CRREL REPORT 96-3

The Northern Sea Route
Its Development and Evolving State of Operations in the 1990s

Nathan D. Mulherin

April 1996

Abstract
The summer of 1991 marked the first time in recent history that Russia offered to escort ships of other countries across the Northern Sea Route (NSR). For moving cargo between the North Pacific region and Northern European ports, the NSR, along Russia's northern coastline, is between 35 and 60% shorter than the traditionally used routes through the Suez and Panama Canals. In addition to its shorter distance, there already exists an extensive ports and shipping infrastructure, a current cargo base, and the potential for developing new markets in Russia and other northern areas. These incentives are attracting considerable attention from the international shipping community, including that portion servicing Alaskan and northwestern U.S. ports. This report is a general compilation of the historical usage, recent trade developments, the current regulatory climate, the physical environment, the ports and navigational infrastructure, cost factors, and practical considerations that may shape future U.S. interests in the route.

Cover: Russian nuclear icebreaker Yamal *prepares to clear a passage for merchant vessels on the Northern Sea Route. (Photo courtesy of Neste Shipping.)*

For conversion of SI units to non-SI units of measurement consult ASTM Standard E380-93, *Standard Practice for Use of the International System of Units,* published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

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Prepared for
U.S. ARMY ENGINEER DISTRICT, ALASKA

PREFACE

This report was written by Nathan D. Mulherin, Research Physical Scientist, Snow and Ice Division, Research and Engineering Directorate of the U.S. Army Cold Regions Research and Engineering Laboratory. It represents one of several investigations supporting a reconnaissance study of the Northern Sea Route. These reconnaissance study projects were funded by the U.S. Army Corps of Engineers, Alaska District, Dr. Orson Smith, Project Manager.

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ABBREVIATIONS AND ACRONYMS

m	meters
km	kilometers
nm	nautical miles
mt	million tons
m/s	meters per second
shp	shaft horsepower
dwt	deadweight tons
loa	length overall
kn	knots
°C	degrees Celsius

AARI	Arctic and Antarctic Scientific Research Institute
ANSR	Administration of the Northern Sea Route
CIS	Commonwealth of Independent States
CNIIMF	Central Marine Research and Design Institute
CRREL	U.S. Army Cold Regions Research and Engineering Laboratory
DMA	Defense Mapping Agency
FESCO	Far Eastern Shipping Company
FSU	Former Soviet Union
GEC	Gulf Engineers and Consultants, Inc.
INSROP	International Northern Sea Route Programme
JIC	U.S. Navy/NOAA National Ice Center
MSC	Murmansk Shipping Company
NSR	Northern Sea Route
RSMOT	Russian State Ministry of Transport
UAF	University of Alaska Fairbanks
USAED	U.S. Army Engineer District, Alaska

The Northern Sea Route
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NATHAN D. MULHERIN

INTRODUCTION

The Northern Sea Route

The Northern Sea Route, or NSR, is the modern-day designation for the Arctic marine route that extends from the Russian islands of Novaya Zemlya to the Bering Strait, which separates the state of Alaska from Russia. It extends a distance of between 2000 and 3100 nautical miles (nm) along Russia's northern coastline, where encounters with bitter cold temperatures, ice-choked seas, shallow straits, blinding fog, and isolation are routine. The route extends across or into four seas of the Arctic Basin: the Kara, the Laptev, the East Siberian, and the Chukchi. It is the most challenging segment of the historic Northeast Passage from Europe to the Far East, offering a shorter distance between seaports in the North Atlantic and the North Pacific relative to the traditional Suez and Panama Canal routes. Transit distances using the NSR between North Pacific and European ports are as much as 60% shorter than the more southern canal routes.

For approximately 50 years before 1991, the Soviet Union devoted significant energy and resources to developing a vast marine transportation system to help bring the abundant natural resources of Russia's isolated northern frontier to its more populated manufacturing centers (Fig. 1). Despite the considerable physical challenges of the Arctic regions, an intricate system of seaports, navigation aids, communications systems, icebreaking ships, ice forecasting, and piloting expertise was developed, to the point where open-ocean cargo transportation now routinely occurs four months of the year along the entire Eurasian Arctic coastline. Shipping traffic, both local and full transit, plies the entire route from the beginning of July to the end of October. On the western end of the route, regular service from Murmansk across the Barents and Kara Seas and up the Yenisey River to Dudinka has been operating virtually year-round since about 1980.

Several variations of the NSR are possible (Fig. 2), depending mainly on the transient ice conditions at the time. The first is the most southerly and conventional coastal route. The second follows a midroute from Cape Zhelaniya (the northern tip of Novaya Zemlya) to Dikson and from Novaya Sibir' Island to the port of Pevek. A third route, which is shorter for through traffic, stays to the north of Cape Zhelaniya, Cape Arkticheski (the northern tip of Severnaya Zemlya), and the Novosibirskiy Islands. A fourth route, 700 nm shorter than the coastal route, is the great circle route by way of the geographic North Pole. This fourth course is not economically feasible at the present time, but in the future it may become viable as transportation technology improves.

International interest

Using their highly advanced fleet of icebreaking ships, the Russians have the experience and technological capability to move ships virtually anywhere in the Arctic during the summer months, a fact that has been demonstrated by several trips to the North Pole by Russian nuclear-powered icebreakers since 1977. Year-round maintenance of the entire route is currently being promoted by the Russians as a way of bringing hard currency into the country. The shorter shipping route might serve to open the entire northern region more to economic development, foreign trade, and tourism.

The shift from socialism to a privatized, market-driven economy in the Soviet Union that began around 1985 resulted in economic and social disruption. The problems were compounded in 1991 with the transformation of the Soviet Union

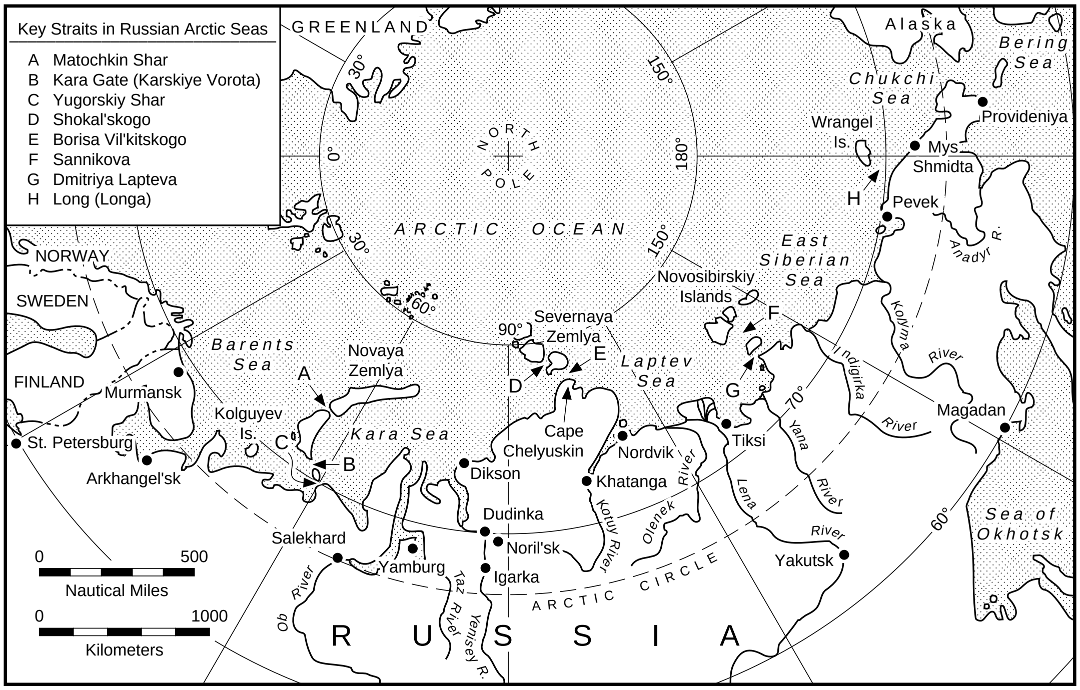


Figure 1. The Russian Arctic.

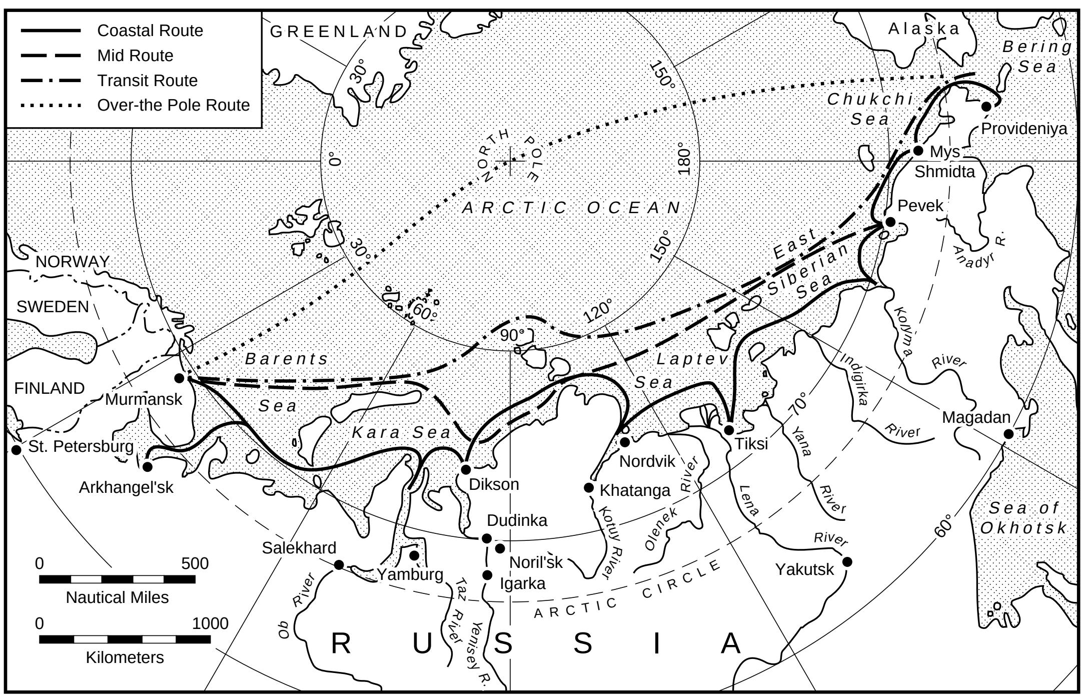


Figure 2. The various Northern Sea Route options.

into the Commonwealth of Independent States (CIS). One way to address these problems may lie in the Commonwealth's ability to stimulate domestic growth and attract foreign trade. Although it is fortunate that authority over the entire NSR transferred intact to the new Russian Federation, inexperience with free enterprise and reductions in state subsidies have resulted in unemployment and excess capacity in all sectors of the economy, including the Arctic marine transportation system.

Historically, the USSR claimed that crucial sections of the Northern Sea Route passed through its sovereign waters, and they guarded these carefully from incursion by foreign vessels, effectively eliminating all foreign traffic. Before 1991, the last transit of the NSR by a foreign ship was in 1940. However, in October of 1987, then-General Secretary Mikhail Gorbachev announced a new spirit of cooperation in the Arctic regions. As one item on the agenda, he proposed opening the Northern Sea Route, with certain restrictions, to all foreign vessels for peaceful and commercial purposes. This landmark change of policy was the first step in the privatization of Russia's Arctic fleet. Important assets, the NSR and the northern fleet continue to be promoted for bringing foreign currency into the country by "selling" premiere Russian ice navigation capabilities to the world. The Russians have proposed the following ways of employing its Arctic fleet to raise foreign capital:

- Escort foreign ships along the route with Russian icebreakers;
- Transport foreign goods aboard Russian ice-strengthened cargo ships;
- Encourage the export and coastal movement of Russian goods in foreign ships;
- Employ idle Russian icebreakers and cargo vessels in the U.S. and Canadian Arctic;
- Promote Arctic tourism.

The world's northern-tier nations and territories have become increasingly attracted to the idea of a trade route that will open new markets to their exports. In addition, income for their own economies will be generated by providing ports of call along the route.

Further development needed

The challenge of the physical environment of the Northern Sea Route will require the development and exploitation of technologies pertaining to ship design as well as ship operations. Public policy alternatives will have to be investigated, some of which pose difficult trade-offs between economic development and other considerations such as social well-being and environmental protection.

Establishing a viable year-round cargo transportation system will require advances in several areas, including:

- Further development of markets for cargoes;
- Development of larger, more powerful, and more economical icebreaking ships;
- Improvement in the navigation infrastructure;
- Consideration of the rights and well-being of the region's indigenous peoples;
- Reduced risk to vessels, cargoes, and the environment, leading to more affordable insurance rates.

All these improvements should serve to make the NSR alternative more competitive with other routes and hence more attractive to international shipping.

THE NORTHERN SEA ROUTE ADVANTAGE

The Northern Sea Route is from 2000 to 3100 nm in length (Ivanov and Ushakov 1992). Estimates vary because the route is not a unique passageway; it is widely regarded as any and all possible routes from the Atlantic Ocean to the Pacific through the myriad straits, passages, open seas, and island groups north of the Eurasian land mass. It is, however, legally defined by the Administration of the Northern Sea Route (ANSR) in Moscow as beginning at the "western entrance of the Novaya Semlya (sic) Straits and the meridian north through Mys Zhelaniya" and ending "by the parallel 66°N and the meridian 168°58'37"W" (ANSR 1991). This essentially constitutes the area extending from the islands of Novaya Zemlya in the west to the Bering Strait in the east.

Navigational difficulties are considerable in the far north due to bitter weather conditions, ice-infested waters, the short daylight season, and isolation. So why is the NSR considered a possible international marine trade route? Some of the many reasons include:

- Shorter distances between northern ports in the Pacific and Atlantic Oceans;
- The presence of an existing cargo base;
- The availability of a currently underutilized transportation infrastructure;
- Potential stimulation of the Russian economy;
- The prospect for investment opportunities in Russia.

While it is beyond the scope of this report to fully expand on these points, each is addressed in somewhat more detail below.

Distance advantage

The primary advantage offered for braving the Northern Sea Route's greater physical challenge is to save time and therefore money. Figure 3 shows the current trade circuit for the Northern Hemisphere encircling the continents through the Suez and Panama Canals. It also shows the NSR nearly bisecting that circuit. The cities of New York, Montreal, London, and Odessa are shown on the Atlantic side and their corresponding "areas of equidistance" are shown on the Pacific side of the circuit. These zones represent destinations that are the same distance from the city of origin by traveling either the NSR or the traditional canal routes. For example, the mileage is the same from London to Hong Kong by either the Suez Canal or the NSR. Therefore, when the NSR is used, any destination north of Hong Kong is a shorter distance from London. The same is true for the London-to-San Francisco–Victoria run. The North American coast north of San Francisco is closer to London via the NSR. Ports in Alaska are especially closer to European ports north of London.

Mileage comparisons of the northern trading routes are shown in Table 1; it can be seen that the savings made possible by the NSR are considerable. A savings of 24% is possible for a Hamburg (Germany)-to-Vancouver (Canada) voyage. The Hamburg-to-Dutch Harbor (Alaska) trip is more than 6000 nm, or 60%, shorter than the Suez Canal route.

Estimates of travel time, based on past performance during the summer season, are also competitive with the Suez and Panama Canal alternatives. Table 2 shows that the average ship speed during seven complete transits from Europe to the Far East was 11.3 kn via the NSR, and for three voyages by way of the Suez Canal it was 12.9 kn. This information, supplied by the Murmansk Shipping Company (MSC) and reported by Wergeland (1991), was summarized from transit data for the 1990 and 1991 shipping season.

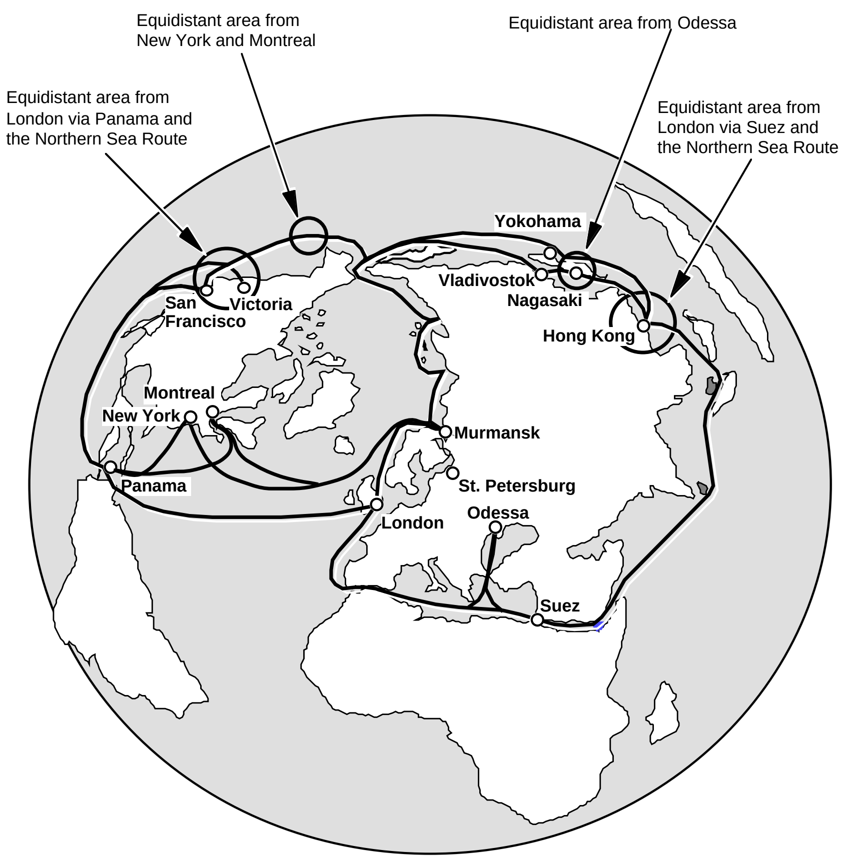


Figure 3. Sea routes between the Atlantic and Pacific Oceans (from Svendsen 1963).

Table 1. Comparison of the distance, in nautical miles, for the NSR and canal alternatives (after Wergeland 1991 and Mikhailichenko 1992).

Route	*NSR distance*	*Shortest canal distance*	*Difference (%)*
Hamburg to Dutch Harbor	4,200	10,400	60
Hamburg to Vancouver	6,635	8,741	24
Hamburg to Yokohama	6,920	11,430	39
Oslo to Yokohama	7,146	12,013	41
London to Yokohama	7,323	11,655	37

Table 2. Comparison of the average speed, in knots, of ships using the NSR and canal alternatives (after Wergeland 1992).

