered by the 2007 *Nairobi International Convention on the Removal of Wrecks*, which is not yet in force. Shipowners are responsible for locating, marking and removing ships, and must carry suitable insurance for this purpose.

Standards for Seafarers in the Arctic and Maritime Labor Law Issues

The Arctic presents a particularly hazardous work setting for those who must live and work under its extreme conditions. Both the IMO and the ILO set international standards for seafarers’ competence and their working and living conditions (Table 4.4). In addition, the World Health Organization (WHO) sets standards for seafarers’ health issues such as medical fitness for duties and requirements for on-board medical supplies. Most international standards are directed to flag states and apply to ships undertaking international voyages, although some requirements are directed to countries in their capacity as maritime labor supply states.

The IMO addresses seafarer competency and training and other safety matters for both ship and crew through the *International Convention on Standards of Training, Certification and Watchkeeping*

Arctic States	Environment												
	London		MARPOL 73/78					Salvage 1989*	OPRC		Anti-fouling 2001**	Ballast Water 2004	Wreck Removal 2007
	London Convention 1972*	Protocol 1996*	Annex I/II*	Annex III*	Annex IV*	Annex V*	Protocol 1997 (Annex VI)*		Convention 1990*	OPRC/NHS 2000			
Canada	√	√	√	√	-	-	-	√	√	-	-	-	-
Denmark	√	√	√	√	√	√	√	√	√	-	√	-	-
Finland	√	-	√	√	√	√	√	√	√	-	-	-	-
Iceland	√	√	√	√	-	√	-	√	√	-	-	-	-
Norway	√	√	√	√	√	√	√	√	√	-	√	√	-
Russian Federation	√	-	√	√	√	√	-	√	-	-	-	-	-
Sweden	√	√	√	√	√	√	√	√	√	√	√	-	-
United States	√	-	√	√	-	√	√	√	√	-	-	-	-

Table 4.5 Ratification of International Environmental Protection Agreements and Instruments. Source: AMSA
Abbreviations: (√) = Ratification; (-) = Not Party; * = In Force; ** = In Force September 17, 2008 (data as of October 10, 2008)

for *Seafarers, 1978* (STCW) and SOLAS. The STCW is again being revised, including standards for medical fitness for duty and hours of work and rest.

Since 1920, the ILO has adopted more than 70 international conventions and recommendations addressing maritime labor conditions and standards for decent working and living conditions for seafarers, for example, hours of rest and work, accommodations, occupational safety and health, wages, food and medical care. More than 35 of these maritime labor conventions and related recommendations were consolidated in the 2006 *Maritime Labour Convention*, which is expected to enter into force by 2011.

IMO, ILO and WHO have not adopted specific mandatory instruments addressing Arctic or Antarctic shipping as distinct from the general requirements. Existing minimum standards apply to ships flying the flag of states party to these conventions, and flag states are responsible for enforcing them on their ships. However, they would also be enforced on non-party ships under the regime of port state control inspection. Outside STCW or the ILO standards, there do not appear to be any special requirements for minimum hours of rest or maximum hours of work and safe manning despite navigation under what could be regarded as especially hazardous conditions.

The Arctic Guidelines also make recommendations on labor issues not dealt with under SOLAS or STCW. The integrated approach adopted by the guidelines recognizes that safe operation in ice-covered conditions “requires specific attention to human factors including training and operational procedures.” The guidelines recommend that crew have ice navigation and simulator training prior to entering Arctic waters, as well as exposure to ice-breaking operations and cold weather cargo handling; and that all ships operating in Arctic ice-covered waters should have at least one qualified ice navigator available to continuously monitor ice conditions when the ship is underway and making way in the presence of ice. The guidelines recommend that the ice navigator provide documentary evidence of having satisfactorily completed an approved training program in ice navigation. Currently, most ice navigation programs are ad hoc and there are no uniform international training standards. Although the Arctic Guidelines are not comprehensive with respect to seafarer training for the Arctic, they are the first international instrument to emphasize the need for specialized training in ice navigation.

Marine Environmental Rules and Standards

The *International Convention for the Prevention of Pollution from Ships, 1973 as Modified by the Protocol of 1978 Relating Thereto* (MARPOL 73/78) establishes international standards for pollutant discharges from ships. The standards are applicable in some Arctic waters (Table 4.5). Six annexes set out technical rules and procedures dealing with the prevention and control of pollution from ships by oil (I), noxious liquid substances (II), harmful substances in packaged form (III), sewage (IV), garbage (V) and air emissions (VI).

MARPOL does not totally prohibit the discharge of wastes in the marine environment. Establishing oily ballast and bilge water discharge limits, Annex I is an important annex for the protection of



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the Arctic marine environment. Oily ballast water from tankers may be discharged at a rate of 30 liters per nautical mile while en route and over 50 nautical miles offshore. Annex I also establishes a 15 ppm discharge limitation on oily bilge water from oil tankers, as well as from other ships. Amendments to MARPOL in 1992 and 2003 introduced a mandatory requirement of double hulls for new oil tankers and an accelerated phase-out period for existing single-hull tankers, as well as prohibition of operation of single-hull oil tankers carrying heavy grade oil as cargo accordingly. A proposal is before IMO to prohibit the use and carriage of heavy grade oil in the Antarctic Special Area, which may be considered in the future whether it should also apply to the Arctic.

Annex IV sets out sewage regulations that apply to ships of 400 gross tonnage or more, or ships that are certified to carry more than 15 persons. Sewage may be discharged at a distance of more

than three nautical miles from the nearest land when a ship has an approved treatment system and the sewage discharged is comminuted and disinfected. Sewage that is not treated may be discharged at a distance of more than 12 nautical miles from the nearest land if the ship is proceeding at not less than four knots and the discharge is not instantaneous but at a moderate rate.

Annex V, while prohibiting the disposal of plastics into sea, still allows ships to discharge some garbage generated by normal operations of a ship and depending on the distance from land. For example, ships are allowed to dispose of packing materials more than 25 nautical miles from the nearest land.

Annex VI allows special sulfur oxide (SO_x) emission control areas to be declared, where sulfur content of ship fuels would be lowered for designated regions (1.5 percent m/m) from the global standard of 4.5 percent m/m. Amendments to MARPOL 2008 introduced increasingly stringent regulations, including gradually decreasing the global cap for SO_x (from 4.5 percent m/m to 0.5 percent m/m) and decreasing SO_x and particulate matter in Emission Control Areas from 1.5 percent m/m to 0.1 percent m/m. Stringent controls were also placed on nitrogen oxide (NO_x) emissions and the ability to create Emission Control Areas for such emissions is now also available. These amendments enter into force on July 1, 2010. However, neither polar region has been proposed for special treatment.

Where the discharge standards under MARPOL Annexes I, II and V are not sufficient for protecting sensitive areas of the marine environment, IMO may designate special areas based on oceanographic and ecological as well as ship traffic conditions. For example, the Antarctic area (south of 60° latitude) is designated as a special area under all three annexes and a very high standard for discharges under Annex I has been established, namely a prohibition on any discharge of oil or oily mixtures from any ship. The Arctic may satisfy at least the oceanographic and ecological conditions for special area designation, if not also ship traffic conditions, as set out in the 2002 IMO *Guidelines for the Designation of Special Areas under MARPOL 73/78*. Before a special area becomes effective, regional coastal states must undertake to provide port reception facilities, an important consideration in the Arctic with its limited port infrastructure.

Marine areas can also receive special protection from the IMO because of their particular sensitivity to international shipping through designation as particularly sensitive sea areas (PSSAs). The IMO has developed *Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas*, most recently revised in 2005. To be eligible for designation as a PSSA, there must be three elements: (1) the area must have certain attributes as set forth in the Revised PSSA Guidelines, (2) there must be an identified vulnerability from

international ship traffic and (3) there must be an IMO measure to address the identified vulnerability. These IMO measures are called associated protective measures and include such things as areas to be avoided, traffic re-routing and separation schemes, mandatory ship reporting, discharges, restrictions and designation as a special area. If the conditions and criteria set out above are satisfied in a given area of the Arctic, that area may be eligible for PSSA designation.

There is also the option of obtaining protective measures under SOLAS without necessarily involving the designation of a PSSA. Routing and reporting measures under SOLAS Chapter V (Regulations 10 and 11) normally associated with safe passage (such as recommended routes, precautionary area and area to be avoided) may be obtained through the IMO to protect the marine environment. Measures of this sort have already been obtained and applied in northern waters, such as Alaska's Prince William Sound, the Baltic Sea and waters off the coast of Norway, Iceland and Greenland.

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 and its 1996 Protocol govern ocean dumping from ships (excluding wastes from normal ship operations) and the dumping (intentional sinking) of ships in the Arctic (Table 4.5). The convention permits dumping except for those wastes listed on a "black list" pursuant to a national ocean dumping permit. The 1996 Protocol adopts a precautionary approach, and only wastes listed on a global "safe list," for example, dredged material and organic wastes of natural origin, may be disposed of subject to a waste assessment audit and a national permit.

Seven Arctic states are parties to the 1990 *International Convention on Oil Pollution Preparedness, Response and Co-operation* (OPRC), which sets out a framework for cooperative measures in relation to pollution incidents involving oil (Table 4.5). The 2000 *OPRC-Hazardous and Noxious Substances (HNS) Protocol* provides a similar framework for cooperation in preparedness and response measures

for dealing with HNS incidents, but not all Arctic states are parties. State parties are required to establish measures for dealing with oil and HNS pollution incidents, either nationally or in cooperation with other countries, and the conclusion of further bilateral or multilateral agreements is encouraged. The OPRC envisages an ongoing need to assess the adequacy of pre-positioned equipment for responding to pollution incidents in light of changing risks, such as an increase in shipping levels.

Under OPRC, trained crew and appropriate damage control materials must be on board ships and offshore installations to implement their ship oil pollution emergency plans to effect damage repair and mitigate pollution, including responding to ice damage. OPRC calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents. State parties have a duty to provide assistance to other states in pollution emergency situations.

Regional and bilateral arrangements are in place that provide a framework for cooperation among some Arctic states under OPRC in the Arctic. For example, the Arctic Council's Emergency Prevention, Preparedness and Response (EPPR) working group has noted the need to increase communication and to share information with the IMO in such areas as dispersant application, waste removal and treatment, in-situ burn up and spill response in ice and snow conditions. Several Arctic states have joint contingency planning arrangements. They include, among others, the *Canada/United States Joint Marine Pollution Contingency Plan* for the Beaufort Sea area, the *Russia/USA Joint Marine Pollution Contingency Plan*, the joint *Russian/Norwegian Plan for the Combating of Oil Pollution in the Barents Sea* and the *Canada/Denmark Agreement for Marine Environmental Cooperation*, which includes annexes for responding to shipping and offshore hydrocarbon spills.



The *International Convention on the Control of Harmful Anti-Fouling Systems on Ships* addresses the use of anti-fouling systems, including paints containing toxic substances such as tributyltin (TBT). The convention, which entered into force on September 17, 2008, requires ships to either not use organotin compounds on their hulls by January 1, 2008 or to have a protective coating to prevent leaching of organotin compounds. Although several Arctic Council states regulate TBT use and the European Union has introduced a complete ban on TBT-based paints, only Denmark, Norway and Sweden are parties to the convention.

An additional vessel-source environmental concern is ballast water, whereby ships take up sea water in order to maintain ship stability and structural integrity. When ballast water is discharged, pathogens and alien living organisms may be released that can disrupt local marine species and ecosystems.

The 2004 IMO *International Convention for the Control and Management of Ships' Ballast Water and Sediments* is intended to prevent, minimize and ultimately eliminate the risks of introduction of harmful aquatic organisms and pathogens via ships' ballast water, but it is not yet in force. The convention details technical standards for the control and management of ships' ballast water and sediments with the goal of shifting ballast water management from exchange to treatment for all ships by 2016. Among the Arctic states, only Norway has consented to be bound by the convention.

The Ballast Water Convention encourages enhancement of regional cooperation, including the conclusion of regional agreements. The 2007 non-binding IMO *Guidelines for Ballast Water Exchange in the Antarctic Treaty Area* provide an example of a regional approach. Various measures are recommended, including the exchange of ballast water before arrival in Antarctic waters. The specific impact of ballast discharges in the Arctic marine environment remains largely unknown. These issues require further research.

The Role of Ports in International Maritime Law

Port state control could play an important role in promoting maritime safety and marine environmental protection in the Arctic. A global network of memoranda of understanding (MOUs) on port state control among national maritime authorities provides a systemic ship inspection approach to ensure compliance with international standards on ship safety, labor, training and pollution prevention such as SOLAS, COLREGS, MARPOL 73/78 and STCW. The inspection data is centralized in databases to which member authorities have access, and is used to track the compliance of a particular ship and the record of violations by flag. The Paris MOU among European maritime authorities is potentially relevant for ships navigating within



the Arctic Circle. The maritime authorities of the Arctic Council states, except for the United States, are parties to the Paris MOU. The United States administers its own port state control system, but has cooperating observer status with the Paris MOU.

Regional maritime authorities in the Arctic may wish to consider whether existing MOUs are sufficient to enforce higher regulatory safety and environmental standards applicable to the Arctic or to coordinate port state control enforcement efforts through a new dedicated MOU. Arctic states would need to consider what uniform standards would be enforced through port state control. Currently, only Canada and the Russian Federation have designated national safety and environmental standards for navigation in their Arctic waters separately from international standards adopted under the auspices of the IMO, including the Arctic Guidelines. The Russian Federation employs a ship inspection system for passage through the Northern Sea Route. Canada requires that ships comply with the *Arctic Waters Pollution Prevention Act* and regulates construction and other standards before navigating in Arctic waters, and inspects for this purpose.

Ports and maritime authorities also play a role in the international maritime security regime. In 2002, the IMO introduced the mandatory *International Ship and Port Facilities Security Code* (ISPS Code), which is linked to chapter XI-2 of the SOLAS Convention, for all commercial vessels over 500 gross tonnage engaged in international trade, as well as mobile offshore drilling units. Public and private ports and terminals must be secure, and ships may be required to provide notice and information to the maritime authorities of the host state. For example, Canada and the United States have advance notice of arrival requirements for ships that vary with the duration of the voyage. Certificates are issued to ships, companies and ports and

security plans are subject to periodic audit. Arctic ports and terminals require a risk assessment followed by adoption of security plans to comply with the ISPS Code. Ships engaged in cargo operations, support services or cruises in the Arctic have to comply with the ISPS Code and cooperate with port and terminal security. In areas under their jurisdiction and in accordance with UNCLOS, Arctic coastal states should have ship control procedures in place, as well as a secure system of assessing threats and sharing intelligence among law enforcement agencies.

International Private Maritime Law Framework

The international customs and practices of the shipping, cruise and merchant communities are likely to govern the Arctic movement of goods and passengers in addition to international maritime law. Since ships move between different countries, their owners’ contracts can be subjected to a variety of different national jurisdictions and laws. To reduce confusion, the international community has concluded international private law conventions that establish uniform contractual regimes for the carriage of passengers and the carriage of goods under bills of lading (Table 4.6).

Shipowners interact with commercial parties, such as cargo owners and cruise passengers, or the suppliers of essential shipping services, like insurers and salvors, through private contracts. The essence of a contract of sea carriage is an agreement for safe transport and delivery by ship in exchange for payment of freight, hire or passage and the allocation of risks and responsibilities of the transit between the parties. These contracts also take into account the relevant international maritime law, with the carrier ensuring that its ship meets international standards for human safety and environmental protection (e.g., SOLAS, the 1972 *International Convention for Safe Containers* (CSC), MARPOL 73/78 and STCW). International shipping organizations and traders’ associations have also developed standardized clauses for particular trades, cargoes and routes and organized them into blank forms of contracts.

Arctic States	Carriage of Goods and Passengers										
	Athens				Hague Rules 1924*	Hague-Visby Rules 1968*	SDR Protocol 1979*	Hamburg Rules 1978*	CSC		Multimodal Transport 1980
	Convention 1974*	Protocol 1976*	Protocol 1990	Protocol 2002					Convention 1972*	CSC Amendments 93	
Canada	--	--	--	--	R	--	--	--	√	--	--
Denmark	--	--	--	--	D	√	a	--	√	--	--
Finland	--	--	--	--	D	√	√	--	√	--	--
Iceland	--	--	--	--	--	--	--	--	√	--	--
Norway	--	--	--	--	D	√	√	--	√	--	--
Russian Federation	√	√	--	--	--	a	a	--	√	--	--
Sweden	--	--	--	--	D	√	√	--	√	--	--
United States	--	--	--	--	√	--	--	--	√	--	--

Table 4.6 Ratification of International Carriage of Goods and Passengers Agreements and Instruments. Source: AMSA
 Abbreviations: (√) = Ratification; (--) = Not Party; (D) = Denounced; (R) = Revoked; (a) = Accession; * = In Force (data as of October 10, 2008)

The international customs and practices of the shipping, cruise and merchant communities are likely to govern the Arctic movement of goods and passengers in addition to international maritime law.

Contracts of carriage for the movement of petroleum, liquefied natural gas (LNG) and minerals moved in bulk in tankers and ore carriers that tramp (sail) around the world from port to port are known as charter parties. Industry bodies like the Baltic and the International Maritime Council (BIMCO) and International Association of Independent Tanker Owners (INTERTANKO) have devised generally accepted standard terms of trade for inclusion in individual charter parties. For example, BIMCO's voluntary "ice clauses" allow a carrier to deviate from the contracted carriage to prevent a ship from becoming icebound.

Packaged, crated and containerized items, including hazardous goods, are carried under contracts represented by bills of lading and sea waybills that are regulated under competing international rules with similar modes of operation and regulatory function. These rules differ in the standards of conduct expected of the carrier, the scope of application of the rules and the limits of liability for their breach. The 1924 *International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading* as amended by the Protocols of 1968 and 1979 (Hague-Visby Rules), or some variant of them, are the most widely applied international regulations. The other rules are the 1978 *United Nations Convention on the Carriage of Goods by Sea* (Hamburg Rules) and the 1980 *United Nations Convention on International Multimodal Transport of Goods* (Multimodal Rules). The United Nations Commission on International Trade Law has prepared a wholly new uniform set of rules, the *Draft Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea*, presented to the General Assembly in October 2008. States that are not party to a particular convention may choose to legislate the rules into carriage contracts, for example, Canada implements the Hague-Visby Rules through the Marine Liability Act. Each set of rules applies to marine transportation in the Arctic just the same as in any other ocean area.

Intergovernmental and non-governmental organizations also influence the standard of care set out in a carriage contract. Since 2006, a number of classification societies have introduced winterization guidelines for navigation in cold climates that establish standards of ship preparedness for Arctic shipping, thereby indirectly establishing the expected minimum standard of reasonable care for cargo.

The commercial carriage of passengers by sea, whether on ferries or cruise ships, is internationally regulated by the 1974 *Athens Convention Relating to the Carriage of Passengers and their Luggage by Sea* and its protocols of 1976 and 1990 not yet in force. A further protocol concluded in 2002 is also not yet in force: the consolidated treaty will be known as the *Athens Convention, 2002*. The carrier

is responsible for the safety of everyone on board, whether crew, cruise company employees or fare paying passengers. The Athens Convention establishes liability rules and limitations for personal injuries to passengers and loss or damage to their luggage. The safety criteria to be followed in order to negate a finding of negligence are established by the international shipping practices of operators, for example, *Association of Arctic Expedition Cruise Operators Guidelines*, as well as by SOLAS and other binding IMO shipping safety rules.

Marine Insurance

Arctic shipping will not be sustainable without the availability of marine insurance at reasonable commercial rates. Unlike most other areas of shipping, the practice of marine insurance is not regulated in an international convention. A business and private law matter, marine insurance is legislated at the national level, for example, Canada and the Russian Federation; and occasionally at a sub-national level, for example, the United States. Insurance practices are driven by international insurance markets. Of particular significance for Arctic shipping is protection and indemnity insurance, offered through P & I Clubs. Until recently, Russian Federation shipping in the Arctic tended to be insured under state schemes, and now P & I coverage is a requirement for trading on the Northern Sea Route.

Although most of the risks associated with shipping are well known and understood by insurers and assureds alike, the risks associated with polar navigation are still not fully known or understood. With the exception of the Northern Sea Route, the Arctic is perceived as an unknown quantity or a marine frontier. As a result, the



Arctic States	Liability and Compensation										
	CLC			FUND				LLMC		HNS 1996	Bunkers 2001**
	Convention 1969*	Protocol 1976*	Protocol 1992*	Convention 1971	Protocol 1976*	Protocol 1992*	Protocol 2003*	Convention 1976*	Protocol 1996*		
Canada	D	√	√	D	√	√	--	--	√	--	--
Denmark	D	√	√	D	√	√	√	D	√	--	√
Finland	D	√	√	D	√	√	√	D	√	--	√
Iceland	D	√	√	D	√	√	--	--	--	--	--
Norway	D	√	√	D	√	√	√	D	√	--	√
Russian Federation	D	√	√	D	√	√	--	--	√	√	√
Sweden	D	√	√	D	√	√	√	D	√	--	--
United States	--	--	--	--	--	--	--	--	--	--	--

Table 4.7 Ratification of International Maritime Liability and Compensation Agreements and Instruments. Source: AMSA
 Abbreviations: (√) = Ratification; (--) = Not Party; (D) = Denounced; * = In Force; ** In Force November 21, 2008 (data as of October 10, 2008)

provision of insurance for Arctic shipping tends to be on a case-by-case basis and expensive, with seasonal additional premiums. The availability and cost of marine insurance is a major constraint on Arctic marine shipping.

Salvage

The availability of salvage services can be expected to be vital for the future of commercial shipping in the Arctic. The 1989 *International Convention on Salvage* establishes the general legal principles for salvors and salvage operations. All Arctic Council states are parties to the convention. Salvage refers to the actual service provided to a ship in need of assistance, the body of law that exists to govern this maritime institution, and the reward due to the salvors for their services. Essentially, salvors are entitled to a reward (a percentage of the value of the salvaged property) for successful salvaging of the vessel or cargo, such as, “no cure, no pay”. Most commonly, private firms of professional salvors respond to shipping casualties, although the Russian Federation has a fleet of polar vessels that provide salvage services. In general, the rights and obligations of the parties to a salvage operation are legislated and subject to industry standard form agreements, the best known being the *Lloyd’s Open Form of Salvage*

Agreement. If there is no contract, the parties will turn to domestic courts to obtain a salvage award. The convention provides for an enhanced salvage award for salvors preventing or minimizing damage to the marine environment.

Generally, there is limited infrastructure for ship repair and/or salvage and pollution countermeasures capability in the Arctic basin or companies with significant Arctic salvage experience. This lack of salvage capability is a concern to marine insurers.

Liability and Compensation

Should there be incidents resulting in oil or other hazardous substance spills that cause damage to the Arctic marine environment, property or economic loss, national and international systems of financial compensation for cleanup and losses sustained will become important. The current international system for compensation for

pollution damage caused by ship-source pollution is fragmented and limited. Separate conventions address oil pollution liability and compensation from tankers; damages from the spill of bunker fuel carried in ships other than tankers, such as cargo ships; and hazardous and noxious substance spills from ships (Table 4.7). Compensation is only available to state parties to the respective conventions and to private bodies or individuals who have suffered damage as a result of the pollution. None of the conventions address damage to the high seas beyond national jurisdiction. In general, under the conventions, the shipowner is strictly liable for the loss or damage up to a certain amount. A supplementary fund may provide additional compensation when the victims do not obtain full compensation from the shipowner or the insurer.

The compensation regime for damage caused by persistent cargo and fuel (bunker) oil pollution from oil tankers is the 1992 *Civil Liability Convention* (1992 CLC) and the 1992 *Fund Convention*, as well as the 2003 *Supplementary Fund Protocol*. These conventions do not apply to spills of bunker oil from ships other than tankers. In the Arctic context, it is unclear if the conventions apply to floating production, storage and offloading units and permanently and semi-permanently anchored ships engaged in ship-to-ship oil transfer operations.

While seven Arctic states have adopted the 1992 Civil Liability and Fund conventions, the United States has established a separate regime under the *Oil Pollution Act of 1990*. The international regime limits compensation for environmental damage to actual restoration costs; U.S. regulations provide compensation for both diminution in value of natural resources and the cost of assessing such damages.

The *International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996* (HNS Convention) also establishes a two-tier international compensation regime for bulk solids (excluding coal and iron ore and radioactive materials), liquids including non-persistent oils, liquid gases such as LNG and liquefied petroleum gases (LPG) and packaged substances. Individual receivers of HNS by sea in state parties to the convention would contribute to the International Hazardous and Noxious Substances Fund. The HNS Convention is not yet in force. Among the Arctic states, only the Russian Federation is a party.

The 2001 *International Convention on Civil Liability for Bunker Oil Pollution Damage*, which entered into force on November 21, 2008, applies to pollution damage caused by the spill of bunker oil from a ship other than a tanker and makes the shipowner strictly liable. The Bunkers Convention preserves the right of the shipowner and insurer to limit liability under any applicable national or international regime. The convention is accompanied by a Resolution (Annex 1) that urges all states to ratify or accede to the 1996 Protocol to

the 1976 *Convention on Limitation of Liability for Maritime Claims* (LLMC 1976) thus increasing the funds available for bunker pollution claims. Among the Arctic states, the Russian Federation, Denmark, Finland and Norway are parties.

Selected National Legal Frameworks: Canada and the Russian Federation

Canada and the Russian Federation regulate shipping in the Arctic under UNCLOS Article 234, as well as under other authorities.

Canada has established special ship construction, equipment and crewing requirements and near zero oil pollution discharge standards through the *Arctic Waters Pollution Prevention Act* (AWPPA) and its regulations. The legislation applies to a 100 nautical mile pollution prevention area, but recent amendments will extend this to the 200 nautical mile EEZ.

Pollution standards for discharges are stricter in Canadian Arctic waters than MARPOL, with only untreated sewage or emergency discharges permitted. The *Canada Shipping Act, 2001* authorizes regulations to be passed establishing vessel traffic services (VTS) zones in an Arctic shipping safety control zone whereby vessel reporting and clearance would be mandatory. To date, only a voluntary non-regulatory VTS zone known as NORDREG has been adopted for the Canadian Arctic. Currently, Canada effectively has a routing requirement in that the Shipping Safety Control Zones (adopted under the



Research Opportunities

- ❑ Comparative investigation of national construction and equipment standards for ships and their consistency with IACS Unified Requirements for *Polar Class* ships.
- ❑ Comparative examination of the extent to which states have followed the IMO Arctic Guidelines.

AWPPA) stipulate when and where ships of certain ice strength can operate. Recently, the Canadian federal government announced plans to extend the application of the AWPPA to 200 nautical miles and to move NORDREG to a mandatory reporting system for ships entering Canadian Arctic waters.

The Russian Federation has opened the Northern Sea Route for foreign shipping under certain conditions and has increased the number of ports in the Arctic region.

Regulations adopted in 1990 and 1996 allow navigation in the Northern Sea Route on a non-discriminatory basis for ships of all states based on *Regulation for Navigation on the Seaways of the NSR, 1991*; *Guide for Navigation through the NSR, 1995*; and *Regulation for Design, Equipment and Supply of Vessels Navigation the NSR, 1995*. In these documents, priority is given to prevailing international legal standards and appropriate rights of the coastal states to ensure maritime safety and to take measures for preventing the pollution of the marine environment. Pollution standards are stricter than MARPOL. For example, no garbage deposits or oily ballast water discharges from tankers are permitted. The regulations impose various conditions for using the Northern Sea Route. An application to Russian maritime authorities has to be made and they would give careful consideration to navigational safety and environmental concerns. A ship inspection (at the shipowner's expense) is required and at least two pilots need to be taken on board. Crew size must be sufficient to allow for a three-shift watch and the master should at least have a 15-day experience of steering ships under ice conditions along the Northern Sea Route. The NSR fee system is continuously improving. The existing fee system is in place to necessitate financial support for icebreaker assistance and NSR infrastructure throughout the year. In the case of future growth in cargo volumes, the charge for each individual vessel passing by the NSR is expected to decrease as the overall volume increases.

The estimated volumes of maritime traffic are about 40 million tons of oil and gas per year by 2020, which may improve the economic effectiveness of cargo transportation through the NSR.

In Summary

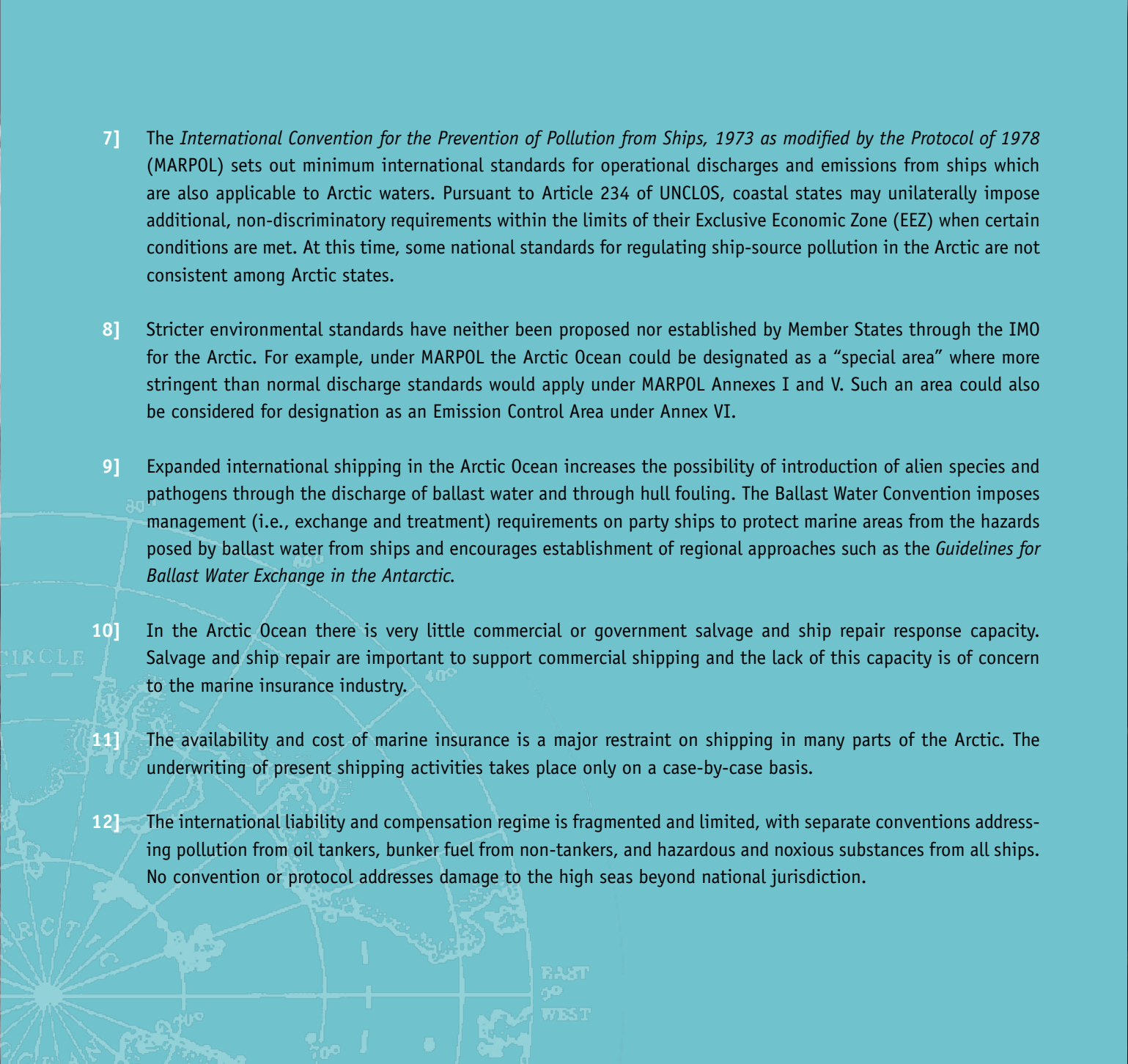
Governance in shipping is characterized by efforts to promote harmonization and uniformity in international maritime law. The reason for the global approach to shipping governance is that by definition and function, shipping is essentially an international tool in the service of global trade. The term governance highlights the complex range of actors that affect shipping law, policy and practice in the Arctic. Indeed, the largest flag states and suppliers of marine labor do not border the Arctic Ocean.

Natural resource, cruise and maritime trade related shipping in the Arctic is on the increase. As marine insurance at reasonable rates becomes available and an appropriate infrastructure is put in place to service Arctic navigation routes, a concomitant increase in international shipping can be expected. This will raise, among others, safety and marine environment protection concerns. There are complex global and national legal regimes that establish standards for navigation and protection of the marine environment that are applicable in the Arctic, however, for those to be effective, a common understanding of those regimes, along with enhanced regional cooperation in ocean management and greater participation by Arctic states in the global international maritime conventions will be needed. If the Arctic marine environment is to be protected, existing regimes will need to be strengthened by Arctic states and the international community.

Not all Arctic states are parties to important conventions, and indeed not all relevant conventions are in force. There is a dearth of mandatory international standards specifically designed for navigation in the Arctic, as well as voluntary guidelines. Arctic states will need to work closely with global and regional international organizations, the people of the North and the international maritime community in regime-building to facilitate governance of Arctic shipping. ☀

Findings

- 1] Differing national viewpoints over what waters may legitimately be claimed as internal and what waters constitute straits used for international navigation have yet to be fully resolved and could give rise to future disputes concerning the exercise of jurisdiction over shipping activities.
- 2] Coastal state authority to regulate foreign shipping in the Arctic Ocean in order to prevent, reduce and control marine pollution was bolstered by Article 234 of UNCLOS. However, the precise geographic scope of coverage (waters covered by ice most of the year within the limits of the Exclusive Economic Zone) and the breadth of regulatory powers, in particular the extent to which a coastal state may unilaterally impose special construction, crewing and equipment standards, given the requirements that such standards must give due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence could give rise to differing interpretations.
- 3] The IMO international voluntary *Guidelines for Ships Operating in Arctic Ice-covered Waters* for the safety of ships and seafarers in the Arctic are currently under review. This review provides an opportunity to assess and strengthen guidance in the area of ship construction, equipment and operations and to consider the need for a legally-binding code in the future.
- 4] Safe navigation in ice-covered waters depends much on the experience, knowledge and skill of the ice navigator. Currently, most ice navigator training programs are ad hoc and there are no uniform international training standards. For example, this could be addressed by developing training standards for navigation in polar conditions and in Arctic safety and survival for seafarers that could be incorporated into IMO's *Standards of Training, Certification and Watchkeeping* (STCW 78/95).
- 5] The International Association of Classification Societies (IACS) has developed Unified Requirements for member societies addressing essential aspects of construction for ships of *Polar Class*. The IACS Unified Requirements for member societies are incorporated by reference into the IMO *Guidelines for Ships Operating in Arctic Ice-covered Waters*. If the application of the harmonized *Polar Class* were to be made mandatory, then it could be an effective way to strengthen safety and environmental protection in Arctic waters.
- 6] Specific international construction requirements for cruise ships operating in polar waters have not been adopted. The cruise ship industry has formed a Cruise Ship Safety Forum to further develop specific design and construction criteria for new vessels, but it remains to be seen how navigation in polar waters will be addressed.

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- 7] The *International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978* (MARPOL) sets out minimum international standards for operational discharges and emissions from ships which are also applicable to Arctic waters. Pursuant to Article 234 of UNCLOS, coastal states may unilaterally impose additional, non-discriminatory requirements within the limits of their Exclusive Economic Zone (EEZ) when certain conditions are met. At this time, some national standards for regulating ship-source pollution in the Arctic are not consistent among Arctic states.
- 8] Stricter environmental standards have neither been proposed nor established by Member States through the IMO for the Arctic. For example, under MARPOL the Arctic Ocean could be designated as a “special area” where more stringent than normal discharge standards would apply under MARPOL Annexes I and V. Such an area could also be considered for designation as an Emission Control Area under Annex VI.
- 9] Expanded international shipping in the Arctic Ocean increases the possibility of introduction of alien species and pathogens through the discharge of ballast water and through hull fouling. The Ballast Water Convention imposes management (i.e., exchange and treatment) requirements on party ships to protect marine areas from the hazards posed by ballast water from ships and encourages establishment of regional approaches such as the *Guidelines for Ballast Water Exchange in the Antarctic*.
- 10] In the Arctic Ocean there is very little commercial or government salvage and ship repair response capacity. Salvage and ship repair are important to support commercial shipping and the lack of this capacity is of concern to the marine insurance industry.
- 11] The availability and cost of marine insurance is a major restraint on shipping in many parts of the Arctic. The underwriting of present shipping activities takes place only on a case-by-case basis.
- 12] The international liability and compensation regime is fragmented and limited, with separate conventions addressing pollution from oil tankers, bunker fuel from non-tankers, and hazardous and noxious substances from all ships. No convention or protocol addresses damage to the high seas beyond national jurisdiction.



CURRENT MARINE USE AND THE AMSA SHIPPING DATABASE

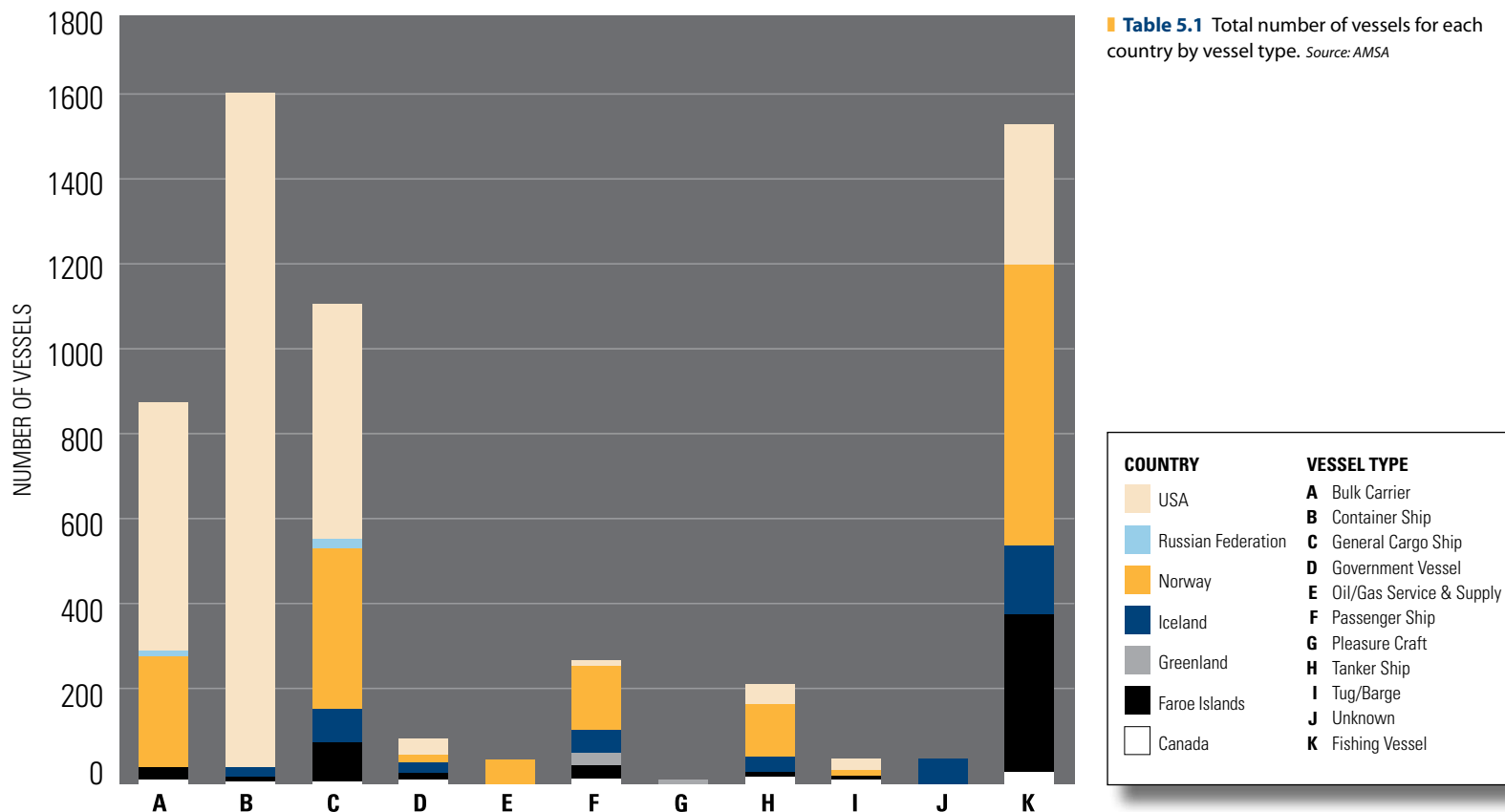
In order to better understand Arctic shipping today, a database of Arctic marine activity for a given year was seen as essential. Since no comprehensive database existed, AMSA undertook the collection of shipping data from all Arctic states. The result is the first comprehensive Arctic vessel activity database for a given calendar year. It contains a range of information on where and when different vessels are operating in the Arctic, what types of vessels, what activity they undertake and what cargo they may be carrying, among other information. The AMSA database is a flexible tool that can be built upon as additional information is obtained and can be used to further assess environmental impacts from vessel activity, locate areas of potential conflicting multiple use and provide a baseline for an analysis of future growth in vessel activity in the region.

