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' Thorvoldson, 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 Novoya 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 *Vega* becomes the first known vessel to achieve a transit of the NEP
1893	Fridjof Nansen's ship *Fram* proves the existence of Arctic current
1903-06	Roald Amundsen in the *Gjoa* 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 *St. Roch* was the second vessel to transit the NWP, the first to do so from west to east
1944	*St. Roc*h is the first vessel to make a one-season transit (in only 86 days going east to west)
1977	*Arktika* 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 destinational 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, fro m 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.

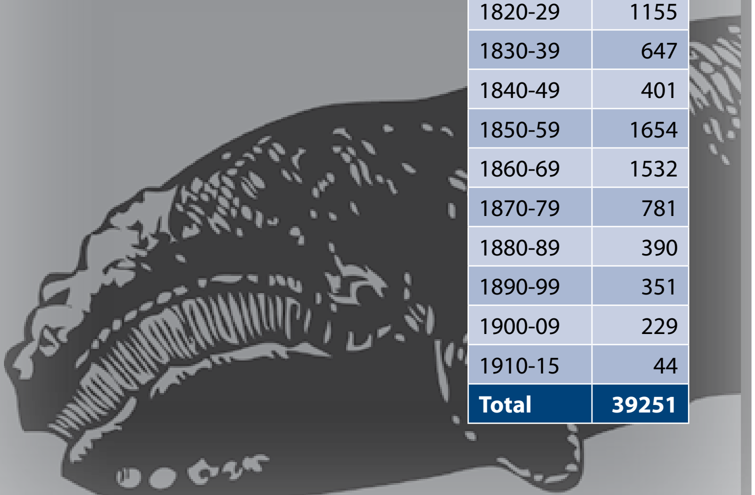
Whaling

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 Wartsila'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 though 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.

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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).

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 Dezhnyov 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 Diomede 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

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.

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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.

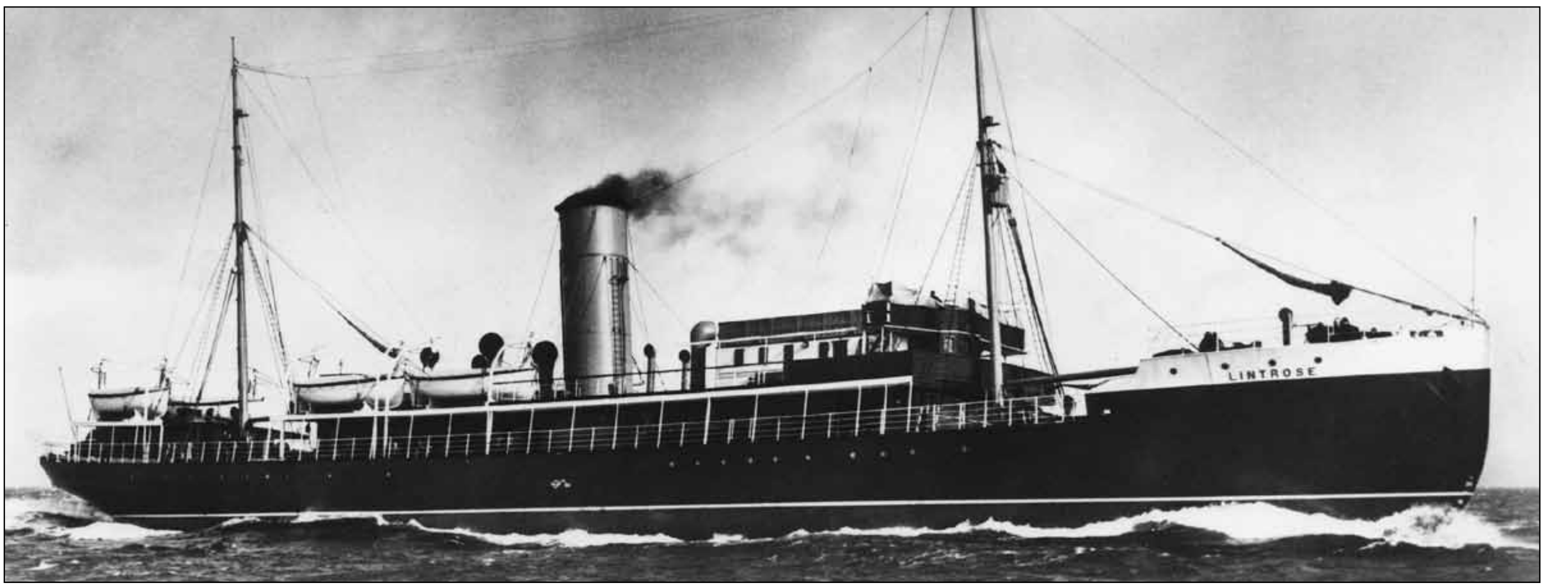
Major Arctic Marine Transport Programs, Studies and Workshops

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.

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