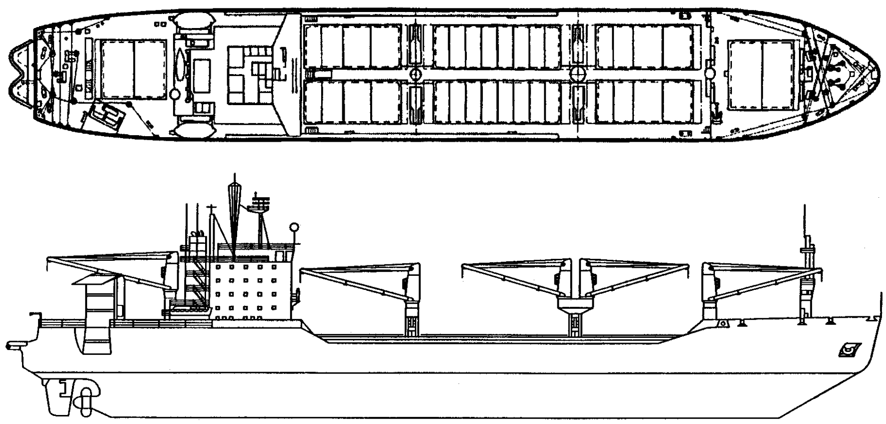
Route	*Number of trips*	*Average speed*
NSR eastbound	4	12.2
NSR westbound	3	10.3
Suez Canal westbound	3	12.9

Computer simulations, the operational experience of Russian *Noril'sk*-type vessels [ice-strengthened, multipurpose cargo ships (Fig. 4) of the highest ice classification* (ULA-class)], and actual transit times for other MSC vessels were used to estimate the mean transit time through various sections of the NSR for the entire year. The latter two sources were used by Wergeland in developing the data presented in Table 3. Although the July-through-October *Noril'sk* speeds are competitive with those attained on the Suez and Panama Canal routes, the slower speeds for the rest of the year offset the savings in distance. The estimated speeds that can be attained with the Russian nuclear-powered LASH (lighter aboard ship) vessel show a freight transportation efficiency that appears more promising. The LASH *Sevmorput* (Fig. 5) is a shallow-draft, icebreaking freighter that is designed to transport up to 74 barges (lighters) or 1300 standard cargo containers. It has an open-water capability of 20 kn but, more importantly, in ice up to 1.5 m thick it does not require icebreaker escort. The LASH has, however, proven to be somewhat of an economic failure. Its nuclear powerplant is very expensive to operate, and fears concerning its safety persist despite Russian reassurances to the contrary (Armstrong 1991).

* The ice classification serves as a measure of a ship's ability to navigate safely in ice-covered waters. Unfortunately, there is no single world standard, and the categories of the many national standards are somewhat difficult to compare. A table of classification equivalencies is included as Appendix A.

Table 3. Average speed, in knots, for vessels on sections of the NSR (after Wergeland 1991).

Route section (west–east)	*Distance (miles)*	*Month*											
		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Noril'sk-type vessels													
Kolguyev Island to Dikson	580	8.6	8.3	8.0	7.8	7.5	7.8	11.0	13.8	14.0	12.8	9.2	8.9
Dikson to Cape Chelyuskin	440	4.9	4.8	4.6	4.4	4.3	4.5	6.0	6.7	7.0	7.3	5.3	5.1
Cape Chelyuskin to Tiksi	540	3.9	3.8	3.7	3.5	3.4	3.6	5.0	7.0	9.0	9.0	4.2	4.1
Tiksi to Provideniya	1,640	7.4	7.1	6.9	6.6	6.4	6.7	14.0	14.5	15.0	14.5	7.9	7.6
Weighted means		6.7	6.5	6.2	6.0	5.8	6.1	10.8	12.0	12.6	12.5	7.2	6.6
Nuclear-powered lighter aboard ship (LASH)													
Weighted means		7.6	9.0	9.0	8.3	7.9	8.3	12.8	14.1	15.4	15.7	10.2	9.8
Total distance	3,200												



Ship stores					
Description		Mass, t	Daily consumption, t/day		
			Underway	In port	
				cargo operation	no cargo operation
Fuel	diesel oil	783	2.0	2.0	1.0
	high viscosity fuel	3,743	76	7.0	3.0
Lubricating oil		185	0.6	0.1	0.1
Boiler water		44.4	—	—	—
Fresh water		457	13.2	13.2	10.0
Fuel heating			provided		
Water ballast heating			provided		

Deck cranes		
Type	Outreach, m	Number and capacity
electro-hydraulic	22	3 × 20
electro-hydraulic	20	2 × 40

Ventilation	
Cargo spaces	naturally and mechanically
Service spaces	naturally and mechanically
Accommodation spaces	provided with air conditioner

Main machinery		
Two geared diesel engine of 14ZV 40/48 Wärtsilä-Sulzer type		
Built in Finland, 1982		
output	× kW (b.h.p)	2 × 7,700 2 × 10,500
Recommended fuel	cSt$_{50^\circ C}$	180
	secR1$_{100^\circ F}$	1,500
Type, number and diameter of propellers	unit × m	VPP 1 × 5.6

Supplementary data
1. The ship is provided with a corner ramp 18 m long and 5.0 m wide.

Figure 4. Noril'sk-*class SA-15 multipurpose, icebreaking cargo ship. (Courtesy of Murmansk Shipping Company.)*

Built at the Shipbuilding Yard Wörtsilö, Turku, Finland, 1982	Ship's type	The single-screw, double-deck motorship with long forecastle, long poop, intermediate engine room and house, corner ramp, icebreaker bow and transom stern

General				Main particulars			
Classification KM ⊛ Y Λ A [2] A2				Length o.a.		m	173.5
Register tonnage	gross	g.r.t.	17,910	Length b.p.		m	159.6
	net	n.r.t.	9,484	Breadth moulded		m	24.0
Service speed	full-loaded	knots	17.0	Depth moulded		m	15.2
	in ballast	knots	17.6	Summer load-line draft		m	10.5
Navigating range		miles	16,000	Loaded displacement		t	30,758
Crew		pers.	39	Deadweight		t	19,942
Height of mast above the baseline		m	51.0	Loading capacity		t	15,648
Capacity	bale	m^3	25,300	Light draft	forward	m	1.10
	grain	m^3	31,185		aft	m	7.45
	containers	TEU	576	Loading capacity per 1 cm draft		tpcm	
	packed timber	m^3	—	Type of hatch covers	Upper deck	Tweendecks	
					end-rolling	hinged to ends	

Description, dimensions and capacities of cargo spaces

	Holds						Tweendecks				Deep-tanks	Cargo hatches	
	Dimensions, m			Capacity, m^3			Dimensions, m		Capacity, m^3		Capacity, m^3	Dimensions, m	
Space no.	Length	Breadth	Height	grain	bale	containers, TEU	Length	Height	bale / grain	containers, TEU	grain	Length	Breadth
1	12.25	20.5	4.50	978	800	4	19.0	5.0	3,100 / 2,799	40	900	12.8	13.0
2	27.0	18.0	8.50	3,657	2,900	96	27.0	5.0	2,900 / 3,793	48	2	19.2	2 × 8.0
3	33.25	18.0	8.50	4,257	3,900	144	33.25	5.0	3,800 / 4,760	64	2	25.6	8.0
4	23.75	18.0	8.50	3,255	2,300	108	23.75	5.0	2,200 / 3,431	44	2	19.2	
5	11.0	23.0	3.25	902	500	4	21.25	5.25	2,000 / 2,746	24	—	12.8	11.0
6	—	—	—	—	—	—	—	—	— / 607	—	—		
	Total			13,049	10,400	356	Total		14,000 / 18,136	220	900		

Figure 4 (cont'd).

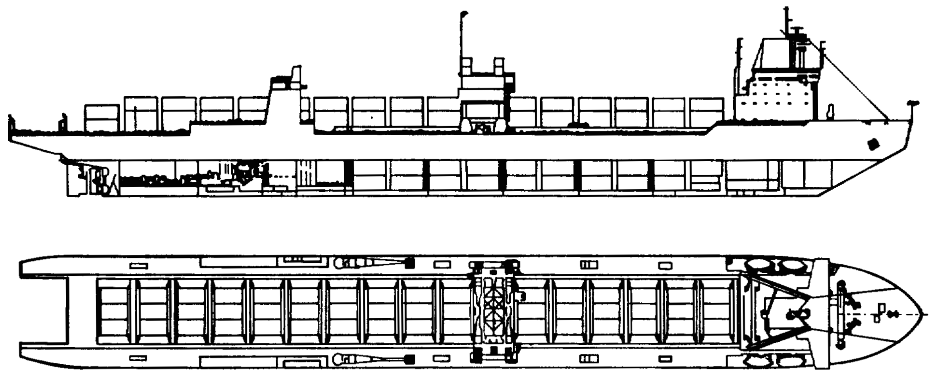


Figure 5. Russian nuclear-powered icebreaking LASH Sevmorput *(from Brigham 1985).*

Brigham* reported difficulties with maneuvering in ice because of its extreme waterline length, its single screw arrangement, and its waterline breadth, which is more than 3 m wider than that of the largest icebreakers.

The *Noril'sk* and future vessels designed for heavy ice service together in convoys led by powerful icebreaking ships will play a major role in expanding commercial traffic on the NSR, increasing the geographic range of regular service and lengthening the shipping season. Indeed, for nearly 20 years it has been a goal of the Soviet Union, and now Russia, to keep the entire Northern Sea Route open for year-round use.

Underutilized existing infrastructure

The marine transportation infrastructure along the northern Russian coastline is well developed. It includes a fleet of the world's most powerful icebreakers and ice-strengthened cargo ships, as well as port facilities and aids for navigation, communication, and environmental forecasting. The reason for this development has been to extract the natural resources of the Siberian region and to supply the northern settlements with finished goods and necessities. Hence, there is an existing transportation network and a flow of goods that can serve as a springboard for establishing new international trading partners and cargoes.

The current economic difficulties in Russia have sidelined a portion of the available transport and icebreaking capacity on the northern route. NSR cargo turnover peaked at 6,578,000 tons in 1987 and has progressively declined since then to 4,903,000 tons in 1991 (Granberg 1992). Increasing foreign use of the NSR can more fully utilize the Russian fleet and provide revenue toward its operation and maintenance. In Granberg's (1993a) own words:

> It may appear paradoxical that at this juncture, in the midst of acute crisis at home, Russia should be actively promoting … the Northern Sea Route … Far from it—this is an integral part of the general strategy of stabilization and development of the NSR. The most pressing objective for the NSR today is to utilize more fully the Arctic fleet and to provide it financial support.

The Russians hope that international tourism to the Arctic Basin and Siberia can be increased to bring in foreign revenue and to employ underutilized resources. During the summer of 1990, the Russian icebreaker *Rossiya* made a voyage to the North Pole with 88 paying tourists from 12 countries aboard. In 1991, the *Sovietskiy Soyuz* repeated the North Pole voyage with 80 more tourists from 15 countries. Two more North Pole cruises took place in 1992 (Mikhailichenko and Ushakov 1993), three in 1993 (Sodhi 1995), and four in 1994 (Anonymous 1994a). It is evident that a voyage to one of the world's few remaining remote and pristine regions can be successfully promoted as adventure to a large number of people. The popularity of these cruises seems to ensure that increasingly more will be available in the future.

International investment opportunities

From the western perspective, Russia's continued pursuit of democratic reform is desirable. More importantly, the health of the Russian economy and the stability of its sociopolitical system is an international asset for obvious reasons. Russia's new policy of openness to world trade can be of

* L.W. Brigham, 1994, U.S. Coast Guard, personal communication.

significant benefit to business partners. The potential exists for foreign investment in the development of Russian shipping and resource extraction. For example, western oil companies are negotiating with the Russians to supply foreign development expertise and investment dollars in the Yamal and Taymyr regions for a share of the raw oil and gas products shipped via the NSR. It is conceivable that other business arrangements can be formed to boost working capital for regional development of the necessary port facilities and service infrastructure along the route.

HISTORICAL REVIEW

Early history

Maritime nations throughout history have sought shipping advantages in distance and time over their rivals. This rivalry spurred early exploration of new trade routes. The terms "Northwest Passage" and "Northeast Passage" came into popular usage more than 400 years ago to refer to desired corridors of travel from Europe to the East Indies via northern waters. The Northwest Passage was a proposed route from Europe westerly across the Atlantic Ocean to the Pacific, by way of the Canadian archipelago. Alternatively, the Northeast Passage accessed the Pacific Ocean from Europe by traveling northerly along Scandinavia to the Arctic Basin and then eastward along Asia's northern coastline.

In time, the idea of a northern sea passage to the Orient fell out of favor as the environmental challenges of the Arctic became more apparent from successive exploratory voyages. However, the prospect of trade along the northern Asian coastline itself continued to inspire exploration in the region. The land and sea journeys of early expeditioners such as Vitus Bering, Willem Barents, Baron F.P. Wrangel, and many others were significant, and their legacy is noted by prominent geographical place names that honor their achievements.

Although attempts to pioneer the route began in the 16th century, it wasn't until 1879 that a west-to-east transit was finally completed, by a Swede, Baron Nils Adolf Erik Nordenskiöld, after a two-year voyage. He was forced to winter-over in the ice at Kolyuchino, just 135 nm short of the Bering Strait, but Armstrong (1992a) states that he most certainly could have completed the route in a single season had he not undertaken an ambitious program of scientific observations along the way.

Early in the twentieth century, the Russian government commissioned two small icebreakers, *Taymyr* and *Vaygach*, to perform an extensive hydrographic survey along the entire northern coast. They worked each summer season from 1910 to 1915 and succeeded in the first, although protracted, east-to-west transit of the passage. Soon, however, international shipping interest shifted away from the Russian Arctic to more accessible routes, not only because of the physical environment, but due to legal accessibility as well.

Claims of sovereignty over the route extend at least as far back as 1704 when an edict of Peter the Great established a Russian monopoly over commercial fishing and hunting in the western Arctic seas. Similar imperial declarations were issued in 1753, 1799, and 1821. Russian legal claims were confirmed by conventions with the United States (1824) and Great Britain (1825). These and repeated Soviet claims following the October Revolution of 1917 have resulted in nearly universal observance of Soviet dominion over the Northern Sea Route (Kolodkin and Volosov 1990; see also Franckx 1988, Butler 1991).

Isolated by a protectionist policy, the Soviets invested heavily in a marine infrastructure that allowed them to settle and develop their northern coastline and reap the abundant natural resources of their frontier. The USSR sought to become independent of other nations for raw materials. The huge nickel deposits at Noril'sk in the Yenisey River basin and the tin deposits at Deputatskiy and Iul'tin were discovered during this period, and gold was discovered in the far northeast, diamonds in the Lena River basin, and apatite near Murmansk.

Recent history

Granberg (1992) breaks down the modern era of Soviet development of the Northern Sea Route into four periods:

- Exploration and settlement (1917–1932);
- Organization of regular navigation and development of fleet and ports (1932 to early 1950s);
- Development completed and regular seasonal traffic established (early 1950s to late 1970s);
- Efforts to establish year-round shipping (late 1970s to present).

Highlights of these four periods of the modern era are presented below.

Before the October Revolution and the Soviet takeover in 1917, there were sporadic attempts at regional exploitation by a few venturesome individuals. Resources such as furs, wool, fish, salt, and coal were marketable products of the northern frontier that encouraged early enterprise. Whaling and sealing also encouraged Arctic marine activity.

The devastation of World War I crippled Russia's economy and created the social discontent that lead to the Soviets' rise to power. The disruption of the railroad system played an important role in initiating regular marine traffic along the northern coast to distribute food goods. In 1920, a Soviet agency, the Committee of the Northern Sea Route (in Russian, *Komitet Severnogo Morskogo Puti*, abbreviated to *Komseveroput*) was established to "equip, improve, and study" the entire route from Arkhangel'sk to the Bering Strait. The activities of this committee were given high priority for establishing a resource transportation system that was regarded as vital to the nation's economy.

In 1932 a German, Otto Shmidt, completed the entire route in the small Soviet icebreaker *Sibiryakov* in just two months. The ship, however, lost its propeller in the ice just short of the Bering Strait and had to be towed by freighter after emerging from the ice under improvised sails (Barr 1978). Still, the voyage was a remarkable achievement and underscored the advanced navigational skills and technological capability of the Russians in this severe environment. Shmidt's second attempt one year later in a Soviet cargo ship, the *Chelyuskin*, ended when the ship was trapped in the ice and crushed.

The first damage-free transit in a single season was accomplished by the Soviet icebreaker *Fedor Litke* in 1934. The next year she successfully convoyed the first two freighters through from west to east. NSR shipping activity increased dramatically by 1936 when 14 freighters were escorted through.

Soviet resolve and experience in ice navigation were unrivaled, and traffic in the Arctic continued to grow. For example, from 1917 to 1934, there were only two sinkings out of 178 round-trip voyages across the Kara Sea to import finished goods to and export timber from Igarka.

In 1932, a new and more powerful government department, the *Glavnoye Upravleniye Severnogo Morskogo Puti* (*Glavsevmorput*), or Chief Administration of the Northern Sea Route,* assumed the role 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" (Arikaynen 1991). Otto Shmidt was installed as its first head, and for the remainder of the decade he dramatically increased freighting along the route. Under his administration, major additions were made to the Arctic fleet, which moved between 100,000 and 300,000 tons of cargo annually and employed from 40 to 150 ships per year. Timber exports from Igarka accounted for as much as two-thirds of the total cargo weight; the rest was mainly supply cargo into the growing industrial areas of northern Siberia. Soviet shipments in the region grew steadily in support of Siberian development, and improving icebreaking technology produced a steady increase in the length of the navigation season (Arikaynen 1991, Armstrong 1992b). These two facts are supported by the figures in Table 4.

In 1940, before the USSR became involved in World War II, a German warship was escorted across most of the NSR for a fee of about £80,000. Hitler's strategy was to quickly move a patrol ship into the Pacific arena undetected. The *Komet,* an armed raider disguised as a merchant ship, was the first foreign ship in over 20 years to be granted passage, and it was the last foreign transit for more than 50 years thereafter. News of her passage was not made public until 1945 with the capture of secret German documents at the end of the war. Armstrong (1958) surmised that the Soviets may

* Various translated names for *Glavsevmorput* have appeared in the literature. Arikaynen (1991) gives "Chief Northern Sea Route Agency," Armstrong (1992b) gives "Chief Administration of the Northern Sea Route," Barr (1991) gives "Directorate of the Northern Sea Route," and Ushakov et al. (1991) give "Main Department of the Northern Sea Route."

Table 4. Soviet shipping activity along the Northern Sea Route (after Ushakov et al. 1991).