Methodology

Vessel activity data for the AMSA study was collected from all Arctic states with coastal waters through the use of a specially designed questionnaire distributed to the Arctic Council's Senior Arctic Officials and PAME working group representatives in February 2006. A number of state administrations responded directly and, in some cases, other organizations were engaged to develop responses on a state's behalf. For the purposes of the study, 2004 was chosen to be the baseline year; where data was found to be insufficient for 2004, data from later years was provided and used for those areas only.

The data requested included such information as the number of vessels operating in the states' waters, the type of vessels, cargo

Vessels Reported in the Circumpolar North Region, 2004



carried, operational routes, fuel used, engine size of the vessels, date of operations, etc. Response to the questionnaire varied. Some responses were submitted with very detailed information, while some were submitted with very basic information or, at times, incomplete. In order to make the database more usable for most types of analysis, some assumptions have been made and post-processing of the data has been undertaken. For example, where route data was unavailable or contained obvious errors, such as passages across land, the information has been adjusted to follow known shipping routes. In terms of data reporting, there is some inconsistency in how states defined vessel types, as some states reported oil carriers as tankers, while others reported similar vessels as bulk carriers or tug and barge. There are also varying levels of certainty regarding the routes traveled, ranging from very complete records of course changes to records that provided only departure and arrival points.

Where limited vessel-specific information was provided, other data sources were integrated, including ferry and cargo vessel sailing schedules, to add additional parameters to the data set. To facilitate

analysis of the raw data, vessels were grouped into standardized vessel categories by the country that reported it and by the season in which it operated (Table 5.2). A summary of total number of vessels per category per country is shown in Table 5.1. Seasons were defined as: Winter - December to February; Spring - March to May; Summer - June to August; Autumn - September to November. For the purposes of the AMSA, the Arctic has been defined according to the internal policies among Arctic Council member states. This has meant that some states reported vessel activity that is below 60 degrees north, the traditional definition of the Arctic.

To further enhance understanding and presentation of the data, the raw data was mapped into a Geographic Information System (GIS), which provided the tools required to manage and analyze the spatial as well as the attribute components. Incorporating the data into a GIS provided for the development of maps that create a visual presentation, allowing for further analysis of all Arctic vessel activities, such as modeling vessel CO₂ emissions and comparing current vessel traffic and mapped ecologically sensitive areas.

Table 5.2 AMSA vessel categories. *Source: AMSA*

Ship Category	General Description
Government Vessels and Icebreakers	An icebreaker is a special purpose ship or boat designed to move and navigate through ice-covered waters. For a ship to be considered an icebreaker it requires three components: a strengthened hull, an ice-clearing shape and the power to push through ice, none of which are possessed by most normal ships.
Container Ships	Container ships are cargo ships that carry all of their load in truck-size containers, in a technique called containerization.
General Cargo	Ships designed for the carriage of various types and forms of cargo and the combined carriages of general cargo and passengers with 12 or less fare paying passengers.
Bulk Carriers	Ships specifically designed for bulk carriage of ore with additional faculties for alternative, but not simultaneous, carriage of oil or loose or dry cargo. Bulk carriers are segregated into the following major categories: handysize (10,000 to 35,000 DWT), handymax (35,000 to 55,000 DWT), panamax (60,000 to 80,000 DWT), capesize (80,000 DWT and over).
Tanker Ships	Propelled ships designed and constructed for the bulk carriage of liquids or compressed gas, as in the case of natural gas.
Passenger Ships	Ships that carry passengers, whether for transport purposes only or where the voyage itself and the ship's amenities are part of the experience.
Tug / Barge	Tug: vessel designed for towing or pushing. Additional activities may include salvage, fire fighting and work duties of a general nature. Barge: non-propelled vessel for carriage of bulk or mixed cargoes on weather or protected decks. May carry liquid cargo in holds or tanks. Some barges are modified for specific purposes (for example, crane barge).
Fishing Vessels	Fishing boats can be categorized by several criteria: the type of fish they catch, the fishing method used, geographical origin and technical features such as rigging. Modern commercial fishing uses many methods: fishing by nets, such as purse seine, beach seine, lift nets, gillnets or entangling nets; trawling, including bottom trawl; hooks and lines, long-line fishing and hand-line fishing; fishing traps. Fishing boats are generally small, often little more than 30 meters (98 ft) but up to 100 meters (330 ft) for a large tuna or whaling ship and can feature holds large enough to keep a good-sized catch.
Oil and Gas Exploration Vessels	There are many specialized vessels that are designed specifically for the exploration and extraction of natural gas and oil.

Using the GIS, the fishing data was defined by fishing vessel days per year, taking the number of fishing days times the number of fishing vessels reported. This number was then assigned to the appropriate Large Marine Ecosystem (LME) based on where the fishing events took place. A bathymetry layer is also provided in GIS format and can be used to discern draft limits to navigation. Map 5.1 shows the map-based depiction of all of the vessel activity in the AMSA database, including fishing vessel activity by LME.

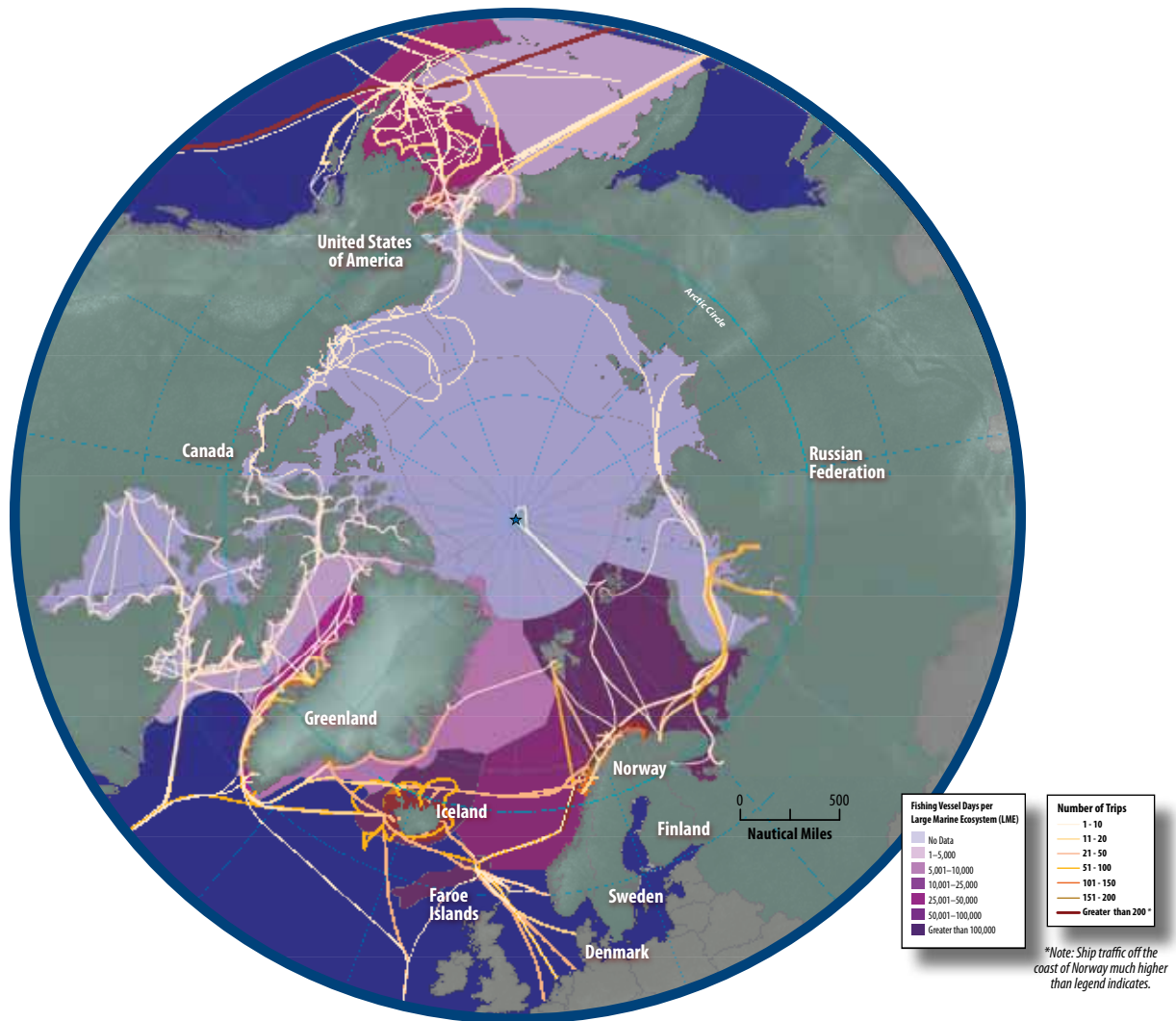
Results

In 2004, approximately 6,000 individual vessels were reported operating in the Arctic, including vessels traveling on the North Pacific's Great Circle Route between Asia and North America through the Aleutian Island chain, defined by the U.S. as within the Arctic. Great Circle Route vessels account for half of all the vessels reported. Excluding the vessels plying the Great Circle Route, the most vessels in one category were fishing boats, at slightly less than 50 percent of the total; with the next largest vessel category being bulk carriers at about 20 percent of all vessels. The AMSA database contains information on individual voyages into or through Arctic waters. This means that the number of individual vessels is not necessarily proportionate to the total number of voyages, as many vessels made multiple trips within the region. Results are also potentially an underestimation of total vessels and marine use for 2004, given probable underreporting bias and obvious data gaps in many areas and vessel types.

While 2004 provides a snapshot of current Arctic vessel traffic, clear trends emerged from the data to show what common types of vessels are operating in the Arctic, where and when most activity is typically taking place. The AMSA database identified four types of vessel activities as most significant in the Arctic in 2004: community re-supply, bulk cargo, tourism and fishing vessel activity operations.

6,000

The approximate number of vessels in the Arctic marine area during 2004, including the North Pacific Great Circle Route.



Map 5.1 Overview of all vessel activity for 2004, including fishing vessels. Source: AMSA

Regional Distribution of Vessel Activities

The overview map of vessel traffic shows that nearly all voyages took place on the periphery of the Arctic Ocean. Regions of high concentrations of traffic include: along the Norwegian coast and into the Barents Sea off northwest Russia; around Iceland; near the Faroe Islands and southwest Greenland; and in the Bering Sea. Different factors determine this distribution of marine activity. In the Bering Sea, in addition to the ships along the North Pacific Great Circle Route (through the Aleutian Islands), most of the ship traffic is bulk cargo ships serving the Red Dog mine in northwest Alaska, fishing and coastal community (summer) resupply. Traffic

The AMSA database identified four types of vessel activities as most significant in the Arctic in 2004: community re-supply, bulk cargo, tourism and fishing vessel activity operations.

Icebreaker Navigation in the Central Arctic Ocean, 1977-2008

One of the historic polar achievements at the end of the 20th century and early in the 21st century has been the successful operation of icebreakers at the North Pole and across the central Arctic Ocean.

Between 1977 and 2008 access in summer has been attained by capable icebreaking ships to all regions of the Arctic basin. Seventy-seven voyages have been made to the Geographic North Pole by the icebreakers of Russia (65), Sweden (five), USA (three), Germany (two), Canada (one) and Norway (one).

Nineteen of the 77 voyages have been in support of scientific exploration and the remaining 58 have been for marine tourism, all but one of the tourism voyages conducted aboard nuclear icebreakers.

Of the 76 icebreaker voyages that have been to the pole in summer, the earliest date of arrival has been July 2, 2007 and the latest September 12, 2005, a short 10-week navigation season for highly capable icebreaking ships.

The Soviet nuclear icebreaker *Arktika*, during a celebrated voyage, was the first surface ship to attain the North Pole on August 17, 1977. *Arktika* departed from Murmansk on August 9 and sailed eastbound initially north of Novaya Zemlya and through Vilkitski Strait to the ice edge in the Laptev Sea. The ship sailed northward to the pole along longitude 125 degrees east and reached the pole on August 17. *Arktika* arrived back in Murmansk on August 23 having sailed 3,852 nautical miles in 14 days at a speed of 11.5 knots.

The only voyage to the pole not to be conducted in summer was that of the Soviet nuclear icebreaker *Sibir*, which supported scientific operations during May 8 to June 19, 1987, reaching the North Pole on May 25. *Sibir* navigated in near-maximum thickness of Arctic sea ice while removing the personnel from Soviet North Pole Drift Station 27 and establishing a new scientific drift station (number 29) in the northern Laptev Sea. This successful voyage in the central Arctic Ocean could be considered the most demanding icebreaker operation to date.

No commercial ship has ever conducted a voyage across the central Arctic Ocean. However, seven trans-Arctic voyages, all in summer, have been accomplished by icebreakers in the central Arctic Ocean through the North Pole.

A voyage across the central Arctic Ocean with tourists was conducted by the Soviet nuclear icebreaker *Sovetskiy Soyuz* in August 1991. The Arctic Ocean Section 1994 Expedition, conducted by Canada's *Louis S. St-Laurent* and the *Polar Sea* of the United States, was the first scientific transect of the Arctic Ocean accomplished by surface ship. During July and August 1994 both ships sailed from the Bering Strait to the North Pole and to an exit between Greenland and Svalbard through Fram Strait. The expedition made



extensive use of real-time satellite imagery (received aboard *Polar Sea*) for strategic navigation and scientific planning.

Two trans-Arctic voyages with tourists through the North Pole were accomplished by the Russian nuclear icebreaker *Yamal* in summer 1996. In summer 2005, Sweden's icebreaker, the *Oden*, and the American icebreaker *Healy* also made trans-Arctic passages in a second and highly successful scientific expedition by surface ships across the central Arctic Ocean.

Although not a trans-Arctic voyage, the operation of a three-ship scientific expedition for Arctic seabed drilling during late summer 2004, mentioned earlier, is noteworthy. Included in the AMSA 2004 database, the expedition was composed of Russia's nuclear icebreaker *Sovetskiy Soyuz* and Sweden's *Oden*, both used extensively for ice management, and the Norwegian-flag icebreaker *Vidar Viking* outfitted for drilling. One of the key accomplishments was the return of a 400-meter sediment core from the seabed that is being used for scientific studies of past Arctic climates.

A review of these historic polar voyages indicates that marine access in summer throughout the Arctic Ocean has been achieved by the 21st century by highly capable icebreakers. The nuclear icebreakers of the Soviet Union and later the Russian Federation have clearly pioneered independent ship operations in the central Arctic Ocean, especially on voyages to the North Pole in summer. Conventionally powered icebreakers have also operated successfully on trans-Arctic voyages in summer, as well as on scientific expeditions to high-latitudes in all regions of the Arctic Ocean. Any planning for future navigation in the central Arctic Ocean would do well to understand the ship performance, environmental conditions and ice navigation capabilities of these successful operations in the ice-covered central Arctic Ocean.



around Iceland, the Faroe Islands and southwestern Greenland is a mix of fishing, domestic cargo supply and cruise ships. The Barents Sea experiences the highest concentrations of marine activity in the Arctic region. Ships plying these waters include: bulk cargo carriers, oil tankers, LNG carriers, coastal ferries, fishing vessels, cruise ships and other smaller vessels. Many ships pass along the Norwegian coast and in Norwegian waters during bad weather en route to Murmansk and northwest Russia. There is tanker traffic in the region and ships servicing the Norilsk Nickel mining complex sail year-round from the port of Dudinka on the Yenisei River to Murmansk.

Marine Use: Arctic Community Re-supply

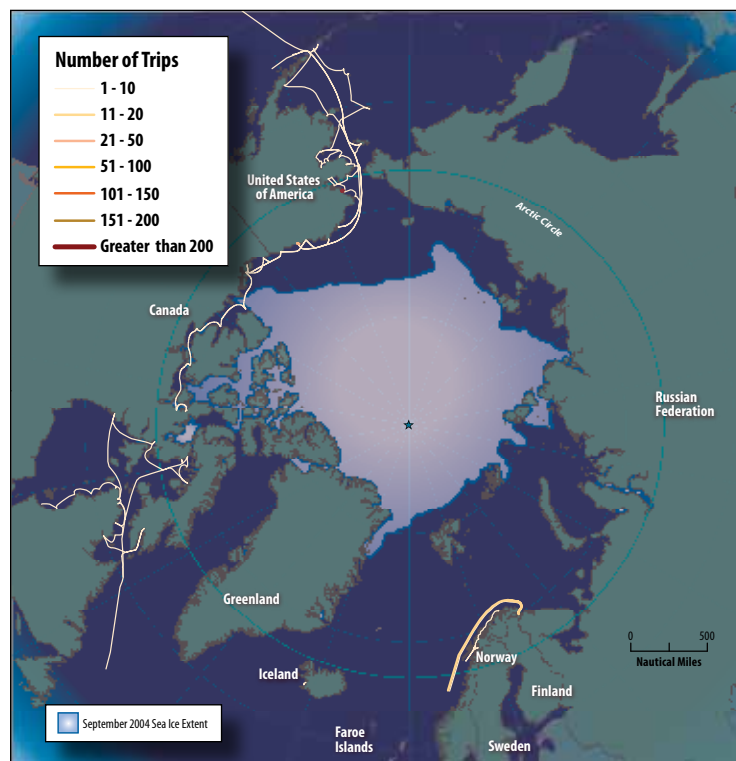
For 2004, community re-supply made up a significant portion of the ship traffic throughout the Arctic. In some areas of the region, this is also referred to as coastal Arctic shipping. In areas such as the Canadian Arctic, eastern Russia and Greenland, this activity was the basis for most ship traffic. Re-supply activities provide a lifeline to many communities that have no or very limited road access and no or limited capacity to handle heavy aircraft. Most

communities serviced - mainly in Canada, the Russian Federation, Greenland, the United States, Svalbard and Bear Island - are ice-locked for parts of the year and rely heavily on marine transportation during the summer months for their dry foods, fuel, building materials and other commodities.

Community re-supply and coastal Arctic shipping involve a range of ship types, including tankers, general cargo and container ships and, in some areas, tug/barge combinations. Tug/barge operations are particularly common in the western Canadian and Alaska Arctic and are used in these regions for mostly community re-supply, as well as for supplying mining and other construction projects. Tug/barge operations typically consist of a tug towing up to three barges. Depending on conditions, a tug/barge train can be a kilometer in length or more. Map 5.2 shows where the tug/barge activity took place, according to the data reported.

Summer resupply is handled by barge traffic along the Alaska Arctic, and in the Canadian Arctic a lack of deepwater ports requires lightering from larger supply ships at select Arctic communities. Lightering (shuttling goods from the anchored main ship to shore) is used to bring cargo ashore and tanker ships transfer petroleum products ashore by way of pumps and floating fuel lines, at many Arctic locations without deepwater access. There are select ports in Greenland, Svalbard and along the Northern Sea Route for normal cargo handling in small ports. Along the coasts of Norway and Iceland, and in Murmansk (northwest Russian Federation), all of which are ice-free year-round, there are deepwater port facilities to handle volumes of cargo from global shipping.

Community re-supply is expected to expand in the coming years due both to population increases in Arctic communities and increasing development in the region, stimulating demand for goods and construction materials. The 2004 AMSA data shows where this type of vessel traffic is occurring and can, therefore, serve as a good



Map 5.2 Tug/barge traffic. Source: AMSA

Bulk transport of commodities such as oil, gas and various types of ore is a significant portion of total Arctic vessel traffic in 2004.

baseline tool when projecting future activity under various scenarios for population and economic growth.

Marine Use: Bulk Transport of Ore, Oil and Gas

Bulk transport of commodities such as oil, gas and various types of ore is a significant portion of total Arctic vessel traffic in 2004 in volume of cargo transported. There are some very large mines in the Arctic producing commodities such as nickel, zinc and other ores, as well as oil and gas producing fields off the coast of Norway and in the Russian and U.S. Arctic. The Red Dog mine in Alaska is one of the world's largest zinc mines. The Norilsk Nickel mine near the port of Dudinka in the Russian Federation is also the world's largest producer of nickel and palladium. Nearly all bulk traffic in the Arctic is outbound, shipping extracted natural resources out of the region to the world's markets. In 2004, there were no Arctic transits of bulk goods east, west or through the central Arctic Ocean.

Most bulk transport takes place during the ice-free season or in ice-free parts of the Arctic including the Norwegian Arctic and parts of the Russian Arctic such as Murmansk. The exceptions are high-value perishable cargoes such as the concentrates from the

Dudinka region and the nickel from Deception Bay in northern Quebec, Canada, which must be shipped year-round because they degrade if left too long without processing. In 2004, these two operations were the only all-season operations recorded in seasonally ice-covered parts of the Arctic, which demonstrates that given economic incentive, year-round operations may be possible in other areas where ice is a limiting factor. In other Arctic mining areas that are ice-locked throughout the winter, bulk cargoes are stored during winter and spring and are shipped out in the brief ice-free summer/autumn season. Because some of the mines, such as Red Dog, produce very large amounts of ore, the ice-free season means heavy traffic and carefully planned bulk shipments to ensure mines get all of the ore out before the fall ice forms. Large bulk carriers, Panamax and Handymax size up to 65,000 tons, visit Red Dog mine in Alaska during the short summer season. Many of the bulk carriers operating throughout the Arctic in the summer are not ice-strengthened or *Polar Class*.

Development of the rich natural resources in the Arctic is a rapidly growing industry. Since 2004, several significant new bulk shipments have begun operations, such as the year-round oil shipments out of Varandey in the Russian Arctic. In early



\$US2.7B

The approximate amount of money received by the U.S. Minerals Management Service for an Arctic offshore lease sale in 2008.

2008, an offshore lease sale conducted by the U.S. Minerals Management Service for the U.S. Arctic totaled nearly \$US2.7 billion; offshore gas appears to be the resource under consideration for development in this Arctic region. In June 2008, the Government of Canada received record breaking bids for oil and gas exploration leases in the Beaufort Sea, including a \$C1.2 billion bid for the rights to explore an offshore area of 611,000 hectares. In September 2008, a test shipment of some of the purest iron ore found on the planet was delivered to Europe from the Baffinland mine in Mary River on Baffin Island. Depending on the regulatory review, the mine could begin year-round operations in the next 3-5 years. As planned resource development projects such as these become operational, bulk carrier traffic in the Arctic will continue to increase. This type of ship activity is likely where the most growth will be witnessed in the near future.

Marine Use: Fishing

Fishing vessel operations constitute a significant portion of all vessel activity in the Arctic in 2004, given that some of the world's most productive fisheries are in the Arctic region. The amount of fishing activity reported in the AMSA database almost certainly underestimates the amount of activity actually taking place, as there are regions of the Arctic for which no data was submitted, but there is known to be commercial fishing occurring. Also, much fishing activity is likely to take place on smaller vessels, which are, for the most part, not captured in the AMSA database. The reported fishing vessel activity takes place in a few key areas, including the Bering and Barents seas; on the west coast of Greenland; and around Iceland and the Faroe Islands. Very limited fishing activity occurs in the Arctic Ocean and the Canadian Arctic Archipelago, mostly small-scale food fisheries. Since fishing in the Arctic takes place up to the ice edge, not in close ice pack conditions, operations are in completely or seasonally ice-free or low ice concentration areas and opportunistic in nature. Fishing vessel activity in the database has been categorized according to the Large Marine Ecosystem in which the activity took place. LMEs are geographical entities defined as ecosystems based on a series of ecological criteria. Each comprises a fairly large sea area,



Map 5.3 Fishing vessel activity. Source: AMSA

Fishing vessel operations constitute a significant portion of all vessel activity in the Arctic in 2004, given that some of the world's most productive fisheries are in the Arctic region.

23

The number of commercial cruise ships transiting the Northwest Passage between 1984 and 2004.

typically 200,000 km² or larger, with distinct bathymetry, hydrography, productivity and trophically dependent populations.

Map 5.3 shows general levels of activity in each of the LMEs within the AMSA area of study and highlights those for which data was not available. Fishing vessel data is presented in terms of days in an area rather than as routes, because fishing vessels typically meander in search of catch rather than follow a specific itinerary. Although further analysis of the impacts of fishing or its potential growth fall outside the scope of this report, it is important to appreciate that fishing activity represents a significant proportion of all current vessel activity in the Arctic region in considering cumulative effects.

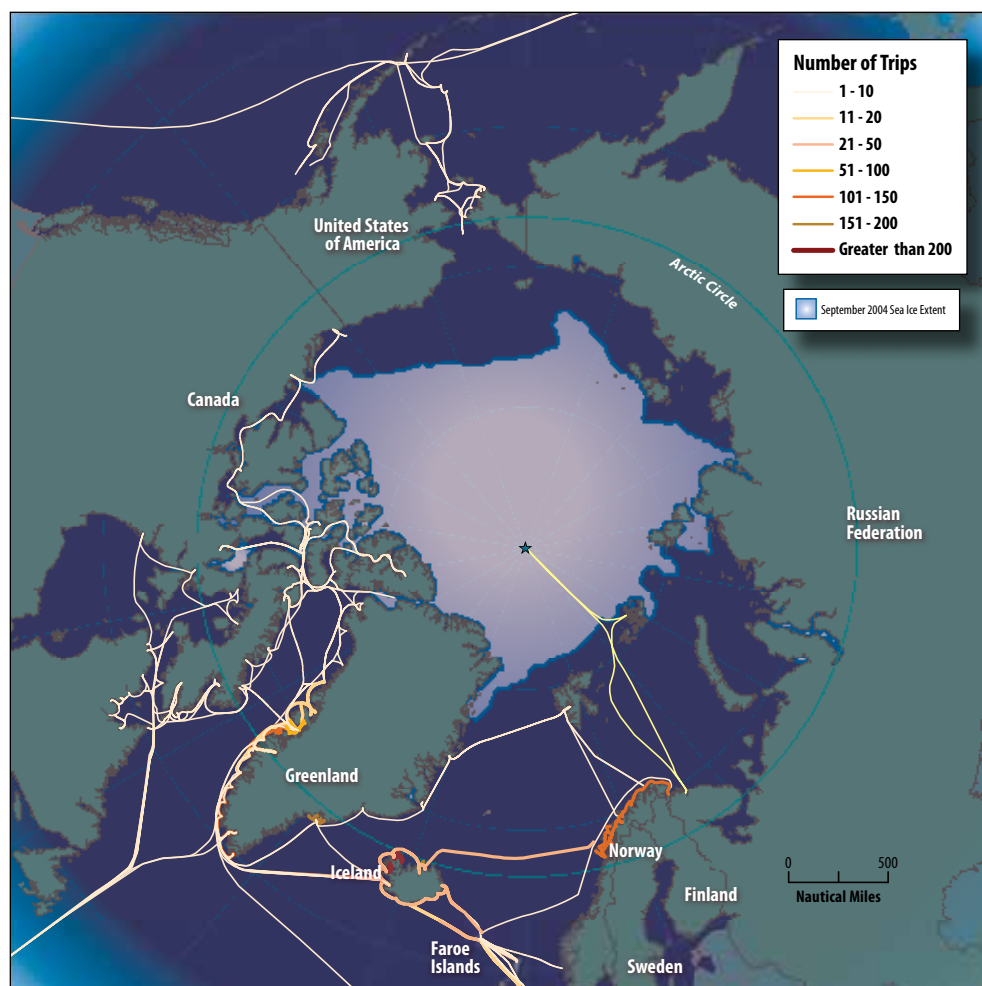
Marine Use: Passenger Vessels and Tourism

Passenger vessel activity represents a significant proportion of the vessel activity reported in the Arctic for 2004. The type of activity captured in the AMSA database includes ferry services, small and large cruise vessels and any other vessels where people are transported, whether for tourism purposes or otherwise. The type of activity taking place varies depending on its location. In Norway, Greenland and Iceland, some of the passenger vessel traffic consists of ferries, carrying people into and out of coastal communities. In other areas, such as Alaska and the Canadian Arctic, ferry services are non-existent and all passenger traffic would be vessels for marine tourism only. Some services, such as the Hurtigruten around Norway and ferry service to Iceland and Greenland from mainland Europe are hybrids, serving both as ferries and cruise ships. Map 5.4 presents the overall passenger vessel traffic in the Arctic for 2004.

Nearly all passenger vessel activity in the Arctic takes place in ice-free waters, in the summer season and the vast majority of it is for marine tourism purposes. In 2004, the only passenger vessels that traveled in ice-covered waters were the Russian nuclear icebreakers that took tourists to the North Pole, voyages they have been making for tourism purposes

since 1990. The heaviest passenger vessel traffic in the AMSA 2004 ship activity database is seen along the Norwegian coast, off the coast of Greenland, Iceland and Svalbard. Though there was some passenger vessel traffic in the Canadian Arctic and Alaska, those numbers were small in comparison to the higher traffic areas.

Marine-based tourism is the largest segment of the Arctic tourism industry in terms of numbers of persons, geographic range and types of recreation activities. The size and type of vessels that service this industry range from relatively small expedition style vessels that hold less than 200 people, to large luxury cruise liners that can hold 1,000 or more. In the Arctic, marine tourism is highly diversified and is driven by five main types of tourists seeking out a range of activities. These include mass market tourists primarily attracted to sightseeing within the pleasurable surroundings of comfortable transport and accommodations; the sport fishing and hunting market driven by tourists who pursue unique fish and game species within



Map 5.4 Passenger vessel traffic. Source: AMSA

157 to 222

The increase in cruise ships making port calls in Greenland between 2006 and 2007.



© Ross MacDonald

wilderness settings; the nature market driven by tourists who seek to observe wildlife species in their natural habitats, and/or experience the beauty and solitude of natural areas; the adventure tourism market driven by tourists who seek personal achievement and exhilaration from meeting challenges and potential perils of outdoor sport activities; and the culture and heritage tourism market driven by tourists who either want to experience personal interaction with the lives and traditions of indigenous people, or personally experience historic places and artifacts.

While Arctic ship-based tours are booked well in advance, many of the itineraries are somewhat opportunistic. The precise route and the ports and communities visited depend on the ice conditions and the difficulty and risk of access. Cruise ships often intentionally travel close to the ice edge and shorelines for wildlife viewing opportunities, increasing the risk of interaction with ice and other hazards. Many Arctic cruise ships visit destinations that were once totally inaccessible to the public, such as the North Pole, Northwest Passage and the Northern Sea Route. Between 1984 and 2004, 23 commercial cruise ships accomplished transits of the Northwest Passage; seven commercial tours were planned for 2008 alone.

According to the Cruise Lines International Organization, the number of passengers served worldwide has grown from about 500,000 in 1970 to more than 12 million in 2006. Additional growth is now occurring in the number and passenger capacity of new cruise ships entering the market. The Royal Caribbean's *Freedom of the Seas* entered the fleet in June 2007 with the largest passenger capacity yet – 3,634 – twice the size of ships built a decade ago. From 2000 to the end of 2008, 88 new cruise ships were introduced. The vast majority of these vessels were not constructed or designed to

Year	Arrivals	Number of cruise ships	Average number of arrivals/ship	Average passenger capacity/ship
2003	164	14	13	490
2004	195	24	8	468
2005	115	25	5	714
2006	157	28	6	546
2007	222	35	6	671
2008	375*	39*	10*	641*

*= Estimates for 2008 (full data not available at time of printing)

Table 5.3 Cruise ship arrivals in Greenland ports and harbors, 2003 – 2008.
Source: Greenland Tourism (Grønlands Turist- og Erhvervsråd)

operate in Arctic conditions, yet as Arctic cruise tourism continues to grow, it is very likely that many of them may make trips to the region. The cruise ship industry considers Arctic voyages to be a vital and especially lucrative part of their international tourism product. This is apparent when considering the price that tourists pay to travel to this region. As of 2008, the prices for Arctic cruises range between \$US2,900 and \$US55,000 per person. The cruise ship industry has indicated that it not only intends to maintain an Arctic presence, but to expand in terms of ship passenger capacity, destinations and extended seasons of operations. This will be encouraged by circumpolar nations that consider tourism important for growing and strengthening their economies.

Cruise ship traffic in the Arctic region has increased significantly in the four years that have passed since the AMSA database was developed. An independent survey indicated more than 1.2 million passengers traveled in 2004 to Arctic destinations aboard cruise ships; however, by 2007 that number had more than doubled.

A specific example of where cruise ship traffic is increasing at a rapid rate is off the coast of Greenland. As Table 5.3 shows, cruise ship visits and the number of passengers visiting Greenland has increased significantly between 2003 and 2008. For example, between 2006 and 2007, port calls into Greenland increased from 157 to 222 cruise ships. The number of port calls in 2006 combined for a total of 22,051 passengers, a number that represents nearly half of Greenland's total 2006 population of 56,901.

In 2008, approximately 375 cruise ship port calls were scheduled for Greenland ports and harbors, more than double the number of port calls seen in 2006. The areas visited by the cruise vessels in Greenland are also changing. Likely driven by increased demand in

Arctic Marine Tourism: A New Challenge

As passenger and cruise vessel traffic continues to increase in the Arctic, infrastructure and passenger safety needs will become of increasing concern. The large number of tourists already cruising Arctic waters now exceeds the emergency response capabilities of local communities (See page 172). The Arctic's cold air and water temperatures require the quick and efficient rescue of capsized vessels and tourists aboard lifeboats and rafts. Even limited exposure to cold weather and seas quickly reduces human endurance and chances of survival. These hazardous environmental conditions prevail in a region that has very scarce emergency response resources and where long distances result in lengthy response times. Emergency protocols become increasingly difficult as both small and large cruise ships seek remote wilderness settings and wildlife habitats. The primary polar attractions sought by tourists are rarely close to emergency response services. This combination of hostile environmental conditions and scarce emergency infrastructure is a serious threat to human life.


When performing search and rescue in the polar regions, there is an urgent need to respond quickly, as the prevention of injury and loss of life depends on timely response, prompt evacuation and the application of medical and other emergency response services. Effective responses can only be accomplished by the design and implementation of appropriate search and rescue management policies and programs, supported by appropriate physical infrastructure and well-trained personnel.

Ship evacuation produces a host of emergency response problems in the polar world. Passengers and crew must be sheltered from inclement weather, properly clothed, nourished and hydrated. The provision of these basic necessities in the polar environment, either sea or land, is formidable. The ability to successfully communicate a distress signal of any sort in the polar world can further exacerbate these threatening circumstances.

Communications in the Arctic may be a challenge. However, ships equipped with adequate communication equipment (for example, digital selective calling-high frequency, or DSC-HF, and Electronic Position Indicating Radio Beacon, or EPRIB) are able to transmit distress messages.

It is not likely that communities located in the remote, high Arctic have sufficient medical resources to respond to illnesses involving hundreds, or perhaps thousands, of cruise ship passengers and crew. And given their histories, the indigenous people living in rural Arctic communities are understandably fearful of exposure to infectious diseases.

A dangerous consequence of the growing popularity and number of cruise ships operating in and transiting through polar waters is the significant increase of marine incidents. Serious marine incidents include sinkings, groundings, pollution and other environmental violations, disabling by collision, fire and loss of propulsion. Rapid increase in the number of cruise ship voyages has led to a similar increase in the number of incidents.

Given the large number of cruise ships and other recreational boaters currently operating throughout the polar seas and the probable growth of those markets, marine operators, Arctic governments and local communities are faced with significant management challenges. 



adventure tourism, Tourism Greenland has reported that in the past few years there has been a marked increased interest in trips to the far North of Greenland, an area that has traditionally not been visited by many tourists. In 2008, 28 vessels were scheduled to travel as far north as Uummannaq, some continuing on to Qaanaaq, both destinations far north of the Arctic Circle and far from good infrastructure or emergency response capabilities. Many of the cruise vessels traveling to these destinations are likely not ice-strengthened. Though this area is classified as ice-free in the summer, this does not mean that ice is not present and, even in small amounts, ice can pose a serious hazard. The Greenland government is very conscious of the rapid growth in cruise ship traffic in their waters and Island Command Greenland, the naval service covering Greenland waters that organizes both rescue and emergency operations, has recently put an increased focus on cruise activities in Greenland waters.

Passenger vessels, in particular cruise ships, is a sector that has experienced rapid growth in certain regions in the few years that have passed since the development of the AMSA database and is one which is expected to expand further in coming years. As this sector grows and more and larger ships begin to ply Arctic waters, it will become increasingly important to understand this type of activity

so that Arctic states are prepared to meet the future needs of these vessels and their passengers.

Marine Use: Icebreaker, Government and Research Vessel Operations

Icebreakers, government and research vessels represent a relatively small proportion of the total vessel traffic in the Arctic. However, they are invaluable for surveying, oceanographic research, vessel escort in ice, salvage, pollution response and search and rescue. For the AMSA database, these vessel types were grouped since they conduct similar missions and also often carry out multiple tasks on a voyage. In the AMSA 2004 database, 83 of this type of ship were reported; however, several Arctic states did not include government vessels in their submission so the total for this category is likely larger. In keeping with the scope of the Arctic Council, naval or military vessels were not included in the AMSA database.

The icebreaker fleets of Canada and the Russian Federation conduct a range of tasks in their respective regions; summer sealift icebreaking duties are an important mission for these ships. Though several icebreakers might be capable of operating in the winter, nearly all icebreaker operations reported in the AMSA are conducted

Community re-supply is expected to expand in the coming years due both to population increases in Arctic communities and increasing development in the region, stimulating demand for goods and construction material.

Year-round Arctic Marine Transport to Dudinka in Support of Natural Resource Development and Production

Since the winter of 1978-79, one of the most advanced Arctic marine transport systems in the Arctic has been the year-round operation comprised of rail traffic between the mines of the Mining and Metallurgical Company Norilsk Nickel to the port in Dudinka, on the Yenisei River and then the 231 nautical mile sailing to Murmansk, on the Kola Peninsula.

MMC Norilsk Nickel is the world's largest producer of nickel and palladium, and is among the top four platinum producers in the world, as well as among the top 10 copper producers. MMC Norilsk Nickel is also a large global enterprise with production facilities in the Russian Federation, Australia, Botswana, Finland, the United States and the Republic of South Africa.

Mining in the Norilsk area began in the 1920s. The region quickly became a critical supplier of non-ferrous metals within the Soviet Union. During the 1950s, the Northern Sea Route Administration was tasked with building a year-round Arctic marine transport system on the western end of the NSR and into the Yenisei.

The development of large, nuclear icebreakers came first with the *Lenin* in 1959 (world's first nuclear surface ship) followed by a small fleet of larger icebreakers of the *Arktika* class. These icebreakers were designed to create tracks in the ice for lower-powered cargo ships to sail in convoy astern of a lead icebreaker.

With unlimited endurance, the nuclear icebreakers could provide year-round services in the deeper waters along the major routes of the NSR. Ice-strengthened cargo ships and shallow-draft icebreakers came next. By the 1978-79 winter season there was enough icebreaking capacity to maintain year-round navigation by convoying ships from the Yenisei west across the Kara Sea and into the Barents Sea to Murmansk. A continuous flow of non-ferrous metal concentrates could be maintained to smelters on the Kola Peninsula and to other industries in the Soviet Union.

During 1982-87 a new icebreaking cargo ship, the SA-15 or *Norilsk* class, was delivered by Finland's former Valmet and Wartsila shipyards to the Soviet Union. Nineteen of these Arctic freighters (174 m length and 19,950 dwt) were built and several today remain in service on the route between Dudinka and Murmansk.

In many respects, the *Norilsk* class multi-purpose carriers revolutionized Arctic shipping in the same manner as the commercial carrier *M/V Arctic* developed for the Canadian Arctic during the same years. With high propulsion power (21,000 shp), the *Norilsk* class ships could operate under their own power as an icebreaker. These ships carried cargoes the length of the NSR in summer

during the late 1980s; during the winter they were used effectively to support the Norilsk-Dudinka operation.

Their proven capability for independent navigation through ice fields without icebreaker support was a significant technological achievement, as well as a notable advance in efficient (and cost-effective) Arctic marine operations. The successful operation of these ships was a harbinger of the future for Arctic marine transport.

In April 1988, a new, shallow-draft polar icebreaker named *Taymyr* was delivered to the Soviet Union by Wartsila's Helsinki shipyard. A single nuclear reactor was installed at the Baltic shipyard in (then) Leningrad, and the ship was ready for service along the NSR and in the shallow Siberian rivers by 1989. A second ship of the class, *Yaygach*, was added to the Murmansk Shipping Company's icebreaker fleet in 1990.


The design of this class represents the apex in the development process for the Soviet polar icebreaker fleet. Coupled in its design are Finnish advances in shallow-draft ship design with nuclear propulsion developed in the Soviet Union. A draft of only 8 meters was attained with *Taymyr*, which compares favorably with the average 11-meters draft of the largest Soviet icebreakers of the period. A power plant producing 44,000 shp provided a capability of continuously breaking 1.8 meters of level ice at a 2-knot speed. These capabilities fit perfectly with the requirements for icebreaking (level river ice) on the shallow Yenisei River to the port of Dudinka; these extraordinary nuclear ships could maintain an ice track out to the Kara Sea through the winter in nearly all conditions.

Year-round shipping to Dudinka functioned throughout the 1990s and the early years of the new century despite the financial challenges facing the Russian Federation. MMC Norilsk Nickel was restructured several times and since 2001 the company has flourished, focusing on economic efficiencies, foreign marketing and potential investments. The marine transport component also received significant attention as the SA-15 *Norilsk* class ships supporting the Dudinka run began to age.

The company's marine operations department worked closely with the Finnish shipbuilder Aker Yards to develop a new freighter class that would be owned and operated by MMC Norilsk Nickel. The vision was for a fleet of five icebreaking containerships designed for year-round operations. The first of the ships, *Norilsk Nickel* (168 meter length, 14,500 dwt, 650 TEU capacity), was completed in Helsinki early in 2006. The new ship is designed as a "double-acting hull" and is fitted with an azimuthing pod for propulsion.

The Azipod concept, as it is called, allows the ship to move stern-first efficiently in the ice; the ship is designed to break 1.5 meter thick ice unassisted. In light ice or open water, *Norilsk Nickel* turns 180 degrees and moves bow first. Ice trials for the new ship were conducted in March 2006 in the Kara Sea and Yenisei River, and the vessel achieved a 3-knot speed continuously moving through 1.5 meter thick ice.

Norilsk Nickel has performed well in operating unassisted (without icebreaker escort or convoy) during its initial two years of

service. With four more of the class being built in Germany, MMC Norilsk Nickel will have an operational fleet of five icebreaking carriers, all highly capable of operating independently through the winter season to serve the port of Dudinka. Safe and efficient, the *Norilsk Nickel* class ships represent a new concept of Arctic marine operations. They will enhance a regional, Arctic marine transport system in western Siberia and better link a key Russian commercial enterprise to world markets. 



in the spring, summer and autumn. During summer 2004, the AMSA database indicates that there were eight voyages that reached the North Pole, including a three-ship scientific expedition designed to drill into the Arctic seabed. The expedition was composed of the Russian Federation's nuclear icebreaker *Sovetskiy Soyuz*, Sweden's icebreaker *Oden* and the Norwegian-flag icebreaking drill ship *Viking Vidar*. During 2004-2008, there were 33 icebreaker transits to the North Pole for science and tourism. An increasing number of icebreakers and research vessels are conducting geological and geophysical research throughout the central Arctic Ocean related to establishing the limits of the extended continental shelf under UNCLOS.

Seasonality of Operations and Sea Ice Extent

The Arctic is defined by extreme seasonal variability, impacting the behavior of the animals that live in and migrate to and from the region, as well as human activity. Generally, most of the central Arctic is ice-covered, dark and very cold throughout the winter months. There are some areas, such as the Aleutian Island chain, the northern coast of Norway, southern Iceland and the Murmansk region in northern Russia where, due to ocean currents and other factors, ice does not form in the Arctic in the winter. However, these areas still experience darkness, extreme cold and variable conditions. The Arctic summer is the opposite extreme,

with 24 hours of light and temperatures that can be uncomfortably warm. The pattern of vessel traffic in the AMSA database shows that vessel activity in the Arctic is highly affected by seasonal variability.

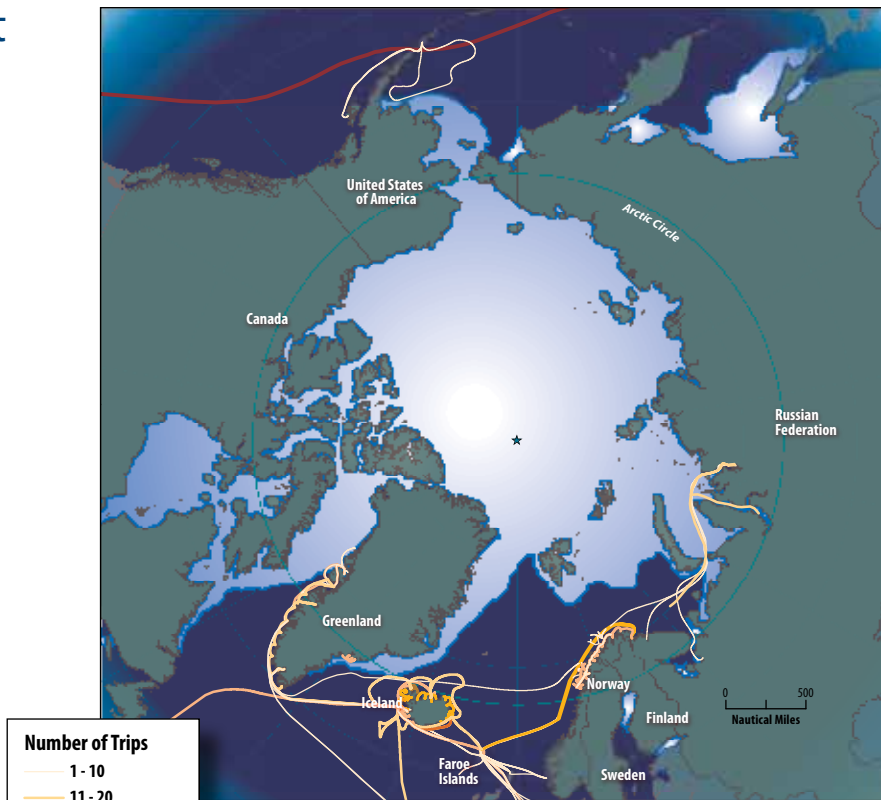
The AMSA GIS database includes Arctic sea ice maps for each month in 2004, with information collected and compiled by national ice administrations working cooperatively to create an Arctic sea ice picture. When layered with 2004 seasonal vessel traffic this data demonstrates how vessel traffic patterns interacted with the minimum sea ice extent at the time.

Maps 5.5 and 5.6 show the differences in sea ice extent between winter (January) and summer (July) traffic levels. Map 5.5 shows virtually no vessel activity in the central Arctic in the winter, although some takes place on the fringes in year-round ice-free zones. As mentioned earlier, the database indicates that only year-round commercial operations in the Arctic in seasonally ice-covered areas were into Dudinka in the Russian Federation and Deception Bay in Canada. These two operations were the only commercial icebreaking activities taking place in 2004; government icebreakers and research vessels conducted all other icebreaking that year. The data indicates that this was done only in the spring, summer and fall seasons.

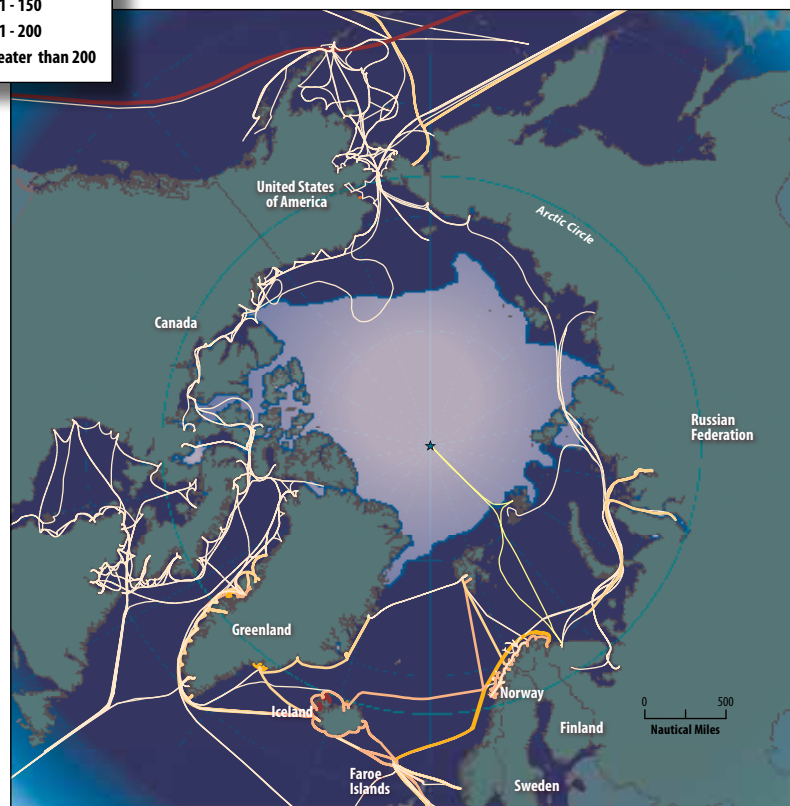
Map 5.6 demonstrates the surge in vessel activity in the summer season, when all of the community re-supply takes place and most bulk commodities are shipped out and supplies brought in for commercial operations. Summer is also the season when all of



Sea Ice Extent Differences



Map 5.5 January traffic.
Source: AMSA



Map 5.6 July traffic.
Source: AMSA

the passenger and cruise vessels travel to the region. Wildlife in the Arctic also follows this pattern: although most species migrate earlier in the spring before ice break-up, animals gather in large aggregations in the summer to feed and reproduce. This is important to consider when examining potential environmental and ecosystem impacts that may result from current or increased vessel activity in the region.

Summer and fall are the safest and most economical seasons for marine activity; therefore, activities such as resource development, tourism or community re-supply will most likely increase in the summer months. There may be a few exceptions, where high value commodities may drive year-round operations, but that will be driven by economics, not climate. If ice conditions continue to change and sea-ice extent reduces as predicted in the near term, the summer and fall shipping seasons will most likely lengthen. Even as perennial sea ice is reduced, winter in the central Arctic will remain inhospitable to marine navigation; therefore, future Arctic vessel activity

will continue to be highly seasonal in the region.

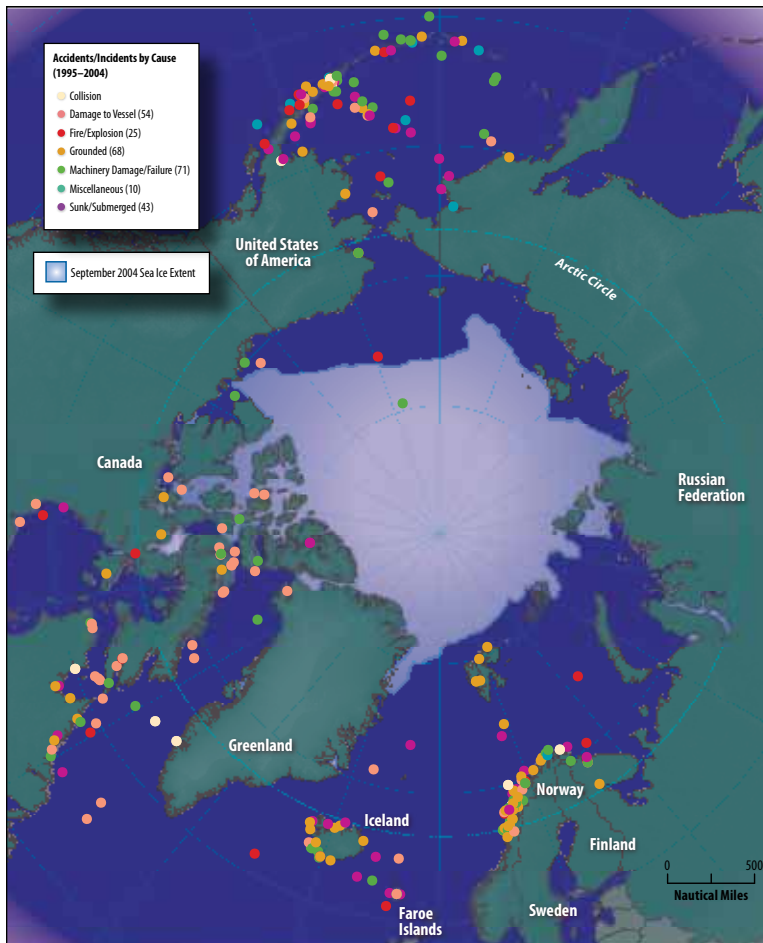
Incidents and Accidents in the Arctic

The Arctic has always been and will continue to be a challenging environment for search and rescue and emergency response (See page 168). This is due to the very large geographic area involved and the relative low density of activity and response capabilities. In order to grasp potential threats to human safety and the marine environment as a result of potential incidents, it is important to understand what incidents may have occurred and where the areas are that have had the most incidents.

As part of the AMSA database, a summary of the incidents and accidents occurring in the Arctic region between 1995-2004 was developed. No one source of data was found to be sufficient to

Table 5.4 Incident summary tables, 1995-2004. Source: Lloyd's Marine Intelligence Unit Sea Searcher Database, Canadian Transportation Safety Board (Marine), Canadian Hydraulics Centre - Arctic Ice Regime System Database.





Map 5.7 Arctic shipping accidents and incidents causes, 1995-2004. *Source: Lloyd's Marine Intelligence Unit Sea Searcher Database, Canadian Transportation Safety Board (Marine), Canadian Hydraulics Centre- Arctic Ice Regime System Database.*

cover the circumpolar region; therefore a compilation of a number of sources was necessary to create the summary. The main sources of information used were the Lloyds MIU Sea Searcher database, the Canadian Hydraulics Centre Arctic Ice Regime System database and the Canadian Transportation Safety Board (Marine.) Though this combined dataset is limited, it provides a basis for a very broad analysis of what type of incidents are occurring in the Arctic region and what areas may be more prone to incidents and therefore at a greater risk of further ones in the future.

The incidents and accidents were categorized by the type of incident that occurred, where and when it occurred, whether there were fatalities as a result, whether there was a significant oil spill involved and whether the vessel involved was considered a total loss for insurance purposes. Incident types were grouped into the following categories:

- **Grounding:** where a vessel came in contact with the bottom and, therefore, required assistance or significant effort to be re-floated. In some cases, vessels could not be re-floated and were either abandoned or broken up for salvage.
- **Collision:** where two vessels make contact resulting in minor to a serious damage to the vessel.
- **Damage to Vessel:** where damage to the vessel occurred, due to a variety of reasons ranging from contact with the pier, collision with ice, extreme weather or other factors.
- **Fire/Explosion:** where a fire or explosion occurred onboard a vessel, resulting in minor to very serious damage to the vessel and other consequences, such as fatalities.
- **Sunk/Submerged:** where a vessel was submerged in water for a period of time or sunk completely due to a range of causes.
- **Machinery Damage/Failure:** where a vessel sustained damage to machinery or complete machinery failure.

It is important to note that the incidents captured as part of AMSA excluded onboard incidents that may have involved injury to passengers and crew, but where there was no damage to the vessel. For a summary of the number and type of accidents and incidents involving vessels see Table 5.4.

Using the exact geographic locations for the different incidents and accidents, the data was entered into the GIS database, along with the different characteristics identified. The result was Map 5.7, which shows all of the reported incidents and accidents reported for the circumpolar region for the period of 1995-2004.

When looking at the geographic distribution of the incidents for the defined period shown in Map 5.7 there are certain gaps and trends that emerge. There is a complete absence of incidents reported in the Russian Arctic and there are some areas where there appears to be a concentration of incidents during the years collected. These areas are along the northern coast of Norway, around the Aleutian Island chain and in the Bering Sea, along the Labrador coast and in Hudson Strait in Canada and around Iceland and the Faroe Islands. These concentrations of incidents are consistent with the traffic patterns shown in the AMSA activity database – areas that show the concentrations of incidents are also those where the largest volume of vessel activity is occurring. This trend is even more apparent when the vessel routes for 2004 are shown on the same map as the incidents.

One of the most dramatic incidents in 2004 was the loss of life and sinking of the *Selendang Ayu* off the coast of Alaska. The incident is a graphic example of the key gaps in infrastructure, emergency

The *Selendang Ayu* Disaster in the Alaska Arctic

On November 28, 2004, after loading 1,000 tonnes of fuel and 60,200 tonnes of soybeans, the *Selendang Ayu* departed Seattle, Washington, with a crew of 26 along the North Pacific Great Circle Route bound for Xiamen, China. Ten days later the 225-meter Malaysian-registered bulk carrier broke apart off the rugged coast of the Aleutian Islands of Alaska resulting in the deaths of six crew members, causing the crash of a U.S. Coast Guard helicopter and spilling an estimated 66 million metric tons of soybeans, 1.7 million liters of intermediate fuel oil, 55,564 liters of marine diesel and other contaminants into the environment further causing the deaths of seabirds and marine mammals (See page 151).

A U.S. National Transportation Safety Board marine accident brief is the basis for this report. Despite passing inspection by port authorities and U.S. Coast Guard officials prior to leaving Seattle, the seven-year old Panamax class vessel encountered engine problems approximately 100 nautical miles from Dutch Harbor, the closest place of refuge, and about 46 nautical miles from the nearest point of land. After leaving port in Seattle, the ship had encountered heavy seas and between gale and strong gale force winds.

On his second transit of the Bering Sea, the vessel's master, a citizen of India and a 32-year seagoing veteran, notified the harbor master in Dutch Harbor via the vessel's satellite phone he was having difficulties and needed assistance. The Coast Guard immediately dispatched the cutter *Alex Haley* but because of the rough seas could only reach a top speed of 10 knots. Nearly six hours later, the cutter reached the *Selendang Ayu* and attempted to slow its drift toward the coastline by attaching a tow line to the vessel until the tugboat *Sidney Foss* arrived, which was then approximately 11 nautical miles away.

In the meantime, the wind and sea conditions continued to deteriorate. Arriving on scene, the tugboat master reported seeing the *Selendang Ayu* lying beam to the sea in 7.6-meter seas, hammered by 45- to 55-knot winds. Some crew members were desperately struggling to remain on the bow as the freighter rolled 25 to 35 degrees with waves crashing over the deck amid passing snow and ice squalls. The remainder of the crew, some who had been up for some 41 hours, worked frantically to restart the engines.

On the scene, the *Sidney Foss* was able to slow the drift but unable to turn the stricken ship's bow into the wind as the vessel drifted closer to the shore. A second tug, the *James Dunlap*, arrived from Dutch Harbor with sunrise 5 ½ hours away, noted the NTSB report. "Because of the sea state and the darkness, the masters of the *Sidney Foss* and the *James Dunlap* decided to wait until daylight before attempting to swing the bow of the *Selendang Ayu* around by putting a line on the stern."

Then, some three hours before sunrise, the towline parted and the stricken vessel continued its now unabated drift toward Unalaska Island. At sunrise, with the *Selendang Ayu* picking up speed toward the coastline, the ship's master dropped anchor in hopes to slow or even stop the drift. It almost worked.

The port anchor immediately caught, slowing and almost stopping the vessel's drift. The feeling of relief was short-lived as some 15 minutes later the ship began slipping its anchor under the unrelenting

pounding of the growing storm and started to drift at 2 knots toward shore. The weather continued to worsen with steep seas of 6 to 7.6 meters and periodic wind gusts of up to 65 knots, which occasionally pushed the waves to 9 to 10 meters. The Coast Guard suggested dropping the starboard anchor, "but the *Selendang Ayu* master said the starboard anchor might foul on the port anchor's chain," the report stated.

Several attempts to reestablish a towline failed and with now fading light and its proximity to shore, the Coast Guard recommended evacuating the crew. The master finally allowed a group of 18, those he considered the least essential for dealing with the emergency, to depart. Wearing lifejackets, but not the reddish-orange buoyant survival or immersion suit that protects against heat loss and ingress of water, they would be extracted in two groups. (At the time of the accident, the *International Convention for Safety of Life at Sea*, SOLAS, required a cargo vessel to carry at least three immersion suits for each lifeboat, unless the vessel had a totally enclosed lifeboat on each side. The *Selendang Ayu* carried two fully enclosed lifeboats, one port and one starboard and was equipped with three immersion suits. In an amendment effective July 1, 2006 the SOLAS regulation was changed to require one immersion suit for each person onboard a cargo ship. An exemption from this requirement for ships that voyage "constantly" in warm climates is not allowed for bulk carriers.)

Using a USCG HH-60 Jayhawk helicopter that had arrived from Cold Bay, Alaska, the first group of nine *Selendang Ayu* crew members were hoisted from the rolling deck. Then only a mile from shore, the ship's port anchor was dropped. It caught. Shortly thereafter, a second Jayhawk helicopter hoisted the second group of nine sailors from the ship. Eight crew members remained on board and continued to work frantically on the engines. As darkness began to close in, the Coast Guard radioed the master and said they wanted to remove the remainder of the crew before sunset. Then came the first of several shudders as the vessel ran aground on a small underwater shelf about 130 meters offshore. Knowing the ship's fate, the master radioed the *Alex Haley* and requested immediate extraction.

The eight remaining crew members gathered on the port bow, where the two previous evacuations had taken place. The vessel was rolling badly in the shallow water and increasing groundswell. Another HH-60 Jayhawk helicopter was dispatched from Dutch Harbor to the scene and a short time later the *Alex Haley* launched the smaller HH-65 Dolphin helicopter. Both aircraft reached the freighter around 6 pm with the larger Jayhawk helicopter performing the rescue. Fifteen minutes later all of the ship's crew, save the master and the USCG rescue swimmer, had been hoisted onboard when a huge rogue wave struck the bow of the freighter, sprayed up and engulfed the Jayhawk. The helicopter's engines stalled, spun around causing its tail and main rotor blades to slam into the side of the crippled ship and crashed into the sea next to the *Selendang Ayu*'s forward port side. The Dolphin helicopter, which had been hovering close by, immediately went into rescue mode and quickly recovered the three-member flight crew and the one *Selendang Ayu* crew member who survived the

crash. With no other sign of survivors, the helicopter headed to Dutch Harbor. While the master and the Coast Guard swimmer were awaiting rescue, the ship broke in two on the rocks. After three hours of being bombarded by crashing waves, howling winds in total darkness, the ship's master and the USCG rescue swimmer were hoisted on board the *Dolphin*, which had returned from its trip to Dutch Harbor. It was 10:35 pm on December 8, nearly 60 hours since the *Selendang Ayu* engines failed.



Map 5.8 Accident location in Bering Sea. Inset shows route of *Selendang Ayu* through Unimak Pass, approximate point at which engine failed, path of vessel's drift without power, and site on Unalaska Island where it grounded.

Source: National Transportation Safety Board

response and salvage services that are readily available in other parts of the world's oceans.

Summary Discussion: Current Arctic Marine Use

As noted earlier, Arctic shipping has existed since the late 1400s, mostly on the periphery of the region. As in the past, most commercial activity today is generally linked to supplying communities or exporting raw goods out of the Arctic. The number of ships operating today in the Arctic is significant in the context of both the unique aspects of the Arctic environment and the insufficient infrastructure and emergency response in many parts of the region, relative to southern waters. However, from the outlook of the global maritime industry, the level of vessel activity found to occur in the 2004 baseline year is still relatively low. To put it into perspective, the total number of vessels reported as operating in the Arctic region (not including fishing vessels and the Great Circle Route traffic) represents less than 2 percent of the world's registered fleet of oceangoing vessels over 100 gross tonnage. Although the total vessels operating in the Arctic may represent a small proportion of the world's fleet, they can still have significant impacts on the environment in which they operate. At current shipping activity levels, it will not take many more ships operating in the Arctic in future years to double or triple the 2004 numbers.

Most shipping traffic in the Arctic is in waters that are either permanently or seasonally ice-free, an important distinction. Permanently ice-free waters include those in the Aleutian island chain, the northern coast of Norway, southern Iceland and the Murmansk region in northwest Russia. In other areas of the Arctic, which are seasonally ice-covered, nearly all the vessel activity occurring in 2004 took place in waters where the ice had melted or was melting and where icebreakers are not required for access. However, an area can be determined to be ice-free and still have ice-related dangers, such as bergy bits and pan ice, which are hard to detect and can damage a vessel.

In recent years, given the changing ice conditions in the Arctic, much attention has been paid to possible trans-Arctic shipping via the central Arctic Ocean, Northwest Passage or the Northern Sea Route. In the AMSA 2004 database, it was found that vessels operated on sections of both the NSR and NWP; however, there were no full transits by commercial vessels on any of three routes. The vessels reported as

operating in the Northwest Passage were either community re-supply or Canadian Coast Guard. On the Northern Sea Route, the only vessels reported were bulk carriers and tankers for community re-supply. None sailed the full route, and the only Russian traffic through the Bering Strait were bulk carriers servicing communities on the far northeast of Russia coming from the Bering Sea. In 2004, no ships transited the entire Arctic Ocean from the Pacific to the Atlantic or vice versa.

The only vessels that went into the central Arctic Ocean in 2004 were the eight trips made to the North Pole, three of which were research vessels carrying out a core drilling expedition and five Russian nuclear icebreakers for tourism purposes. Apart from those trips, all the vessel activity in 2004 took place around its periphery and largely in coastal waters.

In the four years that have passed since the AMSA 2004 baseline year for shipping activity, there has already been an increase in vessel activity in certain sectors. As discussed earlier, cruise vessels have been traveling to the Arctic in rapidly increasing numbers. There has also been new activity in other types of vessel traffic, particularly in the Barents, Kara and Norwegian seas. An Arctic tanker shuttle system has been established to support a route from a new Russian terminal in Varandey in the Pechora Sea to Murmansk and direct to global markets. The first 70,000 dwt tanker for this service, *Vasily Dinkov*, delivered its initial cargo to eastern Canada in June 2008; two additional icebreaking tankers for this operation

have been built in South Korean shipyards. Two similar icebreaking tankers, under construction in St. Petersburg, will be used to ship oil from the Prirazlomnoye oil field in the northern Pechora Sea to a floating terminal in Murmansk. Again, year-round operations are envisioned in seasonally ice-covered waters, in this case to provide a continuous supply of oil to Murmansk for subsequent export by supertanker.

Off the coast of the Norwegian Arctic, the Snohvit (“Snow White”) gas complex is now operational and its first shipment of gas arrived in Spain via an LNG carrier in October 2007; another shipment of Snohvit LNG was delivered to the U.S. East Coast in February 2008. LNG carrier operations out of northern Norway to world markets are poised to increase during the next decade and Norwegian Arctic offshore production is forecast through 2035.

In early 2008, an offshore lease sale conducted by the U.S. Minerals Management Service for the U.S. Arctic totaled nearly \$US2.7 billion; offshore gas appears to be the resource under consideration for development in this Arctic region. Increasing Arctic marine operations off Alaska in the Chukchi and Beaufort seas to support oil and gas exploration are envisioned for the next decade.

While the AMSA database only looks at the year 2004, it is apparent, based on anecdotal information, that Arctic marine vessel activity is in a state of transition. The current types of vessel activities seen today are in support of community re-supply, bulk natural resource shipments, fishing and tourism. It appears there will be a growth in all Arctic shipping sectors, as well as the possible emergence of new opportunities. ☀

Research Opportunities

- ❑ Develop a consistent and accurate circumpolar database of Arctic ship activity, as well as ship accidents and incidents to date.
- ❑ Trend analysis of shipping activity, using the 2004 AMSA database as the baseline.

Findings

- 1] There were approximately 6,000 vessels in the Arctic in 2004: nearly half the vessels were operating on the Pacific Great Circle Route, which crosses the Aleutian Islands and the southern Bering Sea. Of the remaining vessels, about 50 percent, or 1,600, were fishing vessels. The availability of data and reporting on Arctic marine activity varied greatly between Arctic states; several states could not provide comprehensive data for 2004. As a result, the AMSA database likely underestimates the levels of activity throughout the reporting year.
- 2] Marine activity took place throughout the Arctic in 2004 and in recent years icebreaking ships voyaged in the central Arctic Ocean in the summer. However, operations were primarily in areas that were ice-free, either seasonally or year-round.
- 3] The AMSA database indicates that no commercial vessels conducted trans-Arctic voyages on the Northwest Passage, Northern Sea Route or in the central Arctic Ocean in 2004.
- 4] Early in the 21st century there are only a few Arctic regions with year-round shipping in seasonal sea ice. These year-round operations are driven largely by natural resource development such as in the Canadian Arctic and northwest Russia.
- 5] Most shipping in the Arctic today is destinational, moving goods into the Arctic for community re-supply or moving natural resources out of the Arctic to world markets. Nearly all marine tourist voyages are destinational, as well.
- 6] Regions of high concentration of Arctic shipping activity occur along the coasts of northwest Russia, and in ice-free water offshore Norway, Greenland, Iceland and the Bering Sea.
- 7] Most of the Arctic fishing took place in the Bering and Barents seas, on the west coast of Greenland and around Iceland and the Faroe Islands.
- 8] The Arctic states do not generally collect and share Arctic marine activity data in any systematic manner.
- 9] Information about vessel incidents and accidents in the Arctic is not shared among Arctic states, other than through IMO processes. Knowing such information is an important step toward understanding and assessing future risks.
- 10] Cruise ship traffic into and around Greenland has increased exponentially in recent years. The majority of cruise ships observed recently in Arctic waters are not purpose-built for Arctic operations. Many are built for voyaging in open water in lower latitudes and warmer climates.



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*

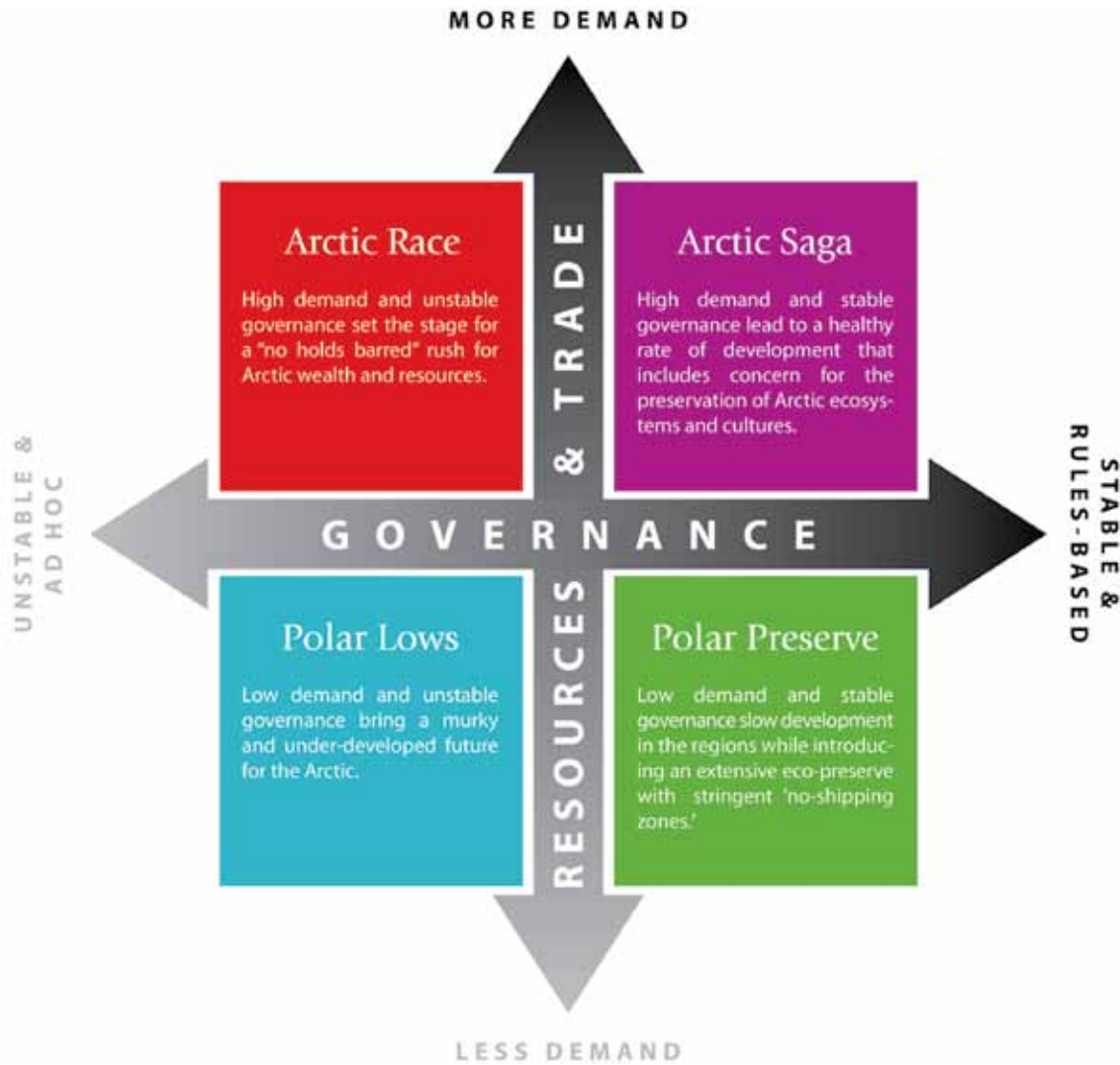


Illustration 6.1 Scenarios matrix. Source: AMSA

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	<ul style="list-style-type: none"> ▲ More Demand for Resources and Trade ◀ Less Stable Governance 	<ul style="list-style-type: none"> ▼ Less Demand for Resources and Trade ◀ Less Stable Governance 	<ul style="list-style-type: none"> ▼ Less Demand for Resources and Trade ▶ More Stable Governance 	<ul style="list-style-type: none"> ▲ More Demand for Resources and Trade ▶ More Stable Governance
High Concept	<p>High demand and unstable governance set the stage for an economic rush for Arctic wealth and resources.</p> <p>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.</p>	<p>Low demand and unstable governance bring a murky and underdeveloped future for the Arctic.</p> <p>This is a world in which domestic disturbances divert attention from global issues, and simmering frictions cause prolonged divisiveness. Global financial tensions are prevalent.</p>	<p>Low demand and stable governance slow Arctic development while introducing an extensive eco-preserve with stringent "no-shipping zones."</p> <p>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.</p>	<p>High demand and stable governance lead to a healthy rate of development that includes concern for the preservation of Arctic ecosystems and cultures.</p> <p>This is a world largely driven by business pragmatism that balances global collaboration and compromise with successful development of the resources of the Arctic.</p>
Primary Drivers of Change	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Much activity dominated by destination traffic supporting resource development • Unilateral governance regimes lead to inconsistent infrastructure with incompatible standards • Seasonal trans-Arctic passage possible, but not economical 	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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" 	<ul style="list-style-type: none"> • 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.

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.



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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 destination 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 destination 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



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.





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 destination 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.

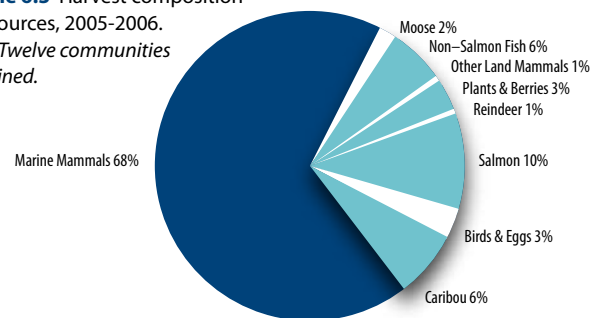


Map 6.1 Vessel traffic in the Bering Strait during the summer of 2004. Source: AMSA

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 walrus, 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.

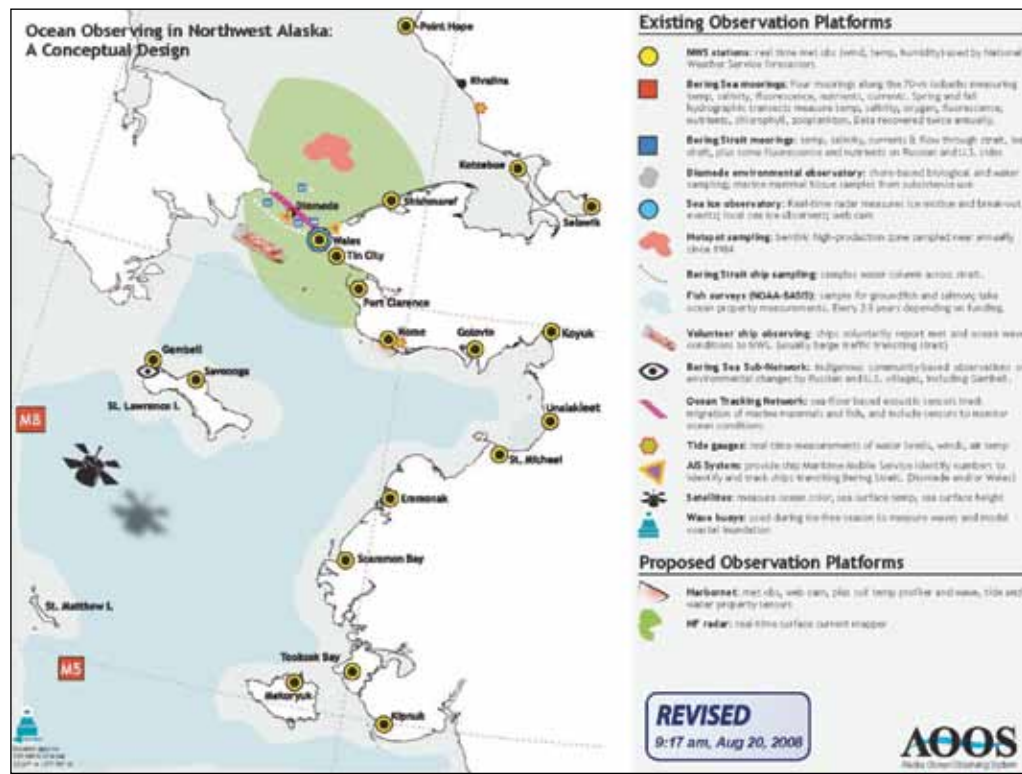
Though current environmental patterns and predictions indicate a profound and long-term ecosystem change to the Bering Strait region, human reliance on marine resources for subsistence remains essential.

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



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

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



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



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.



HUMAN DIMENSIONS

Human dimensions refer to the interrelationships of people and the environment, particularly with respect to environmental change. Often, human dimensions concern broad issues such as government policies or institutional responses to change. In the Arctic, human dimensions research has typically looked at local or regional cases. For marine shipping in the Arctic, both the broad and the local approaches are important to consider. Shipping will occur across the entire region, requiring national and international policies to provide effective management and regulation. Because trans-Arctic shipping will be driven largely by global economic factors, as will more local shipping for resource development, the role of institutions such as shipping companies, regulatory agencies and local or regional organizations who may be affected will all be pertinent.

This chapter addresses primarily the local aspects of human dimensions of Arctic marine shipping, with a particular focus on indigenous communities and traditional activities in the marine environment. Arctic marine shipping will occur in the context of many other changes affecting Arctic residents. Climate change,

which will make the Arctic more accessible to marine shipping, will affect most aspects of the lives of Arctic residents, from traditional livelihoods to infrastructure to the spread of disease. Social and economic change will come from national and global trends in trade and communication. Impacts to the environment and society are most likely to stem from the interactions of human and environmental change, particularly as human choices influence the trajectories of change. In this context, shipping may play a significant role not only on its own, but also, and perhaps even more likely, through combining with other drivers of change.

Arctic marine shipping involves several distinct activities, each with different interactions with local residents and thus different implications and likely impacts. Trans-Arctic shipping of cargo, using the Arctic merely as a corridor between distant ports, has some potential for environmental impact, depending on cargo carried and volume, and thus for affecting local societies that depend on a healthy marine environment. The infrastructure required to support such shipping may include port facilities, search and rescue or emergency response capability, and mechanisms of governance



Map 7.1 Circumpolar coastal human population distribution. Source: AMSA

Economically, more shipping may increase trade or lower costs for Arctic communities, while increased resource development can provide employment and income for Arctic residents and regions.

or enforcement, which may include military presence to preserve sovereign claims over certain waters. Such facilities may provide employment and other economic opportunity for local communities, but could also lead to social disruption if many people move to small communities to take new jobs. Local shipping, to and from Arctic ports, is likely to have more direct influence on communities. Indeed, local shipping today provides for substantial shipments of cargo and fuel to remote communities, allowing for a higher standard of living and lower prices than would be possible by air or land shipment alone. Longer shipping seasons could reduce prices further, or allow greater access by visitors.

Another form of local shipping is that in support of resource development in the Arctic. Supplying mines, oil and gas installations, and other development sites, and transporting the materials that are produced there, is the dominant form of marine shipping in the region today. While it is not clear whether reduced sea ice will

have a major influence on development trends, increased shipping is unlikely to constrain development. If indeed development increases, it will have far-reaching economic consequences for the regions in which it occurs, and will likely have environmental impacts as well.

In addition to mineral and petroleum extraction, fishing in Arctic waters is likely to increase as a result of greater access to ice-free waters. In Greenland in particular, the development of a shrimp fishery has had major impacts on coastal communities and indeed on the national economy, as shrimp constitute a major export from Greenland. In Alaska, participation in commercial fisheries has substantial social and economic impacts on communities, implying that increased involvement in fisheries by more northern communities could have major impacts both positive and negative.

One non-extractive industry likely to benefit from increased shipping access is tourism. For local communities, tourism can be a source of revenue but also a disruption, both from direct (though

A Container of Hazardous Materials Washes Ashore in the Commander Islands, Russian Federation

Bering Island, one of the Commander Islands, lies east of the coast of Kamchatka and west of the U.S. territories in the Aleutians. The only Aleut community on Russian soil and the only inhabited village on the Commander Islands is the village of Nikolskoye with about 750 residents, 300 of them Aleuts. The following is an account of an accident that should serve as a warning sign and an opportunity to examine the Achilles heel in shipping regulation and disaster preparedness, pointing the way toward policy changes to prevent worse disasters.