Year	*1935*	*1940*	*1950*	*1960*	*1963*	*1965*	*1970*
Freight tonnage (000)	246	289	503	1,013	1,390	1,600	2,400
Length of season (days)	93	93	122	128	130	135	145

have had second thoughts about aiding and abetting Hitler, and within about 700 nm of the Bering Strait, they advised the Germans to turn about and return west to avoid U.S. ships patrolling the Strait. The German captain refused, absolved the Soviets from further responsibility for the safety of his ship, and successfully completed the passage unescorted. A new transit record of just 21 days was set (only 14 days were actually spent under way) but, more importantly, the strategic value of the route was demonstrated: the Soviet Union was capable of moving manpower and equipment between the Atlantic and the Pacific Oceans without leaving its own territorial waters.

When the USSR entered the war in 1941, the route became important for bringing Allied supplies into the country. Supply convoys from the west into Murmansk suffered heavy casualties from German U-boats in the Barents Sea as well as the Atlantic. Although the "Murmansk Run" did not make use of the actual NSR, the NSR did become an alternate supply route from American West Coast ports to Russia's northern ports by way of the Bering Strait. In the four seasons of 1942–1945, 120 ships transported approximately 450,000 tons of relief supplies, which amounted to approximately half the freight turnover for the NSR during this period. Most of these voyages offloaded at Tiksi on the Lena River, but 13 were able to reach the Yenisey delta, and one even traveled as far west as Arkhangel'sk (Barr 1991).

Post-war information on shipping figures is difficult to obtain, because comprehensive annual summaries of shipping data were not published. What information there is was gleaned from a variety of sources and news coverage of the most noteworthy events, but it presents a general pattern of relatively constant growth in the marine infrastructure and activities over the next 40 years.

Recent landmark developments

A table of voyages is included in Sodhi (1995) that lists numerous important events in the development of icebreaking technology. From this list, we have selected and discuss below certain events that were most significant toward the opening of the NSR.

In 1959, the Soviets launched the world's first nuclear-powered surface ship, the icebreaker *Lenin*. This was an extremely significant development in Arctic shipping because it expanded the range of travel in isolated regions. In the past, travel into Arctic regions was seriously limited by the ship's fuel storage capacity or the availability of fuel en route. The advent of nuclear-powered ships virtually eliminated this historically significant barrier overnight.

The Soviet offer to open the Northern Sea Route to foreign shipping and provide icebreaking support for a fee was first extended to the world in 1967. A demonstration voyage took place that summer in which a Soviet ship transported cargo from western Europe to Yokohama. Although the transit was successfully accomplished in only 27 days, foreign shippers never seized upon this initiative. Armstrong (1972) presents the possibility that the offer was tacitly withdrawn so that the Soviets would not offend their Arab allies by proposing an alternative to the Suez Canal.

In 1977, the Soviets powered the first surface vessel to the geographic North Pole (Fig. 6). The nuclear-fueled *Arktika*, the world's most powerful icebreaker with 75,000 shaft horsepower, departed Murmansk on 9 August and reached the Pole on the 17th. The return to Murmansk, by way of Franz Josef Land, was completed on 23 August. The 14-day experimental voyage, more than half of which was spent breaking through ice, covered 3852 nm at an average speed of 11.5 kn (Armstrong 1978, Ivanin 1978).

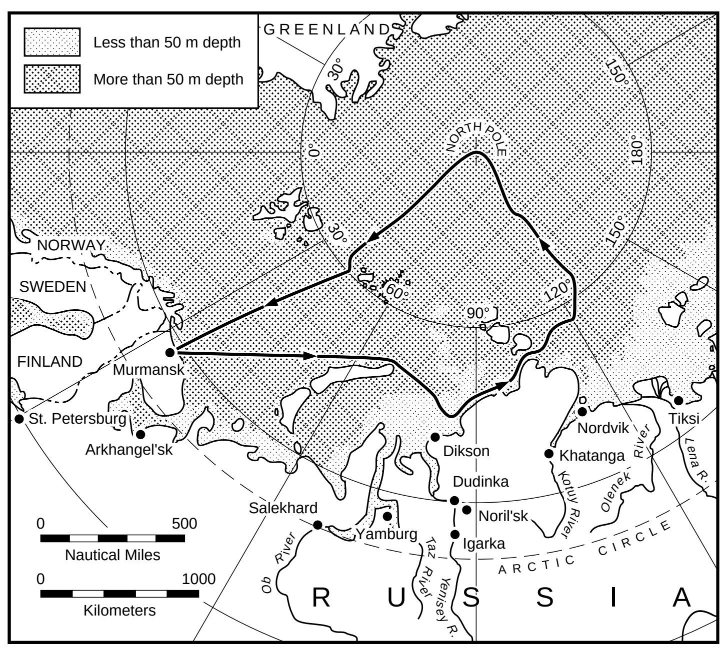


Figure 6. Track of the first surface ship to reach the geographic North Pole in 1977 (after Armstrong 1978).

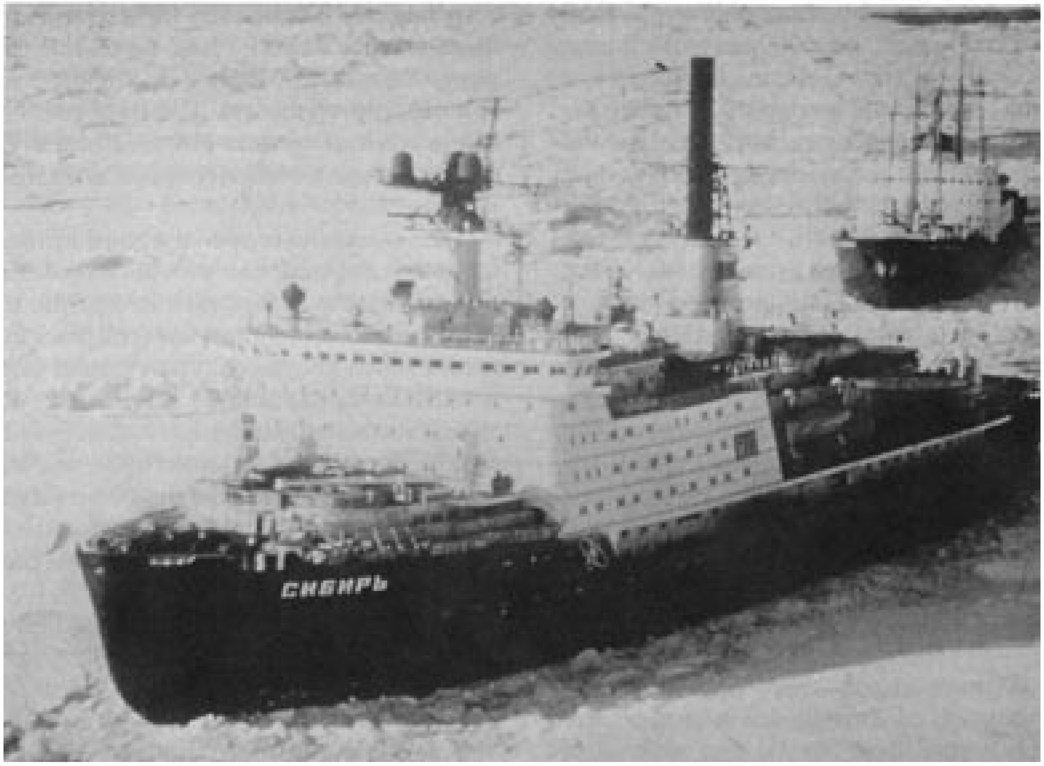


Figure 7. Icebreaker Sibir′ *and icebreaking multipurpose cargo ship* Kapitan Myshevskiy *on first high-latitude crossing of the NSR in 1978. (Courtesy of Sovphoto, Moscow.)*

In 1978 another landmark voyage occurred: the first complete, high-latitude passage of a surface ship. The *Arktika*-class icebreaker *Sibir′* led the *Amguema*-class transport ship *Kapitan Myshevskiy* (Fig. 7), which was loaded with oil-field equipment bound for the Kolyma region (Mikhailichenko 1986). This voyage followed the track identified as the "transit route" in Figure 2. They travelled from Murmansk east through the Bering Strait to Magadan and passed to the north of all the major island groups (except Wrangel Island), shaving many miles off the standard coastal route. Altogether, the convoy covered 3200 nm, of which nearly 3000 was in ice. In addition, the ships left Murmansk in May (a record early departure up to that time) to obtain data on navigating under more challenging ice conditions.

The advent in 1990 of Russian tourist cruises to the North Pole could be considered landmark. The fact that the Soviets have the capability to make routine and profitable excursions there is unique in the world today. As of August 1994, they had succeeded in reaching the Pole on 13 occasions with six different vessels (Table 5). Only four other nations can boast of the considerable achievement of having piloted a surface vessel to 90° North, and they have accomplished this only once and each with a single ship. The Swedish icebreaker *Oden* and the German icebreaker *Polarstern* shared in a scientific expedition and arrived at the Pole on 7 September, 1991. On 22 August, 1994, the U.S. icebreaker *Polar Sea* and the Canadian icebreaker *Louis St.-Laurent* celebrated their attainment of that geographic prize (Brigham 1995). By remarkable coincidence, this joint scientific expedition met the Russian ship *Yamal*, still in the vicinity, which had arrived two days earlier on its sixth polar tourist excursion. This marked the first time in history that surface ships from three separate nations would rendezvous virtually at the top of the globe. The *Louis St.-Laurent* and *Polar Sea* went on to complete an historic first crossing of the Arctic Basin: over the Pole from the Bering Strait to Spitsbergen and Iceland. It is significant that only nuclear-fueled ships have been successful in reaching the North Pole alone. The ability to navigate such long distances in heavy ice has so far required either two diesel-fueled vessels to take turns in the lead (and thus save fuel), or the nearly limitless range of a nuclear-powered vessel.

Increasing international interest

Since Gorbachev's 1987 Murmansk speech (see Armstrong 1988 for a translation of the relevant

Table 5. Icebreakers and voyages that have reached the North Pole.*

	Ship	Date	Country	Powerplant
1	*Arktika*	17 August 1977	Soviet Union	Nuclear
2	*Sibir'*	25 May 1987	Soviet Union	Nuclear
3	*Rossiya*	8 August 1990	Soviet Union	Nuclear
4	*Sovietskiy Soyuz*	4 August 1991	Soviet Union	Nuclear
5	*Oden*	7 September 1991	Sweden	Diesel
6	*Polarstern*	7 September 1991	Germany	Diesel
7	*Sovietskiy Soyuz*	13 July 1992	Russia	Nuclear
8	*Sovietskiy Soyuz*	23 August 1992	Russia	Nuclear
9	*Yamal*	21 July 1993	Russia	Nuclear
10	*Yamal*	8 August 1993	Russia	Nuclear
11	*Yamal*	30 August 1993	Russia	Nuclear
12	*Yamal*	21 July 1994	Russia	Nuclear
13	*Kapitan Dranitsyn*	21 July 1994	Russia	Diesel
14	*Yamal*	5 August 1994	Russia	Nuclear
15	*Yamal*	20 August 1994	Russia	Nuclear
16	*Louis St.-Laurent*	22 August 1994	Canada	Diesel
17	*Polar Sea*	22 August 1994	United States	Diesel

* L.W. Brigham, 1994, U.S. Coast Guard, personal communication.

portion), several developments have occurred to increase foreign interest in using the NSR. A multinational organization, the International Northern Sea Route Programme (INSROP), was formed to undertake any and all activities that would enhance international interest in the route. The lead agencies coordinating INSROP are the Fridtjof Nansen Institute (Norway), the Central Marine Research and Design Institute (Russia), and the Ship and Ocean Foundation (Japan). This project is the first credible attempt to bring together an international working group to comprehensively define problem areas and provide a forum for solutions. INSROP participants recognized the following four areas of concern and assigned member groups to address each one in the form of pilot studies (Østreng and Jørgensen-Dahl 1991):

- Physical conditions and navigation issues,
- Ecological aspects,
- Commerce and trade studies,
- Legal, political, and military–strategic issues.

The INSROP effort received additional impetus in November 1991 from a resolution of The Northern Forum, another organization committed to addressing a variety of northern territorial concerns. Signed by 13 representatives of northern-tier regions in the U.S., Canada, Norway, Russia, Finland, China, Mongolia, Japan, and Korea, the resolution gives approval to the INSROP initiative and encourages a priority emphasis for supporting activities that promote the NSR.

Another international group, known as the Barents Council, has also given its endorsement to the promotion efforts and has formed a subcommittee called the Working Group for the Northern Sea Route. At their meeting in Oslo in September 1992, which was attended by representatives from eleven European, Asian, and North American countries, it was decided to formulate a plan for addressing issues relevant to promotion of the NSR. The activities of these three organizations is evidence of an international commitment toward the route's development and a widely held belief that such development might substantially benefit not only Russia, but many other countries as well.

Foreign response to Gorbachev's invitation and the international activities to promote utilization of the Northern Sea Route began with the leasing of cargo space aboard Soviet SA-15 icebreaking cargo carriers (Brigham 1993). In 1989, there were several of these transits from Hamburg to Osaka. In 1990, six more voyages took place, each requiring about 25 days, which was approximately 10 days faster than a Suez Canal passage.

That same year, the nuclear icebreaker *Rossiya* made the third visit to the North Pole by a surface ship (the second, by the *Sibir'*, took place in 1987 [Frolov 1991]). The unique feature of this nine-day voyage was the fact that the ship was adapted to accommodate 40 foreign tourists who paid $20,000 each for the trip. The cruise was considered such a success that the *Sovietskiy Soyuz* made three similar tourist trips in 1991 and 1992. An interesting description of these polar excursions from the tourist–adventurer point of view appeared in a nationally distributed recreation magazine (Cahill 1993). The popularity of these excursions seems assured, and tourism in the Arctic is a business opportunity that the Russians hope to capitalize on.

In August of 1991, a Russian freighter sailed from Norway to Hong Kong carrying 10,000 tons of steel. This marked the first time that Norwegian cargo had been shipped to Asia via the Northern

Sea Route. The summer of 1993 saw the commencement of sea trials for a Finnish–Russian joint venture using a foreign vessel to supply Russian fuel products to a Siberian destination.* A 16,000-deadweight-ton (dwt) IA Super-class (the highest Finnish ice classification) tanker with a Russian ice pilot on board made three consecutive round-trip voyages. The cargo was taken on at Arkhangel'sk and transported to the mouth of the Yana River in the Laptev Sea, a distance of approximately 2150 nm. It was then offloaded to shallow-draft vessels for delivery to upriver destinations. Each round trip required 19–23 days to complete, which included 2–3 days turnaround time. The 1993 season was estimated to be of 1-in-10-year severity in terms of ice conditions. It was necessary at times to break 3- to 5-m-thick pack ice in a 300-mile section of the Laptev Sea beginning at Vil'kitskogo Strait. Four nuclear-powered icebreakers, stationed in the area to maintain a passage, assisted the tanker through this section, but the tanker was under constant escort by Russian icebreakers only from Dikson to the Khatanga River. The trial voyages were deemed successful, and the run became regularly established in the summer of 1994. It was recently reported that the Neste and Murmansk Shipping collaboration, known as Arctic Shipping Services, now handles all deliveries of petroleum products along the Russian Arctic coast (Anonymous 1994b). Although the Russians are seeking foreign cargo and investment to employ their own idle container ships, Finnish tankers were required for this joint venture. There are, ironically, no ice-strengthened tankers in the Russian fleet, as they were all distributed to other members of the CIS upon the breakup of the USSR.

In the United States, interest in the Northern Sea Route is high in Alaska and the state of Washington (Weathersby 1990). The Department of Commerce and Economic Development for the state of Alaska tried for two years to set up a demonstration shipment using Russian cargo ships to transport Alaskan goods such as fish, ore, timber, or coal to European markets. Unfortunately, negotiations between Alaskan officials and the Murmansk Shipping Company broke down, and the trial voyage planned for the summer of 1993 failed to materialize. Davies (1993a) cited the shipping company's inability to provide the ship type and size needed for the Alaskan cargo. Discussions continued throughout the ensuing winter, but the two sides still could not reach agreement for the voyage to occur during the summer of 1994.

An enterprising voyage carrying foreign goods aboard a Russian ship did, however, take place in the summer of 1993 (Davies 1993b). An SA-15 owned by the Far Eastern Shipping Company successfully transported prefabricated housing materials for oil-field workers from New Westminster, British Columbia, to Novvy Port on the Yamal Peninsula.

Davies (1994) also reported on a transit in September 1993 that was arranged by a freight chartering company based in St. Michaels, Maryland. The company chartered a Russian SA-15 to ship timber from Hamina, Finland, to several ports in Japan. The voyage took 28 days and saved nearly $250,000, according to a company executive. "We avoided the $90,000 cost of using the Suez Canal and reduced our transit time by 14 days with ship costs that run about $10,000 per day." He added, "Based on our experience, I couldn't imagine it [the NSR] not becoming a major international shipping route." Only one short section of ice in the Vil'kitskogo Strait between the Kara and Laptev Seas required icebreaker assistance. Our source stated that the Russians did not charge them for icebreaking services (we presume because a Russian ship was being escorted), but they are contemplating charging up to $100,000 for assisting foreign ships.

Even with the most up-to-date technology, the Northern Sea Route sometimes presents unexpected challenges. As late as 1983, an early October cold spell trapped approximately 50 ships in several locations around the East Siberian and Chukchi Seas. Thirteen icebreakers were dispatched to the scene to effect a massive rescue operation. By late November, the ships were freed (except for one that was crushed by ice), but 30 suffered damage of varying degree (Armstrong 1984, Barr and Wilson 1985). Each voyage into this region still presents a level of risk that will never be eliminated but will likely continue to diminish with technological advances and increased operational experience.

ADMINISTRATION AND REGULATIONS

Administration

From 1932 to 1953, the administration of the Russian marine Arctic rested with the Chief Administration of the Northern Sea Route (CANSR),

* J. Laapio, 1993, Neste Shipping, personal communication.

which was a direct arm of the Council of People's Commissars of the USSR. This special affiliation afforded it great status and power for carrying out its mission to "develop the Northern Sea Route." During this period, great strides were made in organizing regular navigation and developing the fleet and port infrastructure. 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. Since 1970, when CANSR became the Administration of the Northern Sea Route (ANSR), the emphasis has been on achieving year-round trafficability. When it was established, the agency was staffed with 35 people. By 1981, that number had been reduced to 16 and, later still, dwindled further to nine.

With the formation of the Commonwealth of Independent States in 1991, total jurisdiction over the NSR passed to the Russian Federation (Arikaynen 1991). In 1991, the Ministry of the Merchant Marine (ANSR's parent organization) and the Ministry of River Transport were reorganized as departments under the new Ministry of Transport. This consolidation was accompanied by reduced state subsidies, which were followed by additional manpower and funding cuts.