In July 2003, a 20-ton container filled with a hazardous chemical used in cement (tetraethylene glycol diheptanoate) washed up off the western coast of Bering Island, near the northwestern fur seal rookery and 15 kilometers from the local fishing grounds. The container, owned by the DuPont Corporation, was being shipped from South Africa to Korea and was lost at sea in March 2003.

When the container was discovered on the beach, there was no disaster response plan in place. Individuals who got close to the

container to examine it did not have any training in the handling of hazardous materials or the necessary equipment and clothes. They were poisoned and needed medical assistance.

The first attempt to move the container away from the area where tidal waves could throw it on the rocks and break it was unsuccessful. The container cracked and approximately 15 tonnes of the chemical leaked, creating a 400 square-meter oily spill. A later survey counted 46 dead birds and one dead seal.

The Anchorage office of the Aleut International Association, after receiving first news of the accident, made a round of calls to maritime attorneys in an attempt to find legal counsel for the village of Nikolskoye. Finally a firm with appropriate expertise was located in Juneau, Alaska. A telephone conversation, however, was abruptly interrupted by the news that the firm had been hired to represent DuPont.

DuPont provided funds for clean up, environmental assessment and some emergency response equipment. The nature and size of this work was mostly determined by DuPont itself.

This particular accident was small, but it exposed potential problems. Governments may want to identify measures that can help prevent accidents and address response, especially in light of expected increases in shipping.



© Aleut International Association, from the Nikolskoye Administration


■ The container of tetraethylene glycol diheptanoate that washed ashore on Bering Island.

Reflections from the Kola Coast

Shipping is but one of the many aspects of the history of northwestern Russia, one of the many factors shaping today and tomorrow. Murmansk was a bustling seaport during the Soviet era, when at the height of the Cold War it was the fishing capital of Northern Russia. The Murmansk Region is home to about 2,000 Saami, who continue their traditional culture in the inland parts of the Peninsula.

In the Murmansk Region, history has been witnessed, lived, forgotten, suppressed, remembered and altered. Kola Bay, with its nuclear fleets, is poised to be the jumping off point for Arctic opportunities of shipping and mineral development. The Kola coast is a smaller version of the multi-faceted, complex and layered coastal landscape and seascape that is the Russian Arctic coast today.

As a part of the time of transformation, the Kola Saami are witnessing a painful rebirth of their culture and nation. Since the formation of the Russian Federation, they can collaborate with the Saami in neighboring countries. They can participate in the Arctic Council and influence, for example, the development of marine and ocean policies. Even though the seasonal salmon harvest along the fjords of Kola is over and seals are no longer harvested by the Kola Saami, many elders still remember the sites, places and songs of the Kola coast. They remember the yearly cycle of the ocean, birds, fish and other beings.

The Kola Saami are afraid that the increased shipping and construction of new pipelines will ruin the remaining wilderness areas of the Kola. Atlantic salmon spawning rivers, such as the Ponoï, are vital traditional fishing areas for the Saami and their productivity is directly related to the ecological status of the Russian sector of the Arctic Ocean. The Kola Saami are engaging in planning and decision-making to make sure that the people of the Sun Deer will be here now and forever. 



© Arctic Council

likely inadvertent) interference with traditional and other activities, and also from greater attention to some local practices that may not conform with the values or expectations of non-Arctic societies. The presence of large cruise ships and their visits to communities that may have a fraction of the population of the ship itself cannot be ignored. An emergency involving such a ship could easily overwhelm local response capacity. Tourism, like fishing but unlike other forms of shipping, is likely to be focused on some of the same living resources (seabird colonies, marine mammals) that sustain local communities, thus increasing the potential for disruption and conflict.

The local human dimensions of Arctic marine shipping appear to be extensive, but there have been relatively few studies that have considered the implications either of current shipping activities or projections of what is likely to occur in the next few decades. The

AMSA's description of human dimensions of Arctic marine shipping is neither comprehensive nor exhaustive, but is intended to demonstrate how and why marine shipping matters to Arctic communities and to consider what additional work is needed to be able to prevent, mitigate, or otherwise manage shipping to reduce negative impacts and maximize potential positive benefits.

In recent decades and today, Arctic coastal people travel far on sea ice and water, both along coastlines and also out to sea. A comprehensive, up-to-date catalog of indigenous use of the Arctic marine environment does not exist. Compilations of data from Canada and Alaska are two to three decades old. Some more recent studies have examined use patterns near individual communities, but even these are few and dispersed. It is thus impossible to present an overall map or description for the entire Arctic. This section provides instead a few examples of various uses of the Arctic marine environment and

“The Sea Ice Is Our Highway”

Canadian Inuit Perspective on Transportation in the Arctic

Within Canada, Inuit view the Arctic as the places where Inuit have traditionally lived: Nunatsiavut along the coast of Labrador, Nunavik in Northern Quebec, the entire territory of Nunavut, and the Inuvialuit settlement region along the northern coast and around the northern islands of the Northwest Territories.

Life in the Arctic is dependent on movement, and sea ice is integral to this movement. The Inuit have been a nomadic people living in the Arctic since ancient times. As such, our entire culture and identity is based on free movement on the land and sea. Much of the traditional knowledge passed down from generation to generation is meant to hone the skills necessary for hunting and fishing. In order to hunt and fish safely and effectively in the Arctic, we train our young people to recognize different types of ice and to know the dangers associated with different seasons. Inuit hunters spend much of their time out on the ice, mostly in small groups or even alone; therefore, reliable knowledge of the ice can be a matter of life and death.

Interviews conducted by ICC Canada in March 2008 indicate that despite the increased difficulty in finding and harvesting big game and sea mammals due to thinning and less predictable sea ice, Inuit communities are persistent in maintaining their traditional diets. When asked whether changes in ice conditions were affecting their traditional diets, respondents spoke of having to travel further or in a different month than usual; they spoke of dietary substitutions such as hunting more musk-oxen when the caribou migration shifted away from their area; or they explained how melting permafrost has made the natural ice cellars used to age and store meat less effective. Not one of them said anything to suggest they were giving up on hunting despite the considerable challenges some were facing in getting out on the ice and land.

When asked how his life might change because of poorer ice conditions in the future, Tommy Qaqqasiq from Pangnirtung, Nunavut said: “Then we’ll use other equipment. People will still hunt. It’s part of our life. When things change, you just have to go with it.”

After describing in detail how climate change is forcing his community to deal with new challenges, John Keogak of Sachs Harbour shared this idea on how he can continue his harvesting practices:

“A buddy of mine is into making little sleds out of aluminum, which you can use as a little kayak or boat. If you’re out on the ice and you have to cross an open lead or something you can use that. It’s one of the things that can help. I’m going to get one of those. It’s combined as a little sleigh and, if you have to, you can use it as a boat. That’s one way I can adapt.”

With few exceptions, Inuit settlements are located on sea coasts or on major waterways with easy access to the sea. This clearly reflects the importance of the sea to our Inuit way of life. Whether thickly frozen or open for the summer, the sea is our primary means of transportation. The usually ice-covered sea is our highway, the only physical connection between many of our communities and the only way we can access many of the animals we depend on for food (Table 7.1).

As climate change and reductions in sea ice affect the migration routes of the land and sea animals we rely upon, it may be necessary for us to travel even further than before in order to reach them. Inuit hunters are reporting many changes in the locations and times that our traditional animals can be found. In some communities this is reducing the territory that hunters need to cover, while in others they have to travel much further than before in order to harvest enough food for the communities. This is why we are very concerned that sea ice routes remain passable for hunters, as well as the migratory game they follow, and that the entire Arctic environment be kept free from contamination – both in the areas we are now using regularly and in those areas where we may need to hunt in the future.

The primary resource for Inuit is the animals. Our people have always known how to care for this resource. We live in harmony with the land. When we hunt, we only take what we need and make sure to leave enough of the herd so that it can replenish itself. When we talk about the future, we are not talking about a five-year plan or even a 10-year plan. We are talking about our children and our children’s children. We are talking about living in the same communities where we can see the evidence of our ancestors. We are talking about preserving our way of life and the natural environment it depends upon for hundreds and thousands of years.

Ships coming through our seas are a cause for concern. On the one hand, they can be used to supply our communities with building materials and goods for our stores, which might bring a welcome reduction in the high cost of living in the Arctic. However, ships have also caused a lot of damage, as hunter Tommy Qaqqasiq of Pangnirtung explains:

“In recent years, all kinds of cruise ships are coming in to our area. Last year alone, there were maybe five or six cruise ships that came into town. More are coming every year. There’s a national park here in Pangnirtung, further inside the fjord, that’s what they are coming to see. The tourists come into town and buy all kinds of

art, like carvings, craft work, soapstone, whatever they can afford to buy. They help the artists. But hunters have been complaining about those ships because they go all over Cumberland Sound, even to the campsites. People are saying they are scaring away the animals, the mammals and whales. We are really noticing this because in the past couple of summers we hardly saw any narwhals around. Usually we catch our quota, but not in these past years.”

Another example of the difficulties related to shipping comes from the community of Tuktoyaktuk on the Beaufort Sea coast. Tuktoyaktuk has long been a key hub for supply ships servicing many of the Inuit communities in Canada. Because the harbor is also teeming with various species of fish, Tuktoyaktuk is an instructive example of colliding interests between economic activities and Inuit use of the sea. Inuit hunter, trapper and fisherman Chucky Gruben describes the issues:

“We have a hunters and trappers committee here, we take care of the wildlife. We deal with the people, we deal with the shipping companies. We have done some things where, after freeze-up, the ships are not allowed to come into the harbor. But this past year, because of late shipping to other communities, we had to keep our harbor open longer than usual because the supplies hadn’t gone out to the other communities.

“The community of Tuktoyaktuk is right in a harbor where a lot of fishing takes place. ... The east entrance is a place where a lot of people here that do their fishing set their nets right in the channel. Because the ships had made a ship track through the east entrance, they kept it open up right until November sometime, and the people couldn’t set their nets there because of the ships going back and forth. That is one of the impacts of shipping on our harvest.

“Usually with that kind of thing, we do have a say on whether the ships can use the area, but times are changing and every year we get applications to come into the harbor later and later. They wanted to do that the year before last, too, but we had to say no. Last fall we didn’t really have a choice because there was still fuel and a lot of supplies that needed to go out to the other communities, so we had no choice.”

The point to emphasize through these accounts from various Inuit communities is that the environment is vital to our entire way of life as Inuit. If something were to happen to our fragile Arctic ecosystem, our way of life would be lost and we as a people would be lost. Therefore, any activity in the Arctic, whether it is resource extraction, tourism or military-related, must be undertaken according to the Inuit definition of sustainability – it must support the continuation of the Inuit way of life for thousands of years to come.



Table 7.1 Socio-economic projections for the Canadian North from the 2007 Canadian Arctic Shipping Assessment. *Source: Transport Canada*

Region	Demographics	Transportation	Economy
Nunavut	<ul style="list-style-type: none"> • 2006 population: 29,500 • Growth rate 1.8% in 2005 to 2020 	<ul style="list-style-type: none"> • No all-weather roads or rail links between communities • Most communities receive 2 re-supply calls per year 	<ul style="list-style-type: none"> • Dominance of public sector for economic output and jobs • Significant non-wage and subsistence activity • >100 active resource exploration sites • Limited tourism • Growth at 4.7% to 2010, slowing thereafter
Northwest Territories (NWT)	<ul style="list-style-type: none"> • 2006 population: 41,861 • Most communities not expected to grow by 2020 	<ul style="list-style-type: none"> • Mackenzie River communities served by all-weather or winter roads 	<ul style="list-style-type: none"> • High unemployment in coastal communities • Presently no resource projects for river communities • Any shipping impact centred on Mackenzie Gas Project • High Arctic oil and gas potential, but not before 2020 • Some diamond mine development opportunities
Nunavik	<ul style="list-style-type: none"> • 2006 population: 10,783 • Population younger than Canadian average • Growth rate of 2.4% to 2010, to slow thereafter 	<ul style="list-style-type: none"> • Community port programme receives fed/prov support • No all-weather road links to the 14 communities 	<ul style="list-style-type: none"> • Significant non-wage and subsistence activity • Like Nunavut, wage economy is growing through govt., fishing and sealing, tourism, construction and resources • Resource development slow due to lack of road infrastructure
Coastal Cree Communities (in Quebec, Ontario, and Manitoba)	<ul style="list-style-type: none"> • 2006 population: 18,654 • Young population • Declining or levelling growth rates expected post-2010 	<ul style="list-style-type: none"> • Port of Churchill • Limited all-year road access 	<ul style="list-style-type: none"> • Largely subsistence economies • Some benefiting from hydro-electric developments • Resources on the horizon (diamond, gold, uranium) • Churchill – a viable link to Russia?

resulting interactions with marine shipping activities in different forms. These examples are intended to illustrate some of the range of potential interactions and effects.

Arctic marine shipping is one of many factors affecting, or with the potential to affect, the lives of Arctic residents. Predicting exactly how various developments in shipping will affect Arctic communities is difficult at best. For example, there is insufficient information to describe current local human uses of the Arctic marine environment adequately enough to assess the range of likely effects of marine shipping, and researchers cannot anticipate all potential information needs when conducting studies in advance. Rather, findings of the

kind presented in this section can be used to identify areas of potential conflict or interaction between local uses and marine shipping, but further studies should be done of specific areas where shipping activities are planned, in which the details of shipping and current local uses can be compared and evaluated for potential impacts and mitigation strategies.

In the face of uncertainty about what activities will take place, what effects those activities will have and what other factors will be involved, a collaborative management approach and careful planning are required to identify and respond to negative impacts and to identify and harness positive benefits. One hallmark of the collaborative

Extent of Use of the Marine Environment by Aleut Communities

The marine environment is vital for coastal Arctic communities. This is especially true in the Aleut region, where communities are on islands or along the Alaska Peninsula, providing excellent access to the sea but relatively few options on land. As with other data on the extent of marine use by Arctic indigenous communities, the information from the Aleut region is not consistent, comprehensive, and up to date for all communities. Instead, some reports are over a quarter century old, and more recent information does not cover all communities or all species. Nonetheless, tribal representatives confirm that the general pattern of marine use continues today.

Table 7.2 shows the results of surveys concerning traditional harvests in three predominantly Aleut communities in Alaska. Other studies have found that the overwhelming majority of households in Aleut communities use birds and eggs. In Nelson Lagoon, 92.3 percent of households used at least one bird or egg during the study period. In Akutan, the figure was 92.9 percent, compared with 88.9 percent in Nikolski and 73 percent in False Pass. Sharing of harvested birds and eggs was considered to have great cultural importance in all four communities.

Zenia Borenin, president of the Tribal Council for the Native Village of Akutan, described local use of the marine environment:

“The northeast near coastal waters of Akutan Island are important for black bass, chitons, halibut, salmon, razor clams, and sea lions. The southeastern-most near coastal waters is a vital cod and salmon fishing area. There is a sea lion haul out area on the eastern coast of Cape Morgan. A cod and halibut fishing area is located in the near coastal waters northeast of Talus Point.

“Akutan utilizes the coastal waters around Akun Island as well. Seagull eggs are harvested on the northwest shore of the island (Akun Head), and on the small islands southeast of Akun. Salmon and halibut are taken in the area of Lost Harbor. Halibut is harvested in the near coastal waters southwest of the island, and in several areas east of the island. Salmon are taken in Surf Bay, Trident Bay, and in Akun Bay in the area of Helianthus Cove. Akun Bay is an important area for halibut, crab, cod, octopus, and sea bass.”



Table 7.2 Per capita harvests of wild resources from three Aleut communities, with percent contribution from various classes of marine resources.

Source: Fall et al. 1993a, b, 1996

Community	Per capita harvest (kg)	% from salmon	% from other fishes	% from marine invertebrates	% from birds and eggs	% from marine mammals
Sand Point	115.9	54	21	7	2	2
King Cove	116.0	53	17	7	4	1
False Pass	186.9	47	15	6	4	6

approach is that it is adaptive in the sense that it allows for adjustments and alterations based on experience and evaluation as changes take place, rather than creating a fixed system for addressing anticipated issues that may turn out to be ineffective when unanticipated events occur.

An advantage of substantive local involvement is that local residents are often best positioned to weigh the many factors affecting them. The example of the container that washed ashore in the Commander Islands describes the consequences when local capacity for addressing a problem is lacking, a situation exacerbated in that case by the lack of any larger precedent or system for response or accountability. In cases where local involvement in planning or carrying out shipping-related activities was higher, communities generally experienced better results.

One component of local involvement is communication. Many of the participants in the AMSA town hall meetings asked for better information about cruise visits and trans-Arctic shipping plans. Effective communication and continued interaction has been found to be important in oil and gas activities and in tourism in the Arctic. Communication can help reduce the number of surprises for all involved, and early identification of problems can allow more time for resolution.

As noted earlier, projection of shipping activities and their impacts is difficult due to the interactions of numerous factors in the environment and in human society. To some extent, researchers need to develop better methods for studying combined effects of these kinds, just as regulators need to develop better methods for balancing multiple management objectives. Just as importantly, those involved in marine shipping in any capacity need to recognize that flexibility and adaptiveness will be required to recognize and address challenges, problems and opportunities that arise.

Marine shipping encompasses a wide range of activities, taking place in different locations and seasons and with differing degrees of local involvement and effects. The quantity of shipping, likewise, may determine whether effects are largely beneficial or otherwise, and also who is most affected. For example, limited tourist traffic may provide a modest economic opportunity for local artists and handicraft makers, whereas higher levels of traffic may have environmental or other impacts that offset any benefits. As noted earlier, the details of effects will depend greatly on the details of shipping and the characteristics of specific times and places. Nonetheless, the case studies in this section and studies of other types of activities, such as mineral and petroleum development, suggest some observations about what can be expected from increases in Arctic marine shipping.



Beaufort Sea Beluga Whales

Local and Distant Effects of Shipping

The Beaufort Sea population of beluga whales, numbering in the tens of thousands, migrates from the Bering Sea through the Bering Strait into the Chukchi Sea and then eastwards into the Beaufort Sea. The animals pass through the Mackenzie Delta region and into the waters among the western islands of the Canadian Arctic Archipelago. This migratory path takes them through the waters of Russia, Alaska and Canada. The belugas are hunted in all three regions.

During their migration, Beaufort Sea belugas traverse several areas where shipping may be a major presence. The Bering Strait is a crucial chokepoint for any trans-Arctic shipping. The Mackenzie Delta area already sees extensive tug and barge traffic. Shipping through the Northwest Passage will pass through narrow waterways where belugas gather in summer. Offshore oil and gas activities, including shipping, may affect belugas throughout much of their range.

Shipping may also interfere with hunting activities and opportunity, compounding any effects at the level of the beluga population. Further work is needed to examine exactly where and when shipping will overlap with hunting and with key stages of the beluga migration. This information can be used to develop specific management and mitigation plans, perhaps including limitations on shipping to protect belugas and those who hunt them.

In addition to local initiatives, a broader management plan is required to address impacts in one region that may affect other regions. For example, a disaster in the Bering Strait could affect hunters in the Mackenzie Delta region, 2,000 kilometers away, undermining any conservation efforts they have made in their area.



Town Hall Meetings

Town hall meetings were held in various locations in the Arctic as part of the outreach effort of the Arctic Marine Shipping Assessment. The intent of these meetings was two-fold. First, the organizers presented the plans for the assessment and the expectation of increased marine shipping that was driving the study. Second, the organizers sought input from participants regarding their observations, concerns and questions related to marine shipping. This section presents a summary of the main themes that emerged from these meetings.

Arctic residents think about shipping, not by itself, but in a broader context of economic, environmental, political and social change. In the town hall meetings, shipping did not appear to be a cause of great hope or fear, but rather as an additional factor that would influence the future of Arctic communities in various ways. In addition, discussing the future of Arctic marine shipping raised concerns about the ability of small indigenous communities to influence large-scale economic activities.

Environmentally, shipping is seen as a potential source of disruption to marine species. Marine mammals, in particular, are seen as vulnerable to disturbance. In Resolute, Nunavut, a period of increased shipping in the 1990s pushed walrus away from the community, too far for hunters to reach them. Saami fishermen in northern Norway are concerned about impacts to fisheries and fish stocks, particularly from pollution or oil spills. Oil spills are, in fact, one of the largest concerns, especially with the lack of response capability in nearly all areas of the Arctic. Ship traffic also raises the possibility of introductions of invasive species.

Hunters are concerned about impacts to the animals and to their practices. Too much ship traffic could be dangerous for hunters in small boats. In many cases, hunters traveling over sea ice have been cut off by icebreakers, an impact that remains a big concern, especially when travelers' lives could be at risk from unexpected open water. In some areas of the Canadian Arctic Archipelago, caribou migrate over sea ice and could be affected by icebreaker traffic. On the other hand, hunters in Resolute and Iqaluit noted that some marine mammals follow ships. In Iqaluit, the arrival of a ship was often a signal to beluga hunters to look for whales that may have come into the bay. As one hunter in Cambridge Bay, Nunavut, said, hunters are going to adapt, but they cannot survive without healthy animals to hunt.

Economically, shipping offers many benefits. Participants in many communities spoke of the prospect of lower shipping costs if cargo ships can come more frequently or if larger ships can be used. Increased shipping and port activity can also provide jobs. In

Canada, ports for mines have often been located away from communities at the communities' request, to avoid social impacts from the influx of workers. Communities may reconsider that approach or seek other ways to gain economic benefits from port activities. On a smaller scale, cruise ships provide an opportunity for carvers to sell their artwork, making their visits welcome to at least some Arctic residents.

The relative costs and benefits of shipping depend greatly on volume. Modest amounts of traffic, or a few visits by cruise ships, may be seen as largely positive. Increasing numbers of ships and visits, however, pose the threat of greater disruption and little time in between to recover. Culturally and socially, shipping can be a catalyst for disturbance if many newcomers arrive in the Arctic, as has been seen with other forms of development. The Arctic is already experiencing rapid social and cultural change, and additional pressures will only make adjustment harder.

In this context, many participants expressed concern over having little voice in shipping, development and other activities that have so much effect on their lives. In Norway, development of onshore mineral resources and offshore oil and gas are seen as major threats to the Saami way of life. With the extent of global environment, economic and social change, many Arctic people feel they have little ability to influence major developments like Arctic marine shipping. When shipping companies ignore local residents, the feeling of powerlessness is compounded. By contrast, when shipping companies or cruise lines communicate with local residents, the effort is well received and makes people better informed and thus better able to make any adjustments they need to in order to minimize the impacts of ship traffic.

An additional insight from the town hall meetings is that few Arctic residents are aware of the scope of activities that may be coming to their region soon. The meetings were able to provide some information, but many additional questions were raised about the scale of environmental change, the prospects of mineral development and other changes that can be expected in the near future. For Arctic residents, these influences are not separate things that can be treated one by one. Instead, each new factor merely joins the others in shaping people's lives. The degree to which Arctic people retain the ability to determine their own futures remains to be seen. Communication and the ability to exercise at least local influence are seen as key components of sustaining traditional ways and practices.





First, the impacts of shipping depend greatly on the type of shipping, the season(s) in which it occurs and the locations. Trans-Arctic shipping done in ice-free conditions and largely offshore may have few or no local effects, barring an accident. Nonetheless, as the Aleutian region has experienced, accidents can and should be expected, prepared for and responded to promptly and effectively. This is especially true in narrow waterways of the Arctic. In these places, ships must travel close to land and may well encounter local hunters or travelers out in boats. In addition, proximity to communities means proximity to hunting areas and the animals that people depend upon, so the potential for environmental impacts is correspondingly higher in these areas. Tourism, too, is likely to take place largely or exclusively in the ice-free season (with the exception of icebreaker voyages to the North Pole), though cruise ships are likely to visit communities or areas of high biological activity such as bird colonies or marine mammal haul-outs.

Shipping to and from destinations within the Arctic is also largely done during the ice-free season, with important exceptions in the Russian Arctic as well as occasional icebreaker transits throughout the region. Ice-breaking can interfere with over-ice travel by hunters and others and so is potentially a more significant impact than are open-water transits. Icebreaker activity may increase as mineral and petroleum resources are developed in the region, which might make interactions with local travelers more common. Here, too, the potential for environmental impacts is high, both from accidents and from destruction to key habitats such as areas where seals or polar bears make ice dens for bearing young. As with trans-Arctic shipping, the

potential for local impacts is greatest near shore, particularly in narrow passages and straits.

Effects, too, come in several forms. Economically, more shipping may increase trade or lower costs for Arctic communities, while increased resource development can provide employment and income for Arctic residents and regions. As has been noted with regard to oil and gas activities in the Arctic, economic benefits may be considerable and can have a number of secondary effects, such as increased local capacity to provide social, cultural and health services as well as construct and maintain infrastructure.

Socially, increased economic activity and resource development can, but does not necessarily, lead to population growth through immigration, which can create social tension between newcomers and indigenous or other long-time residents. Often, those moving to the Arctic for employment are young men, creating a gender imbalance in the local population, which can exacerbate tensions and social problems. Changes in income, too, are often associated with increases in drug and alcohol abuse, as well as domestic violence and other crime. Many of these negative impacts can be addressed largely or in part, by establishing rotational work schedules, with workers traveling to the region for work shifts of one to several weeks and returning to their home communities during the periods they are off or by physical separation between a community and a development site.

Environmental effects are often the greatest concern from increased industrial activity of any kind, whether resource development or shipping. The environmental effects of Arctic marine



shipping are addressed in other sections of this assessment, but it is important to note that loss of hunting opportunities and degradation of the environment can have substantial impacts on local communities. Concern about these types of impacts can by itself cause stress, especially when hunting and other traditional activities are seen as pillars of cultural continuity but also under threat from other social and environmental changes.

The cultural effects of shipping and development may, therefore, be generally anticipated to be negative, but this is not necessarily the case. Environmental impacts and greater assimilation from exposure to outside influences can cause cultural loss, but tourism can boost local cultural awareness and pride and greater economic well-being can allow investments in cultural programs.

As noted earlier, the difference between negative impacts and positive or neutral ones is often a question of planning and preparation. A large influx of cash into a community can create a boom-and-bust atmosphere, with minimal investment for the long-term and a host of social problems in the short-term. The same economic boom can also be harnessed to produce lasting benefits. Doing so successfully requires extensive local involvement in the planning process, so that local concerns and ideas can be fully incorporated. Not all marine shipping activities will be beneficial for Arctic residents, and some are likely to have negative impacts. Nonetheless, careful attention to good communication and collaborative approaches to management can help keep increases in shipping activity from causing undue stress and harm to Arctic people and may result in benefits to many areas. ☀

Research Opportunities

- ❑ Regional analyses of traditional marine use patterns (spatial and seasonal) for application in the development of strategies and measures to reduce potential conflicts and impacts of multiple users of Arctic waterways.
- ❑ Research on the impacts of noise/sound on marine mammals in regions where current and future marine operations overlap with indigenous hunting (examples: bowhead whale hunting off Alaska's northern coast and beluga hunting in the Canadian Arctic).
- ❑ Detailed, interdisciplinary analyses of the interactions and impacts of marine shipping with Arctic communities. Further assessment of the social, cultural, economic and environmental impacts from shipping to provide insights for planning future Arctic marine systems and operations.
- ❑ Mapping and study of changing indigenous use of Arctic sea ice as a transport medium in the face of climate change and sea ice retreat.
- ❑ Comprehensive review of changes in Arctic marine technology during the past six decades, specifically for Arctic commercial ships, and how these changes may influence the future of Arctic marine transport systems.

While it is not clear whether reduced sea ice will have a major influence on development trends, increased shipping is unlikely to constrain development.

Findings

- 1] Marine shipping is one of many factors affecting Arctic communities, directly and indirectly. The variety of shipping activities and the range of social, cultural and economic conditions in Arctic communities mean that shipping can have many effects, both positive and negative.
- 2] While economic effects of marine shipping may be positive, there are many concerns expressed by Arctic coastal communities about social, cultural and environmental effects.
- 3] There is insufficient information to identify with any precision the likely effects of marine shipping for most Arctic coastal communities. No current database exists for indigenous use in local Arctic waterways that could be used to develop multiple use management measures and potential mitigation strategies.
- 4] The costs and benefits from marine shipping will be unevenly distributed among and within communities and regions.
- 5] Constructive engagement of local residents at the earliest time in a planned Arctic marine development project can help reduce negative impacts, assist in a smooth interaction and increase positive benefits from marine shipping.
- 6] The marine environment and marine resources have long sustained Arctic communities. Thus, Arctic settlement patterns demonstrate a strong marine influence. Local Arctic residents today depend heavily on marine resources for subsistence and the local economy. A combination of over-the-ice travel (i.e., using ice as a platform and means of travel for hunting and fishing) and boat transport (i.e., for fishing, hunting and travel) allows the use of large Arctic marine areas during much of the year. Life in the Arctic is dependent on movement and sea ice is integral to this movement in the high Arctic. Remote indigenous coastal communities are especially vulnerable to marine accidents as they risk losing not only their vital marine resources, but the natural foundation of their cultures and way of life.
- 7] AMSA town hall meetings revealed that Arctic residents think about shipping, not by itself, but in a broader context of economic, environmental, political and social change. Shipping did not appear to be a cause of great hope or fear; rather, as an additional factor that would influence the future of Arctic communities in various ways.
- 8] AMSA town hall meetings indicated that from an environmental perspective, shipping is viewed as a potential disruption to marine species. Oil spills are one of the largest concerns. Hunters are also concerned about the impacts of ships on the animals and on their hunting practices.





ENVIRONMENTAL CONSIDERATIONS AND IMPACTS

Marine shipping, if not properly managed, poses a threat to natural ecosystems. This is especially true for the Arctic. Whether it is the release of substances through emissions to air or discharges to water, accidental releases of oil or hazardous cargo, disturbances of wildlife through sound, sight, collisions or the introduction of invasive alien species, the Arctic marine environment is especially vulnerable to potential impacts from marine activity.

Vulnerability of Arctic Species and Ecosystems

Extreme cold temperatures, ice and strong seasonal variability characterize the Arctic. These extremes have resulted in a range of adaptations among Arctic animals including the ability to store energy when food is plentiful and fast when it is not; highly insulating outer layers such as feather, fur or blubber to keep warm; and a high degree of seasonal migration to and from the region, especially among marine mammals and birds.

The extensive seasonal migrations of marine mammals and birds into and out of the Arctic are key features that determine the vulnerability of Arctic ecosystems. Seabirds, shorebirds and waterfowl move north to breed and feed during the short Arctic summer, exploiting the burst of productivity in the northern ecosystems. Whales and seals have similar migrations to northern feeding areas. Many species aggregate throughout the circumpolar north in very large numbers to feed, mate, give birth, nurture their young and molt. During the periods when Arctic species gather and in the areas where they do so, they are particularly vulnerable to potential environmental stresses, such as accidental discharges from ships and various types of disturbances that ships can cause.

Disturbance during critical stages could disrupt the short feeding season for Arctic species, causing some animals to not get enough food to provide the energy needed for the long migrations they face and for breeding and raising their young. Arctic species, which are reliant on feathers and fur to insulate against the cold, are especially

vulnerable to contamination from oil that will compromise their insulating layers, leaving them exposed and at risk of hypothermia and death. It is the unique adaptations of the various species which live in and migrate to the Arctic that make them vulnerable to potential adverse impacts as a result of shipping and other vessel activities.

The degree of oil pollution in the Arctic marine environment is low, according to the recent Arctic Council Assessment of Oil and Gas Activities, with natural seeps being the largest source of input of oil hydrocarbons. Accidental oil spills were seen as the largest threat. While the Arctic environment is still relatively clean for many types of contaminants, recent assessments by the Arctic Monitoring and Assessment Programme (AMAP) have shown that persistent organic pollutants (POPs) occur at high levels and pose a threat to top predators in marine food chains, including humans. Heavy metals such as mercury, cadmium and lead are also seen as issues of concern in some parts of the Arctic.

Arctic Species: Interactions with Shipping

Arctic marine mammals such as bowhead, beluga, narwhal, walrus and several species of seals migrate south in fall to spend the winter in the southern areas of seasonal ice. In spring, they move north again, using systems of polynyas and leads, often before the break-up of the ice. At this time, these mammals reproduce and give birth to their young. Important wintering areas for marine mammals are in the broken pack ice in the northern Bering Sea, Hudson Strait, Davis Strait and southeastern Barents Sea. From these areas, the mammals follow leads and openings north through the Bering Strait and the Chukchi Sea; north through Baffin Bay into Lancaster Sound, into Hudson Bay and Foxe Basin; and north and east into the Kara and Laptev seas. The leads and openings in the ice are also used by seabirds, eiders and other marine birds on their spring migration to the northern breeding areas.

As climate and sea ice conditions continue to change, the timing and movements of the animals' activity will also be modified, making predictions of the potential interactions between shipping and animals increasingly complex.



The migration corridors used by marine mammals and birds correspond broadly with the main shipping routes into and out of the Arctic. Currently, there is limited overlap during the spring migrations as all shipping activity will typically occur later in the spring than the animal migrations. In the fall, there is likely more opportunity for interaction between ships and migrating species, as both are leaving the Arctic ahead of the formation of the pack ice. As the Arctic climate continues to change, it is very likely that the shipping season could extend earlier in the spring and later into the fall. The spring migration corridors are particularly sensitive and vulnerable areas to oil spills, ship strikes and disturbances, and could be a time of vulnerability for marine mammals and birds. In the future there will be a need to consider the potential risk and interaction between ships and animals during this vulnerable period.

The geographic area covered by this assessment spans a wide range of environmental conditions, from pack ice in the Arctic Ocean to open subarctic waters in the Bering Sea and the Nordic seas in the northeastern Atlantic. The volume of current shipping traffic also varies considerably across the Arctic. Currently, there is significant year-round traffic along the subarctic coast of Norway, around Iceland, on the southeast coast of Greenland and out of the Yenisei River and Pechora Sea to the port of Murmansk in northwest Russia. There is a moderate amount of seasonal shipping to and from destinations in the North American Arctic, and no established trans-Arctic traffic. Risk of negative interaction between vessels and wildlife varies across the region. The North Pacific Great Circle Route between western North America and eastern Asia is a high volume shipping lane that swings through the Unimak Pass in the Aleutian chain, passing in close proximity to important marine mammal haul-outs, rookeries and nesting sites of marine mammals and seabirds, close to active commercial fishing grounds and one of the largest protected essential fish habitats in the world.

The Arctic is Changing

The Arctic climate is warming. The effects of this are now being seen in the retreating sea ice, melting permafrost and the changing timing of the onset of fall and spring, as well as the increasing variability within each season. These changes are affecting Arctic species and ecosystems. Where caribou used to migrate across frozen rivers, they now have to wade. Polar bears swim farther to find food and wait longer in the fall for the pack ice to reform, extending their fasting. Pacific walrus are now hauling out on land in the Chukchi Sea, where they used to haul out mainly on sea ice.

Arctic species and ecosystems are, by nature, highly evolved in function and finely tuned with the timing of seasonal events.

Although some species will benefit from the changes, there are many that are now under stress as a result and, for some, at risk of steep decline. For many species, any potential impacts as a result of current or future shipping activity will be in addition to the stress they are already under due to the changes occurring in their environment. It is beyond the scope of the current assessment to examine the interaction between effects from climate change and effects from future shipping activities. This is in part because of the intrinsic difficulties and the many uncertainties about the future.

Climate experts are projecting that the main change in sea ice will be decreasing ice coverage in the summer along the coastal Arctic seas with the formation of first-year ice occurring later in the fall. Even with a warmer climate, the Arctic Ocean will still remain ice-covered for most of the year. As climate and sea ice conditions continue to change, the timing and movements of the animals' activity will also be modified, making predictions of the potential interactions between shipping and animals increasingly complex.

Ship Based Impacts

Accidental Discharge

The accidental release of oil or toxic chemicals can be considered one of the most serious threats to Arctic ecosystems as a result of shipping. The release of oil into the Arctic environment could have immediate and long-term consequences. Some Arctic animals are particularly sensitive to oil because it reduces the insulating properties of feathers and fur and they can quickly die from hypothermia if affected. This is the case for seabirds, including eiders and other sea ducks, and also polar bear and seal pups. Concentrated aggregations of birds and mammals, often in confined spaces such as leads and polynyas, increase the risk to the animals in the case of an oil spill in the Arctic. Crude and refined oils, including fuel oils used by ships, vary much in their physical and chemical properties. This, in addition to other factors such as temperature, light, waves and ice, plays a major role in the behavior of oil in the environment and the extent of biological effects.

Other potential problems from released oil include the transfer of oil to nests by sea birds landing on oil slicks and the ingestion of oil by animals while preening. This can lead to death or other biological effects both in the short and long term. Even small spills can have large consequences if they occur where marine birds are concentrated.

Chronic seepage of residual oil after a spill can affect the entire food chain in an area because hydrocarbons are taken up by bottom feeding invertebrates, which then end up as prey for sea birds and

Environmental Impacts and Disturbances from Cruise Ships

The number of cruise ships operating in the Arctic is rapidly increasing. These ships are traveling to the region for the scenery and to actively seek out areas of special interest, including exceptional wildlife viewing opportunities. Wildlife is a primary attraction for polar tourists. Polar ecosystems, particularly in coastal environments, and wildlife migratory events provide tourists with opportunities to view many species of land and marine mammals as well as a remarkable diversity of birds. However, because cruise ships are specifically seeking out such events and opportunities, the potential is created for significant impacts on concentrations of wildlife due to disturbance from the ship.

There are numerous ways passenger ships can cause environmental harm. Emission of substances to the local air and ocean, possible incidents including sinkings and groundings, ship operations unsuitable for polar conditions and the inappropriate behavior of passengers ashore are the most prominent impacts. The 2004 U.S. Commission on Ocean Policy reported that, while at sea, the average cruise-ship passenger generates about eight gallons of sewage per day and an average cruise ship can generate a total of 532,000 to 798,000 liters of sewage and 3.8 million liters of wastewater from sinks, showers and laundries each week, as well as large amounts of solid waste (garbage). The average cruise ship will also produce more than 95,000 liters of oily bilge water from engines and machinery a week.

Sewage, solid waste and oily bilge water release are regulated through MARPOL. There are no restrictions on the release of treated wastewater. MARPOL restrictions typically prescribe the allowed distance from shore and rate at which wastes can be released or requires ships to deposit them in shore-side reception facilities. However, the Arctic region lacks infrastructure to adequately dispose of bilge water, sewage and solid waste. Many Arctic communities do not even have sufficient facilities to deal with the waste of their own communities, let alone that of tourist vessels. When ships are forced to stockpile wastes onboard where reception facilities are lacking, the risk of illegal or accidental release into sensitive areas is heightened. The

alternative to depositing waste into onshore facilities is onboard incineration, a practice that also brings with it concerns about localized air pollution.

The extent of the impacts on different Arctic species from cruise ships is difficult to assess due to the lack of Arctic-specific baseline information on wildlife and the relatively recent increase in cruise ship activity. The cruise ship industry has a vested interest in maintaining healthy wildlife populations; however, there are currently no common best practices for the circumpolar Arctic as there is in the Antarctic through the International Association of Antarctica Tour Operators. The Arctic's one cruise organization, the Association of Arctic Expedition Cruise Operators, is limited in scope with its geographic range in the Svalbard, Jan Mayen and Greenland area. Cooperation among cruise ship operators, in partnership with academic and regulatory bodies, is necessary to ensure more sustainable eco-tourism in the Arctic.



other animals, causing effects higher up the food web. Arctic animals are also particularly vulnerable to spills in certain areas and at certain times of the year when animals aggregate in large numbers to breed, nest, bear young and molt.

The Arctic is an extreme environment with a range of weather, light, hazards and with little human infrastructure. Responding to oil spills in these conditions is a major challenge, especially where ice is present. There are currently limited methods for recovering spilled oil in an ice-covered environment. The options currently available for oil spill recovery in the Arctic include mechanical methods, bio-remediation, dispersants and/or in-situ burning. Consequently, strong prevention measures must be of primary concern, while response measures, being both unreliable and untested, should be secondary. The risk of accidental release of oil and other contaminants increases with any increase in shipping activity that involves the use or transportation of oil or other chemicals.

Regular Discharges to Water

As a part of normal operations, ships produce a range of substances that must eventually be eliminated from the ship through discharge into the ocean, incineration or transfer to port-based reception facilities. Referred to as regular discharges these include oil, ballast water, bilge water, tank washings (oily water), oily sludge, sewage (black water), garbage and grey water. Regular ship discharges are regulated through the IMO's *International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto* (MARPOL 73/78) and other IMO conventions, as well as through domestic regulation by coastal states (See page 59). MARPOL has effectively reduced pollution in the marine environment by regulating the release of regular discharges. However, it has not eliminated discharges into the world's oceans altogether.

Ship Category	Ship Sub-category/ Use	Ship Type-Specific Pollution Sources
Government Vessels and Icebreakers	Coast guard vessels, research icebreakers, private icebreakers, government icebreakers, other research vessels	Accident/incident recovery-produced contaminants, emergency dumping oil/fuel, nuclear icebreaker radiation contamination, explosives/munitions, impacts due to icebreaking activity (disruption of ice formation, marine mammals, etc).
Container Ships	Cargo transport	Hazardous goods in transit, convoy collision hazard, grounding hazard (uncharted waters, lack of experienced ice navigation).
General Cargo	Community re-supply vessels, roll on/roll off cargo	Hazardous goods in transit, accidental cargo release, contaminated cargo.
Bulk Carriers	Timber, merchant, oil, ore, automobile carriers	Release of metal contaminants, radiation contamination from cargo, hazardous goods in transit.
Tanker Ships	Oil tankers, natural gas tankers, chemical tankers	Liquid Nitrogen Gas contamination, chemicals and hazardous goods in transit, spills from oil transfer.
Passenger Ships	Cruise ships, ocean liners, ferries	Large volumes of black and grey water release, garbage disposal, cleaning contaminants, disturbance of wildlife through viewing activities, automotive contaminants w/ vehicles ferries .
Tug / Barge	Re-supply vessels Bulk cargo transport	Increased accident hazard (non-propelled), hazardous goods in transit, spills during oil transfer, heavy emitters of air contaminants (black carbon).
Fishing Vessels	Small fishing boats, trawlers, whaling boats, fish processing boats	Increased fire hazard, introduction of pathogens and other contaminants from released fish offal, accidental release of invasive species/related biological contaminants, release of plastics, ghost nets and other fishing debris, seafloor damage from bottom trawlers, depletion of marine species (if not managed), accidental release of refrigerant contaminants.
Oil and Gas Exploration/Exploitation Vessels	Seismic exploratory vessels, oceanic and hydrographic survey vessels, oil drilling vessels, oil and gas storage vessels, offshore re-supply, portable oil platform vessels, other oil and gas support vessels	Hazardous cargo, explosives, acoustic impacts from seismic activities, oil/hydrocarbon contamination, contamination from extraction chemicals, accidental loading/offloading spillage, fire hazards.

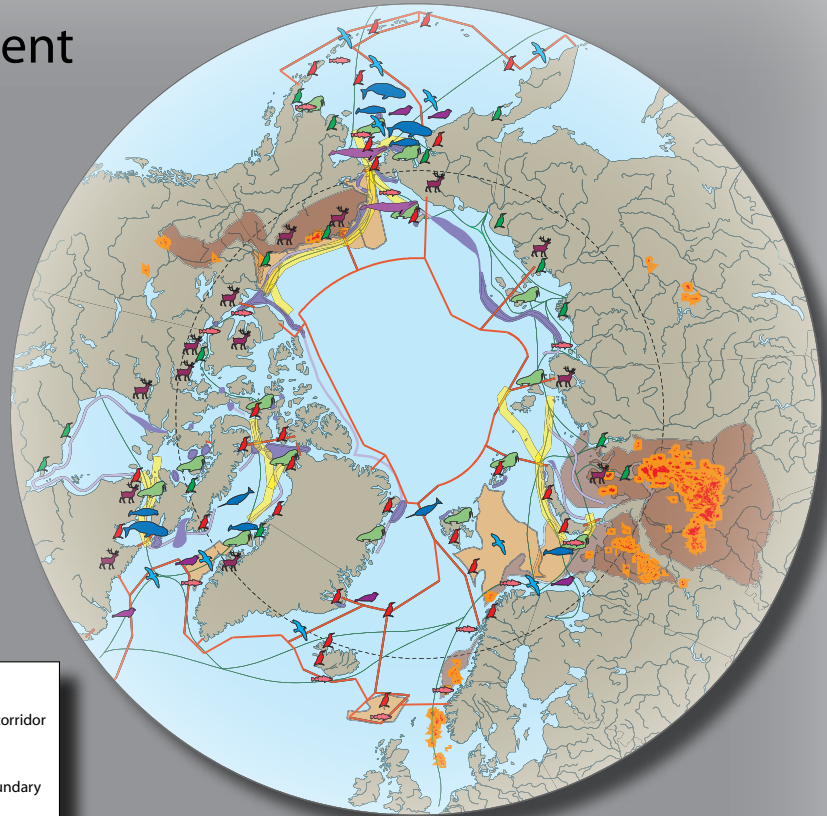
■ **Table 8.1** A range of potential environmental impacts linked to ship types operating in the Arctic. *Note: All ships will have certain impacts linked to the release of grey water, sewage, ballast and bilge water; air emissions; regular and accidental discharge of fuel/oil; introduction of noise and other acoustics such as sonar; and possible strikes on animals. Those listed above are in addition to these and specific to the vessel type.* Source: AMSA





















Oil is released with bilge water with a maximum allowed concentration of 15 parts per million (15 mg per m³) after treatment with an oil separator. Oil is also released with water used for tank washings after required treatment and with restrictions on amount and rate of release to avoid formation of oil film at the surface (i.e., blue shine). Oily sludge, consisting of high molecular hydrocarbon substances, accumulates in fuel tanks in fairly large amounts, constituting typically 1-5 percent of the amount of fuel consumed. Oily sludge must not be released but stored on board and brought to reception facilities in ports.

A recent study of regular discharges from ships in the Norwegian and Barents seas provides an example of the level of discharge expected to be released in an area that has some of the heaviest ship traffic in the Arctic or subarctic region. In this study it was estimated that the amount of oil released via bilge water and tank washings that the MARPOL allowed 15 ppm totaled about two tons of oil per year, a relatively small amount. However, the study found ship operations generate about 13,000 metric tons of oily sludge annually.

Arctic Oil and Gas Assessment

A comprehensive assessment of the oil and gas activities in the Arctic was carried out in 2007 by the Arctic Council under the leadership of the Arctic Monitoring and Assessment Programme working group. This assessment summarized information on the history, current and projected oil and gas activities in the Arctic, and examined socio-economic and environmental effects associated with these activities. The assessment included a detailed description of the main features and species of the Arctic ecosystems and their vulnerability to oil spills and disturbances from oil and gas activities. An illustrative circumpolar map of vulnerable areas based on aggregations of mammals, birds, and fish was produced as an outcome.



	Caribou/reindeer calving grounds		Spawning area - fish
	Seabird colonies		Marine mammal migration corridor
	Staging area - birds		Shipping route
	Wintering area - birds		Large Marine Ecosystem boundary
	Feeding area - grey whale		Major shore lead polynya
	Wintering area - bowhead		Concentrations of polynyas
	Wintering area - narwhal		Producing fields
	Wintering area - beluga		Production areas
	Walrus aggregations		Basin/province with production
	Whelping area - seals		Major exploration basins

An illustrative map from the Arctic Oil and Gas 2007 assessment of areas in the Arctic indicating where selected birds, mammals and fish form major aggregations to breed, stage, migrate or overwinter. When oil and gas activities including transportation occur in such areas, such aggregations are vulnerable to disturbances and oil spills. Source: AMAP

1.0%

The 2004 Arctic shipping contribution of CO₂ emissions to the total from the global shipping fleet.

Wild Card – Ship Stack Emissions – NO_x, SO_x, Black Carbon and Ozone

Ships are powered by engines and fuels that, like other transportation modes, emit CO₂ and water vapor, nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO) and particulate matter (including black carbon [BC]). Most oceangoing ships burn low-quality residual fuels that tend to contain high amounts of particulates from soot (black carbon), sulfur aerosols, ash and heavy metals.

These are pollutants specifically quantified in the inventory of emissions from Arctic shipping in this assessment. These pollutants are linked with specific environmental effects, and complex interactions occur among these substances in the regional and global atmosphere. For example, NO_x is a gaseous contributor to tropospheric ozone formation; SO_x gases form particles that contribute to acid rain and cloud effects on regional climate; and other fine particles like black carbon impact air quality, visibility and climate change.

Shipping's contribution to regional and global impacts from emissions such as CO₂, NO_x and SO₂ have been evaluated by scientists and shown to be significant enough to motivate policy action. However, environmental and climate effects of NO_x and ozone, sulfur aerosols and clouds, and black carbon particles in the Arctic are only beginning to be understood. Black carbon has been proven to have significant climate forcing effects, in addition to its effects on snow and ice albedo, accelerating the retreat of Arctic sea ice.


Background levels of NO_x, the precursor to ozone, are very low in the Arctic and recent studies have found that seasonal increases in ozone are closely linked to seasonal increases in shipping activity. Surface ozone is known to have harmful effects on plant growth and human health and is the basis for photochemical smog.

Ship stack emissions in and near the Arctic will increase along with growth in shipping activity, except where regulations like MARPOL Annex VI require steep reductions in sulfur emissions through fuel sulfur limits or pollution reductions in specially designated regions. The specific benefits of reducing impacts in the



Arctic through control of ship emissions need to be further studied, and the AMSA inventory for 2004 provides a good baseline inventory to evaluate scenarios that may achieve these benefits.

Based on AMSA findings, the report recommends continued study of ship-based emissions and trends. Climate change policy is currently focused on CO₂ from ships and the potential climate response to lower ship sulfur emissions is becoming recognized. NO_x emission controls may mitigate some of the Arctic regional ozone impacts suggested by one international study and the AMSA inventory provides an opportunity to update previous research findings.

More recently, scientists are recognizing that black carbon particles have potentially significant impacts on the vulnerable Arctic environment and climate that need to be quantified. The AMSA contribution to further research may be very important, given that recent studies suggest that reduction of the positive climate forcing due to BC would decrease both global warming and retreat of the sea ice and glaciers and would therefore provide an opportunity for effective short term mitigation of global warming. 

The release and deposition of black carbon in the Arctic region is of particular concern because of the effect it has on reducing the albedo (reflectivity) of sea ice and snow.

Table 8.2 Estimated emissions in the Arctic for 2004 by ship type. *Source: AMSA*

Emission amounts were calculated using the AMSA marine activity database (See page 70), which is based on information reported by Arctic Council member states. Baseline information was provided in different formats and to different degrees of detail between states.

Vessel Category	Fuel Use (kt/y)	CO ₂ (kt/y)	BC (t/y)	NOx (kt/y)	PM (kt/y)	SOx (kt/y)	CO (kt/y)
Bulk	354	1,120	122	26.9	17.9	18.6	2.57
Container	689	2,170	239	52.5	35.0	36.2	5.01
General Cargo ¹	590	1,860	202	44.9	29.9	31.0	4.29
Government Vessel	117	368	40.1	8.89	5.92	6.13	0.85
Other Service Vessel	3	11	1.19	0.26	0.18	0.18	0.03
Passenger Vessel	349	1,100	120	26.6	17.7	18.3	2.54
Tanker	269	848	92.5	20.5	13.7	14.1	1.96
Tug and Barge	17	54	3.38	1.32	0.88	0.91	0.13
Fishing ²	1,020	3,230	363	78.0	52.0	53.8	7.4
Total	3,410	10,800	1,180	260	173	179	25

1. A review and comparison of the AMSA estimated fuel use by General Cargo vessels with recent activity-based inventories completed by Norwegian researchers at DNV suggest that this category may be overestimated, due to the world fleet characteristics for general cargo ships reflecting larger vessels with more installed power than typical for Arctic operations.

2. A review and comparison of the AMSA Fishing vessel data with more direct activity-based estimates completed by DNV for Norwegian fishing vessels suggests that this first estimate may be in the range of three to four times higher than what was found by DNV. This is likely because the AMSA fishing vessel estimates are based primarily on days at sea, which assumes the vessel engine runs at varying capacity for the entire period at sea and may overestimate fishing vessel emissions and fuel use.

The amount of legally discharged oil under MARPOL in the Norwegian study indicates that current amounts of legally discharged oil should not pose a significant threat to the local ecosystem so long as the laws are strictly followed. MARPOL requires oily sludge to be disposed of in port-based reception facilities. Norway is unusual in the Arctic region in that it has good port reception facilities in all of its Arctic ports, but that is not the case in many other areas of the Arctic. In some areas, limited port side infrastructure as well as the cost of disposing of waste using port reception facilities provide incentive for illegal dumping of wastes produced on board.

Considering the sheer volume of oily sludge produced in Norwegian waters alone, it would take only a small percentage of the oily sludge produced to be illegally discharged for it to cause environmental damage. Illegal release of oil and oily sludge can cause oiling of animals and birds, can be toxic to marine and terrestrial ecosystems and extremely difficult to clean up. Contamination can last for years in ocean sediment and other compartments of the marine environment, sometimes presenting contaminated prey upward within marine and coastal food chains. Oily sludge is not the only regular discharge that can end up in the ocean. Under MARPOL it is legal to discharge garbage and raw sewage into the water once a ship is a certain distance from shore. The presence of significant amounts of garbage and other debris in the ocean can result in a number of environmental impacts. These range from damage to marine habitat, entanglement of wildlife, introduction of bacteria and disease (from untreated human sewage) and the ingestion of plastics and other unsuitable items by marine mammals and birds. As vessel activity

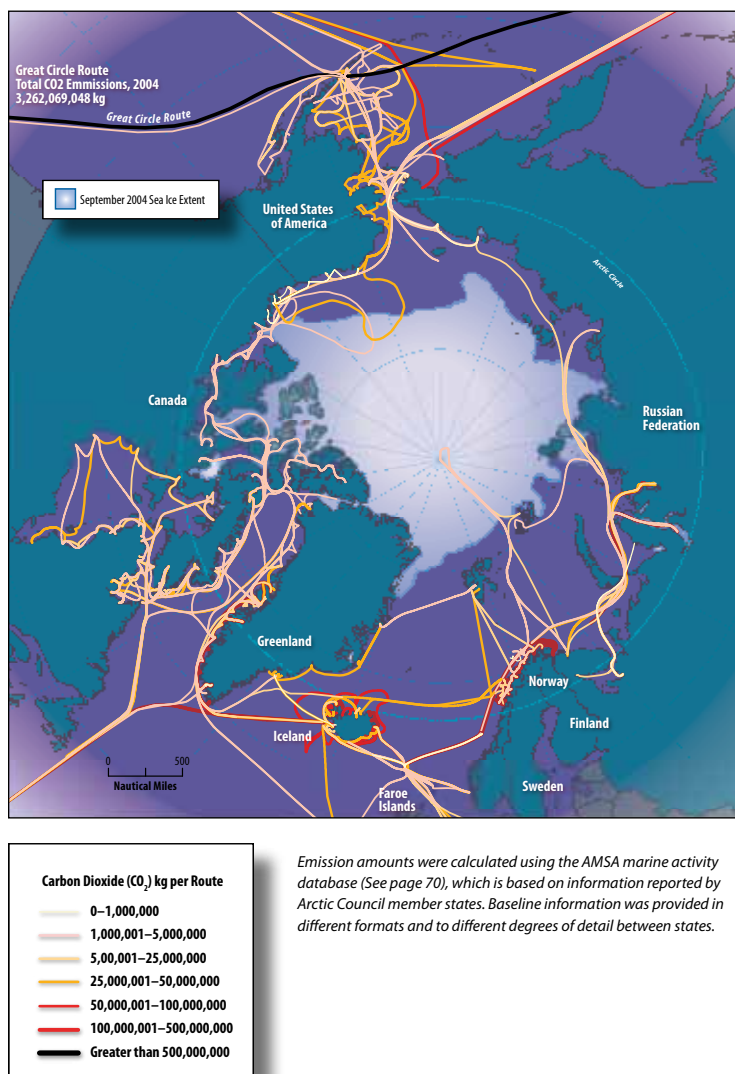
increases in the Arctic, the management of regular discharges from all vessels will need to be seriously considered so that environmental impacts are minimized.

Ship Emissions to Air

Studies assessing the potential impacts of international shipping on climate and air pollution demonstrate that ships contribute significantly to global climate change and health impacts through emission of GHGs (for example, carbon dioxide [CO₂], methane [CH₄], chlorofluorocarbons [CFC]), aerosols, nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO) and particulate matter (PM). Air quality impacts may result from the chemical processing and atmospheric transport of ship emissions. For example, NOx emissions from ships can combine with hydrocarbons in the presence of sunlight to produce ozone pollution, which can potentially affect visibility through haze, human and environmental health and has been associated with climate change effects.

The AMSA has developed the world's first activity-based estimate of Arctic marine shipping emissions using empirical data for shipping reported by Arctic Council member states. Emissions were calculated for each vessel-trip for which data was available for the base year 2004. The 515,000 trips analyzed represent about 14.2 million km of distance traveled (or 7.7 million nautical miles) by transport vessels; fishing vessels represent over 15,000 fishing vessel days at sea for 2004. Some results could be an underestimation of current emissions, given potential underreporting bias and anecdotal reports of recent growth in international shipping and

Map 8.1 Arctic shipping emissions map. Source: AMSA



trade through the Arctic. Researchers at DNV recently completed a similar activity based emissions inventory for Norwegian waters (*Operational emissions to air and sea from shipping activities in Norwegian sea areas. DNV Report No. 2007-2030*). A review and comparison of the DNV results with the Norwegian portion of the AMSA results showed good agreement for all vessel types, except for general cargo and fishing vessel estimates. The AMSA results for Norway were sometimes greater than, and sometime less than, the DNV results, generally falling within 10 percent to 30 percent confidence. The AMSA evaluates ship emissions of greenhouse gases and air quality pollutants that may have regional or local impacts; however it does not directly conduct the detailed studies needed to determine the level of impact (Table 8.2).

Results show CO₂ emissions from international shipping in the Arctic region to be approximately 10,800 kilo tons per year tons (kt) CO₂ per year. Given that total CO₂ emissions from international shipping globally are about 1,000 MMT CO₂ per year, Arctic contributions for 2004 amount to about 1 percent of total ship CO₂ emissions, not an amount that would cause significant effects in the global context. However, pollutants such as black carbon (BC), particulate matter, nitrogen oxide (NO_x), carbon monoxide (CO) and sulfur oxide (SO_x), which may be small contributors to global inventories on a mass basis, may have regional effects even in small amounts. Current IMO regulations under MARPOL Annex VI that place requirements on the sulfur content of marine fuels, once implemented, will dramatically reduce SO_x emissions from global shipping. As a result, observable impacts from SO_x should decline and there may be indirect effects on the climate forcing properties of other air pollutants such as NO_x and BC.

Black carbon is a component of particulate matter produced by marine vessels through the incomplete oxidation of diesel fuel. The release and deposition of BC in the Arctic region is of particular concern because of the effect it has on reducing the albedo (reflectivity) of sea ice and snow. When solar radiation is applied, reduced albedo increases the rate of ice and snow melt significantly, resulting in more open water, and thereby reducing the regional albedo further. In the Arctic region in 2004, approximately 1,180 metric tons of black carbon was released, representing a small proportion of the estimated 71,000 to 160,000 metric tons released around the globe annually. However, the region-specific effects of black carbon indicate that even small amounts could have a potentially disproportionate impact on ice melt and warming in the region. More research is needed to determine the level of impact this could have on ice melt acceleration in the Arctic and the potential benefits from limiting ships' BC emissions when operating near to or in ice-covered regions. The potential impacts of black carbon should also be a point of consideration when weighing the costs and benefits of using in-situ burning of oil in spill response situations.

As part of the AMSA emissions inventory, the amounts of carbon dioxide and black carbon emitted were mapped using the GIS database of shipping routes and areas of fishing vessel activity reported by Arctic states (Map 8.1).

The CO₂ emitted by all vessels was mapped according to the location of activity; emissions from transport vessels (non-fishing vessels) were assigned to reported routes and fishing vessel emissions were assigned to the Large Marine Ecosystem in which the fishing fleet operated. The map shows that the heaviest CO₂

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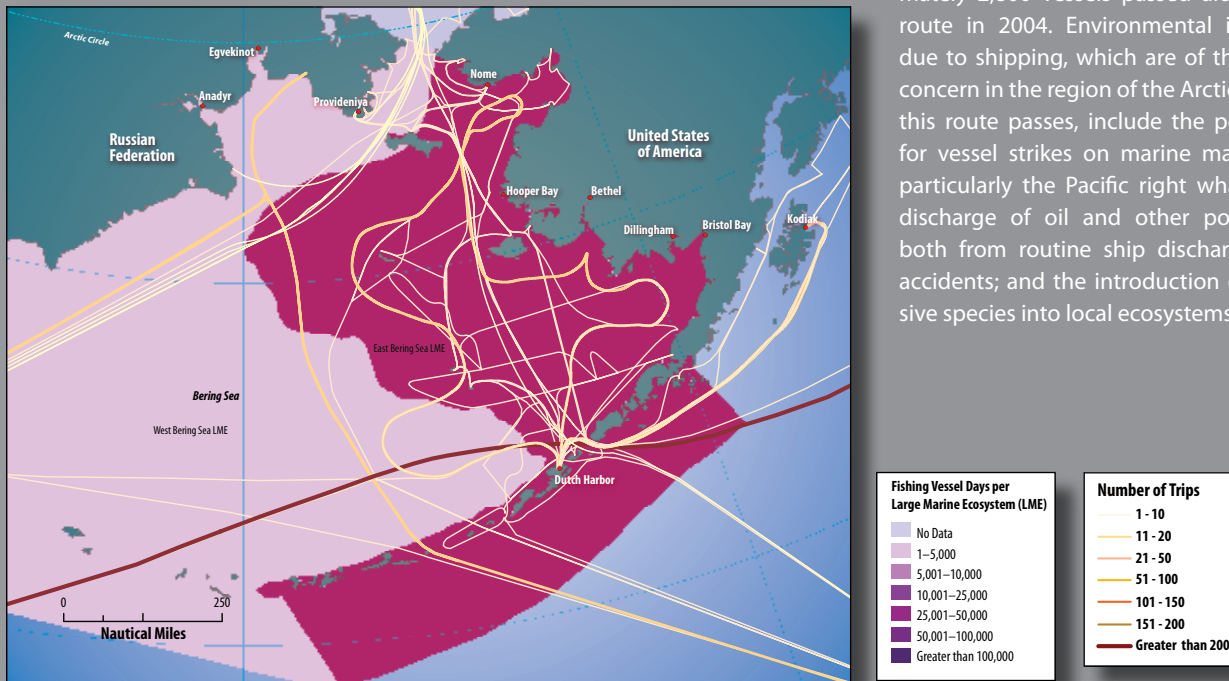
Aleutian Islands/Great Circle Route

The North Pacific's Great Circle Route is the most economic pathway for commerce between northern ports of the west coast of North America to ports in eastern Asia. The segment of this route considered in this analysis is the portion that extends from the western Gulf of Alaska, westward offshore from the Alaska Peninsula and through the Aleutian Islands including the passes at Unimak Pass and the Rat Islands. This portion of the route traverses two Arctic Large Marine Ecosystems (LMEs), the East Bering Sea LME and the West Bering Sea LME.

The East and West Bering Sea LMEs are characterized by their subarctic climate and are strongly influenced by a persistent atmospheric low pressure system that produces intense storm activity and strong ocean currents, particularly through the Aleutian Island passes. The marine and coastal environment in the region where the Great Circle Route passes includes rocky shorelines, fjords and tidal wetlands. This region seasonally supports populations of shorebirds, nesting seabirds, herring and other marine resources as well as millions of salmon during their migrations to streams of origin.

The route also passes through the U.S. Alaska Coastal Maritime Wildlife Refuge, which provides nesting and foraging habitat seasonally for millions of seabirds and year-round habitat for thousands of marine mammals. The populations of several marine species in this region are depressed, declining or otherwise considered particularly sensitive and in danger of potential extinction. Commercial fisheries in the region where the Great Circle route passes provide a large proportion of the annual landings by the U.S. fishing industry. Salmon, halibut, herring, crab, groundfish and many other fisheries are pursued annually in the region. In 2004, Alaska fish landings were 2.43 million metric tons, valued at \$US 1.17 billion.

The AMSA estimates that approximately 2,800 vessels passed along this route in 2004. Environmental impacts due to shipping, which are of the most concern in the region of the Arctic where this route passes, include the potential for vessel strikes on marine mammals, particularly the Pacific right whale; the discharge of oil and other pollutants both from routine ship discharge and accidents; and the introduction of invasive species into local ecosystems.



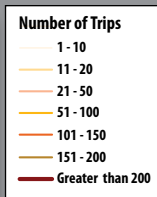
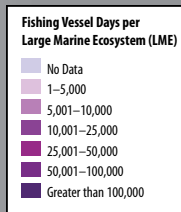
Map 8.2 Aleutian Islands regional traffic and LME map. Source: AMSA

13,000

Metric tons – The approximate amount of oil sludge generated annually by ships operating in the Norwegian and Barents seas.

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Barents and Kara seas



Map 8.3 Barents and Kara seas regional traffic and LME map. Source: AMSA


There is a large volume of shipping in the Barents Sea and considerably less in the Kara Sea. The main shipping route into the area is along the coast of Norway. A main shipping lane goes through inshore waters, and much of the traffic to and from ports in northern Norway follows this route. Traffic to and from Russia follows an offshore route in the open sea to ports in Murmansk, the White Sea and other areas. Transport of oil from Russia is from ports in the White Sea, Murmansk, Pechora Sea (i.e., Kolguev and Varandey), and Ob' and Yenisei estuaries in the Kara Sea. There is also year-round shipping of nickel ore by Norilsk Nickel from a port in the Yenisei estuary. In the western Barents Sea, there is a shipping route to Svalbard with seasonal traffic of cargo ships supplying the communities, bulk carriers transporting coal and cruise ships. There is also a substantial number of fishing vessels that operate year round in the ice-free part of the southern and central Barents Sea, while there is little fishing activity in the Kara Sea.

In 2006, Norway adopted an integrated management plan for the Norwegian part of the Barents Sea and adjacent waters off the Lofoten Islands. In the preparatory work for this plan, an assessment of environmental impacts from shipping was carried out and valuable and vulnerable areas were identified. The plan established a forum on environmental risk management headed by the Norwegian Coastal Administration, which is tasked with providing better information on risk trends in the area, especially as regards acute oil pollution from ships and other sources. In July 2007, the IMO established regulations that require larger cargo vessels and tankers transiting the Norwegian coast of the Barents Sea to operate further away from the coast than in the past. This requirement is intended to allow a longer response time in case of accidents that could impact the Norwegian coastal environment and resources.

Vulnerable areas in the Barents and Kara seas have been identified in relation to oil and gas activities, based on where there are aggregations of animals that could potentially be impacted by oil spills or disturbances from activities. The Barents Sea holds more than seven million pairs of breeding seabirds, with major colonies on Svalbard, the western section of Novaya Zemlya off the coast of northern Russia and along the coast of northern Norway. The oceanographic polar front and the ice edge in the western and central Barents Sea is a concentrated zone of life in spring and summer with aggregations of seabirds and seals. The polar front area is also the wintering area for the large Barents Sea capelin stock and for

seabirds such as thick-billed murre. Svalbard and Franz Josef Land in the northern Barents Sea are important breeding and feeding areas for seabirds, walrus and seals, and denning areas for polar bear. The southern and eastern Barents Sea is a wintering area for many seabirds and sea ducks that breed further east in the Russian Arctic. The Pechora Sea area and the southern Kara Sea lie adjacent to tundra and wetlands that are important breeding grounds for geese, ducks and shorebirds. Many of these use coastal habitats for staging during spring migration and after breeding when they prepare for the fall migration out of the Arctic.

The southern Barents Sea is a rich fisheries area with large stocks of cod, haddock, capelin, juvenile herring and shrimp. A major stock of polar cod spawns under ice in the Pechora Sea region, and this region is also the main wintering area for white whales of the Karskaya population that is migratory between the Barents, Kara and Laptev seas. The smaller White Sea beluga population has its wintering area in the Voronka and Gorlo area at the entrance to the White Sea. The Barents Sea harp seal population has its whelping and molting areas on the ice also at the entrance to the White Sea. The Novaya Zemlya population of Atlantic walrus has its wintering area in the pack ice in the Pechora Sea region. White whales and walrus migrate north in spring following lead systems west of Novaya Zemlya, and the white whales continue east through the northern Kara Sea and into the western Laptev Sea in early summer. There are two subpopulations of polar bears in the Barents and Kara seas with seasonal migrations following the ice.

There are no documented negative impacts on animals in this area from shipping activities. Accidental oil spills have occurred and have been associated with high local mortality of seabirds. However, these incidents have not had material impacts at the population level for the affected species. Ship strikes of whales could occur in some areas but there are no reports to suggest that the level of impact is significant. The greatest concern is the threat from accidental oil spills that could have a large impact on seabirds and other marine birds, and also on marine mammals such as polar bear and on spawning polar cod. If shipping activities increase in the future, potential disturbance of wintering marine mammals and ship strikes of whales will become a concern. 

and black carbon emissions were found in the Bering Sea region, around Iceland, along the Norwegian coast and in the Barents Sea. There are also moderate emissions along the western coast of Greenland.

Potential Disturbances from Ships and Shipping Activity in the Arctic

Sound and Noise Disturbance

All vessels produce sound as a by-product of their operation. Typically, vessels produce low frequency sound from the operation of machinery onboard, hydrodynamic flow noise around the hull and from propeller cavitation, which is typically the dominant source of noise. The sound a vessel produces relates to many factors including size, speed, load, condition, age and engine type. The larger the vessel and/or the faster it is moving, the more noise it produces. Many vessels also employ hydroacoustic devices such as commercial sonar, echosounders, side scan sonar for navigation, depth finding, seafloor mapping or to detect biologics as a regular part of their operations. These types of devices produce short pulses and use frequencies ranging from low to high, depending on their utility.

For most marine vertebrates, making, hearing and processing sounds serve critical biological functions. These include communication, foraging, reproduction, navigation and predator-avoidance. In particular, toothed whales have developed sophisticated biosonar capabilities to help them feed and navigate; large baleen whales have developed long-range communication systems using sound in reproductive and social interaction; and pinnipeds (i.e., seals, sea lion, walrus, etc.) make and listen to sounds for critical communicative functions. Many fish utilize sounds in mating and other social interactions.

The introduction of noise into the environment can adversely affect the ability of marine life to use sound in various ways and can induce alteration of behavior; reduction of communication ranges for social interactions, foraging, and predator avoidance; and temporary or permanent compromise of the auditory or other systems. In extreme cases, too much noise can lead to habitat avoidance or even death. Noise can also affect physiological functions and cause more generalized stress. Determining when impacts of noise exposure from any source become biologically significant to a species is often difficult. Nevertheless, this is an area where additional research is ongoing and needed in key areas.

Many environmental effects resulting from ship disturbances can be effectively mitigated through the use of best practices and the implementation of management measures.

Where there is an overlap between potential noise sources and the frequencies of sound used by marine life, there is particular concern as to how sound sources can interfere with important biological functions. The predominately low frequency sounds associated with large vessels is similar to the general hearing sensitivity bandwidths of large whales and many fish species. The ambient noise environment in the Arctic is more complex and variable than in many other ocean areas due to the seasonal variability in ice cover. In addition to natural sources contributing to background levels, anthropogenic sources, like vessel traffic, can also have a profound impact on these levels. In most regions in the northern hemisphere, shipping noise is the dominant source of underwater noise below 300 hertz.

Many environmental effects resulting from ship disturbances can be effectively mitigated through the use of best practices and the implementation of management measures. With regard to noise disturbances, such measures could include rerouting to avoid some areas in sensitive periods, lower speed, and alternative engine and hull designs to make ships more silent. There may be a need to plan potential future shipping lanes in the Arctic so as to avoid large seabird colonies, marine mammal haul-outs and other areas where animals are aggregated. In late 2008, the IMO's Marine Environment Protection Committee (MEPC) formed a correspondence group that is now working to identify and address ways to minimize the introduction of incidental noise into the marine environment from commercial shipping in order to reduce the potential adverse impact on marine life. This group aims to develop non-mandatory technical guidelines for ship-quieting technologies, as well as potential navigation and operational practices for all IMO member states. This work will be aimed at the global shipping industry and is not likely to contain Arctic specific considerations.

Icebreakers and Disturbance

All icebreaking operations, whether by independent commercial icebreaking ships or government icebreaker escort, can potentially cause disturbances to wildlife and local communities both through the noise they create and the trail of open water left astern. Compared to other vessels, icebreakers produce louder and more variable sounds. This is because of the episodic nature of the

icebreaking, which involves ramming forward into the ice and then reversing to begin the process again. Some icebreakers are equipped with bubbler systems to aid in clearing ice from the vessel's path and these can create an additional noise source. Noise from bubbler systems and propeller cavitation associated with icebreaker movement has the potential to alter animal behavior and to disrupt the hearing ability and vocalization of marine mammals.

Wildlife has been found to exhibit a range of behavior in the presence of icebreakers. For example, beluga whales were found to be aware of the icebreaker vessels presence at distances of more than 80 kilometers away, and exhibit strong avoidance response at 35 to 50 km away. However, narwhal whales were found to display only subtle responses to the same disturbance.

The opening of channels through the ice by icebreaking vessels can impact Arctic residents and alter animal behavior. Open water channels take time to freeze and this can disrupt the movements of animals and people over the ice. In many areas of the Arctic in winter, the only naturally occurring ice openings are polynyas caused by winds or ocean currents. Artificially opened water channels can be problematic for marine mammals and other species, which confuse them for polynyas and can get trapped too far from the ice edge as the channel eventually refreezes.

Vessel Strikes on Marine Mammals

Vessel collisions, resulting in death or serious injury of marine mammals, are a threat to marine organisms worldwide. Vessel collisions or ship strikes occur mainly with large whale species, small cetaceans (i.e., dolphins, narwhal, beluga), marine turtles and sirenians (i.e., manatees, dugongs). Records indicate that nearly all large whale species are vulnerable to ship strikes. Vessel collisions with marine mammals can result in death, massive trauma, hemorrhaging, broken bones and propeller wounds.

Databases have been constructed which track the number of ship strikes occurring. These report more than 750 known cetacean vessel strikes through the world's oceans, including nearly 300 incidents involving large whales. Virtually all motorized vessel types, sizes and classes are represented in these databases. It should be noted, however, that any database will likely underestimate the number

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Bering Strait

Current shipping activity in the Bering Strait and Chukchi Sea predominately comprises community re-supply and destination traffic.

Traffic plying the Bering Strait, one of the narrowest sea lanes in the world, also traverses remote areas with difficult access for incident response, rescue and contaminant or debris cleanup. The U.S. Beaufort Sea coast has no port facilities or harbors suitable for refuge for medium to deep draft vessels and there are also very limited facilities on the Russian side of the strait. Given its restricted geographic nature, confounded by ice movement and strong ocean currents, the Bering Strait area is a major chokepoint for vessels transiting the region. The Aleutian Low creates persistent high winds and stormy conditions that elevate risk to vessels and cargo transiting the Aleutian and Commander islands area. These severe weather patterns may reduce the effectiveness of response to spills or other incidents.

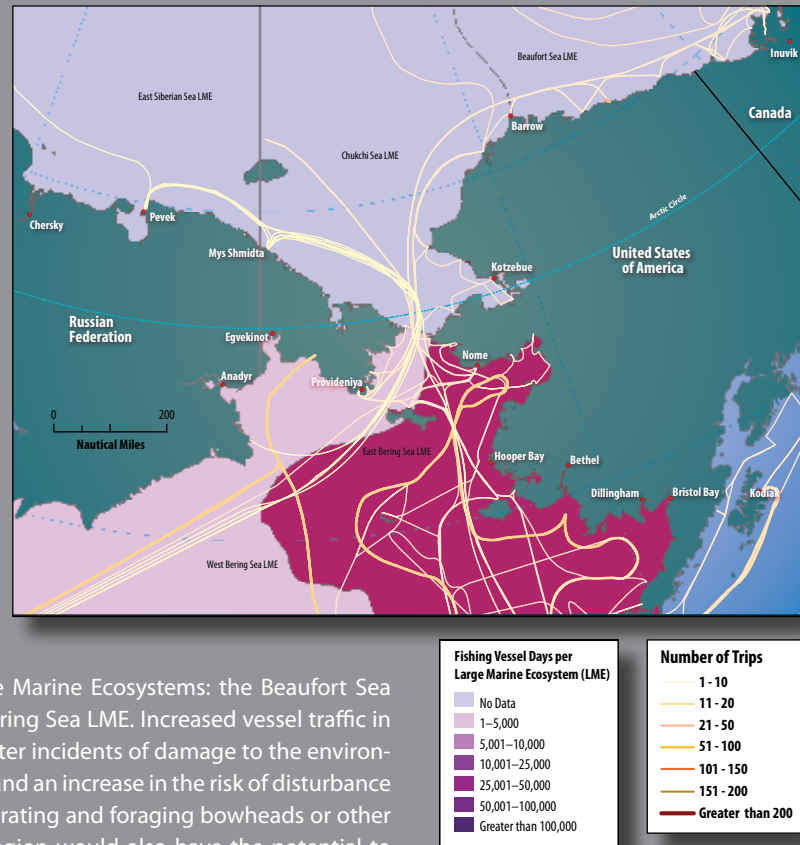
This region includes four of the Arctic Large Marine Ecosystems: the Beaufort Sea LME, the Chukchi Sea LME, and East and West Bering Sea LME. Increased vessel traffic in the Beaufort and Chukchi seas may result in greater incidents of damage to the environment from ships, including pollutant discharges, and an increase in the risk of disturbance effects such as ship noise and ship strikes on migrating and foraging bowheads or other marine mammals. Any vessel incidents in this region would also have the potential to adversely affect major populations of nesting shorebirds, waterfowl and other birds that utilize breeding, nesting and foraging habitat along the coastal Beaufort and Chukchi seas and along the coast of western Alaska.

The eastern Bering Sea supports some of the largest commercial fisheries in the world. Increased vessel use of the eastern route that traverses the eastern Bering Sea may increase potentially adverse interactions with this region's rich fishery resources, fishing communities and hundreds of fishing vessels and support vessels. Spills due to accidental or illegal discharge from vessels could drift ashore to western Alaska areas where seasonal herring and salmon fisheries occur.

The western Arctic stock of bowhead whales seasonally migrates through the Bering Strait, Chukchi and Beaufort seas. In the Bering Strait, they are physically constricted to a relatively small corridor, exposing them to increased interactions with vessels transiting this area during spring and fall. Bowhead whale migration could also potentially be disrupted by icebreakers. Whales could move further offshore following the open leads created by icebreaking vessels, putting them out of reach of coastal whaling communities. Any disruption of the spring and fall hunts, or any injury or mortality to bowheads would be considered a major issue to coastal Alaskan and Siberian communities.

Ice-dependent marine mammals in this region, such as polar bear, walrus and seals, already stressed due to sea ice retreat, may be at increased risk from any additional ship-sourced stressors or contamination, as populations will become increasingly concentrated around retreating sea ice.

Map 8.4 Bering Strait regional traffic and LME map. Source: AMSA



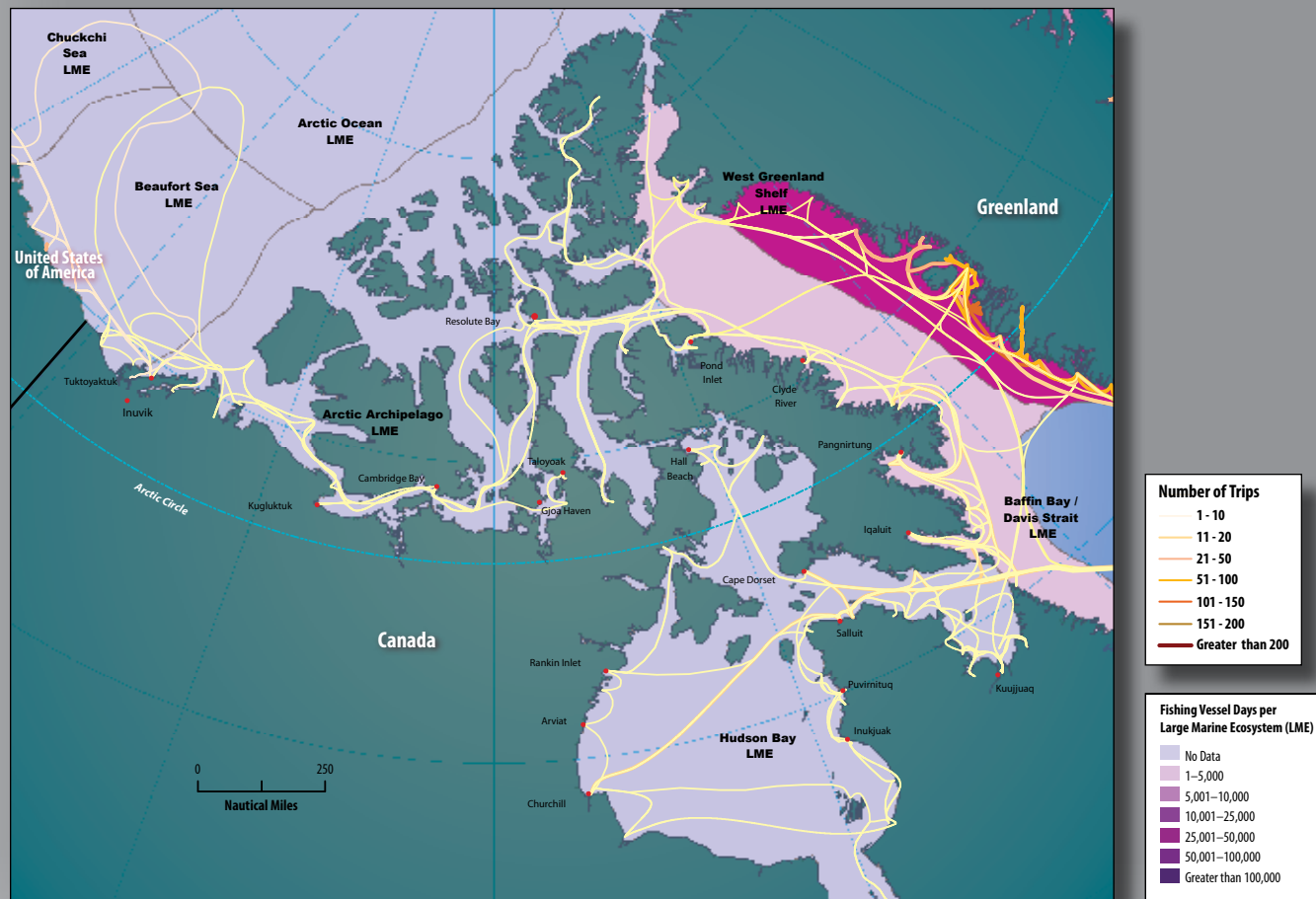
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Canadian Arctic

For many years shipping has been the main link to the outside world for remote Arctic communities in Canada and yearly sealifts remain the key source of goods and necessities for many communities. Shipping in the Canadian Arctic has been occurring in a safe and relatively environmentally sustainable way for many years. This has been due to the historically low level of activity, as well as the regulatory restrictions that have been in place to protect Canadian Arctic waters from shipping since the 1970s in the form of the *Arctic Waters Pollution Prevention Act*. The types of shipping activity occurring in the Canadian Arctic during 2004 can be grouped into the following activities: community re-supply (i.e., tug-barge, cargo, fuel tankers), Canadian Coast Guard

and research activity, cargo and re-supply support for resource development operations, cargo shipments in and out of the Port of Churchill and tourism.