These two ministries once centrally managed the three water transport sectors of international ocean shipping, internal river/canal shipping, and domestic coastal shipping. They were responsible for determining all investment decisions, service arrangements, productivity targets, and fees for services. Centralization made possible regional specialization of marine assets. Most ports and cargo carriers were thus developed and managed for specific purposes to support the centrally formulated plan of the Soviet Union. This system may have worked well under the nearly all-Union trading pattern, but the breakup of the USSR in 1991 left each of the new republics without certain key facilities. Even though all ports of the Arctic and Pacific Rim regions remained under control of Russia, several key, high-volume ports and cargo carriers in the Baltic and Black Sea regions were lost to other nations of the CIS. For example, Russia's port capacity was reduced by 53%, as 11 of 18 ports were lost. This represented over 6 million tons (mt) of cargo-handling capacity per year. Novotalinn Port, which became operational only in 1986 and was the former Soviet Union's (FSU's) premier grain storage and shipping site, became part of Estonia. The port of Riga, one of only two modern container-handling facilities, went to Latvia. In 1990, only 63% of FSU sea trade was routed through what are now Russian ports. Most of the rest passed through the Baltic republics and Ukraine (Holt 1993).

The maritime fleet was also divided up. This reapportionment changed the national statistics dramatically: in 1992 a large portion of Russian sea trade was channeled through newly foreign ports (37%) and moved by foreign vessels (46%), resulting in a hard currency drain of nearly US $3 billion (Peters 1993).

Although this is recognized by the Russian shipping industry as a problem, it is difficult to address because of the lack of central control, aging of the Russian fleet, and the technologically inferior state of its cargo-handling infrastructure. The trend will be difficult to reverse in the current trading climate. The major national carriers have become self-sustaining enterprises, free to follow their own corporate strategies with the exception only of setting rates and ship acquisition and disposal. With the emphasis on generating hard currency income, shipowners favor servicing foreign clients as much as possible. About a third of the entire Russian fleet was involved in this type of cross-trading in 1992. Another popular strategy is for shipowners to register their vessels under a third-country flag so that more lucrative rates can be charged for services. A third strategy is to form independent joint ventures with foreign partners and to place fleet assets into pools of ownership that fall outside the control of the Transport Ministry. Hard currency is required to move cargo on these ships, hard currency that ends up primarily in foreign banks. Both the ruble's low value relative to international currencies and the unavailability of Russian ships to meet national needs increase the drain on the country's reserves.

The director of the ANSR, since May 1990, is Vladimir Mikhailichenko. He is the ex-captain of the ice-strengthened vessel *Pavel Ponomarev* and understands well the field operations end of the system. The ANSR is currently responsible for the overall planning, coordination, and execution of organizational and regulatory activities for marine operations. It is responsible for meeting the annual Arctic freight transportation goals, while at the same time ensuring that personal and environmental safety is maintained (Mikhailichenko and Ushakov 1993). These are very large tasks for such a small department to address adequately. One of Mikhailichenko's primary goals is to bring in more foreign revenue to reduce the Arctic fleet's dependence on state subsidy.

After Gorbachev's 1987 speech, regulations for foreign use of the NSR and a framework for administering them needed to be developed, protocols for escorting foreign ships had to be established, navigation guides and maps had to be declassified and made available, and so forth. The Russians officially opened the route to foreign use in July of 1991.

Management of field operations

Actual operations, including scheduling, route assignment, navigational support, pilotage, and so forth, are controlled by two marine operations headquarters (MOHQs). Their areas of authority are divided at longitude 125°E. Ships and shipments originating at the western end of the route are directed by the MOHQ located at Dikson on the Kara Sea coast. The formerly state-owned Murmansk Shipping Company (MSC) runs the Dikson MOHQ. Contractual arrangements for plying the route in this direction must be made in advance with MSC's administrative offices in Murmansk. For traffic originating at the eastern end, the corresponding authority is the Far Eastern Shipping Company (FESCO). FESCO's administrative offices and MOHQ are located in Vladivostok and the East Siberian Sea port of Pevek, respectively. The staffs at the MOHQs are composed of personnel skilled in all aspects of in-ice navigation, including ship captains, reconnaissance aircraft and ice pilots, and weather and ice forecasters. In addition, these are centers for search and rescue, emergency ship repairs, and the enforcement of safety and pollution-prevention measures.

Regulations for passage

The *Regulations for Navigation on the Seaways of the Northern Sea Route* (Mulherin et al. 1994) were formulated by the Head Department of Navigation and Oceanography under the USSR Ministry of Defense. Adopted in July 1991, they comprise a 21-page pamphlet in both Russian and English that is quite widely available, as it has been reprinted in several conference proceedings and trade publications. In short, the regulations require:

- ANSR approval for passage,
- Ship certification for ice worthiness and an experienced Master. If the MOHQ determines that his level of experience is inadequate, it may assign an ice pilot to the vessel for all or part of the voyage,
- Proof of indemnity for possible damage liability (mainly pollution),
- That vessels follow the directives of the MOHQ or face removal from the route.

The regulations, in effect, grant full authority to the MOHQ to conduct all NSR shipping as field conditions warrant.

Three additional ANSR publications reportedly elaborate further on the rules and procedures. According to Mikhailichenko and Ushakov (1993), these are:

- *Requirements for the Design, Equipment, and Supply of Vessels Navigating the Northern Sea Route*,
- *Rates Charged for Escorting Foreign-Flag Vessels Through the NSR*,
- *Guide to Navigation Through the Northern Sea Route*.

The first publication, in Russian (an unofficial translation can be found in Mulherin et al. 1994), details such requirements as double hulls, steel plating thickness, powerplant size, and propeller design. Other requirements for foreign vessels include a 30-day supply of fuel, a 60-day supply of food, and a water-distilling plant aboard for drinking water. In 1993, Mikhailichenko* stated that the second document ("Rates Charged …") was not yet published.

Mikhailichenko and Ushakov (1993) stated that the third publication, "Guide to Navigation …", was slated for release by July 1992. However, its publication has been seriously delayed as a result of the country's socioeconomic difficulties. In December 1993, Maliavko† reported that the guide was only in draft form and would be released by the Russian Head Department of Hydrography sometime in 1995, in Russian. He translated its main sections as follows:

Section 1:	General overview
Section 2:	Hydrological/meteorological description
Sections 3–6:	Navigation directions for the various seas

* V. Mikhailichenko, 1993, Administration of the Northern Sea Route, personal communication.

† M. Maliavko, 1993, HydroCon, Ltd., St. Petersburg, Russia, personal communication.

Section 7: Navigational beacons and radio frequencies
Section 8: General ice navigation techniques

It was apparent that this publication might be useful for characterizing the navigational setting of the NSR, so CRREL contracted with HydroCon, Ltd., a Russian geographic publications supply company in St. Petersburg to obtain a copy of the draft and translate it for our use. HydroCon completed all necessary arrangements and, during the period May–July 1994, sections of the translated document were received at CRREL. Its table of contents is reproduced as Appendix B. It is an exhaustive, 600-page compilation of regulations, environmental information, sailing directions, and miscellaneous navigational instructions. Maliavko later indicated that he may publish and market his English translation of the Guide to coincide with the official release of the Russian original.

THE TRADE SETTING

Peters (1993) presents a detailed and frank evaluation of the water transport industry in Russia today, and most of the near-term news is not encouraging. This is a particularly dynamic period in the transformation of the FSU. Great and rapid change will undoubtedly occur in the next few years in Russia. Aside from the commodities of coal, petroleum, wood exports, and grain imports, international trade is of lesser importance and languishing. Total cargo turnover decreased with the onset of political and economic turmoil in the late 1980s and the subsequent breakup of the Soviet Union in 1991. For this section, we have relied heavily on Peters' report, which was the waterborne transit portion of an economic analysis of and prognosis for the entire Russian transportation system by the World Bank (Holt 1993).

Water transport can be subdivided into 1) international ocean transport, 2) cabotage (domestic port-to-port trade), and 3) internal river transport (not considered "sea trade"). Cabotage is a tiny contributor to Russia's freight transport total, amounting to a minuscule 0.15%, but it is a very important mode of supply for the northern frontier. River transport accounted for only 17 mt or 10% of international trade in 1992. All three of these categories are probably more important for trade along Russia's Arctic coastline than elsewhere in the country. It can be seen in Figure 8 that the rivers there, which generally flow from south to north, form an extensive navigable network. East-to-west movement of Siberian cargo is accomplished by first moving it along the rivers to railheads in the south or to seaports in the north.

Russia's water-borne transport network is a relatively small component of the entire national cargo transportation system, which includes highways, railroads, pipelines, and air service. Figure 9 shows the volumes of freight moved by various methods in 1991 and those projected through 1995. Road and rail transport were by far the prime movers of all freight (95%). River and sea cargo (564 and 103 mt, respectively) amounted to less than 3% of all Federation tonnage moved in 1991.

In 1992, only 7.5% of Russia's total trade was transported by ship: 165 mt by sea, 542 mt by river and canal, and 35 mt in cabotage. Only 17 mt of Federation sea trade was international in nature. River trade in 1993 was 470 mt; it is expected to drop to around 450 mt or less by 1995. Cabotage is off three-fold, and river ports work at only 40% of capacity (Berenyl et al. 1994).

For international cargo transport, the importance of Russia's waterborne sector becomes more evident. Excluding transport by pipeline, more than 70% of all its international trade moved by water in 1988 (50% of all export tonnage and 76% of all import tonnage), as shown in Figure 10. Russia's international trade in the final few years of the Soviet Union ranged between 508–609 mt annually, with roughly four times more imports than exports. Even though the international tonnage handled annually in all of the nation's ports combined was approximately equal to the annual throughput of Shanghai, China, alone, cargo transport by water is crucial for Russia's relatively small international trade. The above figures reflect the basic Soviet philosophy of self-reliance and all-Union trade. Before the breakup, only 5% of all cargo was international. After the breakup of the Union, fundamental changes in the composition and direction of trade flows were inevitable, and they are still occurring. Commerce between the newly formed nations of the CIS was no longer considered domestic; this was reflected in immediately higher international trade statistics. However, the waterborne sector's share of international freight decreased by approximately 40%, from 281 mt in 1988 to 167 mt in 1992, due to the heavy reliance on rail transport within the CIS whose members suddenly became international trading partners.

Although highways and railroads move by far

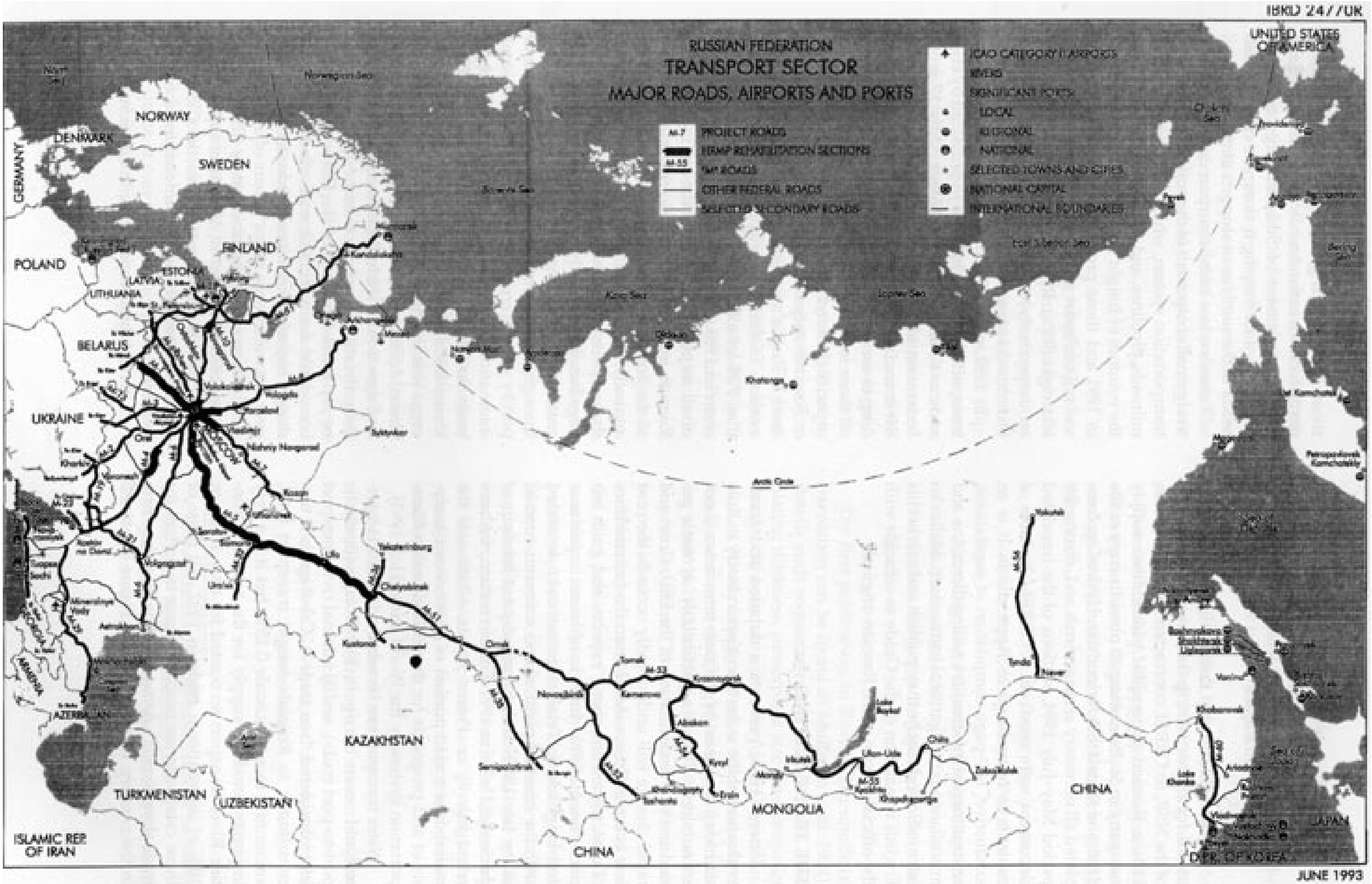


Figure 8. Russian transportation systems (reprinted courtesy of Holt 1993).

Mode	1991	Est. 1992	Proj. 1993	Proj. 1994	Proj. 1995
All Traffic	23,601	19,088	17,700	18,201	19,101
including General Purpose	5,855	4,374	4,560	4,725	4,900
Railway	7,745	6,678	6,170	6,300	6,550
including General Purpose	1,956	1,825	1,910	1,975	2,050
Road	14,688	11,504	10,703	11,073	11,724
including General Purpose*	2,731	2,550	2,650	2,750	2,850
including Rosavtotrans†	2,396	2,350	2,250	2,325	2,450
including Own Account	11,957	10,700	10,900	11,100	11,900
River	564	374	339	363	382
including General Purpose	50	47	46	51	55
Sea	103	101	87	90	94
Pipelines	499	430	400	373	348
Air	2	1	1	2	2

* Includes international, intracity, intercity.

† Excludes Mosavtotrans and St. Petersburgavtotrans. As of 1993, "Rosavtotrans" will be a Russian joint stock trucking company.

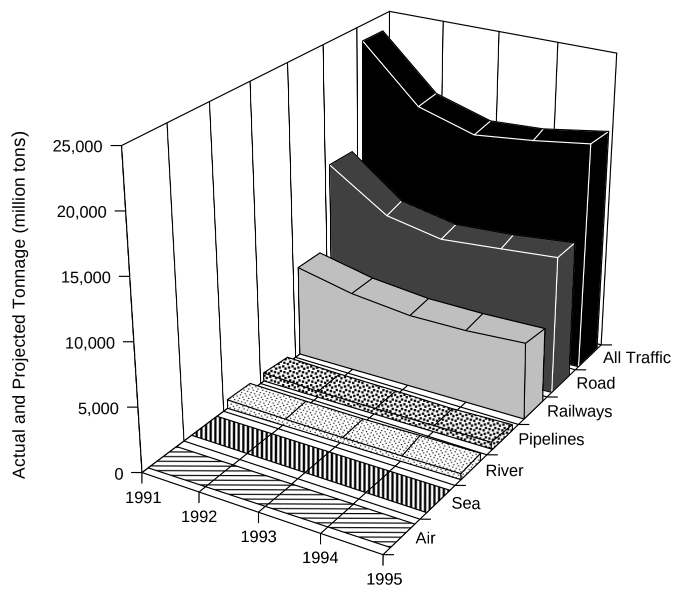
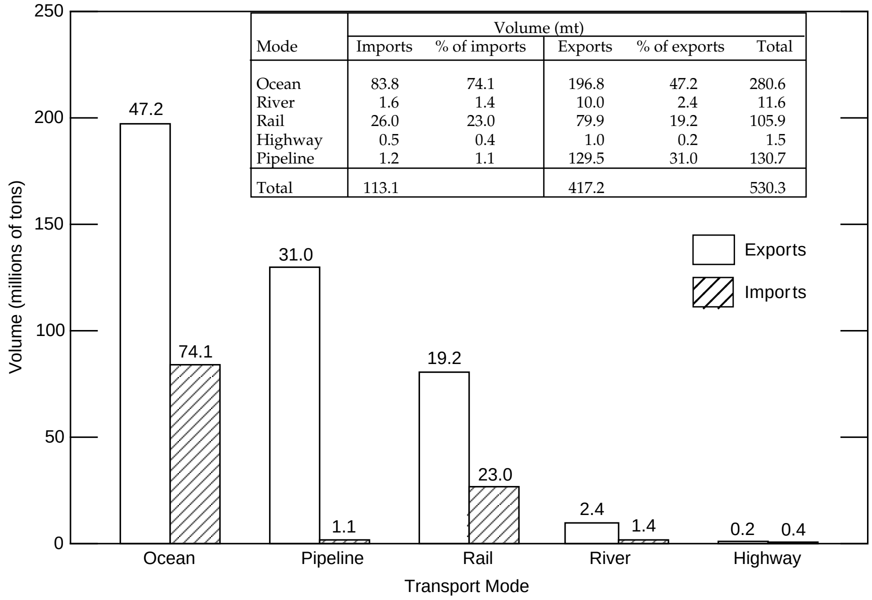


Figure 9. Actual and projected tonnages of Russian freight, in million of tons (mt) by various transportation modes (from Holt 1993).