The Canadian Arctic remains one of the last frontiers for natural resources and one of the last areas of relatively pristine wilderness on earth. It is a region with virtually no roads, no rail lines and where air services are infrequent and very costly. The lack of infrastructure and the extreme climate have, until recently, made this region uneconomical for large-scale resource development. Rising prices of oil, gas and other commodities and the changing climatic and geographic restraints may combine to allow significant and rapid increases in resource development



Map 8.5 Canadian Arctic regional traffic and LME map. Source: AMSA

activity in the Canadian Arctic, which would lead to increased destination shipping traffic in the region and intra-regional traffic. How this potential increase may impact the local environment is not known. However, any increase in activity brings with it a corresponding increase in the risk of damage to the environment both from normal ship operations and accidents or emergencies. Due to the current relatively low levels of shipping activity occurring in the Canadian Arctic, any increase in activity in this region will be significant.

Currently four of the Arctic's 17 Large Marine Ecosystems occur in Canadian waters: Hudson Bay, Baffin Bay/Davis Strait, Arctic Archipelago and Beaufort Sea. The Canadian Arctic is home to a diverse range of wildlife that thrives across this variety of ecosystems. These populations are now under stress to varying degrees due to the changes occurring in the Arctic environment as a result of global climate change.

Areas that are vulnerable to new developments include wintering areas of bowhead and beluga in Hudson and Davis straits, spring migration routes for those whales into Hudson Bay and Foxe Basin and north into Lancaster Sound. Seabird breeding colonies and staging areas for migratory waterfowl and shorebirds occur in several locations throughout the region.

Specific adverse impacts associated with shipping activity that are of the most concern in the Canadian Arctic include the discharge of pollutants into the marine environment and the disruption or disturbance of migratory patterns of wildlife that would, in turn, impact indigenous hunting activity. In this region, icebreakers leave behind open water channels that may disrupt the movements of wildlife and people traveling on the ice. Icebreakers or other ships traveling through ice-covered waters where seals are whelping can impact nearby seals through flooding dens and wetting baby seals with their wakes. Marine mammals are known to congregate in shallow bays and migrate through the Canadian Arctic Archipelago. As shipping traffic increases in this region there will be increased potential for conflict between ships and marine mammals in narrow and geographically restrictive areas. Other ship impacts outlined in this section such as noise impacts, introduction of invasive species and ship emissions are also of concern.



of actual occurrences because many go either undetected or unreported. In some cases carcasses are found, but because injuries are internal or due to advanced decomposition, it may be difficult to determine cause of death. When large vessels are involved, the mariner may not be aware that a strike has occurred.

There are relatively few known incidents of Arctic or ice-adapted marine mammal species being involved in ship strikes. The relatively infrequent occurrence is a result of relatively lower vessel traffic in high latitudes as compared to major trading routes and human population centers in lower latitudes. However, of consideration is that certain Arctic species, such as the bowhead and Pacific right whale, have features that make them potentially vulnerable to ship strikes, particularly as vessel traffic increases in their waters. Arctic toothed whales, namely narwhals and beluga whales, are probably less vulnerable to ship strikes, given their greater maneuverability and social behavior that lends them to aggregating in large groups enhancing their detection. It should be noted, however, that records of roughly comparable mid-sized species such as pilot whales, killer whales and various species of beaked whales also appear in ship strike databases.

Vessel speed has been implicated as a key factor in the occurrence and severity of vessel strikes with large species. Several independent studies indicate that vessel speeds of 10-14 knots increase by one-half or greater the probability that a whale will survive a collision with a ship.

As vessel traffic increases in the Arctic, modifications to customary vessel operation in key cetacean aggregation areas or vessel speed restrictions can be an effective measure to mitigate potential impacts on vulnerable species such as bowhead whales and, to a lesser extent, narwhals, beluga whales and other Arctic marine organisms. Where feasible, vessel routing measures may also be applied in order for ships to avoid known cetacean aggregation areas. A number of steps have been taken by some states outside the Arctic region to reduce the threat of ship strikes to endangered large whale species, including shifting shipping lanes and applying to the IMO to establish a vessel "Area to be Avoided." The IMO's MEPC is currently working on development of a non-mandatory guidance document for minimizing the risk of ship strikes on cetaceans which will be aimed at the global maritime industry.

Light Disturbance

Birds of all species appear to be attracted to lights. This puts them at risk of collision with lighted structures. The attraction to light and resulting risk of collision varies depending on the weather, season and the age of the bird. The fall migration in the Arctic is

when most bird attraction and collision issues emerge, as young birds are traveling for the first time and inclement weather becomes more frequent. Light attraction of marine birds is not yet a significant issue in the Arctic. This is because most birds are in the Arctic in the summer months to breed, when there is little or no darkness; and most Arctic-breeding seabirds are diurnal and, therefore, less active at night.

Despite these factors, there are still risks. During the non-breeding period in ice-free waters and as the presence of lighted ships and structures increases, risks are heightened. A wide variety of

nocturnal species nest in the North Pacific, especially in the Aleutian Islands. Storm-petrels are vulnerable in late summer and early fall, when hundreds have been known to pitch on a vessel during foggy conditions. These problems are not unique to the smaller nocturnal species. Common and king eiders, both large ducks, have collided with large shrimp vessels in waters off western Greenland, causing injury or death.

Introduction of Invasive Species

The introduction and spread of alien invasive species is a serious problem that has ecological, economic, health and environmental impacts, including the loss of native biological diversity worldwide. Although the introduction of invasive species into the Arctic environment has been minimally studied, it is an issue that deserves further study in the context of a changing climate and potential increased shipping in the Arctic region.

The risk of introduction of invasive species will increase as shipping volume increases in this region. As with ship operations in non-Arctic areas, the threat of introduction comes from four sources: ballast water discharge, hull fouling, cargo operations and casualties or shipwrecks.

- **Ballast Water**

The IMO's *International Convention for the Control and Management of Ships Ballast Water & Sediments* addresses ballast exchange and treatment. As of November 2008, 16 states including Norway, representing about 3.6 percent of the world's merchant shipping, have ratified this convention. Under the IMO convention standard, a small percentage of viable organisms will still be discharged.

- **Hull Fouling**

In subarctic waters, transfer of aquatic invasive species on the hulls of ships has become a serious threat to the environment, rivaling ballast water discharge. However, hull coatings on ice-capable vessels may be effective antifouling agents, as would the scouring effects of passage through ice.

- **Cargo**

Most international movements of goods are regulated by fumigation and biosecurity provisions to prevent the movement of invasive species in cargo. This is also applicable to the Arctic region. Much of the sealift and re-supply movements into the Arctic are palletized, increasing the potential for unwanted organisms to be entrained in the cargo.

Research Opportunities

- ❑ Investigate the effects of ship noise and physical presence, including avoidance behavior on Arctic marine animals at the individual and population level. Such research would contribute to determining distances at which animals are disturbed from ships, the potential for ship strikes and assessment of the need for mitigation strategies if adverse effects are predicted.
- ❑ Complete regional modeling of ship emissions in order to investigate the current and potential impacts from these emissions along major routes and near key port regions in the Arctic. This will contribute to more accurate assessment of regional impacts on air quality, pollution, haze and visibility, and climate forcing due to the release and deposition of black carbon and other aerosols.
- ❑ Conduct baseline surveys of aquatic species in major recipient ports in the Arctic region and research the potential survival of species introduced through different vectors. Carry out a risk assessment of invasive species introduction under current international standards in order to determine the need for Arctic specific protections.
- ❑ Conduct further research on the transport, fate and effects of oil in ice-covered waters, and on technology, methods and procedures to clean-up and remove spilled oil to reduce environmental impacts.

MARPOL 73/78

Regular ship discharges are regulated through the IMO's *International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto*

- **Casualty**

Ship accidents and sinkings can introduce invasive species into the local environment. As an example, shipwrecks in the Aleutians have caused significant ecological damage through the introduction of predatory rat species onto islands that have large aggregations of nesting seabirds.

Due to climate change and the potential increase in shipping activity, the introduction of invasive species may require more attention than it has received in the past. In particular, trans-Arctic shipping between the North Atlantic and North Pacific could potentially represent a vector for transfer of species in ballast water or on hulls to new areas where the environmental conditions resemble those in their home waters. Introduction of rodent species to islands harboring nesting seabirds, as evidenced in the Aleutian Islands, can be devastating. With limited baseline data on what species might actually be at risk from ship operations such as ballast water discharge, the use of the precautionary approach and proactive preventative actions are encouraged.

Green Ship Technology in the Arctic

Technology has a role to play in the mitigation of environmental impacts in the Arctic and elsewhere. Many of the potential impacts from shipping that have been discussed in this assessment can be effectively reduced or eliminated through the use of current or developing technologies, as well as best practices. Examples include stack scrubbers that remove harmful substances such as sulfur and black carbon from a ship's emissions; water treatment systems for sewage, bilge water, ballast water and other discharges; technologies that harness wind or solar power to reduce fuel consumption; or the use of cleaner fuels that emit less harmful substances when burned. Given the sensitivity of the Arctic environment and the potential impacts from shipping, the development and application of green ship technologies should be a priority. These new technologies can be expedited through industry incentives, such as the green ship technology fund in Norway; or regulatory requirements, such as the IMO *International Convention for the Control and Management of Ships Ballast Water & Sediments*. ☀



Selendang Ayu Impact

On December 8, 2004, the cargo ship *M/V Selendang Ayu* lost power as it was transiting the North Pacific's Great Circle Route and eventually came ashore near Dutch Harbor in the Aleutian Islands, where it broke into two sections (See page 88). Operations to rescue the crew from the *Selendang Ayu* resulted in loss of life for both rescuers and crew, increasing the adverse effects of this incident. Despite removal and recovery efforts, the ship eventually discharged its cargo of 66 million metric tons of soybeans, an estimated 1.7 million liters of intermediate fuel oil, 55,564 liters of marine diesel and other contaminants into the environment.


For three weeks the weather delayed response to the environmental hazards of the incident. Strong winds, rough seas and the remoteness of the spill stalled the clean-up and search for oiled animals.

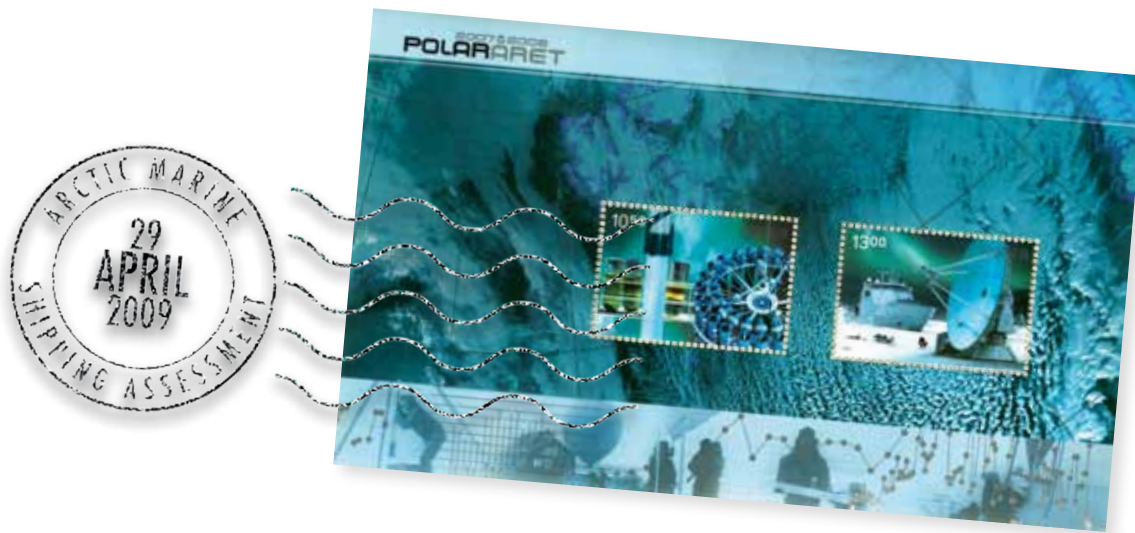
To study the impact of the spill on shorebirds, the U.S. Fish and Wildlife Service released 162 bird-size blocks of wood from the grounding site more than a month after the incident. The blocks helped determine where contaminated dead birds might have drifted. The exercise led to the immediate recovery of 29 oiled birds, 19 that were dead or dying and 10 that were recovered and released. During the course of the clean-up, 1,603 bird carcasses and six sea otter carcasses were recovered. Because of the delay in the recovery efforts, it is likely the number of wildlife impacted was greater. By mid-February 2005, 38,000 bags of oily solid waste had been reclaimed. The clean-up effort was ongoing until June 2006, and the long term impacts on local populations are yet to be fully assessed. This information was drawn from a recent U.S. Fish and Wildlife Service report on the incident. 🌊

Findings

- 1] From an environmental point of view, Arctic shipping poses a threat to the region's unique ecosystems. This threat can be effectively mitigated through careful planning and effective regulation in areas of high risk.
- 2] Release of oil into the Arctic marine environment, either through accidental release, or illegal discharge, is the most significant threat from shipping activity.
- 3] Ship strikes of whales and other marine mammals are of concern in areas where shipping routes coincide with seasonal migration and areas of aggregation.
- 4] The introduction of invasive species into the Arctic marine environment from shipping can occur and the risk may be enhanced due to changing climate, possibly making conditions more favorable to some species. The most risk exists where a transfer of organisms from ecosystems of similar latitudes and conditions can occur. Of particular future concern is the transfer of organisms across the Arctic Ocean from the North Pacific to the North Atlantic or vice versa.
- 5] There are certain areas in the Arctic region that are of heightened ecological significance, many of which will be at risk from current and/or increased shipping. Many of these areas are located in geographically restrictive locations or chokepoints where much shipping activity also occurs, such as the Bering Strait, Hudson Strait, Lancaster Sound, Pechora Sea and the Kara Port.
- 6] Migratory marine mammals such as bowhead, beluga, narwhal and walrus have wintering areas in the southern extent of the sea ice and spring migration routes into the Arctic through systems of leads and polynyas also used by many seabirds, ducks and other marine birds during spring migration. These migration corridors correspond broadly to the current main shipping routes and travel through geographic chokepoints.
- 7] The black carbon emitted from shipping in the Arctic could have significant regional impacts by accelerating ice melt.



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- 8] Ship emissions including greenhouse gases (GHGs), Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x) and Particulate Matter (PM) may have negative effects on the Arctic environment and will increase in the Arctic region proportionately with increased shipping activity. Effective reduction of ship emissions can be achieved through the application of feasible and best available technologies, through air emissions reduction techniques and, most importantly, through effective implementation of relevant IMO regulations.
- 9] Sound is of vital biological importance to marine mammals and anthropogenic noise produced through shipping and other vessel activity can have various adverse effects on Arctic species.
- 10] Subarctic seas support some of the richest fisheries in the world in the Bering Sea and the Barents Sea. These two areas are also the location of the heaviest shipping traffic now occurring in the Arctic region. A potential accidental spill of oil or other hazardous and noxious substances in these areas could have large economic, social and environmental impacts.
- 11] Environmental effects on marine mammals, seabirds and fisheries from ship sourced disturbances, noise, or potential accidental/illegal release of oil and other hazardous and noxious substances may impact culturally and economically significant subsistence harvests of these animals.
- 12] The most immediate impacts of climate change in the Arctic will be the reduction of summer sea ice, longer open water seasons in the fall and the reduction of the year-round presence of multi-year ice. These changes may have far reaching implications for Arctic ecosystems and will also result in the lengthening of the current shipping season. Shipping in the future may be occurring much later into the fall and possibly earlier in the spring, thereby increasing the possibility of interaction between migrating and calving species and ships.



ARCTIC MARINE INFRASTRUCTURE

When compared with marine infrastructure in the world's other oceans, the Arctic is significantly lacking throughout most of the circumpolar north. The current increase in human activity in the Arctic is placing new demands on Arctic infrastructure needed to support safe marine shipping, protect the environment and respond to emergencies. Anticipated increases in Arctic marine shipping during the coming decades will place additional demands on infrastructure and require innovative, cooperative solutions that best use the limited resources available in this remote region.

The findings contained in this section are the result of extensive input received across a wide spectrum of interests from those experienced in Arctic marine operations, including representatives from the Arctic states. The analysis of current Arctic infrastructure included surveys based on information from the Arctic states regarding Arctic ports, capabilities for handling larger vessels, search and rescue assets and icebreaker capacity. In addition, an international workshop was held at the University of New Hampshire in March 2008 to consider infrastructure needs and gaps associated

with emergency response to Arctic incidents. Workshop participants represented a broad spectrum of expertise including governmental agencies, industry, non-governmental organizations and indigenous people from the Arctic nations. The workshop, "Opening the Arctic Seas: Envisioning Disasters and Framing Solutions," considered five realistic emergency scenarios in diverse locations throughout the Arctic. Incidents envisioned involved vessels caught in ice or in a collision, oil spills, search and rescue, environmental damage and disruption of indigenous communities. The workshop report provides a qualitative analysis of risk factors for Arctic marine incidents likely to happen as shipping, tourism, exploration and development of natural resources such as oil, gas and minerals increase with the retreating ice cover (See page 176).

Major Arctic infrastructure themes emerged and are reflected throughout this section and its findings. Currently, vast areas of the Arctic have insufficient infrastructure to support safe marine shipping and respond to marine incidents in the Arctic. This includes such critical infrastructure components as the accuracy and availability of timely information needed for safe navigation; availability

of search and rescue assets, pollution response assets and supporting shoreside infrastructure to respond appropriately to marine incidents; port reception facilities for ship-generated waste; and availability of deepwater ports, places of refuge and salvage resources for vessels in distress. While there are notable exceptions, where infrastructure is more developed, they are the exception rather than the rule. To assist with ship navigation, locating refuges, pollution response and other activities, adequate weather forecasting and warning capabilities are essential and necessitate adequate observations, models and forecasts.

Emergency response is particularly challenging in the Arctic for a variety of reasons, including the remoteness and great distances that are often involved in responding; the impacts of cold, ice and a harsh operating environment on response personnel and equipment; and the lack of shoreside infrastructure and communications to support and sustain a response of any significant magnitude. Prevention of marine accidents, and actions designed to strengthen the effectiveness of preventive measures, are especially critical for Arctic marine shipping given the difficulties of responding once an incident has occurred. Preventive measures include ensuring that vessels operating in the Arctic meet appropriate design, construction and equipment standards; that vessel personnel have the specialized skills needed for operating in Arctic conditions, including operations in

ice-infested waters where applicable; and that information needed for safe navigation is available, from accurate charts to timely information on meteorological and ice conditions and on other vessel traffic and activities in the area.

While there are many challenges associated with strengthening Arctic marine shipping infrastructure, there are also opportunities to develop measures to improve safe marine shipping operations and protect the Arctic environment in anticipation of the continuing increase in Arctic marine activity, rather than responding after an incident has occurred. Considering the long lead time to put marine infrastructure in place, this should be considered early in the prioritization process.

Systems Related to Safe Navigation

To the mariner, there are several environmental factors that make the Arctic uniquely difficult to navigate compared to temperate waters. These include: presence and movement of sea ice, icebergs, cold air and water temperatures, variable and often unpredictable severe weather, magnetic variation, solar flare activity and extended daylight or nighttime conditions. These environmental conditions, combined with the remoteness of the region from commercial shipping centers and shipping lanes, highlight the need for improved systems to support safe navigation in the Arctic region.



Ship Name	Country of Ownership	Year Entered Service	Propulsion Plant*	Operations
ARKTIKA	Russian Federation	1975	N:75,000	NSR
ROSSIYA	Russian Federation	1985	N:75,000	NSR
SOVETSKIY SOYUZ	Russian Federation	1990	N:75,000	NSR; Arctic tourism
YAMAL	Russian Federation	1993	N:75,000	NSR; Arctic tourism
50 LET POBEDY	Russian Federation	2006	N:75,000	NSR
POLAR STAR	United States	1976	GT:60,000 DE:18,000	Arctic and Antarctic research and logistics
POLAR SEA	United States	1977	GT:60,000 DE:18,000	Arctic and Antarctic research and logistics
TAYMYR	Russian Federation	1989	N:47,600	NSR
VAYGACH	Russian Federation	1990	N:47,600	NSR
KRASIN	Russian Federation	1976	DE:36,000	NSR; Antarctic

Table 9.1 Ten most powerful icebreakers in the world. Note: DE = Diesel-Electric; GT = Gas Turbine; N = Nuclear; NSR = Northern Sea Route. Source: AMSA
* shaft horse power

Arctic Charting

Hydrography is the oldest science of the sea. The earliest explorers were often hydrographers and cartographers who recorded their discoveries on marine charts, sometimes to claim new territory, and always to ensure safe passage.

Modern marine charts are compiled from accurate hydrographic surveys conducted onboard specialized vessels equipped with echo sounders that measure water depths and satellite navigation systems, such as the Global Positioning System (GPS), that determine the geographic positions of these soundings. Numerous other sources of information are used in the creation of charts, such as shoreline location, details of navigational aids, place names, conspicuous land-based features, overhead cables and underwater pipelines. Data on navigational charts are also corrected for the movement of tides, such that the depth portrayed is normally the minimum the mariner will find under the keel. Expert information specialists combine all these various sources of data into navigational charts, taking extreme care to ensure the information is clear and accurate for use by mariners. The collection of the hydrographic data required and the process to produce a new navigational chart can often take years.

In light of the limited amount of marine traffic, the historical survey methods (ship-based and ice-based) and the significant costs and the volatility of the weather conditions, hydrographic surveys in the Arctic have not achieved the same level of coverage and quality as surveys in southern latitudes. As a result, Arctic charting base hydrographic data is not adequate in most areas to support current

and future marine activities. This situation could improve if collection methods and platforms were developed that would be minimally affected by the Arctic conditions of weather, ice and isolation.

For hundreds of years, navigation at sea has relied upon the manual plotting of vessel location on traditional paper charts. Modern Electronic Chart Display and Information Systems (ECDIS), combined with satellite-based positioning, bring hydrographic data into onboard computers, greatly improving the navigation information available to the mariner and potentially reducing the reliance on traditional aids, such as floating buoys and fixed lights. Advances are also being made in consolidating information such as weather and ice conditions into electronic charting systems, further assisting mariners.

Recognizing the benefits of electronic charts, the International Maritime Organization (IMO) has proposed compulsory carriage of ECDIS and Electronic Navigational Charts (ENCs) on high speed craft from July 1, 2008 onward for all new craft and from July 1, 2010 onward for existing craft. In addition, IMO's Safety of Navigation Subcommittee has reached consensus to implement the mandatory carriage of ECDIS on new passenger ships above 500 gross tonnage by 2012, with a broadening of this requirement in subsequent years.

Arctic nations report various levels of ENC coverage for their northern waters (Maps 9.1, 9.2, 9.3). The presence of an ENC does not guarantee adequate information for safe navigation, however, as they are normally created using the same information available on traditional charts. As previously mentioned, the hydrographic data in many Arctic locations is either non-existent or in serious need of improvement.

10%

The portion of the Canadian Arctic that the Canadian Hydrographic Service says has been surveyed to modern standards.

Arctic Marine Infrastructure Terminology

For the purpose of this assessment, “infrastructure” is defined broadly to address all major aspects of marine shipping, including vessels and crews, the systems needed to gather and supply accurate and timely information for safe navigation and operations, the personnel and resources needed to respond to a variety of potential emergencies, port reception facilities for ship-generated waste and the shoreside facilities needed to provide supplies and logistics in support of marine shipping and emergency response. “Vessels” include tankers, passenger vessels (ferries, large and small cruise ships) and pleasure craft, bulk carriers, container ships, fishing vessels, tug and barge combinations, offshore supply vessels, research ships, icebreakers and other watercraft. “Officers and crew” includes vessel personnel with special expertise for operations in cold and ice-infested waters, such as ice navigators or ice pilots, and considers the training, experience and expertise required for all vessel personnel when confronting the unique challenges of Arctic marine operations. “Emergency response resources” include response assets such as aircraft, vessels and specialized equipment; the logistics and supply chains needed to support these operations both at sea and ashore; and the availability of related shoreside facilities and resources such as port, medical, refueling facilities and living quarters to accommodate emergency responders. “Shoreside facilities” include ports and port facilities, particularly ports with adequate depth to accommodate larger vessels, potential places of refuge, airports and shoreside transportation systems.



© United States Coast Guard

Increased Arctic activity, coupled with the difficulties in deploying and maintaining navigational aids in the region, presents an opportunity to implement ECDIS to improve navigation safety and save costs. The benefits of ECDIS, however, are wholly dependent on the underlying hydrographic navigational charts and consequently the hydrographic data on which they are based. Coverage of GPS, or other means of positioning, is also crucial to take full advantage of the system.

Canada, the United States, the Russian Federation and Denmark are carrying out charting activities that include portions of the Northern Sea Route and the Northwest Passage. These countries, as well as Iceland and Norway, are all member states of the International Hydrographic Organization (IHO) whose mission “is to facilitate the provision of adequate and timely hydrographic information for worldwide marine navigation.”

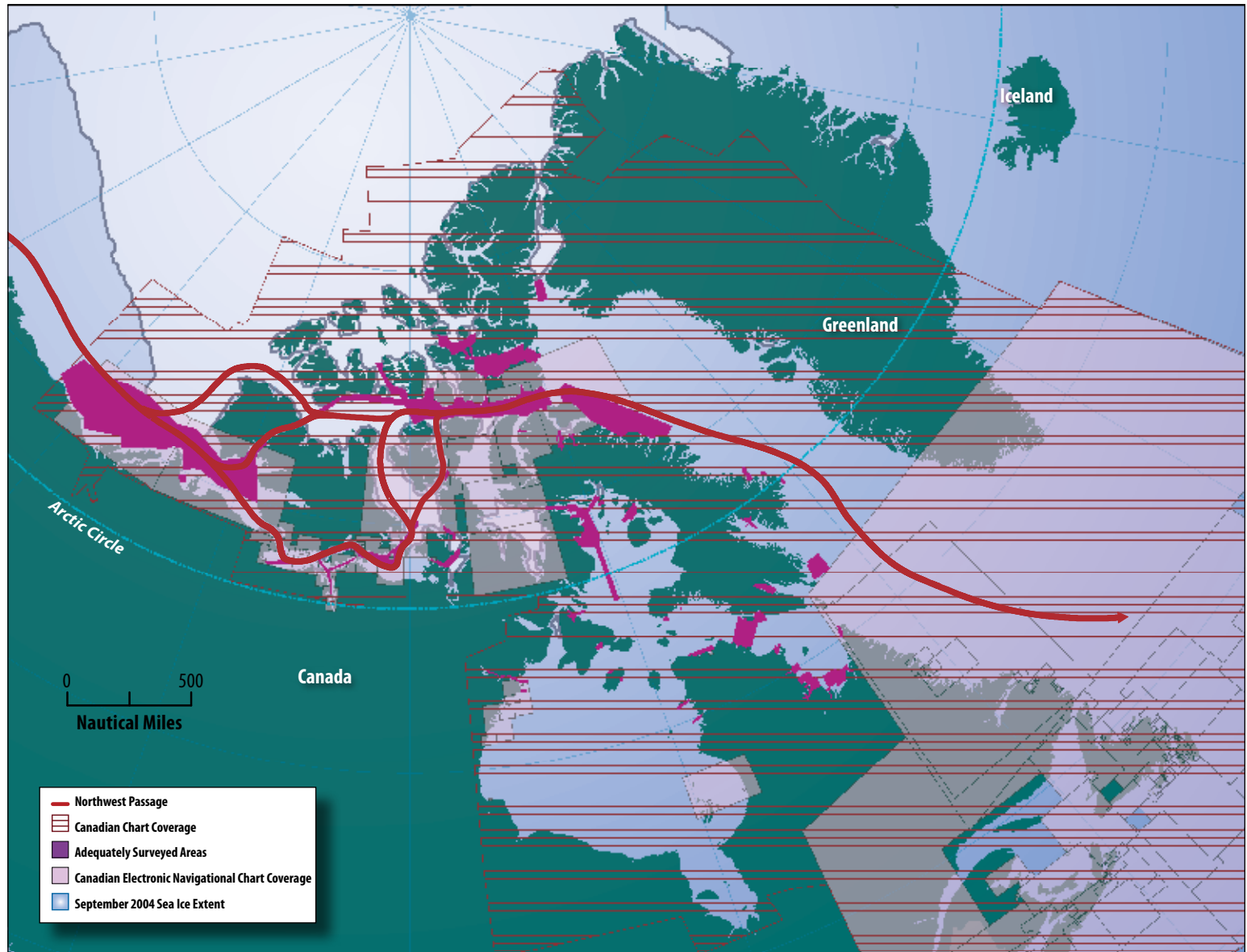
While there are published charts whose physical limits cover both the Canadian Northwest Passage and the Russian Northern Sea Route, the quality of the underlying data varies widely from modern, high resolution hydrographic surveys to no sounding information in some areas.

The quality and accuracy of navigational charts is entirely dependent on the hydrographic data used to compile them. Hydrographic surveys in the Arctic are logistically very complicated, expensive to undertake and highly dependent on weather and ice conditions. In addition, hydrographic offices normally prioritize their efforts based on a risk classification approach. Because the Arctic has traditionally seen smaller volumes of marine traffic, these risks have been perceived as low compared to other regions and progress in improving hydrographic coverage in the Arctic has been painstakingly slow.

IHO provides the current state of hydrographic surveys for member countries throughout the world. In Greenland, the limit for navigable waters has been set to 75 degrees northern latitude due to the permanent ice cover and the sparse population of its east coast. Within Canada, a high proportion of Arctic waters are inadequately surveyed or covered by frontier surveys only. A similar situation exists in the Russian Federation where ice conditions have precluded the systematic survey of the central parts of the Laptev and East Siberian seas. Only passage sounding

1933

The year the Russian Federal State Unitary
“Hydrographic Enterprise” began conducting surveys.



Map 9.1 Canadian charting and survey status. Source: AMSA

data is available for the deep water areas of the Sea of Okhotsk and the Bering Sea. The following figures illustrate the status of individual countries.

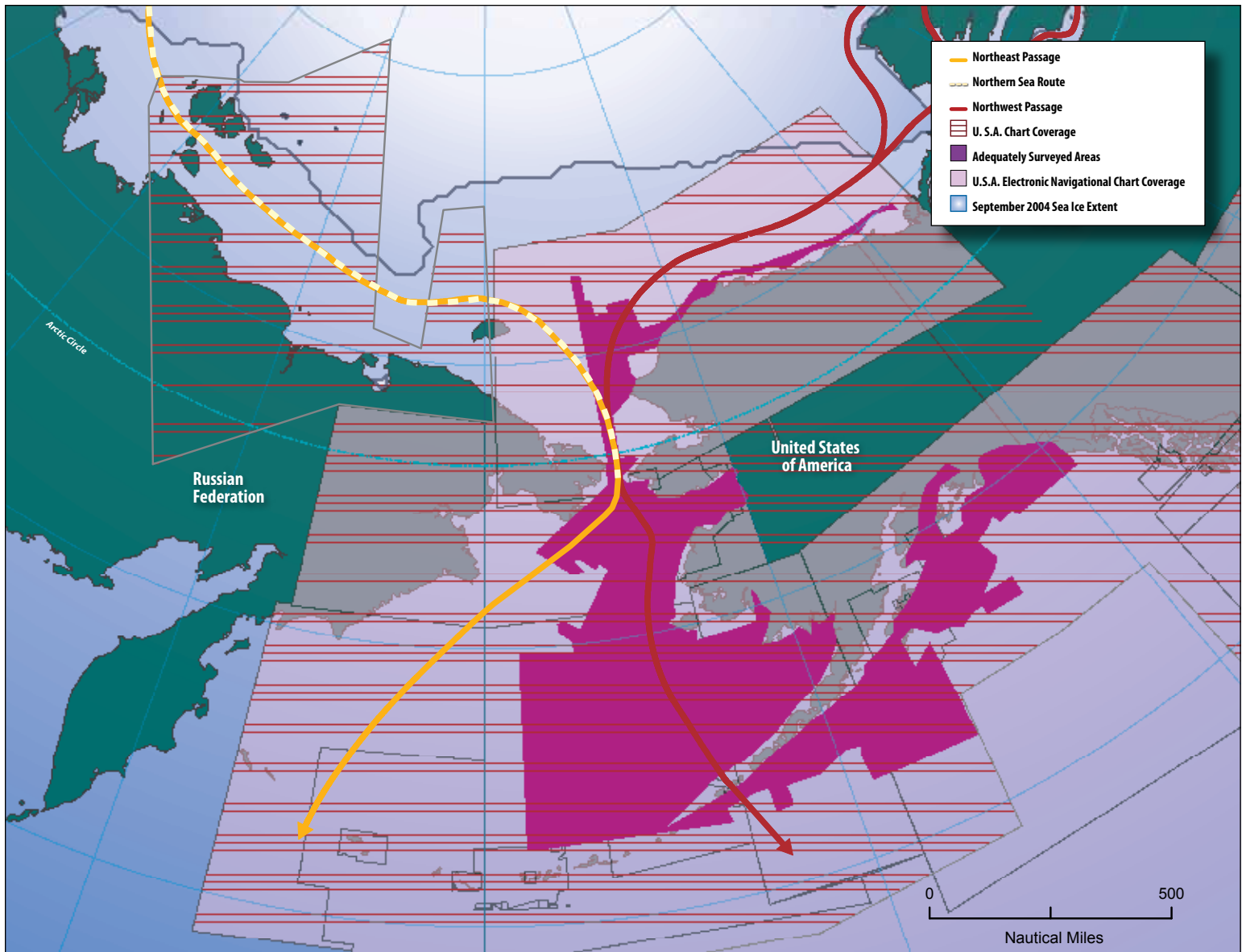
The Canadian Hydrographic Service reports that 10 percent of the Canadian Arctic has been surveyed to modern standards (Map 9.1). Coverage is often minimal and collected using rudimentary equipment and methods.

Surveys of the U.S. Arctic have been predominately along the northern coast of Alaska (Map 9.2).

The Russian Federal State Unitary “Hydrographic Enterprise” (SHD), formerly known as the Hydrographic Department, has

conducted surveys since 1933. For the main areas of the Arctic shelf that cover 90 percent of the traditional navigation routes, detailed underwater topography is available (Map 9.3). Coastal surveys are completed for the Chukchi Sea, the East Siberian Sea, the Kara Sea, the navigable part of the Gulf of Ob’, the shipping channel of the Yenisei River up to the port of Igarka, the shipping channel of the Khatanga and Kolyma rivers and the entrance of the Bykovsky waterway from the sea to the delta of the Lena River.

The SHD has set modern standards for Russian hydrographic surveys that recommend survey methods to ensure the detection of all



■ **Map 9.2** U.S. charting and status of surveys in the Arctic. *Source: AMSA*

underwater obstacles on routes of intense navigation. To meet these modern standards, charts will need to be updated and, in the near future, an appreciable amount of work will have to be done. This includes detailed surveys of recommended shipping routes, harbors and anchorages for cargo operations using an instrumental area survey by special hydrographic equipment; regular measurement in areas not yet surveyed or surveyed with poor accuracy and details; and regular measurements in regions that are difficult to access because of ice conditions.

As mariners traverse the waters of nations around the world, they must be able to reliably interpret hydrographic products,

independent of the country of origin. By becoming members of the International Hydrographic Organization, hydrographic offices agree to achieve uniformity in data quality and presentation standards. The emergence of digital products, most importantly electronic charts, has introduced a new aspect to the dissemination of hydrographic data. While a convergence of data sharing approaches is underway, significant inconsistencies remain. The Arctic provides an excellent opportunity to demonstrate the benefits of an open approach to data sharing in the international hydrographic community.

Sea ice is what sets the Arctic apart - what makes navigation in the Arctic especially unique and hazardous.



© German Shipowners' Association

Ice Information in the Arctic

Without sea ice, the needs for environmental information in the Arctic would be little different from the world's other oceans - wind and weather, waves, tides, currents, etc. Sea ice is what sets the Arctic apart - what makes navigation in the Arctic especially unique and hazardous.

Sea ice in the Arctic has an annual cycle of freeze and melting that will not change in the future. When the sun goes down in the autumn and the extreme cold arrives, the ocean freezes. March is the month of maximum ice coverage. Through the summer months, the ice melts and retreats to a minimum extent in September.

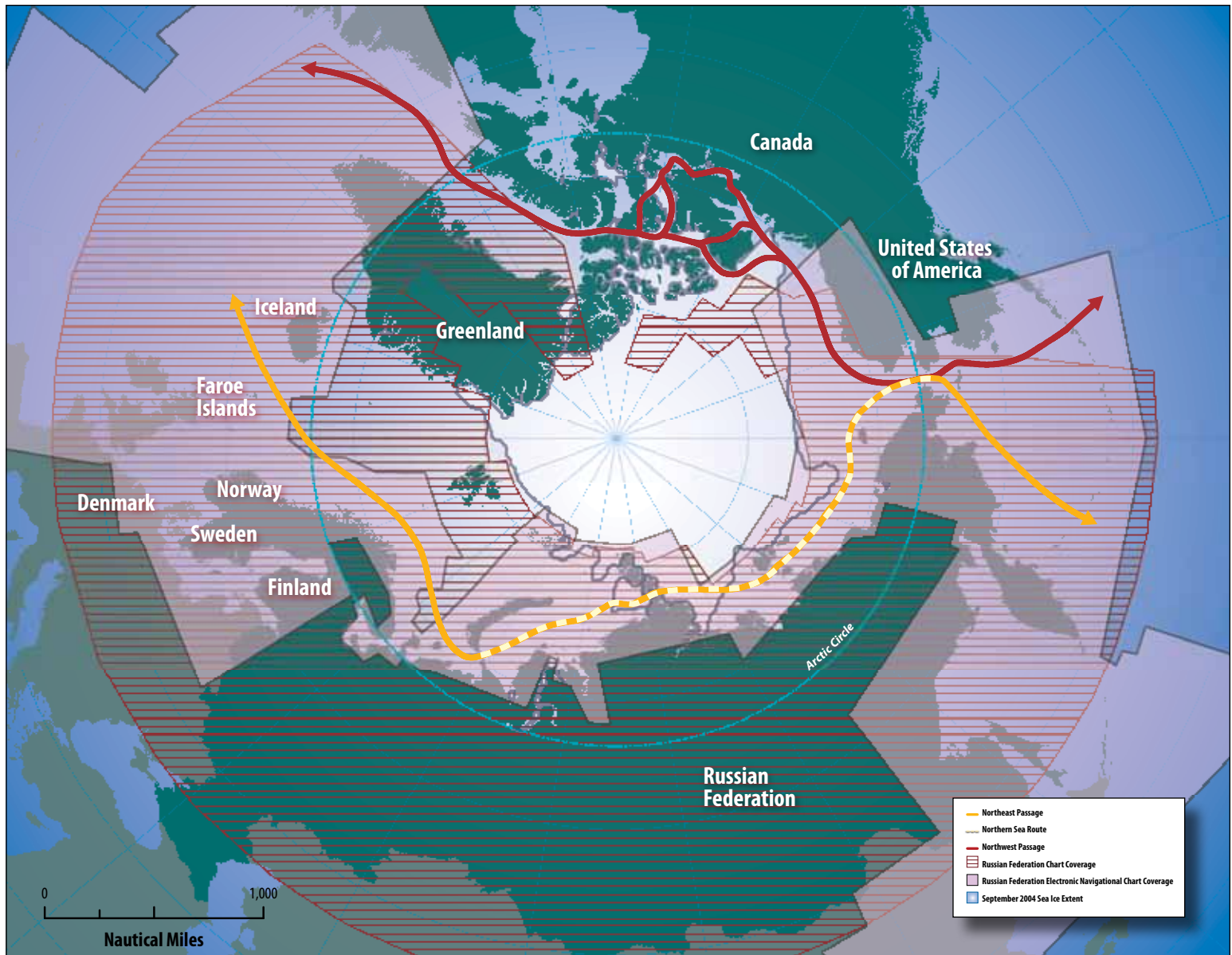
It is generally agreed that the reduction in the thickness and extent of Arctic sea ice will continue into the future until, eventually, the Arctic will become free of sea ice in summer - much like the Baltic Sea, Sea of Okhotsk or the waters off the east coast of Canada. However, this will not eliminate the hazard that ice presents to Arctic shipping. There will still be a winter ice cover and significant inter-annual variability means that not all of the ice will melt every year, so scattered old ice floes will hide in the pack ice along with icebergs and ice island fragments. Moving ice driven by winds and currents will create a dynamic and hazardous operating environment. Variability in the onset of autumn freeze-up will present the risk of getting trapped in the Arctic over winter. Spring break-up to mark the start of summer navigation will vary and, as happens now in more southerly seas, shippers eager to start work will test the limits of their vessels in ice.