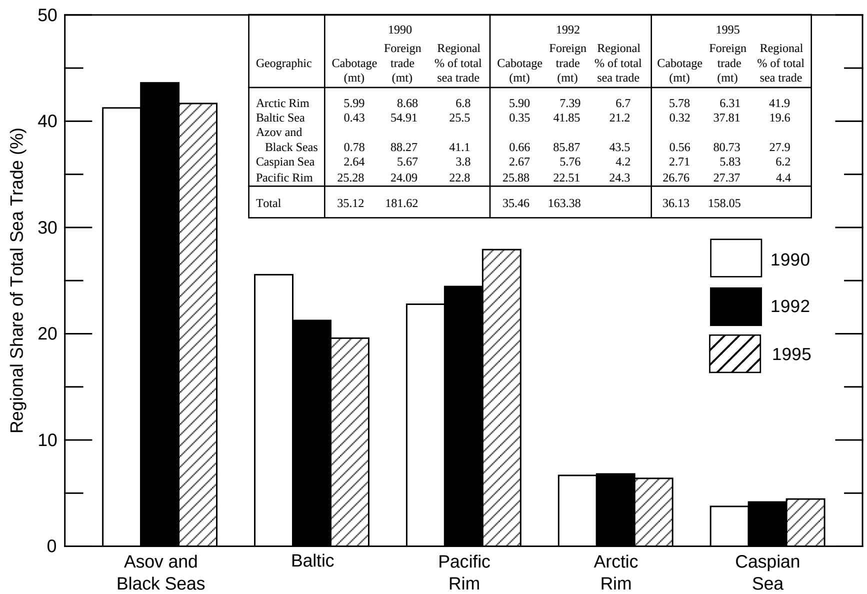
the majority of all freight, waterways are the primary mode in certain regions where other means are not practical. In some relatively isolated regions, it is the only mode available. The waterborne sector is vitally important throughout northern Siberia, since the highway and railroad systems have not extensively penetrated into this area. Siberia's navigable waterways are approximately four times the length of its railroads and eleven times longer than its road system.

Russia's international sea-trading partners are primarily (76%) developed Western and Far Eastern nations, such as those of Western Europe and North America, and Australia, Japan, and South Korea. Exports went mainly to Italy, The Netherlands, Great Britain, and Spain, while imports arrived mainly from Canada, France, and Japan. The next largest group of trading partners (11%) was composed of developing countries, with India alone accounting for more than 54% of trade with this group. A further 9% is traded with nations of the FSU, and less than 5% is traded with other socialist countries such as North Korea, China, and former Yugoslavia. These statistics reveal that Russia generally exports raw materials and imports finished goods.



Mode	Volume (mt) Imports	% of imports	Exports	% of exports	Total
Ocean	83.8	74.1	196.8	47.2	280.6
River	1.6	1.4	10.0	2.4	11.6
Rail	26.0	23.0	79.9	19.2	105.9
Highway	0.5	0.4	1.0	0.2	1.5
Pipeline	1.2	1.1	129.5	31.0	130.7
Total	113.1		417.2		530.3

Figure 10. The Soviet Union's 1988 international trade, in millions of tons, by various transport modes. Values shown above each bar represent percentages of total exports and imports (from Peters 1993).



Geographic	1990 Cabotage (mt)	1990 Foreign trade (mt)	1990 Regional % of total sea trade	1992 Cabotage (mt)	1992 Foreign trade (mt)	1992 Regional % of total sea trade	1995 Cabotage (mt)	1995 Foreign trade (mt)	1995 Regional % of total sea trade
Arctic Rim	5.99	8.68	6.8	5.90	7.39	6.7	5.78	6.31	41.9
Baltic Sea	0.43	54.91	25.5	0.35	41.85	21.2	0.32	37.81	19.6
Azov and Black Seas	0.78	88.27	41.1	0.66	85.87	43.5	0.56	80.73	27.9
Caspian Sea	2.64	5.67	3.8	2.67	5.76	4.2	2.71	5.83	6.2
Pacific Rim	25.28	24.09	22.8	25.88	22.51	24.3	26.76	27.37	4.4
Total	35.12	181.62		35.46	163.38		36.13	158.05	

Figure 11. Actual and projected annual tonnage of Russian sea trade, in millions of tons, by region (from Peters 1993).

Russia's sea trade by region is illustrated in Figure 11. In 1992, seaports of the Black and Azov Seas accounted for 44% of the Federation's total tonnage, mainly in the form of grain imports and oil exports. The Pacific Rim ports generated 24%, accounting for 73% of all Federation cabotage. Although Arctic ports handled only 7% of all sea trade, when considered along with those of the Pacific Rim, the role of the NSR for the nation's throughput is substantial.

The composition of international trade in 1992 is shown in Figure 12. Crude oil and petroleum derivatives were 57% of all exports. Dry bulk cargo was 62% of all imports. Cabotage consisted of nearly 40% each of dry bulk and general cargo. Dry bulk comprised mainly grain (44%), iron ore

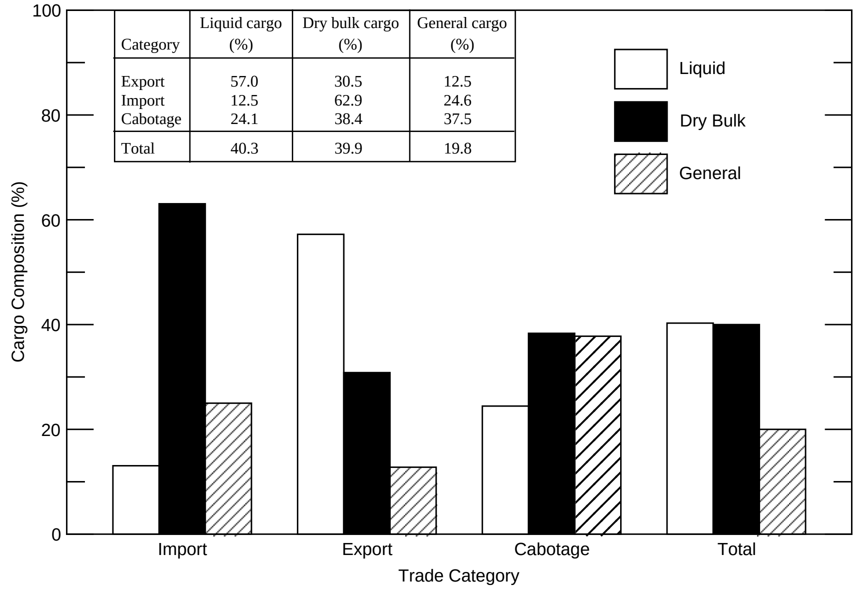


Figure 12. Russia's trade composition percentages for 1992 (from Peters 1993).

(21%), and coal (15.3%). More than 50% of cabotage dry bulk was coal. In the past three years, liquid exports and imports have fallen off by 10% and 15%, respectively, while dry bulk cargoes have increased by similar proportions. Cabotage cargoes were relatively unchanged in composition.

Although the near-term outlook for Russia's sea trade shows reasonable stability now after a 30% drop between 1988 and 1992, it is expected to grow as privatization in the industry matures. Peters (1993) predicts that an improving economy, political stabilization, industrial recovery, and expected full convertibility of the ruble should help international water trade grow by 4.5% annually by 1996. He also projects an annual growth rate in cabotage of 3.5%.

THE PHYSICAL SETTING

In this section we summarize general information on the physical environment in the Russian and Alaskan Arctic regions, according to the various seas progressing from west to east. The information was derived from Brigham and Voelker (1985), Barnett (1991), Vefsnmo et al. (1991), Batskikh and Mikhailichenko (1993), and RSMOT (in prep.). For more detailed information, the reader is referred to the research of climatological conditions conducted for the U.S. Army Corps of Engineers NSR Reconnaissance Study (Proshutinsky et al. 1995)

The continental shelf is extremely wide off Russia's north coast (Fig. 13), and the seas overlying it are shallow. In general, the winter distribution of sea ice across the Russian Arctic is characterized by the growth of shorefast ice in vast areas where the water is less than 30 m deep. Calculations based on climatic conditions show that the maximum ice thickness averages 120 to 130 cm in the Kara Gate, 160 to 170 cm near Dikson and in the Longa Strait, and 190 to 200 cm in the straits of Vil'kitskogo and Dmitriya Lapteva. These mean values can vary by 30 to 50 cm depending on year-to-year conditions. The presence of snow has a large effect on the fast-ice thickness, because it acts as an insulating blanket over the growing ice and reduces its thickness.

Seaward of the fast-ice boundary, the ice cover is in constant motion due to ocean currents and winds. This region of moving ice, known as "pack ice," continually experiences openings, called leads, where the ice cover pulls apart, and convergence areas, where the ice crushes together to form pressure ridges and fields of broken rubble. Recurrent open water in specific locations due to prevailing winds and currents are known as "polynyas" (Fig. 14). During the freezing period (roughly August to May), new ice is continually being produced in the leads, and these areas of thinner ice and the polynyas are obvious lines of weakness that are exploited to maximum extent by ice pilots and sea captains. Figure 15 shows the general distribution of various ice types across the Arctic Ba-

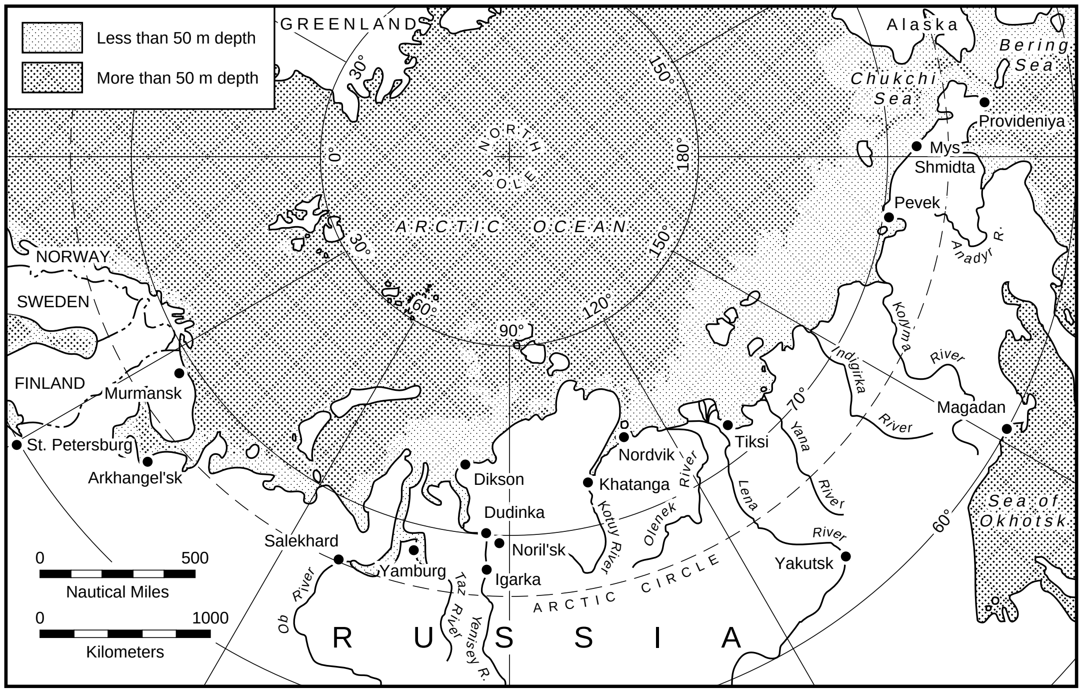


Figure 13. The bathymetry of the Russian Arctic.

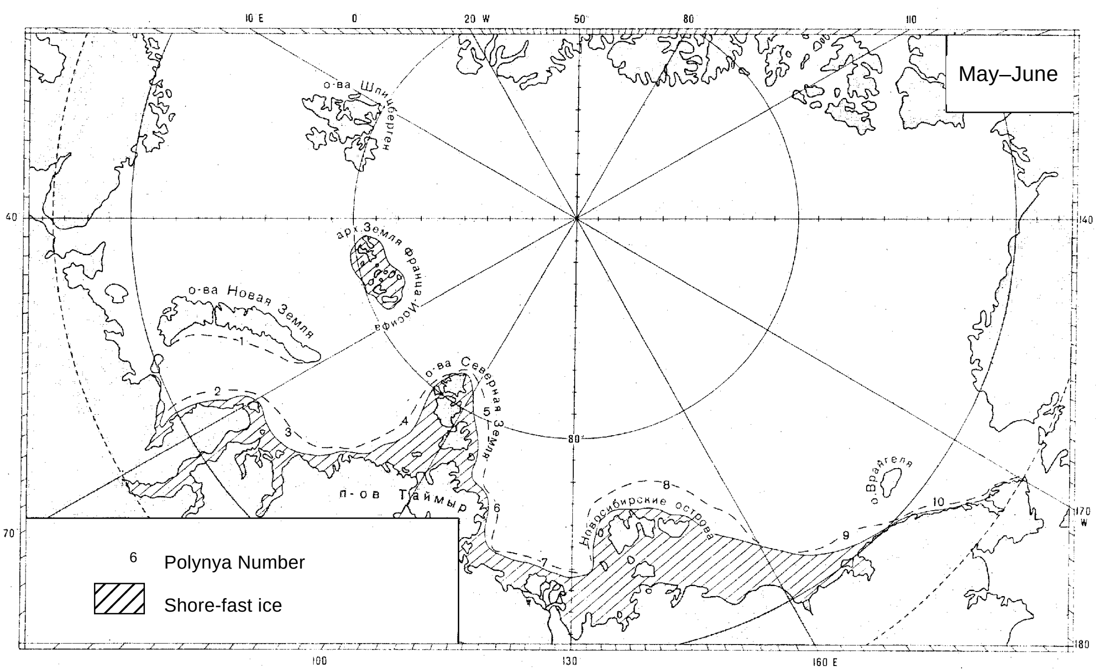


Figure 14. Location of offshore and recurrent open water areas, or "polynyas," during the time of maximum ice development (May to June). (Translated from RSMOT, in prep.)

sin at the time of maximum ice development (May to June). In the areas of convergence, rubble ice refreezes into much thicker and stronger masses. In some places, due to the presence of land barriers, prevailing winds, currents, and so forth, ice accumulates in large enough masses that it survives the summer season. These ice fields, or massifs, sometimes cover hundreds of square kilometers and are found in the same regions every summer. Figure 16 shows the location of nine such massifs along the Northern Sea Route. They all experience some degree of seasonal fluctuation in

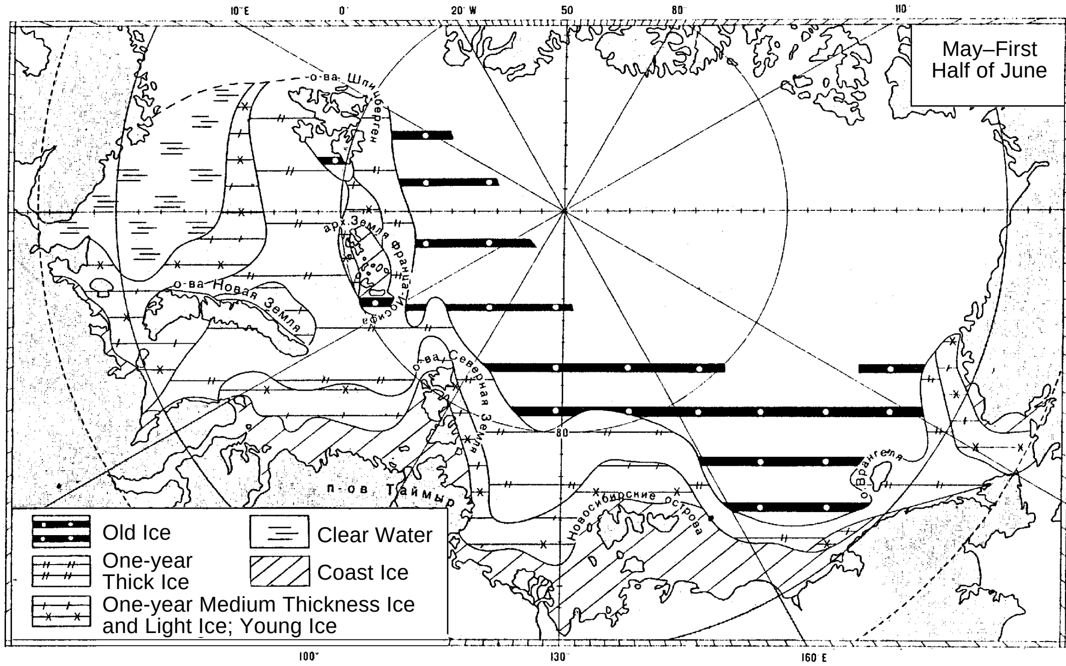


Figure 15. General distribution of various ice types at the time of maximum development. According to WMO (1970), multiyear ice is that which has survived at least one melt season and is not less than 2.5 m thick; first-year thick ice is between 1.2 and 2 m thick; first-year medium ice, first-year thin ice, and young ice covers the range from 0.1 to 1.2 m thick. (Translated from RSMOT, in prep.)

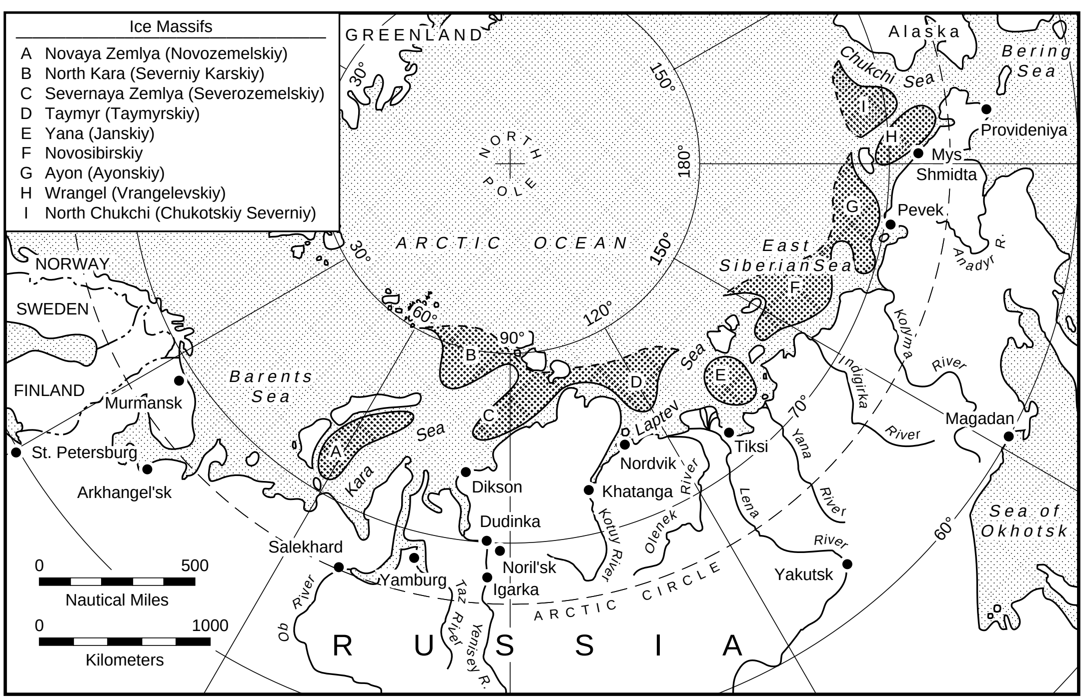


Figure 16. Location of recurring ice massifs (from Gudkovich et al. 1972).

Table 6. Probability (%) of occurrence of conditions that require icebreaker assistance through various NSR massifs (from Buzuev 1991).

Ice massif	*Amguema*-class			*Noril'sk*-class		
	Jun	*Aug*	*Oct*	*Jun*	*Aug*	*Oct*
Novaya Zemlya	95	0	0	95	0	0
Severnaya Zemlya	100	75	25	100	60	5
Taymyr	95	65	40	95	55	15
Novosibirskiy	95	60	20	90	45	10
Ayon	95	35	15	95	30	5
Wrangel	95	10	25	95	5	5

size. For example, the Novaya Zemlya massif nearly melts out completely, while the Taymyr, Ayon, and Wrangel massifs are more resistant and experience less ablation.

Table 6 shows the probability for ice conditions that necessitate icebreaker assistance through NSR massifs for ULA-class ships (the highest ice classification for cargo ships under the Russian registry). The data include observations from 1970 through 1991. Although the individual probabilities are quite low for October, there is a high probability that all cargo vessels will need icebreaker assistance somewhere along the way, even in October. In fact, Section 7.4 of the ANSR regulations (1991) stipulates that escort is mandatory for all foreign ships seeking passage at any time through certain island straits (Vil'kitskogo, Shokal'skogo, Dmitriya Lapteva, and Sannikova).

The summer season occurs roughly from June to September when the ice cover melts significantly, diminishing in both extent and strength. Figure 17 shows the seasonal changes in the normal ice cover. It can be seen that the greatest seasonal fluctuation occurs at the east and west ends of the route. This is due to the influence of ocean currents moving northward from the warmer Atlantic Ocean in the west and the Bering Sea in the east, which accelerate ice decay in the spring and retard freezeup in the fall. Of greater interest to shipping is the mean July-to-September location of the ice edge with 7/10ths or greater concentration.* These isolines are shown in Figure 18. This map does not take into account the location of the ice massifs, as the September and, to a large extent, the August isolines are well north of the massifs shown in Figure 16.

Between the freezing and melting seasons is a brief interphase of ice pack movement from wind and ocean currents. This interphase is character-

* Ice concentration is usually expressed in tenths or octas describing the amount of sea surface covered by ice as a fraction of the total area being considered.

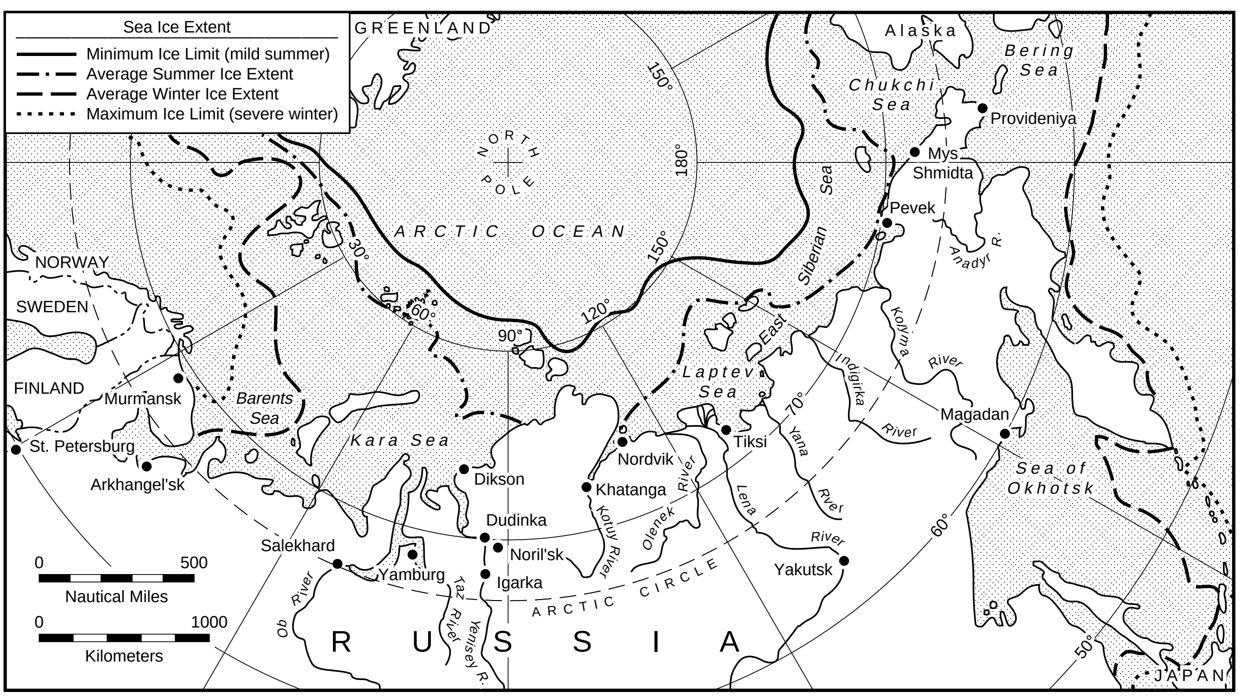


Figure 17. Seasonal extent of the sea-ice edge (from Barnett 1991; USNODC 1986a,b).

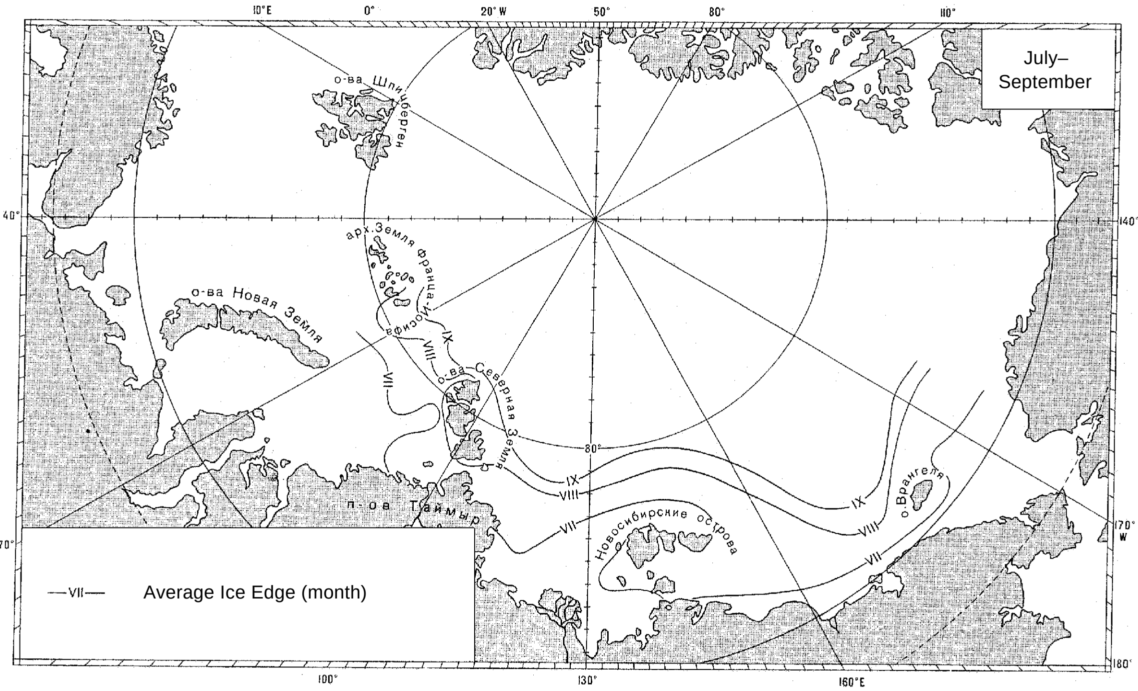


Figure 18. Mean sea-ice extent for concentrations of 7/10ths and greater for July through September. (Translated from RSMOT, in prep.)

ized by near-freezing air temperatures that produce little ice growth or decay. Shipping activity routinely occurs throughout the melt and the autumn interphase. The Russians would like to extend the shipping season into the freeze period and the spring interphase. Table 7 provides a summary of the environmental conditions encountered in the Eurasian seas of the Northern Sea Route.

As previously mentioned, the bathymetry of the Russian Arctic is characterized by the continental shelf lying at relatively shallow depth over vast areas. For example, the average depth of the entire East Siberian and Chukchi Seas is only 58 m and 88 m, respectively (Østreng 1991). Tidal changes range from 5 to 7 m in the Laptev Sea, from 3 to 4 m in the East Siberian Sea, and are no more than 2 to 2.5 m in the Kara Sea (Buzuev 1991). The limiting depths for navigation are those found in the various straits. Most exceed 20 m, except the Sannikova and Dmitriya Lapteva straits located

Table 7. Summary of environmental conditions of the Eurasian seas along the Northern Sea Route (from Barnett 1991).

	Barents	*West Kara*	*East Kara*	*Laptev*	*E. Siberian*	*Chukchi*
Mean air temp. (°C)						
Winter	–10 to –15	–15 to –20	–25 to –30	–30	–30	–20 to –30
Summer	—	5	2	—	2 to 5	2 to 5
Mean fast ice thickness (cm)	50 to 150	120 to 200	200	200 to 250	170 to 200	130 to 180
Average date of minimum ice cover	15 Sept	24 Sept	14 Sept	17 Sept	13 Sept	12 Sept
Summer ice cover relative to winter max. extent (% of area)	10	25	48	47	57	20
Average date of complete freeze-up	Never	Mid – late Nov	Mid Nov	—	Mid Oct	Mid – late Nov
Average date of min. ice extent	15 Sept	24 Sept	14 Sept	17 Sept	13 Sept	12 Sept

south of the Novosibirskiy Islands, which are only 13 m and 8 m deep, respectively. These extreme shallows limit the size of ships that can pass safely to those under 20,000 dwt unless they are specially designed for shallow-water operations (Wergeland 1991). The more northerly routes are deeper, but ice conditions are also more severe.

The Barents Sea

The Barents is the warmest of the Eurasian seas, and the only one not totally ice-covered in winter. During the most severe winters, only about 90% of the surface is covered with ice (70% and 50% in normal and mild winters, respectively). It experiences the greatest seasonal variation of sea-ice extent. Its ice cover is dramatically affected by the influx of warm water from the Atlantic, which moderates the ice conditions in the southern and southwestern Barents. General ocean circulation and prevailing winds in winter advect ice southwestward from the northern Barents ice pack. The southern Barents in winter, however, experiences generally southwesterly winds that introduce warm maritime air and inhibit ice growth. Winter mean air temperatures are relatively mild (–10 to –15°C). First-year ice thickness averages 50 to 100 cm in the south and 120 to 150 cm in the north. Severe winter conditions are the result of occasional shifts in the normal positioning of the Icelandic low and Siberian high pressure systems, which cause southeasterly winds to dominate. Such a shift brings in cold continental air off the Siberian plateau, which gives rise to greater ice production in the southern Barents.

The protection offered by the perimeter location of the major island groups of Svalbard, Franz Josef Land, and Novaya Zemlya prevents the influx of ice from neighboring seas where ice production is greater. In addition, weaknesses in the ice cover are prevalent on the leeward side of most island groups in the Barents. Prevailing easterly winds continually drive the ice offshore so that ice that is present at any time is newly formed and relatively thin. These lee-side polynyas are generally evident throughout the winter off Nordaust Land, Kong Karls Land, Kvitøya, Novaya Zemlya, and especially Franz Josef Land. The spring–summer melt pattern usually initiates and expands from these areas. During summer, the polynyas typically expand southward to meet the northerly retreating main ice edge, forming vast tongues of open water. In a normal summer the ice edge retreats to about 78°N. While all the major islands have actively calving glaciers, icebergs are not a serious concern to navigators in the Barents at any time.

The Kara Sea

The other seas along the Russian coast are influenced by cold continental air masses and hence experience much colder air temperatures than the Barents. Mean winter temperatures range from –15 to –20°C in the southwest Kara and from –25 to –30°C in the north and east Kara. Mean summer air temperatures range from 0 to 5°C. The sea ice cover is greatly influenced by its relatively landlocked perimeter, winds, river runoff, and shallow bathymetry. Due to Novaya Zemlya, there is little exchange of warm water from the Barents. Likewise, Severnaya Zemlya inhibits exchange with the Laptev Sea. Water and ice mass exchange is almost entirely with the Arctic Ocean to the north.

Fast ice forms along the entire Kara coastline, and it is generally narrow, except in the eastern Kara where it extends outward for 80 to 110 nm. Throughout fall and winter, the only substantial openings in the ice cover usually occur at the boundary between this fast ice and the outer pack ice. Offshore winds tend to push the pack away from the stationary ice, creating occasional lanes of newly forming ice. This transport mechanism produces thicker ice to the north. The coastline at the eastern end of the Kara is about 400 nm farther north than at the western end, resulting in cooler air and sea conditions in the eastern sector. The ice thickness in a normal winter ranges from 120 cm in the southwest to 200 cm in the northeast.

Summer melting in the Kara typically begins at the outer edge of the fast ice when ice production ceases. A few weeks later the fast ice breaks free and drifts seaward. Rivers flowing into the Kara constitute more than half of all the runoff entering the Eurasian seas. Warm spring runoff produces early open-water areas at the major estuaries, and by midsummer, the western Kara is normally ice-free as far north as 75°N. There may be open water as far north as 82°N during a mild summer. There is, however, a cold ocean current running southward along Novaya Zemlya that piles ice into the Kara Gate. This ice often survives through an unusually cool summer.

In the eastern Kara, summer melting is less extensive; nearly half of its area remains ice-covered throughout a normal summer. The year-to-year variability, however, ranges from 0 to 80% coverage. In addition to a more northerly latitude, warm river inflow is dramatically less here than in the western Kara. There is no prevailing summer wind pattern, but in some years, westerly winds concentrate ice at its eastern barrier of Severnaya Zemlya and the Taymyr Peninsula, creating a difficult barrier to navigation.

Freezeup begins in September in the colder northeast Kara and in October in the less saline central region where the Ob' and Yenisey Rivers enter. After that, the intervening region rapidly grows an ice cover that connects the two. The extreme southwest sector, extending 95 to 150 nm eastward from the Kara Gate, normally remains open into November, but with large year-to-year variation (late October to late December).

The Laptev Sea

Sea-ice distribution in the Laptev is influenced by cold winter temperatures, southerly winter winds, ocean currents, heavy river inflow, and a vast continental shelf of very shallow depth. With the extraordinarily broad continental shelf in this region, half of the entire Laptev is less than 50 m deep, and south of 76°N its depth does not exceed 25 m. Because of these shallow waters, the Laptev and the East Siberian Seas have the largest expanse of fast ice in the world from January to June. The fast-ice thickness typically reaches 200 cm due to mean midwinter air temperatures of –30°C and can grow up to 250 cm thick during severe winters.

Similar to the process previously discussed for the Kara, prevailing southerly winter winds continually push the pack ice northward away from the fast ice, resulting in a nearly permanent lane of weakness. The amount of old, thick ice found in the Laptev is limited not only by these winds but also by northward ocean currents. The total area of summer melt is particularly extensive due to this reduced presence of old ice. In the western Laptev, however, the ice drift is southward, and large masses of ice are deposited along the coast of Severnaya Zemlya and the Taymyr Peninsula. Along with the eastward ice deposition from the Kara Sea, the Vil'kitskogo Strait and the Taymyr coast present a serious challenge to navigation at all times of the year.

Many rivers empty into the Laptev, but the Lena accounts for more than 70% of the total inflow. The summer melt pattern is greatly influenced by this warm water influx. Large areas of open water expand outward from the deltas so that, by the end of summer, the Laptev is typically ice-free as far north as 77°N (only 74°N for the western portion). Winds are light and variable in summer, but prolonged easterlies transport additional ice into the Taymyr ice massif.

The East Siberian Sea

Of all the Eurasian seas, the East Siberian experiences the least amount of summer melting. On average, more than 50% remains ice-covered throughout the summer season. The persistence of the ice cover is attributed to cold winter and cool summer air temperatures, prevailing winds, ocean currents, a wide continental shelf, and meager river inflow.

The East Siberian Sea is the shallowest of the Eurasian seas. The broad continental shelf allows fast ice, averaging 170 to 200 cm thick, to extend as far as 270 nm outward from the coast. In winter, prevailing southerly winds bring in cold continental air, producing a winter mean air temperature of –30°C. These winds also cause weak ice conditions and potential navigation lanes at the outer edge of the fast ice as they do in the Kara and Laptev Seas.

In summer, the winds shift to northerly, bringing in polar air. In addition to cool air temperatures, warming from river inflow is limited. Total river discharge into the East Siberian Sea amounts to only 20% of the Kara's total and only 35% of the Laptev's. Ocean currents favor the influx of ice from (rather than its removal to) the Arctic Ocean, resulting in the permanence of the Ayon massif that protrudes into its eastern sector. Winter freezeup begins in the north in September and is usually complete by mid-October.

The Chukchi Sea (Russian)

The Russian portion of the Chukchi Sea is almost totally ice covered from early December to mid-May. It experiences a large seasonal variation in ice cover, losing about 80% of its maximum winter extent during the summer season. The extent of its summer ice melt is exceeded only by that in the Barents. Important factors that influence sea-ice distribution in the Chukchi are the sea's bathymetry, winds, ocean currents, air temperatures, and the presence of Wrangel Island. Winter mean air temperatures range from –30°C in the west to –20°C in the east due to the inflow of relatively warm water from the Bering Sea. Consequently, winter mean ice thickness ranges from 180 cm in the west to 130 cm in the east. Because the continental shelf is less extensive, only a 10- to 15-km-wide band of fast ice forms along the mainland and the Wrangel Island coast. Ocean currents tend to concentrate old ice from the Arctic into

Longa Strait under great pressure, which can sometimes present the greatest navigational obstacle of the entire route. It was at this location that the 50-ship convoy became ice-bound in the autumn of 1983. The only midwinter area of weakness is a lee-side polynya that forms off Wrangel Island that can occasionally be more than 50 nm wide. The prevailing onshore winds of winter normally shift around to a more offshore flow in the spring, resulting in a narrow lane of open water along the coast for the duration of the shipping season.