As more ships venture into the Arctic, the demand for ice information, as well as other ocean data, products and services,

will continue to increase and the resources available to meet this increased demand will be stretched. The ice parameters needed in the future will not change significantly but will be required over larger geographic areas and longer periods of the year. Operators will still need to know where the ice is and isn't; where it's going to be, how closely packed it is and how thick and strong it is; generally, how difficult it will be to go around or, when necessary, go through. These parameters will be needed on a variety of space and time scales - from the hemispheric to the local, from months and weeks to daily or even hourly - to support tactical and strategic route planning for ships, scientific study and the development of policy and regulations to ensure safe marine practices.

The needs of mariners for ice information are currently met by a number of organizations, including national ice services that produce information for the Arctic that is generally freely available as a public service funded by tax-payers; academic institutions that provide ice information as part of an ongoing research program or to support field research campaigns; and commercial ice information services that provide services that are specific to individual clients with particular needs. As more ships venture into the Arctic and the demand for ice information and related services increases, there will be increasing pressure on the resources of ice information providers.

The national ice services collaborate in the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology Expert Team on Sea Ice, the body that establishes and maintains the standards for ice information internationally; and in the International Ice Charting Working Group (IICWG), an ad hoc group



Map 9.3 Russian Federation chart and ENC coverage of the Northern Sea Route. Source: AMSA

that coordinates ice information services internationally and advises the Expert Team on Sea Ice. As a result of this collaboration, there is an internationally accepted nomenclature for ice in the ocean, common charting and coding practices and cooperative information sharing among the ice services.

Ice information products include ice charts depicting the distribution and characteristics of the sea ice in an area; satellite images of ice-infested waters, often with interpretative text added; and text messages describing ice conditions. There is a wide range of scales for these products - from hemispheric charts that are useful

for long-range planning to the navigation scale to support tactical vessel movements.

It is certain that the needs for ice information will evolve as more Arctic shipping develops. It is impossible to predict exactly how that evolution will occur because it depends on many factors - how the ice distribution itself changes, where resources are found, what markets are developed, advances in ship design and improving technology to observe, produce and disseminate ice information. The following examples are intended to provide illustrations of the particular ice information needs for some probable scenarios.

Potential shipping routes for extracting resources - principally oil, gas and minerals - will primarily be along shortest distance lines from the production sites to the markets. It is likely the vessels used in this trade will be purpose-built for the trade in question and will operate year-round. They will be ice-strengthened and powered sufficiently to handle the most severe ice conditions encountered along the route. Ice information of most importance to these vessels will be that which can help them reduce time and fuel consumption en route as well as minimize the risks and delays that can be caused by difficult ice conditions around loading docks and piers.

Arctic transit shipping, using the Arctic Ocean as a short cut between Atlantic and Pacific, is not expected to become common because of the seasonal nature of the ice cover. Vessels designed to reliably pass through the winter Arctic ice cover will be greatly disadvantaged economically during the ice-free season. If transit shipping does occur in the Arctic, it will likely be limited to the summer season. These vessels will have some ice-strengthening to handle summer Arctic ice encounters but will not be able to deal with winter conditions. The most important ice information for this trade will be medium- and long-range forecasts of break-up and freeze-up to help companies decide when to head for the Arctic and when to get out in order to avoid being trapped over a winter. Close in the order of importance will be analyses and short-range forecasts of ice concentration, strength and motion to allow masters en route to set courses that avoid ice as much as possible.

Marine Weather Information for the Arctic

Modern weather information, including information for shipping, is based on numerical models. Numerical weather prediction analyses and forecasts are available for the Arctic from all of the major meteorological centers that run global models. States having the need for more detailed information for the Arctic areas have implemented high resolution models covering the Arctic region according to their needs.

In addition, Arctic coastal states provide marine weather information for their coastal waters. In most cases information for shipping is issued for large areas extending well offshore. Within the coverage of INMARSAT Global Maritime Distress Safety System transmissions, marine safety information in the form of gale and storm warnings is in place consistent with all other high sea areas in the world. However, no responsibility has yet been assigned for the high seas regions of the Arctic outside the coverage of INMARSAT, although an initiative is underway to do so by the World Meteorological Organization. Several states have offered to issue and/or prepare weather information for the Arctic. Progress in this initiative is expected and routine weather bulletins for the high Arctic areas may be in place in a few years. Prediction of the development and paths of lows giving rise to high winds is of particular concern for Arctic shipping. Accurate

forecasts of sea ice, wave height, wind direction and speed, visibility, temperature and superstructure icing are the most important routine forecast parameters for shipping - with at least the same accuracy and timeliness requirements as on the other oceans.

Although weather forecasts for the Arctic are based on the same tools using the same techniques as in other areas of the world, the scarcity of observations in the Arctic makes the monitoring of the weather more difficult than in areas with more observations. Meteorological observations in the Arctic rely on drifting buoys placed on top of the sea ice. A new generation of buoys that will withstand multiple freeze-thaw cycles is currently under development and is urgently needed to provide surface observations in the Arctic Ocean. The ability to measure the conditions of the atmosphere and ocean from satellites is, however, developing rapidly and, with adequate surface validation, the quality of weather forecasts will approach the quality used in other areas.

Wave Information for the Arctic

Because of the ubiquitous presence of sea ice, waves have not been a major navigational hazard in the Arctic. However, with less sea ice to dampen the waves, this will no longer be the case in the future. Wave information is typically packaged along with marine weather information in sea ice-free areas. New operational modeling capability will be needed to deal with a partial ice cover and its effect on wave generation and transmission. Buoys that measure the wave heights and directions are essential for model validation but none of these exist in the Arctic for operational reporting. Because of the necessity to deal with winter ice, a new generation of buoys will have to be developed.

Marine Aids to Navigation

The safe and effective use of northern waters by maritime shipping relies heavily on such safety systems as fixed and floating aids to navigation, long-range aids to navigation (shore-based electronic or satellite-based), as well as safety and navigation information broadcasts. While southern waters and well-used maritime routes are well served by established systems, northern waters are served by a patchwork of these systems. Ships navigating in the Arctic encounter unique situations. Ships usually use a combination of satellite positioning and traditional navigation techniques.

Of the eight circumpolar countries, six have coastlines. Of these, Canada, Denmark, Norway, Iceland and the Russian Federation maintain active aids to navigation (ATON) networks. More specifically: The Canadian Coast Guard maintains a number of seasonal fixed and floating aids throughout the Canadian Arctic. These are placed

The future increase in human activity in the Arctic, including Arctic marine shipping and the continued overflight of the Arctic region by commercial aircraft, will place increasing demands on the SAR infrastructure.

around the last week in June by icebreakers in Ungava Bay, Hudson Strait, Frobisher Bay and in the western Arctic by the third week in July. There is an active aids program along the Mackenzie River, serviced by two CCG shallow draft tenders. These aids are then picked up and the fixed aids deactivated as the icebreakers leave the Arctic, generally by the last week in October.

Norway maintains aids to navigation along its entire coast and at Svalbard along the coast and in fjords. Of note are a number of fixed and floating aids to navigation in Svalbard internal waters. It is expected that the requirement for aids to navigation in the Svalbard area will increase based on analyses of both the changing traffic patterns and the utilization of better risk analysis methodology.

Denmark has a permanent system of radio communication and radar beacons (RACON) along the west coast of Greenland from Uummannarsuaq/Kap Farvel to Qeqertarsuup Tunual/Diskobugten, as well as a system of coastal fixed aids, such as daymarks, from Uummannarsuaq/Kap Farvel to Upernavik.

Iceland maintains a number of fixed and floating aids to navigation in its internal waters including a Digital Global Positioning System and RACON beacons and has a permanent system of radio communication for radio monitoring of its fishing fleet.

The Russian Federation has an extensive system of fixed and floating aids to navigation mainly in the harbors of the NSR, which also includes some lighted and unlighted beacons and daymarks along the coast between ports.

The United States has no aids to navigation along the north coast of Alaska. The current U.S. short-range ATON footprint in the



Arctic extends a short distance north of the Bering Strait where the largest zinc mine in the world (Cominco's Red Dog mine) near Kivalina receives ore carriers. North of the Aleutians along the coast of the Bering Sea, the U.S. has some floating and fixed ATON near the Pribilof Islands and Bristol Bay for tug, barge and fishing vessel traffic. In the Aleutian chain, there are several areas where navigational aids are maintained for local traffic, as well as for the trans-Pacific shipping transiting this region.

Marine Communications, Traffic Monitoring and Control

The historical standard for communicating weather, wave and ice information to ships at sea is the radio facsimile broadcast. While its use is being eclipsed world-wide by digital communications, the analogue radio broadcast remains an important source of information in the Arctic. Radio stations in the United States, Canada, the United Kingdom, Denmark, Germany and the Russian Federation broadcast analysis and forecast charts for sea ice, icebergs, sea state and weather, as well as providing vessel traffic services and general marine communications.

Norway has established a very advanced system composed of Automatic Identification System (AIS) and Maritime Communications and Traffic Services along the Arctic coast. In January 2007, a Vessel Traffic Service (VTS) for the coast of northern Norway was established in Vardø, operated by the Norwegian Coastal Administration (NCA).

The service is designed to monitor and guide vessels, to promote safe and efficient navigation, and to protect the marine environment against undesired events in the Barents Sea and along the Norwegian coast. The area of operation for Vardø VTS Center is the Norwegian Economic Zone (NEZ) outside the baseline, the area around Svalbard and the area outside Tromsø and Finnmark in northern Norway. The VTS Center interacts with vessels, other government agencies, the NCA duty team that is responsible for national response and with the Norwegian SAR for search and rescue services. The administration also coordinates, on a daily basis, the tugboat preparedness in North Norway in conjunction with Regional Headquarters North-Norway (Norwegian Armed Forces) and the NCA duty team.

The United States marine communications infrastructure in Alaska is concentrated where vessels operate the most. There is excellent very high frequency (VHF) coverage throughout southeast Alaska and into portions of the Bering Sea north to St. Paul and the Bristol Bay area. North of this region there is local VHF coverage at Nome, Kotzebue and Barrow. Barrow and Kotzebue, both north of the Bering Strait, also have high frequency (HF) NOAA radios. Mariners in these areas can speak directly to a weather expert via HF radio. Outside of VHF marine coverage, the U.S. Coast Guard relies on high frequency or satellite communications. Canada operates a seasonal system, while the Russian Federation is planning to augment their existing service during the next two years with further investment up to the 2020 timeframe. The Danish Navy operates a year-round high frequency radio station on the southwest coast of Greenland and maintains the IMO mandatory ship reporting system, GREENPOS, for all ships on voyage to or from Greenland ports and places of call. Furthermore, Denmark maintains a number of stations with limited communications capabilities in the south/southeast and lower western half of Greenland. Iceland has an advanced system of AIS along its coast with 23 base stations and repeaters with total coverage of the coastline. The maritime radio system has recently been renewed in VHF, MF (medium frequency) and HF bands and two new NAVTEX stations have been established. The traffic monitoring is carried out by the Maritime Traffic Service in Reykjavik operated by the Icelandic Coast Guard.

Communications using VHF, MF and HF as well as satellite are generally sufficient for the lower Arctic areas (Hudson Bay, Foxe Basin, southern Greenland waters and waters of the Northern Sea Route); however, once the high Arctic is reached, voice and data transmission become problematic.

Most modern ships are equipped with satellite digital communications equipment - not only for safety reasons but for the management and navigation of the ship. This equipment relies on geostationary INMARSAT satellites that do not provide service northward of about 80° N latitude. Other systems, such as the IRIDIUM constellation of 66 polar orbiting satellites, provide worldwide coverage including the Arctic. IRIDIUM is capable of providing a Ship Safety and Alerting System that meets IMO requirements but its data transfer rates are very low (less than 9.6 kb/s). The feasibility of communicating ice charts and satellite images to ships in the Arctic via the IRIDIUM system has been demonstrated but communications are limited and often interrupted. Other regional systems such as the Mobile Satellite System (MSAT) offer limited voice and data

transfer capability only in North America including the Canadian Arctic Archipelago.

Improvements in capacity and reductions in cost are necessary for IRIDIUM and other regional systems to become a practical, widespread solution for the Arctic not only for voice, but more importantly for data transmission. The Russian Federation has been using communication satellites in highly elliptical orbits that provide long residence time over the Arctic (“Molniya” orbits) for television and other communications needs for several decades and, in 2007, pledged to improve radio and telecommunications in the Arctic.

It should be noted that the Canadian government has initiated a “Polar Communications and Weather space mission for Canada’s North,” (PCW) which is planning to provide robust 24/7 two-way satellite communications capability to all of the Canadian north for rapid high rate data transmission and information products, as well as low-data rate communications capability and also near-real time meteorological information products about the north to users throughout Canada.



Various maritime training institutions are developing, or have developed, ice navigation courses, employing full mission bridge simulators and associated software products.

Norway is in dialogue with the United Kingdom, Denmark (Greenland), Faroe Islands and Iceland with regard to establishing a regional North Atlantic AIS/VTMIS (Vessel and Traffic Monitoring and Information System). The system is planned to be in force in 2009, and will facilitate the implementation of Article 9 of the Directive 2002/59 and the establishment of the SafeSeaNet Tracking Identification Relay and Exchange System (STIRES) as presented in the STIRES study (Saab AB, PM PM 374185).

Satellites and aerial surveillance systems can improve monitoring capability and serve to improve compliance with state regulations such as those intended for pollution prevention, or traffic reporting schemes that consequently can help in protecting the environment. As shipping increases in the Arctic regions, the requirement for improved voice and data transmission coverage becomes paramount.

Personnel and Maritime Training

Considering the Arctic operational environment and the lack of infrastructure, safe navigation in the Arctic is often dependent on the skills of a limited number of seasoned northern mariners. The Arctic offers significant navigational challenges, especially to the uninitiated. For decades, safe navigation has rested in the hands of a small number of experienced officers in a few countries. Their training has mostly been on-the-job with relatively little in the way of formal ice navigation education except within the limited regular navigation curriculum. With increased shipping in the Arctic, the need for skilled mariners will increase. Earlier melt periods and later freeze-ups will allow a greater amount of multi-year ice and ice of land origin (iceberg fragments such as growlers and smaller pieces called bergy bits) into the shipping lanes of the Northern Sea Route and the Northwest Passage, as well as in Greenland waters. It should be noted that less ice does not mean less danger. Understanding of the special conditions influencing navigation in the Arctic is crucial to the maintenance of a safe shipping regime.

The IMO's *Guidelines for Ships Operating in Arctic Ice-covered Waters* and the *International Convention on Standards of Training, Certification and Watchkeeping of Seafarers* (STCW '95) call for specialized training for mariners in Arctic waters. The guidelines define an ice navigator as "any individual who, in addition to being qualified under the STCW Convention, is especially trained and otherwise

qualified to direct the movement of a ship in ice-covered waters." It also states: "The Ice Navigator should have documentary evidence of having satisfactorily completed an approved training program in ice navigation. Such a training program should provide [the] knowledge, [the] understanding and proficiency required for operating a ship in Arctic ice-covered waters, including recognition of ice formation and characteristics; ice indications; ice maneuvering; use of ice forecasts, atlases and codes; hull stress caused by ice; ice escort operations; ice-breaking operations and effect of ice accretion on vessel stability." It also provides guidelines for companies operating in Arctic ice-covered waters to develop a training manual, including the development and inclusion of drills and emergency instructions, emphasizing changes to standard procedures made necessary by operations in Arctic ice-covered waters. These drills and emergency instructions would be incorporated into the routine vessel operational training.

The STCW includes mandatory training requirements for passage planning and ice navigation in ice-covered waters. This section also authorizes the use of approved training simulators to achieve the stated training requirements. The concept of an officer experienced in navigation in ice, as well as the qualifications required, forms part of various national legislation and rules among northern countries such as the Canadian *Arctic Waters Pollution Prevention Act* and its associated regulations: the *Joint Industry Coast Guard Guidelines* for the control and operation of oil tankers and bulk chemical carriers in ice control zones of Eastern Canada.

The Russian Federation has a modern Arctic maritime training regime concentrated in the following marine educational centers: the Admiral Makarov State Maritime Academy in St. Petersburg; the Admiral Nevelskoy Far East State Maritime Academy in Vladivostok; the regional center of continuing professional education at the Captain Voronin Maritime College in Arkhangelsk; the "MARSTAR" Academy in St. Petersburg; and the Primorsk Shipping Corporation training Center in Nakhodka.

These centers train prospective Arctic navigators using the "Preparation for Navigation in Ice Conditions" course developed by the Makharov Training Center. These courses are designed around three subdivisions: theoretical training, simulator training and practical training onboard a vessel. The courses follow the requirements



As more ships venture into the Arctic, the demand for ice information, as well as other ocean data, products and services, will continue to increase and the resources available to meet this increased demand will be stretched.

expressed in the IMO STCW 78/95 Requirements; the IMO's *Guidelines for Ships Operating in Arctic Ice-covered Waters* and finally those specified by the Russian *Rules of Navigation on the Seaways of the Northern Sea Route*.

The course trains officers in all aspects of operations in ice-covered waters, through theoretical and simulator-based training including: the preparation and planning for voyages in ice-covered waters; operating, navigating, maneuvering and escorting ships in Arctic ice-covered waters, including recognition of ice formation and its characteristics; features of maneuvering in ice of different density and thickness; communication between cargo vessels and icebreakers; and familiarization with emergency and search and rescue operations.

The prospective navigator must follow a practical regime composed of two phases that reinforces the theoretical and simulated aspects of the training already received, as well as knowledge passed on from more experienced operational personnel. These include practical navigation training where the student is taken onboard as a bridge officer trainee and is supervised by the navigating officers; and practical deck training where the student is taken onboard as a regular member of the ship's crew and studies features of ice operations from their point of view.

Certification of Ships' Officers and Crew

Maritime administrations around the globe are tasked with the certification process, which is linked to the maritime licensing programs for most countries. Several areas, such as vessel security officers, radar navigation and pilotage, have been fully addressed with special endorsements on individual licenses. Certification for tanker operations, vessel classification, vessel design and equipment for vessels operating in ice-covered waters has been established. Several regulations address oil spill response and environmental issues.

Various maritime training institutions are developing, or have developed, ice navigation courses, employing full mission bridge simulators and associated software products. The IMO has created a program of model training to assist institutions developing ice navigation courses with an emphasis on meeting STCW requirements. Several countries have instituted courses, including Finland and the Russian Federation, for the Baltic region, as well as Norway and Argentina. Canada has developed a model course using a simulator at the Marine Institute in St. John's, Newfoundland. While these classes begin to address the deficit in standardized ice navigation training, international harmonization is still necessary in order to provide the next generation of qualified northern navigators.

Incident Response and Capacity

As marine activity continues to expand in the Arctic, statistical trends indicate that the potential risk of vessel mishaps and marine pollution incidents also increases. The inherent navigational and environmental hazards and limited number of experienced personnel, combined with Arctic ecosystem sensitivity, heightens the need for greater incident response capacity and preparedness. It is important to learn, as soon as possible, what has been spilled, where and when in order to address it in an appropriate manner.

Protection of the Environment: Oil and Other Hazardous Spills Response

Marine incident prevention is based upon addressing four conditions that may result in pollution incidents:

- human error or failure caused by fatigue, malfeasance, unfamiliarity or other conditions either exclusively or in conjunction with each other;
- lack of operational readiness and preparedness caused by marginal or unprepared ship or crews;
- older vessel or vessel operating outside of operation parameters; and
- Arctic climate and situational unknowns caused by less predictable or rapidly changing weather, ice conditions, iceberg awareness or failure of mechanical systems unprepared for the rigors of Arctic operations.

Alone, or in combination, these conditions contribute to a myriad of scenarios for pollution and are the focus of the vast majority of preventive measures.

In addition, the variety of pollutant types and sub-types threaten the environment in different ways depending upon their chemical nature and how they behave when released. This may include circumstances such as waterway type, time of year, weather (wind, temperature) and local geography. Further adding to these circumstances are the variables associated with the potential impacts or sensitivities related to shoreline ecosystems, marine ecosystems, socio-economic systems or, in general terms, the overall exposed environments that would be lost or degraded.

Given the recognition that prevention may greatly diminish but not necessarily eliminate pollution threats, all maritime nations support preparedness and response activities. The challenge lies in the creation and sustainability of a preparedness and response regime that deals with the innumerable combinations and permutations possible.

While there are exceptions, there are few Arctic-based resources to address oil spills, especially the ability to recover trapped oil in hulls and compartments in both shallow and deep water.

Internationally, the Arctic countries are all signatories to MARPOL 73/78 (Annex I and II), COLREG Convention 72, STCW Convention 78 and Load Lines Convention 1966 and Protocol 1988, all of which fundamentally support the domestic legal frameworks for limiting vessel casualty situations. While these conventions apply internationally, the unique Arctic conditions relating to ice cover, weather fluctuation, limited basic infrastructure due to remoteness and particular biological susceptibilities increase the reliance on clear and robust prevention and preparedness regimes.

The Emergency Prevention, Preparedness and Response working group of the Arctic Council has created several products for dealing with oil spills in the Arctic. These products are available to the general public through <http://eprp.arctic-council.org> and include:

- an Arctic Guide referencing emergency systems and governmental contacts for all circumpolar nations that is updated annually;
- a Shoreline Cleanup and Assessment Manual (2004) for use in determining the most appropriate techniques for enhancing shoreline recovery;
- a series of Circumpolar Maps of Resources at Risk from Oil Spills in the Arctic (2002);
- a Field Guide (1998) for oil spills response referencing all manner of protection and recovery techniques; and
- an Environmental Risk Analysis (1998) of Arctic activities that indicates current potential spill sources.

Of particular note, the series of circumpolar maps, <http://eprp.akvaplan.com>, provides a first order overview of information for stakeholders to easily identify potential sources of spills and internationally important biological resources that could be at risk. The map catalogue includes thematic, regional and seasonal views including fish, bird, mammal, human population and protected areas.

A review of each Arctic state’s response profile reveals a relatively consistent allocation of marine pollution interests from federal to local levels. In addition, there exists a number of longstanding bilateral agreements between adjacent countries that encourage cooperative efforts and transfer of best practices. For example, Norway and the Russian Federation have a bilateral oil spill response agreement for the Barents Sea that is exercised annually. There is no multilateral oil spill response agreement for the Arctic, but it may warrant an umbrella or multilateral agreement and/or a contingency planning process. Because of the diverse nature of the areas and interest, there is no particular advantage or disadvantage to any one model provided that entities share their objectives and communicate effectively.

In terms of current and future marine traffic, the Arctic is an immense, seasonally variable waterway with very little development along its shores. Despite the current disposition of resources and regimes, a more consistent country by country approach is required to address the pollution risk more effectively. Issues related to identifying risk areas, establishing timelines for response and ultimately designing a consistent response capacity remains a challenge.

Logistics - the procurement, maintenance and transportation of materials, facilities and personnel - are dependent upon existing Arctic infrastructure. This is a critical component of all Arctic operations. Sea-state and environmental exposure will place larger burdens on logistics supply lines. In the absence of shore-based infrastructure, longer range planning for refueling and replenishment are required. Distances between ports, coupled with the unpredictability of weather, may complicate access and supply, as well as removal of recovered product and waste. With public expectation of four season response capability for large or environmentally disastrous spills, the logistics infrastructure may need to be modified.

The issue of logistics is not surprisingly a significant and mostly limiting factor in facilitating an effective response. In remote areas, two distinct situations exist in relation to the provision of logistics: incidents within reasonable distances from established communities and those in more remote settings. Pre-existing infrastructure or pre-placement of response assets typically support this first scenario, while remote incident sites require the creation of infrastructure from the ground up. A mobile and relatively self-sustaining infrastructure is called for currently and likely into the foreseeable future. Selecting a site for this type of infrastructure becomes the key logistical issue facing a response and obtaining local knowledge of the areas is considered vital.

Environment		Response			
Response	Oil Location	Countermeasures			Feasibility
		Contain/Recover	Burn	Disperse	
Source Control					
Control of Free Oil					
Protection					

Oil Locations

- Oil On The Surface In Open Water
- Oil Submerged Under Open Water
- Oil On Water Surface Mixed In Ice
- Oil Submerged Under Broken Ice
- Oil Beneath Ice
- Oil On Ice
- Oil Submerged Under Solid Ice

Seasons

- Open Water
- Transition
- Frozen

Countermeasures Methods

- Mobile Floating Barriers
- Stationary Barriers
- Subsurface Barriers
- Boms
- Trenches Or Slots
- Diversions Booms
- Advancing Skimmers
- Stationary Skimmers
- Vacuum Systems
- Burning Oil On Water Contained In Booms
- Burning Oil On Ice
- Burning Oil On Broken Ice
- Vessel Dispersant Application
- Aerial Dispersant Application

Table 9.2 Summary of typical response countermeasures in various seasons and seas. Source: *First Responder's Guide for Arctic Oil Spills, EPPR*

It is important to learn, as soon as possible, what has been spilled, where and when in order to address it in an appropriate manner.



© United States Coast Guard

Oil spills in ice are more complicated to address than oil spills in open waters and there are several challenges connected with oil spill response in ice and snow and cold water. Apart from the normally long distances from existing infrastructure, the oil is less accessible in ice-covered waters. The oil can be spilled on ice or snow, in open pools between ice floes, in open channels behind vessels or even under the ice from pipelines or other sources.

There are some advantages in addressing oil spills in ice compared to open water. The weathering rate is normally much slower for an oil spill in ice as the emulsification rate is slower, resulting in an increased window of opportunity for use of most response techniques. The spreading of oil will be normally slower also, resulting in a large oil film thickness that may be favorable for oil spill response. The reduced weathering of oil in these conditions does, however, maintain the levels of its more toxic components for greater periods of time, thereby increasing the availability or risk of uptake by organisms.

Arctic Oil Spill Recovery Operations: Technology and Tactics

Effective Arctic oil spill recovery operations require advanced planning and international cooperation. All available methods must be available and considered for each situation although some methods have proven more effective in ice-covered waters. Along with planning and cooperation, training, incident communications and risk management are key elements to any oil recovery operation.

Mechanical recovery techniques combined with oil detection and tracking methods, currently dominate the in-field capabilities

of most nations. However, tracking, detecting, as well as modeling oil in ice-covered waters has inherent environmental limitations. The mechanical methods are often considered the most environmentally friendly recovery methods. The concept is to create barriers via floating or alternative booms, recover the oil out of the sea with a mechanical skimmer and then do the post-treatment for the recovered oil in a controlled manner in environmentally safe conditions. However, the mechanical methods are laborious and time consuming and their efficiency is low. Further, mechanical methods often require complicated logistical support in the form of equipment and personnel transportation, which in remote or harsh conditions cannot easily be provided. Mechanical recovery in ice and snow conditions must meet challenges in terms of booming, skimming, recovery and pumping capabilities. Each of these areas has specific challenges to optimum recovery efforts.

Chemical dispersion can be utilized to promote the formation of oil droplets in order to accelerate the natural dispersion and biodegradation of spilled oil. Dispersants (surfactants) can be applied to control offshore slicks or oil that accumulates in coastal areas that have significant tidal or flushing action. In order for dispersion to be effective there needs to be limited weathering of the spilled oil, a cohesive slick, an oil within the viscosity ranges of dispersibility, an appropriate dispersant to oil ratio and turbulent mixing. Only a few research studies have been performed in the past 20 years regarding the use of dispersants on oil spills in ice-infested waters, either from an effectiveness or environmental-impact perspective, and these are of limited value in assessing the situation in realistic terms. Logistical support and effectiveness may also be a challenge when using dispersants. Limited studies such as the Joint Industry Program (JIP) on Oil in Ice, have followed the long-term fate of dispersed oil, but most impacts have been derived from laboratory studies.

In-situ burning, or ISB, is a treatment method that can be used for oil on open water, on ice and in broken ice, if adequate oil thickness can be achieved to sustain burning. This may require the use of booms or herding agents. While continued studies are needed to best determine the ISB effectiveness window of opportunity, for in-situ burning to be a viable option, planning, special equipment and training specific to ISB must be in place before the limited window of opportunity presents itself during a spill. Burnability is a function of oil type (chemical/physical factors), oil thickness on the interface and its state of weathering/degradation. While colder Arctic temperatures are a force to overcome for ISB in ice-covered waters, other natural degradation processes such as slower rates of spreading, evaporation and emulsification have supported burning.

450

The approximate number of lives saved in 2007 because of the Automated Mutual-Assistance Vessel Rescue System.

From the recovery rate point of view, in-situ burning seems to be the most effective method for clean-up of oil spills in ice and snow conditions. Furthermore, removal efficiency exceeding 90 percent can be achieved in ideal conditions (open water, fire booms and quiet conditions), but a burning rate of 60 to 70 percent can be considered as representative for burning on ice-free water. The burning rate can also be zero percent if the oil is not ignitable. ISB may be more limited due to weathering of the oil than the use of dispersants. This is significantly more effective than rates of 10 to 20 percent for mechanical recovery. Alternatively, in-situ burning will generate smoke and soot, thus moving part of the pollution from the sea to the air, and will leave a burn residue that must be recovered. Monitoring and assessment of these results is always necessary.

Oil may be removed by biological degradation. Oil-degrading bacteria naturally exist in the seas with oil, including the cold and icy waters. By adding oxygen and/or nutrients and/or bacteria a possible acceleration of this fundamentally natural process can occur. While bioremediation is an effective countermeasure for small spills with high surface areas (e.g., very thin staining or coating on shorelines), it is a relatively slow process, possibly requiring months if not years to fully accomplish and is best suited for post-spill response final treatment.

Protection of People and Property

The current search and rescue, or SAR, infrastructure in the Arctic, while varying between regions, is limited. For example, while there is a robust set of assets off the coast of Norway to respond in an emergency, there is little to no infrastructure along the coast of Greenland to respond to a passenger ship in distress. A survey of search and rescue resources among Arctic states indicates limited availability of fixed wing aircraft and helicopters in most of the region. Some survey responses included icebreakers and seasonal patrol vessels that can be used for SAR when near enough to an incident. However, in general, there are shortages of critical SAR response assets, such as long-distance, heavy-lift capacity helicopters. The usefulness of these assets is often limited by weather and other operating conditions. Emergency response efforts are further hampered in many regions by an insufficient shoreside infrastructure needed to provide basic logistics and support functions for SAR missions. The location and availability of SAR assets are often problematic given the vast distances and frequent harsh operating conditions typical in this region. In some instances, such as in connection with oil and gas activities, private industry addresses these gaps and shortfalls by providing its own supplemental SAR capacity



as part of its ongoing Arctic operations, but this remains the exception rather than the rule.

Arctic states have attempted to maximize the effectiveness of existing SAR resources by entering into bilateral and sub-regional SAR agreements with neighboring nations that have improved coordination of SAR responses in specific areas of the Arctic. For example, the Russian Federation, Canada and the United States have a search and rescue agreement. Norway and the Russian Federation have a bilateral search and rescue agreement for the Barents Sea that is exercised annually. There are also informal search and rescue arrangements with local governmental and private entities. There is no multilateral search and rescue agreement covering the entire Arctic region.

The future increase in human activity in the Arctic, including Arctic marine shipping and the continued overflight of the Arctic region by commercial aircraft, will place increasing demands on the SAR infrastructure. Many of the infrastructure deficiencies discussed in this report, such as the insufficient number of accurate charts or the need for better real-time information concerning the operational environment and communications difficulties, will also impact search and rescue efforts.

The need to strengthen search and rescue capabilities was specifically recognized by the representatives from the Russian Federation, Canada, the U.S., Denmark and Norway who met in Ilulissat, Greenland, in May 2008. “The increased use of Arctic waters for

tourism, shipping, research and resource development also increases the risk of accidents and, therefore, the need to further strengthen search and rescue capabilities and capacity around the Arctic Ocean to ensure an appropriate response from states to any accident,” states the Ilulissat Declaration. “Cooperation, including on the sharing of information, is a prerequisite for addressing these challenges. We will work to promote safety of life at sea in the Arctic Ocean, including through bilateral and multilateral arrangements between or among relevant states.”

Passenger Vessel Safety in the Arctic

The most significant emerging challenge to the existing search and rescue infrastructure arises from the increase in marine tourism and passenger vessels operating in Arctic waters. As large passenger vessels continue to operate more frequently and farther north in the Arctic, the prospect of having to conduct mass rescue operations with limited SAR resources increases. Recent growth in Arctic marine tourism is outpacing infrastructure investment, development and support throughout the region. There are several potential problems associated with responding to an incident aboard a cruise ship. The potential number of people that would have to be rescued from a cruise ship far exceeds the capacity of most SAR response vessels and aircraft available in the Arctic. Cruise ships have a minimal capacity for self-rescue. Compliance with IMO guidelines for passenger



Emergency response is particularly challenging in the Arctic for a variety of reasons, including the remoteness and great distances that are often involved in responding; the impacts of cold, ice and a harsh operating environment on response personnel and equipment; and the lack of shoreside infrastructure and communications to support and sustain a response of any significant magnitude.

vessels operating in remote areas is voluntary and, as a result, the planning and capability for self-rescue varies. Passengers are likely to be ill-prepared for the weather, which decreases their likelihood of survival if they are not rescued quickly. There are also a host of logistical challenges associated with the lack of shoreside infrastructure in most of the Arctic needed to accommodate and care for those that are rescued, including the lack of sufficient food, lodging and medical facilities. In many cases, the only available platform with capacity to feed and house rescued passengers would be another cruise ship.

A number of potential actions are available to address the challenges presented by emergency response to passenger vessel incidents in Arctic waters. First, ships intending to conduct passenger vessel transits in the Arctic would greatly improve the prospects for a successful rescue and survival of passengers and crew if they coordinated their transits with other passenger ships in the vicinity. In two incidents in the Antarctic, passengers and crew from stricken vessels were successfully transferred to other nearby passenger vessels. One of the stricken passenger vessels, the *M/V Explorer*, sank shortly after the transfer. Second, provisions in the *Enhanced Contingency Planning Guidance for Passenger Ships Operating in Areas Remote from SAR Facilities* (IMO 2006) provide valuable guidance for passenger vessels operating in remote areas such as the Arctic. The voluntary guidelines provide detailed information on emergency drills and inspections, and contain additional requirements for lifeboats, life rafts and survival kits that would allow passengers and crew to better survive the harsh Arctic environment until SAR response arrived on scene. The value of these guidelines is dependent in large part on the degree to which they are adopted and implemented. Third, search and rescue operations could be improved and limited resources used to best advantage by sharing information, lessons learned and best



practices arising from incidents that have already occurred in polar regions, including the two latest Antarctic incidents.

The advantages of mutual assistance between vessels operating in the Arctic, although particularly significant for passenger vessels, extend to all vessels. Voluntary systems have been established that allow search and rescue authorities to identify and request assistance from other vessels in the vicinity of a vessel in distress. The Automated Mutual-Assistance Vessel Rescue System (AMVER) is one such established system that can be accessed by Arctic SAR authorities to identify a possible source for assistance in any distress case in the Arctic region. There are more than 17,000 vessels enrolled in the AMVER network, representing 155 countries. On any given day, more than 3,500 vessels are available to divert and assist in a distress situation at sea. Approximately 450 lives were saved in 2007 because of AMVER. Participation is voluntary unless mandated by a vessel's flag state, shipping company or other authority.

€4.4B

The amount of money invested since 2004 to improve Murmansk's deepwater port facilities to include new oil, coal and container terminals as well as expanded rail lines.

Participating vessels provide regularly updated information on their SAR capabilities and intended track to rescue coordination centers. AMVER information is released only to recognized SAR agencies for safety-of-life-at-sea purposes, and provides rescue coordination centers with data on vessels in the vicinity of a SAR case that may be available to divert and assist.

Another example is the Russian Vessel Monitoring System, referred to as *VMS Victoria*. The system is intended for near real-time automated monitoring of vessels positions provided vessels are fitted with the ship satellite communication systems: INMARSAT-C or INMARSAT-D+, and for delivering the collected position reports data via Internet to remote users. *VMS Victoria* caters to the shipowners, operators and organizations responsible for control and surveillance of maritime vessels, as well as for search and rescue at sea. There are more than 1,200 vessels enrolled in the system, among them more than 600 foreign flag-state vessels. *VMS Victoria* operates constantly and allows its users: to track the movements of their fleets by receiving regular automated position reports from the vessels; to request an immediate position report from any vessel on demand if required; and to send short text messages and FleetNet broadcasts to a vessel/vessels. *VMS Victoria* processes messages in real time and then transmits them to INMARSAT. It is anticipated that the establishment of the LRIT-system will be an important system to identify ships in the vicinity of a distressed vessel, thereby requesting them to provide assistance.

Promoting the use of mutual vessel assistance systems such as AMVER or *VMS Victoria* would serve to supplement the extremely limited search and rescue resources and improve SAR capacity in the Arctic.

Although Arctic states often have existing agreements in place to coordinate SAR operations with neighboring nations, there are several advantages to creating a multilateral Arctic SAR agreement that would cover the entire northern region for both aeronautical and maritime SAR. A multilateral SAR agreement for the entire Arctic region would facilitate the most effective use of limited SAR resources throughout the Arctic and would ensure that available Arctic SAR facilities closest to a vessel or aircraft in distress are identified and respond first, regardless of nationality, in order to reduce response time and potentially save the most lives. A region-wide agreement would also improve SAR response by serving as the framework within which to conduct joint exercises and training; share information, lessons learned and best practices; and identify and improve mechanisms for mutual cooperation, coordination and support in search and rescue and emergency response.

The creation of a more comprehensive multilateral SAR agreement would build on existing proposals for an aeronautical Arctic

SAR Memorandum of Agreement to include both aeronautical and maritime SAR, as encouraged by the *International Convention on Maritime Search and Rescue, 1979*, as amended; the *Convention on International Civil Aviation, 1944* (Annex 12), as amended; and the *International Aeronautical and Maritime Search and Rescue Manual* (IAMSAR Manual). The proposed Arctic Region SAR agreement would identify aeronautical and maritime SAR region lines of delimitation; as affirmed in both conventions, such delimitation of SAR regions is not related to and would not prejudice the delimitation of any boundary between nations.

A multilateral SAR agreement would serve as the centerpiece of cooperation and coordination in support of Arctic emergency response operations while providing an important example of a mutually beneficial regional approach among Arctic nations to address important shared issues of concern.

Since Arctic and Antarctic emergency responses are similar in many ways, Arctic and Antarctic nations engaged in polar SAR could benefit from consultation and cooperation on issues of mutual concern and applicability. The five nations responsible for SAR in the Southern Ocean (New Zealand, Australia, Argentina, Chile and South Africa) currently meet to address many of the same challenges that face the eight Arctic Council nations concerning distance, harsh environment and limited SAR resources. In August 2008, New Zealand, Australia, Argentina, Chile, South Africa, United States, France, United Kingdom and the Council of Managers of National Antarctic Programs (COMNAP), met in Valparaiso, Chile, to discuss improving Antarctic SAR coordination and cooperation. One means of enhancing cooperation would be through mutual efforts of the Arctic Council and Antarctic Treaty Consultative Meetings. Future proposals and recommendations on polar SAR could be coordinated between both international fora to ensure continuity and standardization where appropriate.