The summer melt pattern is primarily influenced by the influx of warmer water from the Bering Sea. Breakup initiates in the eastern end and progresses westward. At the height of summer (mid-September), the Chukchi is normally 80% free of ice. Summer air temperatures average from 2 to 5°C. Winter freezeup is usually delayed into September or October by this warmer inflow, and open water north of the Bering Strait is found into late November.

Alaskan waters

The information presented in this section was extracted primarily from the Arctic Marine Transportation Program summary report by Voelker (1990). The program, which took place from 1979 to 1986, collected field and operational data during 12 deployments of a U.S. *Polar*-class icebreaker to the ice-infested waters surrounding Alaska. The program's purpose was threefold:

- To assess the feasibility of commercial marine operations in ice,
- To obtain data for improving ship design for ice operations,
- To define the environmental conditions along potential shipping routes.

Therefore, this environmental summary contains information on the Chukchi, Beaufort, and Bering Seas that is more applicable to ship trafficability than that presented for the Russian seas.

Based on an analysis of meteorological and satellite imagery data and experience gained from the ship deployments, 13 specific geographic areas were identified as having differing levels of environmental severity in terms of trafficability (Fig. 19). These zones are based on representative conditions that would result during an average ice year with winds trending from the north to northeast and prevailing throughout the winter season. The winter season for the Bering Sea is considered to be six months long (December through May). Winter in the Chukchi is nine months long (November through July), and in the Beaufort Sea it lasts 10 months, beginning in October and ending in July.

The Bering Sea

In the Bering Sea, open water can be expected from about the Pribilof Islands southward. The southern limit of zone 1 marks the ice edge where pack ice in low concentrations is found. According to the *Alaska Marine Ice Atlas* (LaBelle et al. 1983), zones 2 and 3 are areas of landfast ice with a level-ice thickness range of 100 to 130 cm based on freezing degree-day calculations (LaBelle et al. 1983). Areas marked as zone 4 lie in the shadow of

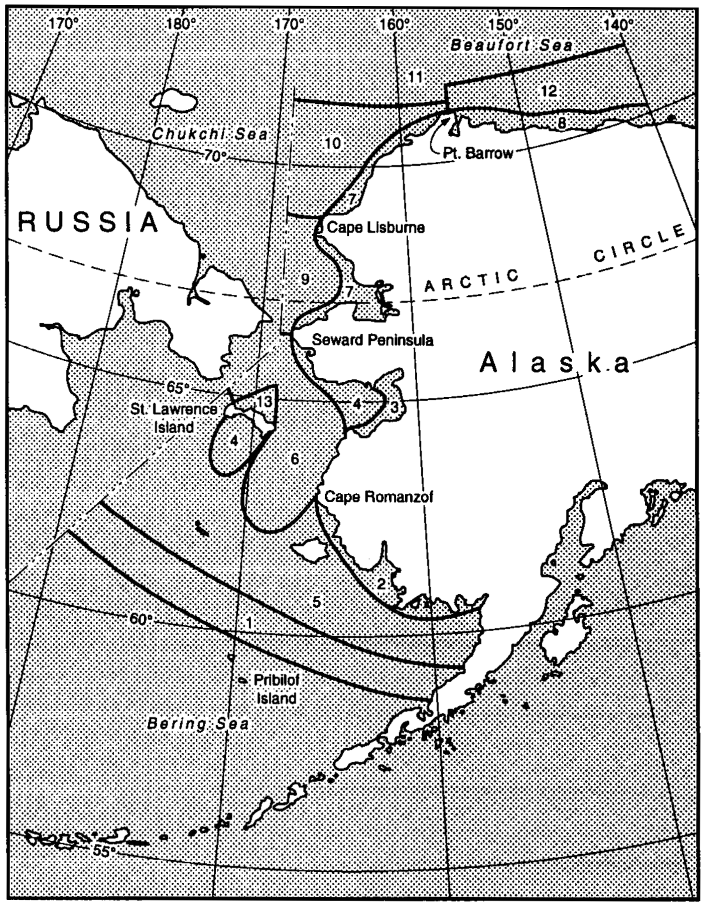


Figure 19. Zones of environmental severity affecting marine trafficability in Alaskan waters. The numbers from 1 through 13 represent increasing degrees of navigation difficulty in the areas indicated (after Voelker 1990).

land masses and are thus somewhat sheltered from the degree of ice movement and consolidation that occurs in more exposed locations. Ice here is usually less than 30 cm thick during periods of prevailing northerly wind. Zones 5 and 6 are regions of dynamic ice displacement, resulting in pressure ridges, rubbled floes, and open leads caused by ice drift averaging 0.3 to 0.5 kn. Ice, which is transported primarily by wind, consolidates to a thickness of between 30 and 120 cm. The most severe ice conditions in the Alaskan Arctic are found just south of the Bering Strait (zone 13). Ice becomes extremely rubbled and compacted to the windward side of St. Lawrence Island.

Year-round marine traffic using current icebreaking capabilities is technically feasible throughout most of the Bering Sea, but it is usually suspended from late December to mid-May, according to the U.S. Coast Pilot manual (USDC/NOAA 1981). Fast ice begins to form along the coast and in sheltered areas sometime in October. Pack ice formation in the more open areas begins its southward progression in November with the seasonal cooling of the water. According to Brower et al. (1988), 97% of the ice found in the Bering Sea actually forms there with very little southward influx of ice through the Bering Strait. Winter ice coverage in the Bering is highly variable from year to year, and even month to month, due to shifts in prevailing winds that produce leads and polynyas of short duration. Thick, multiyear ice is generally not found in the Bering Sea, since the ice cover melts out completely during the summer.

The Chukchi Sea (Alaskan)

The U.S. portion of the Chukchi Sea is divided into three different zones of severity. Zone 7, adjacent to the Alaskan coastline, is a region of relatively stable and level shorefast ice ranging in thickness from 155 to 190 cm. Zones 9 and 10 roughly divide the Chukchi at 69°N latitude. The ice conditions in zone 9 are generally more serious than those found anywhere in the Bering (except zone 13) and include pressure ridges, thick rubble ice, and ice pressure. Zone 10 conditions are made more serious still by the greater concentration of drift ice that enters from the Beaufort Sea. The drifting ice ranges from 150-cm-thick first-year ice to 9-m-thick multiyear floes.

Freezeup in the northeast Chukchi begins in mid-September to early October and progresses southwestward. The U.S. Coast Pilot manual recommends that southbound ships be south of the Bering Strait by early November. Two winter deployments to the north Chukchi during the Arctic Marine Transportation Program, however, concluded that year-round transits are technically—but probably not economically—feasible using current U.S. icebreaking capabilities. The study pointed out that the full 60,000-shaft horsepower (shp) operational capacity of the *Polar*-class icebreakers was often required and that ice piloting and operating skills were extremely important. Average air temperatures for coastal stations in February, the coldest month, range between –18 and –30°C, while extremes of –45°C and below have been recorded. Winds can be severe and prolonged, leading to extreme ice pressures and dangerous wind-chill conditions for personnel. The five-year return period for maximum sustained winds for both the Chukchi and Beaufort Seas is 68 kn.

The disintegration of the seasonal ice cover begins, usually around mid-May, at the seaward edge of the fast ice along Alaska's northwest coast in response to strong offshore (easterly) winds that develop in March and April. However, the pack ice generally remains close in to Pt. Barrow until late July or early August.

The Beaufort Sea

The Beaufort Sea presents the most challenging navigation conditions in Alaskan waters. The narrow region along the northern coastline (zone 8) grows fairly stable landfast ice averaging 200 cm thick. The area contains not only level first-year sea ice, but also has an abundance of pressure ridges and multiyear ice. At the seaward edge of the fast ice, at approximately the 20-m isobath, is a shearing zone marking the transition to highly dynamic pack ice that constitutes zones 11 and 12. Shear ridges in this transition zone are larger and more extensive than anywhere else on the Alaskan coastline. Both zones have an abundance of very large (several km in diameter) multiyear floes and first-year rubble that produces massive pressure ridges. Zone 12 experiences a greater frequency and intensity of pressured ice conditions because of its relative position with Alaska's north coast and prevailing northeasterly winter winds. February air temperatures along the coast average –28 to –30°C. Summertime air temperatures average 2 to 6°C. Because ice transit operations there are so demanding, refueling stops for nonnuclear-fueled icebreakers along the way would be required where none currently exist. The median date for opening the cargo transport season around Barrow to Prudhoe Bay is August 2, but it has

Table 8. Joint Ice Center's sea ice severity data for Alaska's north coastal waters (from USN/NOAA NIC 1994).

Parameter	*Median 1953–1993*	*Extremes 1953–1993*
Initial opening date of coastal route to Prudhoe Bay*	3 Aug	18 Jul–never
Length of navigation season (days)	61	0–112
Final closing date	6 Oct	NA† –7 Nov
Number of days route entirely ice free	25	0–92
Distance (nm) from Pt. Barrow northward to:		
Ice edge on 10 August	0	0–50
Heavy pack edge** on 10 August	5	0–70
Ice edge on 15 September	25	0–165
Heavy pack edge on 15 September	70	0–210

* Opening date based on the initial date that the entire route from the Bering Sea to Prudhoe Bay may be navigated through ice cover of less than 5/10 concentration.
† No closing date in 1975 because the route never opened.
** Boundary between greater than 5/10 ice cover to the north and less than/equal to 5/10 to the south.

varied between 19 July and 3 September. The length of the navigation season also varies considerably, as shown in Appendix C. In 1975, the route never opened, whereas in 1993 it was considered navigable (5/10 ice concentration or less) for 112 days. Table 8 presents the means and extremes of sea-ice conditions affecting navigation in northern Alaskan waters from 1953 through 1993.

THE NAVIGATIONAL SETTING

Sources consulted

DMA sailing directions

The Defense Mapping Agency Hydrographic/Topographic Center in Bethesda, Maryland, publishes and sells a series of detailed sailing directions for the entire globe. Navigational details for the NSR are described in the Agency's Publication 183, *Sailing Directions: Northern Coast of Russia* (DMA 1993). In addition to sailing directions, this publication provides important information about the region's river and seaports.

Russian State Hydrographic Department

The State Hydrographic Department under Russia's Ministry of Transport has, since the formal opening of the route, been compiling an official NSR navigation guide for foreign consumption. It is to be published as the *Guide to Navigation Through the Northern Sea Route,* and was described earlier (see Administration and Regulations). Our draft translation of this document served as a major source of the information presented below.

INSROP Working Paper I.1.1

A paper by Kjerstad (1994) published by the International Northern Sea Route Programme provides perhaps the latest information publicly available on navigation guides, regulations, operational aids, and communication systems. Though we did not receive it in time to thoroughly review and incorporate its contents into this report, the interested reader is advised of its existence and from where it can be obtained (see *Literature Cited*).

Routes, distances, and depths

The overall distance from one end of the NSR to the other is variable because of the choice of routes available. Due to variable ice and hydrographic conditions, longer routes may be more favorable in terms of the time required for passage. Figure 20 shows the distances between various waypoints along the route. In general, the shorter (in distance) transit routes between Novaya Zemlya and the Bering Strait are the northern variants. These routes need to be weighed against the likelihood of more severe ice conditions to be found farther off the coast.

The Russian Arctic is characterized by expansive seas (the Kara, the Laptev, the East Siberian, and the Chukchi) separated by island archipelagoes (Novaya Zemlya, Severnaya Zemlya, Novosiberskiy, and Wrangel), with several routing choices around or through each. The choice of route is determined by several factors, including the voyage origin and destination, the current ice conditions or those to be expected based on meteorological and hydrodynamic forecasting, and the location of icebreaking resources at the time.

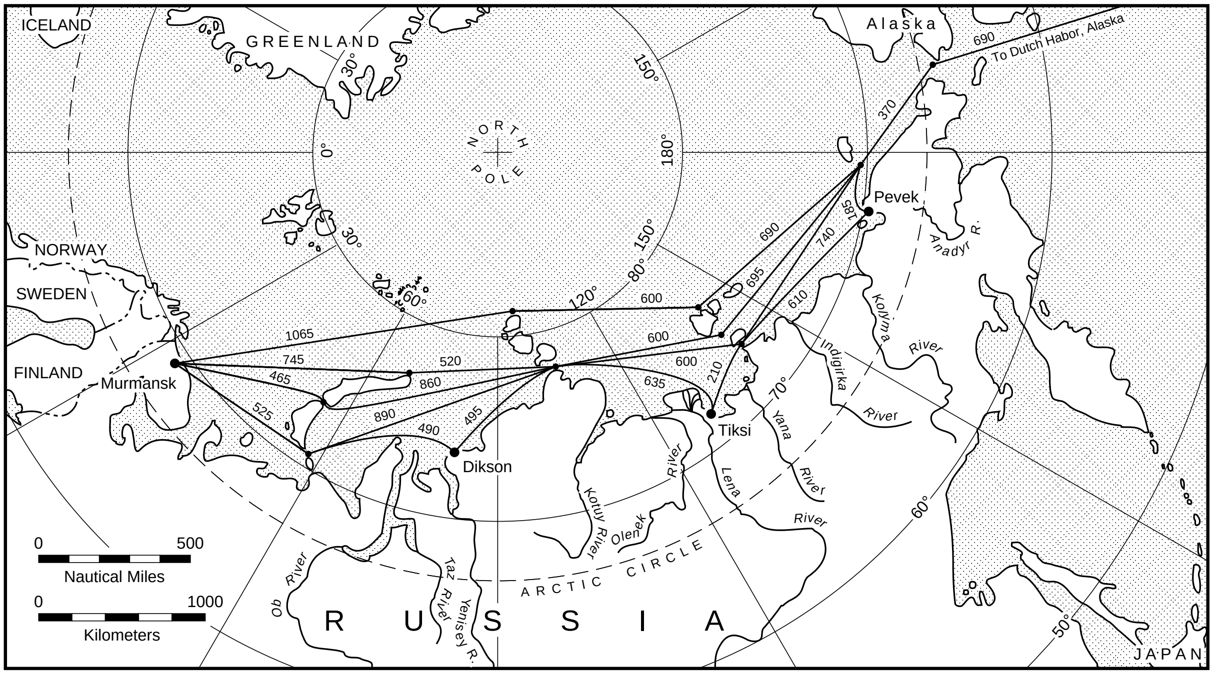


Figure 20. Approximate distances, in nautical miles, of the various route segments between Murmansk and Dutch Harbor.

The NSR is approached from the west through the Barents Sea. The islands of Novaya Zemlya separating the Barents and Kara Seas mark the westernmost end of the NSR. In addition to the high-latitude route around Cape Zheleniya, the northernmost tip of the archipelago, there are three navigable passages through this island group that can be used by deep-draft vessels. The southernmost two are most commonly used: the straits of Yugorskiy Shar, which lies south of Vaygach Island, and Karskiye Varota (the Kara Gate) to the island's north. The third, Matochkin Shar, the strait that divides Novaya Zemlya proper into two large islands, was often used over the last 40–50 years as a nuclear test site and is currently closed to shipping (Kjerstad 1994). The shortest distance from Murmansk to the Kara Sea and the western terminus of the NSR is 465 nm, through the Matochkin Shar Strait. The greatest distance is 745 nm, around Cape Zheleniya. The average depth of the Kara Sea is 90 m (Hume 1984).

The NSR enters the Laptev Sea after passing through or around the Severnaya Zemlya archipelago. The most often-used passage is also the southernmost, Vil'kitskogo Strait. It separates the island group from Cape Chelyuskin on the Taymyr Peninsula. At nearly 78°N, Cape Chelyuskin is the Russian mainland's most northerly point and consequently the weather and ice conditions in this region are often the most challenging of any part of the route. Much less frequently used are Proliv Shokal'skogo, the strait separating the islands of Bolshevik and Oktyabra'skoy Revolyutsh, and the high-latitude route around Cape Arkticheski, the archipelago's northern tip located at 81°N. The shortest distance from Murmansk to the Vil'kitskogo Strait is approximately 1260 nm, around Cape Zheleniya. Following the coastal route, the distance from Murmansk to the Vil'kitskogo Strait (through the Kara Gate) is 1510 nm.

The East Siberian Sea is usually entered from the west in one of three ways: 1) the southernmost passage is the Dmitriya Lapteva Strait, lying between Lyakhovskiy Island and the mainland; 2) the Sannikova Strait, the next further north; and 3) the high-latitude route to the north of the entire archipelago. The straight-line distance between the Vil'kitskogo Strait and either of these two straits is 600 nm, and the distance from Murmansk is 1660–2360 nm.

The Longa Strait, the 75-nm-wide water passage between Wrangel Island and the Chukotka mainland, marks the transition from the East Siberian to the Chukchi Sea. The Ayon and the Wrangel ice massifs in this area usually create some of the most challenging ice conditions for navigation on the entire route. However, the ice within the strait is nearly always more navigable than it is to the

Table 9. Approximate length, minimum width, and depth of key straits (from DMA 1993; RSMOT, in prep.).

Strait	*Location, passage from–to*	*Length (nm)*	*Width (nm)*	*Depth (m)*
Yugorskiy Shar	Novaya Zemlya, Barents–Kara Seas	21	6	12
Karskiye Vorota	Novaya Zemlya, Barents–Kara Seas	18	14	21
Matochkin Shar	Novaya Zemlya, Barents–Kara Seas	55	1	12
Vil'kitskogo	Severnaya Zemlya, Kara–Laptev Seas	60	30	25
Shokal'skogo	Severnaya Zemlya, Kara–Laptev Seas	80	10	37
Dmitriya Lapteva	Novosibirskiy, Laptev–East Siberian Seas	63	30	6.7
Sannikova	Novosibirskiy, Laptev–East Siberian Seas	120	16	13
Longa	Wrangel Island, East Siberian–Chukchi Seas	—	75	20

north of Wrangel Island. The average straight-line distance from the straits of the Novosibirskiy Islands to the Bering Strait is 1090 nm, and the total distance from Murmansk is 2720–3520 nm.

Table 9 summarizes the approximate lengths, widths, and depths for the straits described above. Other distances of interest may be obtained from Table 10.

The major straits used for passage

The sources for the following information are DMA (1993), Kjerstad (1994), and RSMOT (in prep.) unless otherwise indicated. The major navigable straits are shown on Figure 1.