Gaps in Preparedness and Response Operations

Remote surveillance and detection technologies (i.e., satellite communications, GPS availability, weather stations) are critical for establishing situational awareness for both preventive and response issues. This overall capability is limited in the Arctic due to a lack of coverage and the availability of real-time weather information.

Lightering in emergency situations and salvage typically represent two distinct marine activities that may be used in whole or in part to prevent and/or recover pollutants, and are considered in many cases synonymous with mechanical response capacities.

While all Arctic states individually support the overall strategic goal of limiting negative environmental impact and establishing

sustainable development, the potential for increased shipping has led to increased concern for threats, risk and evaluation of potential consequences worldwide. This leads to a high expectation by public and environmental groups for adoption of stringent preventive measures, as well as thorough mitigation and restoration measures in the event of an incident. This has also contributed to an increasing gap in maintaining realistic response expectations. To address this pressure many recent workshops and panel discussions have indicated a need for more harmonious pan-Arctic shipping rules. Cooperation at this level requires nations to develop common goals and objectives based upon mutually acceptable and scientific criteria. Ultimately the communication of these objectives is vital in maintaining realistic expectations.

While there are exceptions, there are few Arctic-based resources to address oil spills, especially the ability to recover trapped oil in hulls and compartments in both shallow and deep water. A multi-lateral oil spill contingency plan or an oil spill agreement may be options to address this issue.

Ports

In temperate maritime areas, deepwater ports and the services they provide are typically relatively close to global maritime shipping and often taken for granted. The situation in the Arctic is quite different. Deepwater ports, places of refuge, marine salvage, adequate port reception facilities for ship-generated waste and towing services are rarely available. The availability of port infrastructure and support directly influences the level of risk associated with transiting a particular waterway and corresponds to the levels of marine insurance rates.

Ports and Intermodal Transport Links

There are few deepwater ports in U.S. or Russian waters near the Bering Strait. The closest U.S. harbor with deep water is Dutch Harbor in the southern Bering Sea. On the Russian Federation side, the nearest deepwater port is Provideniya. Other Russian ports near the Bering Strait that are closed to foreign ships are Egvekinot, Anadyr and Beringovskiy.



Arctic Marine Incidents Workshop

A key AMSA workshop, *Opening the Arctic Seas: Envisioning Disasters and Framing Solutions*, was held in March 2008 at the Coastal Response Research Center of the University of New Hampshire. The center, a partnership between the U.S. National Oceanic and Atmospheric Administration and UNH, develops new approaches to spill response and restoration through research and synthesis of information.

In cooperation with the U.S. Coast Guard and U.S. Arctic Research Commission, the center hosted the workshop to identify key strategies, action items and resource needs for preparedness and response to potential Arctic marine incidents. The 50 workshop participants represented a spectrum of constituencies and expertise including government agencies, the marine industry, Arctic indigenous groups, academia and non-governmental organizations. Experts from the U.S., Denmark, Canada, Russian Federation, Norway and Finland and one non-Arctic state, South Africa, participated.

The workshop focused on the qualitative risk factors for five plausible Arctic marine incidents developed by the organizing committee and bear some similarities with incidents that have already occurred in polar waters. The incidents were designed to explore: spill response; search and rescue; firefighting and salvage; communications; governance and jurisdiction; and legal issues. The five incidents were:

- **Cruise ship grounding in the west coast of Greenland**
Mid-September grounding in a fjord of a cruise ship with 1,400 passengers. Progressive flooding makes the ship unstable and all passengers and crew must abandon ship.
- **Bulk carrier trapped in ice in the central Arctic Ocean**
September/late season crossing of the Arctic Ocean en route to the Bering Strait and the Pacific Ocean. Ice damages the ship's rudder and propeller. The ship's non-ice strengthened hull makes wintering impossible. Rescue operations are challenging due to the remote location and changing sea ice cover.
- **Fire and collision in offshore operations in the Beaufort Sea**
In late winter, a drill ship, two oil spill response vessels and one ice management icebreaker are conducting exploratory drilling operations in 50 meters of water 20 nautical miles offshore within the disputed U.S.-Canada border area in the Beaufort Sea. An engine room fire on the icebreaker causes it to lose control and collide with the drill ship, rupturing a ballast tank. The drill ship empties 700 barrels of Arctic grade diesel fuel to maintain stability; 300 barrels of diesel fuel are also spilled because of the fire on the ice management ship. Crew members on both vessels suffer injuries.
- **Oil tanker and fishing vessel collision in the Barents Sea**
The collision occurs in near-zero visibility within the disputed Russia-Norway border in the Barents Sea. The tanker releases

25,000 barrels of crude oil in the water and must be towed to a place of refuge to avoid potentially spilling its remaining cargo. The fishing vessel sinks making salvage impractical.

- **Tug and barge grounding on St. Lawrence Island in the Bering Sea**
In May in broken ice conditions, a tug loses power while towing a barge laden with mining explosives and other containerized cargo for several Arctic communities. Pushed by a storm surge, the tug and barge are grounded in an area that was a critical habitat for threatened and endangered species and a haul-out location for Pacific walrus. The tug and barge are separated by several miles, the tug ruptures a fuel tank, containers are in the water and some wash onshore.

Workshop participants were divided into five groups each working on a single, plausible incident. Four questions were addressed by each group: If this incident happened today in the Arctic, how would we respond? How would we prefer to respond? What are the gaps and needs that exist today that prevent us from responding in the preferred manner? What do we need to do to address those needs and fill the gaps?

The exercise yielded the following themes:

(A) Ports and Waterways Management

- Designate potential places of refuge in the Arctic and develop guidelines for their use; an international effort should also rank them by seasonal environmental conditions.
- Establish policies and systems to control ship movements such as route planning; use of Automatic Identification Systems on all Arctic ships; vessel tracking systems and designation as Particularly Sensitive Sea Areas from IMO.

(B) Vessels and Crew Safety

- Institute mandatory safety regulations for Arctic operations; the current IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters address specific construction, fire safety, lifesaving, navigational, operational and crew training issues, but they are voluntary; mandatory training for ice navigation and emergency response in polar environments is necessary; a non-binding regulatory framework seems inconsistent with the hazards of Arctic navigation and the potential for environmental damage in the Arctic Ocean.

(C) Response Agreements and Plans

- Existing search and rescue and pollution contingency plans do not provide enough detailed information to facilitate an effective response; there is a need for Arctic-wide agreements for SAR and pollution response; agreements and response plans should

designate which nations respond in specific areas and clarify operations in disputed regions; agreements and response plans should also ensure foreign responders can participate in operations unimpeded by customs and immigration issues; Arctic states could establish an integrated response management center to manage the execution of agreements and facilitate the decision-making process.

(D) Strategies to Improve Prevention and Preparedness

- Conduct comprehensive environmental risk assessments and impact assessments to assist in decision-making, route planning, emergency response, etc.
- Increase emergency response assets, equipment and supplies in the Arctic, placing emphasis on regions of active development; self-sustaining, forward-operating response bases should be established.
- Improve knowledge for Arctic incident response through training and engagement of the local community, responders and the maritime industry; Arctic indigenous people should be trained in response and local communities must participate in response operations.

(E) Strategies to Improve Response

- Consider alternative countermeasures for oil spill cleanup; mechanical measures in ice-covered waters may be impractical and alternative response options should be considered (dispersants, chemical herders, sinking agents, in-situ burning, etc.).
- Expand communications capabilities throughout the Arctic; expanded shore based (VHF and HF) and satellite systems are required.
- Improve logistical support capabilities for responders; support for response personnel in remote Arctic regions must be brought to the region of operations.

(F) Strategies to Foster Community Involvement

- Involve indigenous people and local communities in planning, response, recovery and restoration decisions and operations.
- Conduct outreach to local communities and keep all stakeholders well informed.

(G) Strategies to Ensure Availability of Funds for Response

- Establish an international Arctic response fund to offset the costs of SAR and pollution response.
- Increase penalties and insurance requirements for ships operating in the Arctic to ensure response funding and act as a deterrent.

The workshop identified three key areas of data and research needs: (1) the updating of weather data due to a lack of overall information, and investment to update navigational charts for Arctic regional seas, ports and waterways; (2) studies on the behavior of oil in cold water and technologies for spill response (including the detection of oil under ice as well as cleanup measures for oil in ice); and (3) improving the baseline information for Arctic resources (biological/ecological resources and areas important for human use and cultural significance) that could be affected by potential marine incidents.

Two themes resonated throughout the workshop: The Arctic states need to foster and enhance their cooperation to improve joint contingency plans and multinational agreements, as well as to agree to develop mandatory safety regulations for Arctic marine operations. The proper management of risk using appropriate policies and strategies, supported by scientific research, can lead to reduced risk for loss of life and environmental damage.



Map 9.4 Plausible Arctic marine incident locations. Source: AMSA



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This situation differs with the region between the Atlantic and Arctic oceans, where there are many Norwegian, Icelandic and Russian deepwater ports. There are a number of deepwater ports along the west coast of Greenland. In the Arctic, there are essentially no deepwater ports along the North Slope of Alaska or throughout the Canadian Archipelago, except for that of Tuktoyaktuk, which, while having a relatively deepwater port, suffers from a shallow approach channel and a high degree of in-fill silting, situated as it is in the delta of the Mackenzie River. Mention should also be made of the limited port facilities at Resolute Bay, in the middle of the archipelago, which acts as a center of transportation, communications and administration for the high Arctic but which can only handle ships of 5m draft alongside a sunken barge used as a dock. Ships of deeper draft must anchor in an open roadstead.

In Hudson Bay, the Port of Churchill is Canada's only northern deepwater seaport with well sheltered, along-side berthing facilities. It provides access, via rail, to the interior of Canada and North America in general. The growing Port of Churchill offers four berths for the loading and unloading of grain, general cargo and tanker vessels. The Port can efficiently load Panamax size vessels. The link between Murmansk and Churchill has become known as the "Arctic Bridge" since it requires sea and rail systems to complete the transport of goods to North American destinations. The use of the Port of Churchill eliminates time-consuming navigation, additional

handling and high-cost transportation through the Great Lakes and St. Lawrence Seaway. The current shipping season runs from mid-July to the beginning of November. The use of icebreakers could significantly lengthen the shipping season. Another significant port in the Eastern Canadian Arctic is Iqaluit, which requires that ships anchor and use barges to land their cargo and features some of the highest tides on the planet as well as one of the largest tidal ranges in existence.

The Canadian government has recently proposed an upgrade to the rail link to Churchill, as well as the development of a deepwater port at the old mining town of Nanisivik in Nunavut on Baffin Island, to be used primarily by the Department of National Defence. It is unclear what facilities this port will have since it is not situated near a major population center, major shipping route or railroad. In addition to the proposed port at Nanisivik, future planned development on Baffin Island also includes the iron-ore mine at Mary River under construction by Baffinland Iron Mines Corporation that will include a railroad to the planned port at Steensby Inlet.

In contrast, the northern coast of the Russian Federation has several deepwater ports that have been supported by the Northern Sea Route Authority and fleet of icebreakers for several decades. Murmansk is well known for being the largest deepwater port north of the Arctic Circle that is ice-free throughout the year. Murmansk also provides intermodal access to northern European and Asian

industrial centers. In recent years, Russian Arctic ports in the Barents Sea, including Murmansk, have expanded significantly as offshore oil and ore production have increased in the region. Since 2004, more than €4.4 billion have been invested in improving Murmansk's deepwater port facilities to include new oil, coal and container terminals as well as expanded rail lines. Murmansk port capacities are projected to increase to an annual 28.5 million tonnes by 2010 and 52 million tonnes by 2020. Other Russian Arctic ports along the Northern Sea Route include Pevek, Tiksi, Igarka, Dudinka, Dikson, Vitino, Arkhangelsk and Novy. These ports are well-established and supported by the Russian icebreaker fleet, although many require long river transits to access.

Unique to the region is the Port of Varandey on the Pechora Sea coast. As oil production expands in the Russian Arctic, LUKOIL, in cooperation with ConocoPhillips, has developed Varandey into a deepwater oil export terminal. The Varandey facility consists of an onshore tank farm with a total rated capacity of 325,000 cubic meters (2,000,000 barrels); and an innovative fixed ice-resistant oil terminal 14 miles offshore, with a height of more than 160 feet. The terminal includes living quarters and a mooring cargo handling system with a jib and a helicopter platform; two underwater pipelines, connecting the onshore tank battery and the offshore oil terminal; and an oil metering station, auxiliary tanks, pumping station and power supply facilities. Sovkomflot has one new 70,000 DWT ice-strengthened oil tanker in operation and two being built in South Korean shipyards, to shuttle oil to Murmansk, as well as other locations in Europe and North America.

There are likely to be significant practical difficulties to be encountered in finding and supporting suitable places of refuge for ships in need of assistance in the Arctic and in providing such ships with adequate support.



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Places of Refuge

The Ilulissat Declaration outlined the need to cooperate to improve search and rescue and disaster response capability in the Arctic as marine activity increases. Central to this objective is the need for deepwater places of refuge and marine salvage/support capability.

According to IMO's *Guidelines on Places of Refuge for Ships in Need of Assistance*, a place of refuge means a location where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation, and to protect human life and the environment. A ship in need of assistance means a ship in a situation, apart from one requiring rescue of persons on board, which could give rise to the loss of the vessel or an environmental or navigational hazard.

With an increase in international Arctic shipping, it is likely that ships in need of assistance may need to request refuge in sheltered waters of the Arctic states. There are likely to be significant practical difficulties to be encountered in finding and supporting suitable places of refuge for ships in need of assistance in the Arctic and in providing such ships with adequate support. In the Arctic, harsh environmental conditions and increasing marine traffic densities make this course of action even more critical. Potential place of refuge guidelines detail the process by which port authorities decide where to allow a damaged ship to berth. In an attempt to balance shipping interests with the protection of natural and cultural resources, selection of such places should incorporate input from potentially affected governments, communities, the shipping industry and other stakeholders. Authorities should also rank places based on seasonal environmental conditions.

The European Union Places of Refuge Framework provides a model for the development of potential place of refuge guidelines by Arctic nations. Western Norway has an established system for places

of refuge based on IMO guidelines and the EU framework, including predefined places if applicable. The system will be expanded to include the entire Norwegian coast, including Svalbard, by late 2009 or early 2010. The places of refuge are evaluated based on the EU Safety at Sea project.

Other Infrastructure Components

Arctic marine infrastructure includes components not required or taken for granted in temperate waters. Polar icebreakers and marine salvage capability are risk mitigators from the perspective of marine insurance companies. If a vessel navigating in the Arctic has readily available polar icebreaker and/or marine salvage support, the risk to the vessel and corresponding financial risk to owners and insurers is substantially reduced.

Icebreakers

Government and private icebreakers are a key resource in the development of the Arctic. Generally, icebreakers are able to carry out the following roles: maintenance of shipping tracks in ice-covered waters, close escort of shipping in ice, provision of ice information, sovereignty support/representation, search and rescue, environmental response, command platform for emergency response, medical evacuation in remote areas, harbor breakout, electrical power supply, science platform, constabulary function (maritime security), transporting cargo (northern re-supply and logistic support) and fisheries conservation and protection.

There are some 50 icebreakers in the world fleet. The Russian fleet is by far the largest and most powerful, counting icebreakers powered by nuclear power plants, with five of 75,000 shaft horsepower (shp). The Russian Federation recently announced the allocation of some 15 billion rubles to build another 75,000 shp icebreaker. The next largest

The world's icebreaker fleets are aging and will require significant investment during the coming years to maintain their effectiveness and capability.

fleet of Arctic-class icebreakers is that of the Canadian Coast Guard. The Canadian Government recently announced an investment of \$C720 million to provide an Arctic-class replacement for the *CCGS Louis S. St-Laurent*. Most other countries that operate icebreakers own one or two, other countries such as Denmark and Norway have small fleets of ice-strengthened vessels generally intended for fisheries patrol and interdiction. The world's icebreaker fleets are aging and will require significant investment during the coming years to maintain their effectiveness and capability. For instance, Canadian icebreakers are on the average 30-plus years old, while those of the U.S. are 30 years old, with the exception of the *USCGC Healy*, which was built in 2000. Of note is the recently issued report, *Polar Icebreakers in a Changing World*, which is a needs analysis of U.S. icebreaking requirements in the coming years. In addition, it is also known that a number of other countries are either building or planning construction of new icebreakers primarily intended for science research, namely the European Union and South Korea.

Icebreaker construction is very specialized and very expensive. Steel is thicker and stronger than that required for normal cargo ship construction. In addition, there are other necessary specific features, such as horizontal and vertical construction members that are deeper and stronger, reinforced icebelts and redundant features. These details are specified in a number of national regulations governing construction of ice-class ships, namely those of the Russian Federation, Canada, Finland and Sweden; as well as classification societies such as the American Bureau of Shipping, Det Norske Veritas, Germanischer Lloyd and Lloyd's Register. Recently, the International Association of Classification Societies approved their *Polar Class* construction standard as one of a number of "Unified Requirements." Classification societies have one year to enter the new requirement in their respective rules. Classification societies have the new requirements in their respective rules, and some are expected to keep their existing rules.



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Marine Salvage Support

In the Arctic Ocean, with the exception of Norway, Iceland and ports along the Northern Sea Route, there are few places of refuge or government/commercial salvage response to support commercial shipping. Generally, there are limited ship repair and/or salvage infrastructure and pollution countermeasures capabilities based around the Arctic basin. This lack of an Arctic salvage capability is a concern to the marine insurance industry.

There is inadequate port, salvage, towing and other necessary marine infrastructure support for the growing amount of commercial traffic transiting the Great Circle Route through the Aleutian Islands. This was highlighted by the 2004 *M/V Selendang Ayu* engine failure and subsequent grounding with a spill of more than 1 million liters of fuel oil along the northern side of Unalaska Island (See page 88). This incident could have been prevented if large tugs and adequate salvage support were nearby; instead, the nearest tugs capable of handling this type of emergency were in Seattle, Washington. After the 738 ft *M/V Selendang Ayu's* engine broke down in gale-force Bering Sea winter weather, several efforts to tow it by small tugs based out of Dutch Harbor failed.

Baltic Sea Case Study

Introduction

As the Arctic Ocean becomes seasonally ice-covered, coupled with the likelihood of increased marine shipping activity, an evaluation of the Baltic Sea marine shipping regime could be considered as a model for ship operations, information systems, incident response and harmonization of regulations.

The countries of the Baltic Sea Area work to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation under the Convention on the Protection of the Marine Environment of the Baltic Sea Area and its governing body, the Baltic Marine Environment Protection Commission (HELCOM). All detailed information of the HELCOM activities is placed on website www.helcom.fi.

The Baltic Sea area is a sensitive marine ecosystem that needs comprehensive nature conservation and protection measures. The Baltic Sea states within the framework of HELCOM designated 89 areas as Baltic Sea Protected Areas (BSPAs) on the basis of their significance for marine nature conservation and protection of habitat and species. Work is still ongoing to designate other offshore areas as BSPAs. In order to harmonize the approaches and implementation process for marine protected areas (MPAs) in the Northeast



Atlantic and the Baltic Sea, HELCOM and the OSPAR Commission, the governing body of the Convention for the Protection of the Marine Environment of the North-East Atlantic, have developed a detailed work program on marine protected areas closely linked to the European Union network for the protection of European fauna and flora, the so-called NATURA 2000 network.

The Baltic Sea States are dependent upon safe, secure and sustainable sea transports. The maritime traffic in the Baltic Sea area is dense and has increased notably since the beginning of the 1990s. The annual turnover for oil and oil products in the Baltic Sea is calculated to be approximately 160 million tonnes. On top of that, 500 million tonnes of other goods are annually transported by ships within the Baltic Sea area. Therefore an extensive regime of protective measures consisting of both international and national regulations is in place

inside and adjacent to this semi-enclosed sea; examples of relevant measures are compulsory reporting and traffic surveillance, routing systems, compulsory pilotage and the designation of the area as a Special Area under Annexes I and V; and as a SOx Emission Control Area under Annex VI of the MARPOL 73/78 Convention.

Navigation Systems and Ship Operations

The Baltic Sea has some of the densest maritime traffic in the world. More than 2,000 ships are en route in the Baltic on an average day, not including ferries, smaller fishing boats or pleasure craft. Among those 2,000 ships, some 200 are oil tankers with a cargo up to 150,000 tonnes.

Several ferry lines connect the states in the Baltic proper. Some of the world's biggest ferries are transporting goods and people

between Sweden and Finland and there are several other ferry lines; i.e., between Sweden and Germany, Denmark and Germany, and between Denmark and Sweden. Most of the year intensive fishing for herring, cod and salmon takes place, sometimes in close vicinity to the major shipping lanes. Incidents are not rare considering that up to 2,000 fishing boats could be at sea on an average day. In summer, large numbers of cruise ships from all over the world enter the Baltic Sea area to visit the many coastal cities of cultural interest, such as Helsinki, St. Petersburg, Tallinn, Riga, Gdansk, Rostock, Lübeck, Copenhagen, Visby and Stockholm. Also numerous pleasure craft are sailing between the more than 500 ports or between different archipelago areas in the Baltic Sea. Oil and gas activities are for the time being few, but are expected to grow in the southern section of the area.

Compulsory Reporting and Traffic Surveillance

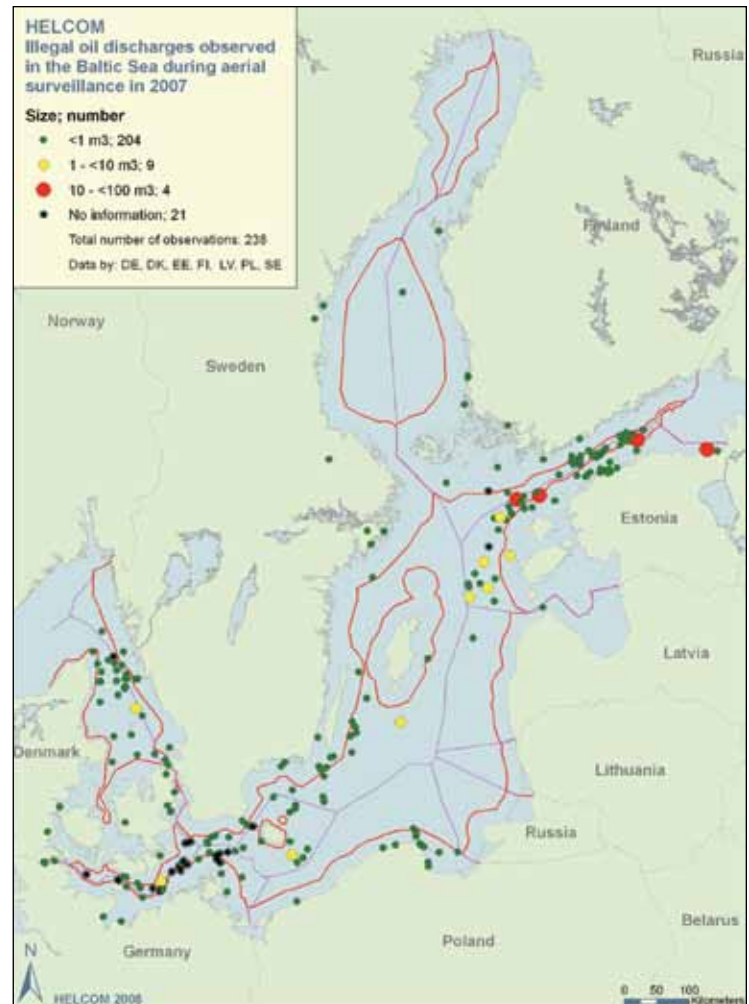
When ships enter the Baltic Sea they have to go through the Kattegat and the Great Belt or the Sound. There is intense traffic in the northern part of the area, where an extensive part of the traffic goes to and from Denmark as well as to and from the Baltic Sea. Large vessels follow the traffic lane Route T.

It is recommended that all ships of 20,000 gross tonnage and above navigating Route T should participate in the radio reporting service SHIPPPOS together with all ships with a draft of 11 meters and more; loaded oil-, gas- and chemical tankers of 1,600 gross tonnage and above; and all ships carrying radioactive cargoes.

The system provides beneficial information to ships about other ship movements in the area. IMO has adopted a mandatory ship reporting system in the Great Belt Traffic Area. Ships with a gross tonnage equal to or exceeding 50 and all ships with a draft of 15 meters or more are required to submit a ship report to the VTS Centre.

Mandatory ship reporting systems have been established nationally by the Baltic Sea states in approaches to oil terminals and other ports. Article 4 of the EU directive 2002/59/EC of June 27, 2002, establishing a community vessel traffic monitoring and information system, states the operator, agent or master of a ship bound to a port of a member state shall report information to the port authority at least 24 hours in advance or in certain cases earlier. The information includes ship identification, port of destination, estimated time of arrival, etc.

A new mandatory reporting system has been introduced in the Gulf of Finland using the Gulf of Finland Mandatory Reporting System, GOFREP. In accordance with the IMO resolution, Finland, Estonia and the Russian Federation require that all vessels exceeding



Map 9.5 Location of oil spills observed in the Baltic Sea area in 2007. Source: HELCOM

300 gross tonnage are required to participate in the GOFREP system when sailing in the international waters in the Gulf of Finland. This reporting system will allow automatic reporting with AIS and automatic response from the GOFREP.

IMO resolution MSC.138(76) recommends masters use new and improved navigation equipment including Electronic Chart Display and Information System (ECDIS) onboard ships navigating Route T with a draft of 11 meters or more; oil tankers navigating the Sound with a draft of seven meters or more; chemical tankers; gas carriers; and ships carrying a shipment of irradiated nuclear fuel, plutonium and high level radioactive wastes (INF cargoes) irrespective of size. ECDIS supports plotting and automatically monitoring ships' positions throughout their voyage. The risk of collisions and groundings will be reduced by superimposing AIS and radar information on the electronic chart display.

Research Opportunities

- ❑ Research to advance the convergence of critical navigational information including hydrography (ENCs), weather, ice conditions and other data into integrated shipboard navigation systems.
- ❑ Research into technologies for hydrographic data collection, especially for adaptation to the Arctic environment. This should include the use of unmanned, underwater (under-ice) vehicles, multibeam technology, through-the-ice data collection, and airborne systems for the collection of nearshore depths and for shoreline identification.
- ❑ Research on satellite remote sensing and surface validation to develop means of monitoring ice thickness across the Arctic Ocean.
- ❑ Simulated conditions or field testing of oil spills and other pollutants to determine behavior including fate and effects. This should include improvements in remote surveillance and detection technologies; improved oil-in-ice modeling capabilities and long-term fate and effects of lingering oil.
- ❑ Focus on further development and improvement of ice service products and services on ice thickness, iceberg detection, forecasting of ice drift and drift of icebergs.
- ❑ Research on behavior of oil in cold, ice infested areas including establishing forecasting models to compute the drift of oil in such waters.
- ❑ Further development of satellite based oil detection algorithms for ice-covered areas.
- ❑ Research on effective response techniques and technology for oil spill recovery on ice, broken ice and cold water.

Routing Systems

A transit route (Route T) through the Kattegat, the Great Belt and the Western Baltic has been established for deep draft ships. Routing systems have been established for ships navigating the Sound. A deepwater route (DW) from Bornholm, south of the Hoburgen bank and up to the border with the Estonian Economic Zone fulfilling the IHO S44 standard for hydrographic surveying has been established. With a clearance of 10 nautical miles to the banks, this will allow a ship with, for example, an engine failure, ample time for speed reduction to be able to drop anchor.

Fifteen traffic separation schemes are established and adopted by IMO in eight parts of the Baltic Sea Area. Two schemes are established in Samsø Belt/Great Belt, two in the Sound, one off Kiel lighthouse, one south of Gedser, one south of Öland Island, one south of Gotland Island, two in the entrance to the Gulf of Finland and five in the Gulf of Finland.

Pilotage

Pilotage services are established locally by the port states and are normally compulsory for ships over certain sizes.

Due to the *Copenhagen Treaty 1857*, ships sailing to or from the North Sea to the Baltic Sea are not required to use pilots. The IMO recommends that when navigating the entrances to the Baltic Sea, local pilotage services should be used by ships as identified in Resolution MSC.138 (76). Certified pilots for the entrances to the Baltic Sea are available in Denmark and, for ships passing through the Sound, in Sweden. Certified Baltic Sea deep-sea pilots are available in all Baltic Sea States.

Weather and Wave Information Systems

Weather and wave monitoring and information systems have been established by the Baltic Sea States in the Baltic Sea area. Weather and wave information is available for seafarers at all times.

Ice Information Systems

Baltic Icebreaking Management (BIM) is an organization with members from all the Baltic Sea states: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, the Russian Federation and Sweden. The overall objective of BIM is to ensure a well functioning, year-round maritime transport system in the Baltic Sea through the enhancement of strategic and operational cooperation between the Baltic Sea countries in the area of winter navigation assistance.

The Internet site, www.Baltice.org, is a single access point to reliable and up-to-date information related to winter navigation in the Baltic Sea area.

Protection of People and Property: Incident Response and Overall Coordination

Search and rescue at sea means saving and protecting lives of persons in distress in the sea area. This includes many different duties like assisting vessels and boats in distress at sea, preventing disasters, searching for missing people and performing medical transport in the archipelago and sea area. The basis for carrying out these duties is enacted in international treaties and decrees. All authorities operating in the Baltic Sea area carry out SAR at sea. Also participating are merchant shipping and voluntary organizations. For example, in Finland, the Border Guard is responsible for SAR service at sea and the Maritime Rescue Coordination Centre and maritime rescue sub-centers lead SAR operations. When the persons or environment are no longer in danger, commercial companies carry out the salvage of vessels and cargo.

Protection of the Environment: Oil and Other Hazardous Spills Response

The cooperation in combating spillages of oil and other harmful substances in the Baltic Sea area is based on the Helsinki Convention and HELCOM Recommendations on combating matters, adopted by the Helsinki Commission.

In accordance with the Helsinki Convention the Contracting Parties shall maintain the ability to respond to spillages of oil and other harmful substances into the sea threatening the marine environment of the Baltic Sea area. This ability shall include adequate equipment, ships and manpower prepared for operations in coastal waters as well as on the high seas.

According to the Helsinki Convention, the Contracting Parties shall agree bilaterally or multilaterally on those regions of the Baltic Sea Area in which they should conduct aerial surveillance and take action for combating or salvage activities whenever a significant spillage of oil or other harmful substance or any incident causing or likely to cause pollution within the Baltic Sea area has occurred or is likely to occur.

In cases where a Contracting Party is not able to cope with a spillage by the sole use of its personnel and equipment, the Contracting Party in question can request combating assistance from other Contracting Parties, starting with those who seem likely also to be affected by the spillage.

Monitoring / Enforcing Compliance with Marine Regulation

Port State Control

Port State Control systems have been established by the Baltic Sea States in all Baltic Sea ports in accordance with the Paris Memorandum of Understanding.

Aerial Surveillance

By international law, any release of oily wastes or oily water from ships is prohibited in the Baltic Sea, where oil pollution can affect sensitive ecosystems for long periods. But ships persist in making illegal discharges, despite improvements in port reception facilities and a harbor fee system, which means there is no financial gain to be had from polluting the sea. Every year national surveillance aircraft detect several hundred illegal oil discharges in the Baltic Sea. The actual number of illegal discharges is probably much higher than this. In fact, during most years more oil is released on purpose around the Baltic Sea than is spilled accidentally.

Internationally Coordinated Surveillance Flights

The HELCOM states endeavor to fly, at a minimum, twice per week over regular traffic zones including approaches to major sea ports, as well as in regions with regular offshore activities; and once per week over the regions with sporadic traffic and fishing activities. Twice a year, several Baltic Sea states jointly organize surveillance flights (24 to 36 hours): one covering the southern part of the Baltic Sea and another flight over waters further north.

Arctic Maritime Training

Maritime training in ice conditions is available by private companies in the Baltic Sea area.

The content of the courses includes ice characteristics and ice classifications, ice charts, ice classes, winterization, ship operations in ice, independent navigation in ice, icebreaker operations and ice navigation in convoy. Training of ship maneuvering in ice is done in a full-mission simulator. ☀

Findings

- 1] Considering the Arctic operational environment and the lack of infrastructure, safe navigation in the Arctic is often dependent on the skills of a limited number of seasoned northern mariners. The demand for skilled mariners is increasing, the number of experienced Arctic mariners is decreasing and there are no universal or mandatory formal education, training and certification requirements in place for ice navigators or crew to prepare them for Arctic marine operations.
- 2] Based on the information provided, significant portions of the primary Arctic shipping routes do not have adequate hydrographic data, and therefore charts, to support safe navigation. This appears most critical in the Canadian Archipelago and the Beaufort Sea and possibly other areas in the Arctic; at the same time the Russian Federation has broadly identified a requirement for updated hydrography in its Arctic waters. In addition, expansion of the current routes is required to allow alternative courses when hazardous ice conditions are encountered, for entry to points of refuge when necessary, and to support access to natural resources.
- 3] Electronic Chart Display and Information Systems (ECDIS), especially when coupled with Digital Global Positioning System, improves navigational safety by providing precise, real-time positioning along with holistic display of navigation and environmental information critical for safe navigation in the Arctic. ECDIS may also reduce the requirements and costs associated with deploying and maintaining traditional aids to navigation systems. This creates a high expectation that hydrographic offices will have electronic charts ready for use in the primary navigation routes in the Arctic by 2012. However, the use of ECDIS is wholly dependent on the availability of accurate navigational charts, which rely on comprehensive hydrographic surveys and data.
- 4] Arctic Maritime Traffic Awareness - There are few systems to monitor and control the movement of ships in ice-covered Arctic waters as an effective way to reduce the risk of incidents, particularly in areas deemed sensitive for environmental or cultural reasons.

- 5] There are serious limitations to radio and satellite communications for voice or data transmission in the Arctic because there is not complete satellite coverage of the region.
- 6] There is no binding requirement to implement the recently developed and adopted International Association of Classification Societies (IACS) Unified Requirements concerning *Polar Class* and the December 2002 IMO *Guidelines for Ships Operating in Arctic Ice-covered Waters*; consequently polar vessel construction standards are unevenly applied.
- 7] For safe operations, ships navigating in the Arctic need the same suite of meteorological and oceanographic data, products and services as in the other oceans plus a comprehensive suite of data, products and services related to sea ice and icebergs. As the shipping season becomes extended, significant increases in resources will be needed to expand the information services accordingly.
- 8] Emergency response capacity for saving lives and pollution mitigation is highly dependent upon a nation's ability to project human and physical resources over vast geographic distances in various seasonal and climatic circumstances. The current lack of infrastructure in all but a limited number of areas, coupled with the vastness and harsh environment, makes carrying out a response significantly more difficult in the Arctic. Without further investment and development in infrastructure, only a targeted fraction of the potential risk scenarios can be addressed.
- 9] The operational network of meteorological and oceanographic observations in the Arctic, essential for accurate weather and wave forecasting for safe navigation, is extremely sparse.



The Arctic Council's Arctic Marine Shipping Assessment was a four-year, multinational-led project, under the direction of the Protection of the Arctic Marine Environment (PAME) working group, that included more than 185 experts in maritime and related fields; 13 major workshops in Canada, Finland, Iceland, the Russian Federation and the United States; and 14 town hall meetings in selected Arctic communities, supported by the Permanent Participants of the Arctic Council. Funding for the *AMSA 2009 Report* was a public-private partnership effort.

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AMSA Workshops

July 2006 - Calgary, Canada: ICETECH06 and Stakeholder Workshop
March 2007 - Akureyri, Iceland: Arctic Navigation Conference
April 2007 - San Francisco, United States: GBN Scenarios Workshop I
July 2007 - Helsinki, Finland: GBN Scenarios Workshop II
October 2007 - Ottawa, Canada: Marine Infrastructure Workshop
February 2008 - St. Petersburg, Russian Federation: NSR Partnership Workshop
March 2008 - University of New Hampshire, United States: Arctic Marine Incidents Workshop
March 2008 - Ottawa, Canada: Arctic Indigenous Use Workshop
April 2008 - San Francisco, United States: Environmental Impacts Workshop
July 2008 - Calgary, Canada: ICETECH08 and Stakeholder Workshop
September 2008 - London, United Kingdom: Marine Insurers Workshop
September 2008 - Seattle, United States: AMSA Environmental Impacts Workshop
October 2008 - Cornwall, Canada: AMSA Integration Workshop

AMSA Town Hall Meetings

April 2006 - Iqaluit, Nunavut, Canada
July 2006 - ICC General Assembly, Barrow, Alaska, United States
August 2006 - Tuktoyaktuk, Northwest Territories, Canada
March 2007 - Akureyri, Iceland
March 2007 - Reykjavik, Iceland
September 2007 - Unjárga/Nesseby, Porsanger, Norway
September 2007 - Billávuotna /Billefjord, Porsanger, Norway
June 2008 - Iqaluit, Nunavut, Canada
June 2008 - Pond Inlet, Nunavut, Canada
June 2008 - Resolute Bay, Nunavut, Canada
June 2008 - Cambridge Bay, Nunavut, Canada
June 2008 - Inuvik, Northwest Territories, Canada
June 2008 - Yellowknife, Northwest Territories, Canada
August 2008 - Nome, Alaska, United States

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BP Shipping

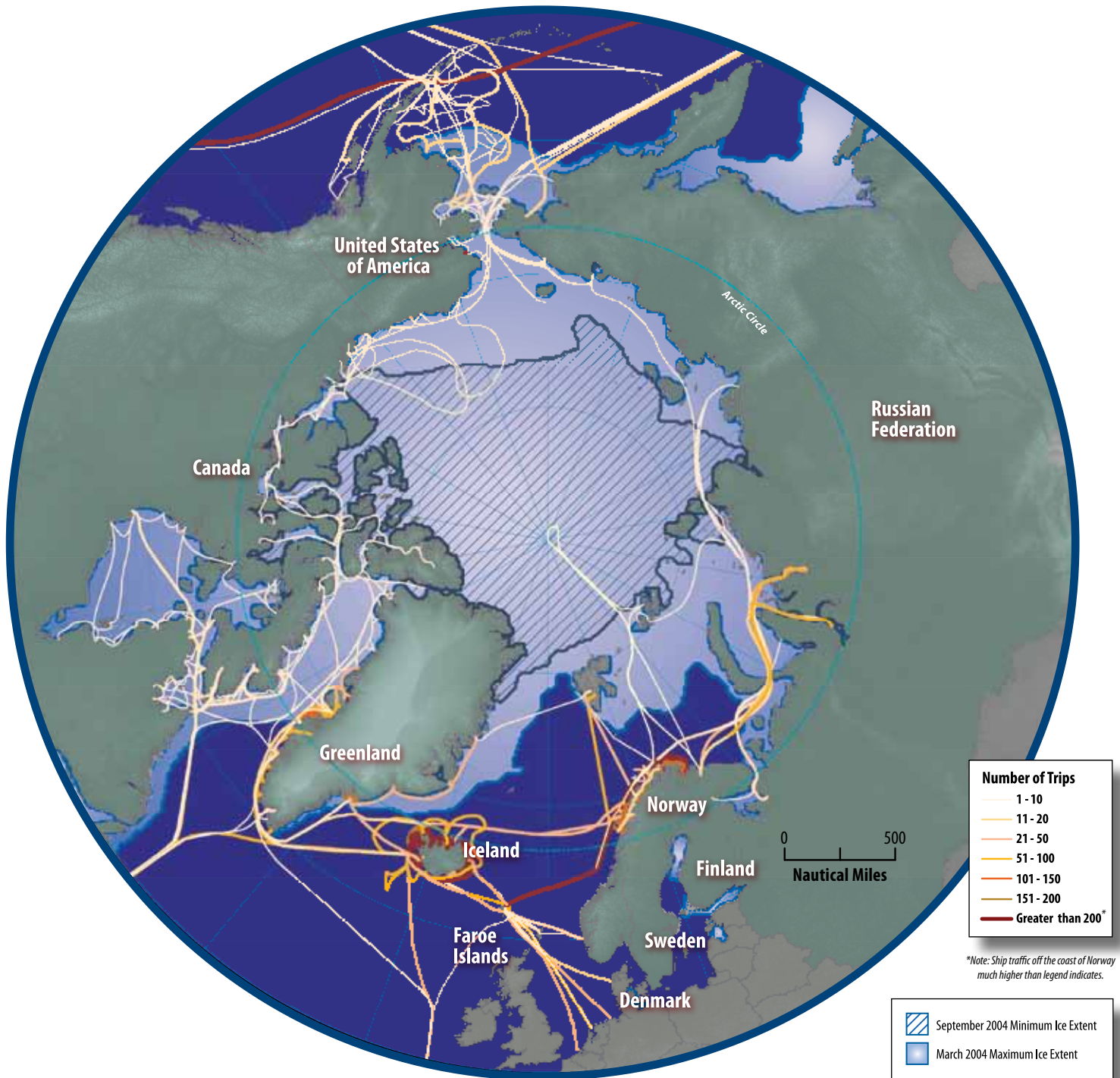
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■ Shipping traffic in the Arctic for the AMSA survey year 2004. Source: AMSA