Yugorskiy Shar Strait, between the Barents and Kara Seas, is approximately 21 nm in length, about 5.5 nm wide at its narrowest point, and trends in a southwest-to-northeasterly direction. Depths in this strait are very irregular, with several off-lying shoals and shallow banks that extend far offshore. The marked fairway has a minimum depth of 12 m, but the water level is increased somewhat by east winds and lowered by west winds. Tidal variations in depth are normally 0.9 m. Surface currents usually flow from the Barents to the Kara at a rate of 0.25–0.5 kn. Figure 21 shows the general scheme of surface currents during the period of navigation for the entire Russian Arctic. Maxi-

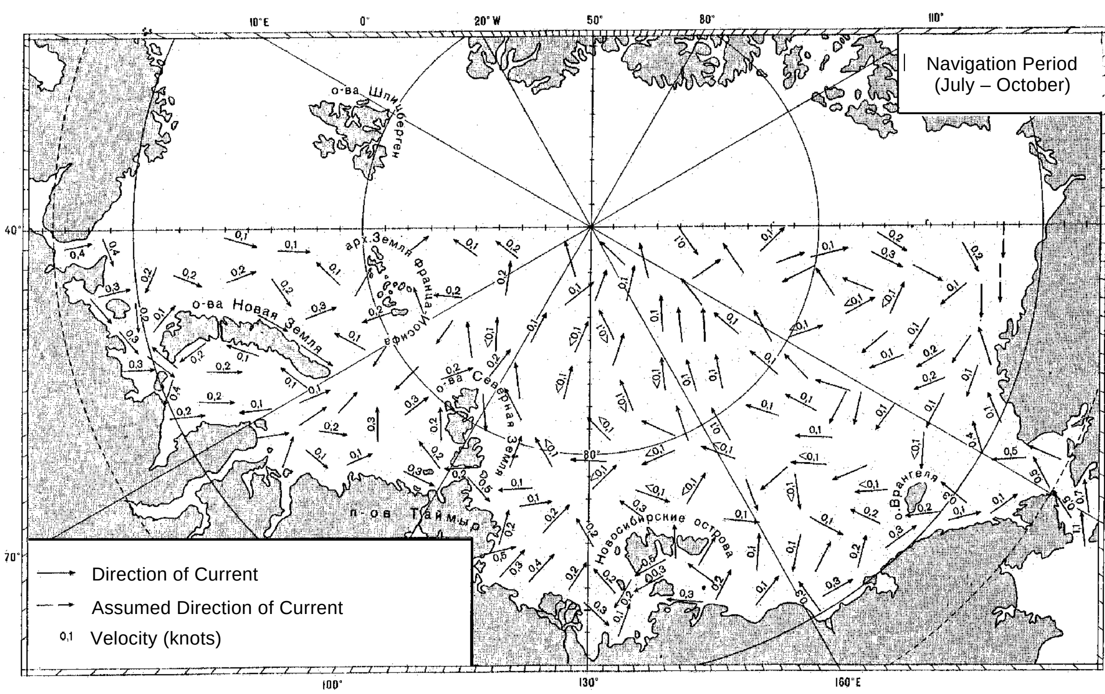


Figure 21. General scheme of constant surface currents (0–10 m deep) during the normal period of navigation (July through October). Constant currents are sometimes called "permanent currents" and are distinct from those due to wind and tides. They result primarily from the presence of water density gradients and can change with the seasons. (Translated from RSMOT, in prep.)

Table 10. Distances, in nautical miles, between waypoints along the NSR and other ports of interest (from Kjerstad 1994).

Tromsø	Tromsø																					
Murmansk	407	Murmansk																				
Arkhangel'sk	772	435	Archangel'sk																			
Yugorskiy Strait	848	578	659	Yugorskiy Strait																		
Kara Gate	799	523	607	65	Kara Gate																	
Matochkin Strait	678	466	617	320	260	Matochkin Strait																
Cape Zhelaniya	905	745	920	650	590	330	Cape Zhelaniya															
Dikson	1289	1013	1097	477	490	461	310	Dikson														
Dudinka	1619	1343	1429	807	820	791	640	330	Dudinka													
Igarka	1715	1439	1523	903	916	887	736	426	136	Igarka												
Vil'kitskogo Strait	1686	1410	1491	874	887	858	521	496	826	922	Vil'kitskogo Strait											
Khatanga	2234	1958	2039	1422	1435	1406	1069	1044	1374	1470	548	Khatanga										
Tiksi	2321	2045	2126	1509	1522	1493	1156	1131	1461	1557	635	786	Tiksi									
Sannikova Strait	2285	2009	2090	1473	1486	1457	1120	1095	1425	1521	599	770	325	Sannikova Strait								
Laptev Strait	2288	2012	2093	1476	1489	1460	1123	1098	1428	1524	602	773	210	93	Laptev Strait							
Pevek	2864	2588	2669	2052	2065	2036	1699	1674	2004	2100	1178	1349	819	579	609	Pevek						
Bering Strait	3350	3074	3155	2538	2551	2522	2185	2160	2490	2586	1664	1838	1390	1065	1110	558	Bering Strait					
Provideniya	3460	3184	3265	2648	2661	2632	2295	2270	2600	2696	1774	1948	1500	1175	1220	668	110	Provideniya				
Dutch Harbor	4150	3874	3955	3338	3351	3322	2985	2960	3290	3386	2464	2638	2190	1865	1910	1258	690	615	Dutch Harbor			
Valdez	4955	4679	4760	4143	4156	4127	3790	3765	4095	4191	3269	3443	2995	2670	2715	2063	1495	1420	805	Valdez		
Vancouver	5682	5406	5487	4870	4883	4854	4517	4492	4822	4918	3996	4170	4080	3755	3800	3248	2332	2241	1626	1210	Vancouver	
Vladivostok	5885	5609	5690	5073	5086	5057	4720	4695	5026	5121	4199	4373	3925	3600	3645	3093	2535	2425	1880	2680	4378	Vladivostok
Yokohama	6043	5767	5848	5231	5244	5215	4878	4853	5183	5279	4357	4531	4441	4116	4161	3609	2693	2583	2580	3380	4258	931	Yokohama

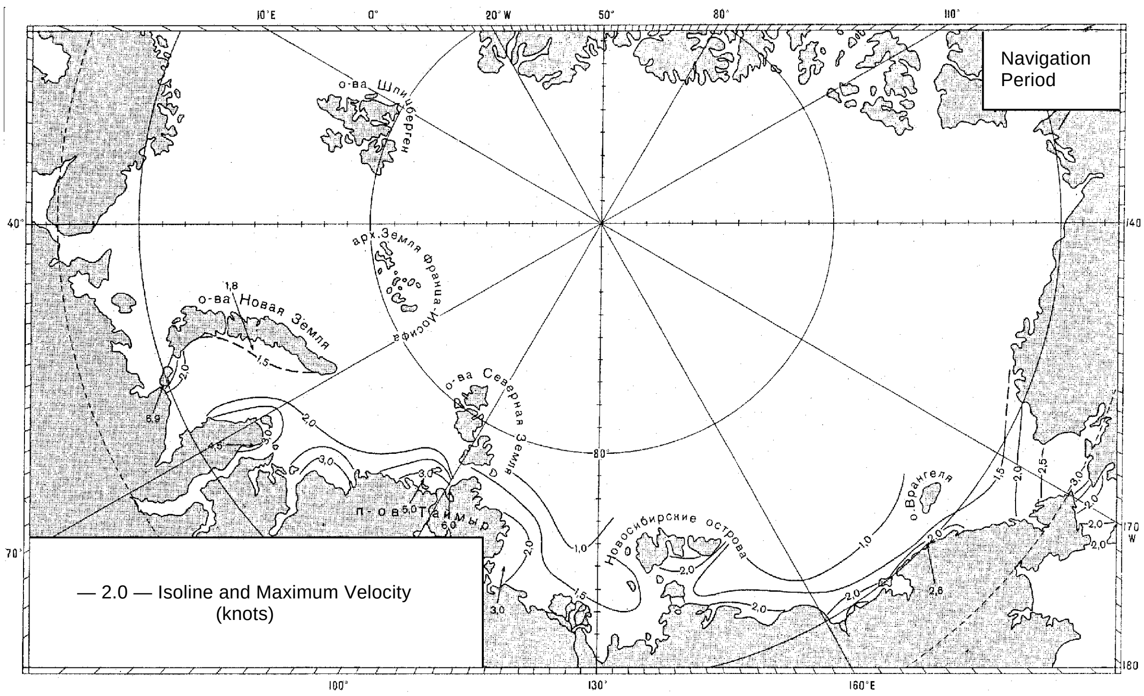


Figure 22. General scheme and maximum velocities of summary currents near the ocean surface (0–10 m deep). Summary currents are the resultant combination of all local currents (i.e., tidal current, wind-driven current, permanent current, etc.). (Translated from RSMOT, in prep.)

mum currents in the narrowest section of the strait due to semidiurnal tides are about 2.5 kn, while currents due to northeast winds can reach 4.5 kn, which can interrupt the tidal current. Figure 22 shows the general scheme of summary current velocities along the northern Russian coastline. Though highly variable, the mean date for ice breakup in the strait is June 28, and for the end of the navigation season it is November 23.

Karskiye Varota, commonly referred to as the Kara Gate, is the most often-used passage from the Barents to the Kara Sea. It is approximately 18 nm long and also trends in a southwest-to-northeasterly direction. Due to many islands, islets, and submerged obstacles, its fairway is reduced to less than 14 nm wide at its narrowest point. Surface currents trend from the Barents toward the Kara at a rate of 0.5 to 1 kn, but with a southwest wind they can reach 2 kn. Tidal currents are greatest in the western end of the strait, where they can reach 2.5 kn; they decrease in the middle section to as little as 0.5 to 0.75 kn. Ice conditions are highly dependent on those in the adjacent waters of the Kara Sea; northwest winds can quickly move the Novaya Zemlya ice massif in to block the east entrance. Heavy fogs and poor visibility are frequent throughout the archipelago region during any season of the year, but their occurrence reaches a maximum during July and August.

The Matochkin Shar Strait, currently closed to foreign vessels, is approximately 55 nm long, and trends west to east from the Barents to the Kara Sea. The strait cuts between the high mountains of the northern and southern main islands of Novaya Zemlya and is only a mile wide on average. Depths are very irregular throughout, but the minimum fairway depth of 12 m is found near the western end. Due to high intervening mountains, the weather conditions at the west end of the strait can be very different from those at its eastern end. Ice conditions, though usually mild at the western end, can be severe during east winds at the Kara Sea entrance due to the presence of the Novaya Zemlya massif. Tidal currents are quite regular, averaging about 2 kn, and reversing direction every 6 hours. In the narrowest sections of the strait these currents can reach 3.5 to 5 kn. Winds can affect the period and direction of the currents so that a change in regularity of the currents is an indication of the winds to be expected.

The *Vil'kitskogo Strait,* a west-to-east trending strait from the Kara to the Laptev Sea, is approximately 60 nm long and 30 nm wide at its narrow-

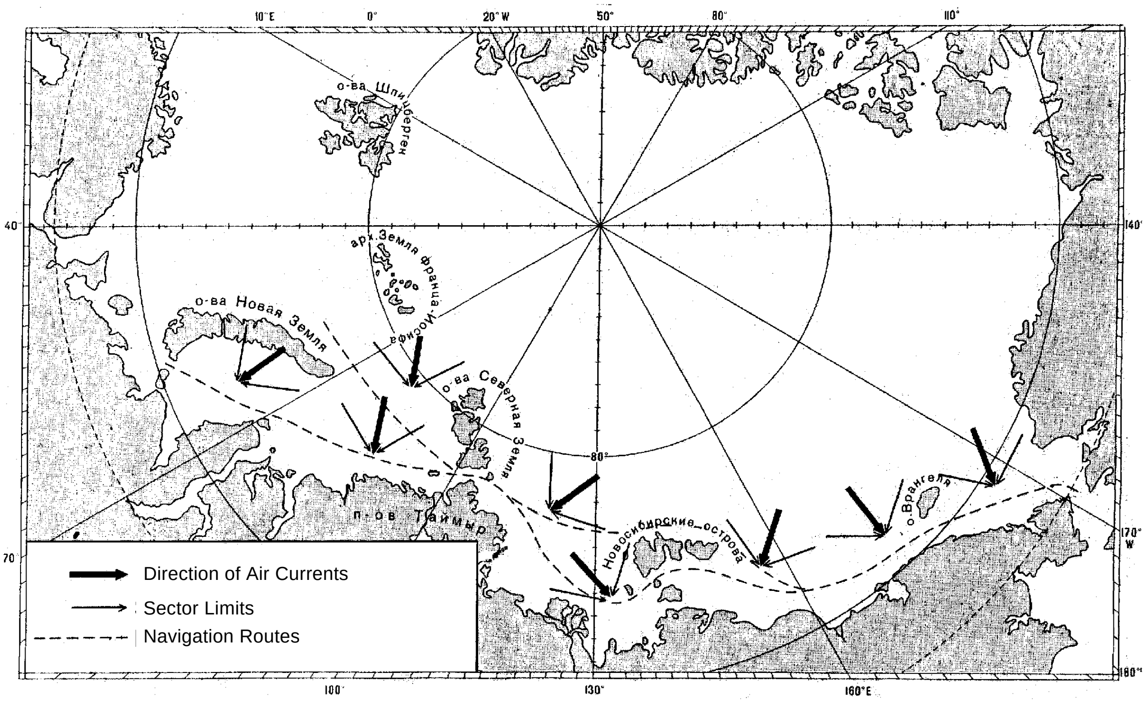


Figure 23. Location and ranges of wind directions that tend to create compacted ice conditions that are generally unfavorable for navigating along the NSR. (Translated from RSMOT, in prep.)

est point. The minimum depth of the fairway is reported to be greater than 25 m. RSMOT (in prep.) states that the depths are generally 100 to 200 m, except in the western approach where they are "somewhat less." It appears that depth throughout this strait is not a limiting factor for vessels of any size. A northeast current of 1.5 kn normally prevails in the strait but it can increase to 3 kn on a southwest wind. Ice conditions are highly variable in terms of location and can change rapidly, depending on the wind. The wind primarily determines the direction and velocity of the ice drift. West winds create difficult ice conditions in the western approach. Winds from other directions are generally more favorable. Figure 23 shows the general range of wind directions that create more difficult navigational conditions along the entire NSR.

The Shokal'skogo Strait, a passage between the Kara and Laptev seas that trends southwest to northeasterly, is 80 nm long and 10 nm wide at its narrowest point. Depths within this strait are not a limiting factor for shipping, as the minimum depth, which lies at the southwest entrance, is 37 m. Due to ever-present challenging ice conditions, Russian pilotage is mandatory for all ships using this strait. Severe magnetic variations of up to 54°E have been observed here.

The Dmitriya Lapteva Strait, a west-to-east trending passage from the Laptev to the East Siberian Sea, is the strait most often used by ocean-going traffic between these two seas. It is 63 nm long and 30 nm wide and separates the Novosibirskiy archipelago from the Russian mainland. Although the western part of the fairway is deep and clear of submerged obstacles, the eastern portion has several areas that restrict traffic to vessels with less than 6.7 m draft. This strait reportedly is not penetrated by heavy Arctic ice and that which is found there is only of the first-year variety. Navigating this strait during August and September is usually not difficult except during exceptionally cold years. RSMOT (in prep.), however, states that ice conditions in the vicinity are complicated and a principal hindrance to navigation. Passage is often only possible under icebreaker escort. Winds during July to September are relatively calm, averaging 3–8 m/s. East winds are the most settled and last from 1 to 10 days. The number of stormy days, with winds as high as 30 m/s, average 3 to 4 days per month in the western part of the strait and 1 to 2 days per month in the eastern part. Visibility is obscured by fog 15 to 19 days per month in July and August, decreasing to 8 to 12 days in September. The semidiurnal tidal fluctuation is only 0.1 to 0.3 m, but storm surge caused by northwest winds can be as much as 2.4 m in the strait. Constant currents under calm conditions are from the west at 0.1 to 0.3 kn. Under the influence of typical winds, currents are 0.2 to 1.3 kn and can change direction very quickly following a change of wind direction.

The Sannikova Strait, another west-to-east trending passage from the Laptev to the East Siberian Sea, is approximately 160 nm long with a fairway at least 16 nm wide. Minimum depths in the fairway are greater than 13 m. Severe ice conditions are often encountered, forcing a deviation from the recommended track through the strait. Deviations to the north are riskier in terms of submerged obstacles. Freezeup commences in early October and is complete by the end of the month. The ice, mainly landfast, remains in the strait until mid-July (the mean date of breakup is July 21) when strong or prolonged east winds favor its clearance. West winds tend to bring in heavy ice from the Laptev Sea. Depending on the ice conditions in the East Siberian Sea, final clearing in the strait can occur anytime from early August to late September.

The Longa Strait, an expansive passage separating Wrangel Island from mainland Russia, is the transition between the East Siberian and the Chukchi Seas. It is so wide that it is not treated as a strait by either DMA or RSMOT. That is, the sailing directions issued by both agencies are not explicit as to its west-to-east geographic limits or for specific hydrometeorological conditions to be found therein. Kjerstad (1994) lists southern and northern route variations through this strait as being 120 nm and 160 nm long, respectively. The directions given are for approaching either the mainland or the island, as opposed to navigating between them. Depths are apparently not of concern when keeping to offshore courses. In general, heavy accumulations of rubbled ice that make navigation difficult can be expected. Fog is also a challenge during the warm season. In both July and August the mean number of foggy days is 16, decreasing to about eight in September.

Navigation aids

Icebreaker escort

Operations while en route are monitored and strictly controlled by the regional MOHQ. The regulations issued by the ANSR describe the various modes of assistance that the MOHQ can require, depending on the severity of ice conditions:

- Shore-based pilotage, recommending routes for specific locations,
- Aircraft-assisted pilotage (fixed-wing and/or helicopter),
- Russian ice pilot on board,
- Icebreaker leading escort,
- Icebreaker escort with a Russian ice pilot on board.

Shore-based guidance is likely to be rendered at the beginning and end of a transit voyage, that is, in ice-free areas of the Barents and Chukchi Seas. The level of control and guidance increases with the severity of ice conditions, both existing and expected. "Icebreaker escort with ice pilot on board" is mandatory for the perennially difficult straits of Vil'kitskogo, Shokal'skogo, Dmitriya Lapteva, and Sannikova.

The shore route has been sectioned into six zones of varying environmental severity by Batskikh and Mikhailichenko (1993). Each has its own environmental character requiring different navigational tactics:

1. From Murmansk to Kolguyev Island (33° to 50°E longitude)—Generally ice-free or has only primary ice present. Ice-class vessels can ply on their own without icebreaker assistance.
2. From Kolguyev Island to the port of Makarova (50° to 85°E)—Navigation requires assistance by *Arktika*-class (75,000 shp) icebreaker through drifting first-year ice.
3. From Makarova to the northernmost mainland peninsula of Chelyuskin (85° to 105°E)—Navigation through fast ice under convoy of *Arktika*- or *Vaygach*-class (50,000 shp) icebreaker.
4. From Chelyuskin Peninsula to the Novosibirskiy Islands (105° to 140°E)—Ice conditions and tactics are similar to those for section 2.
5. From the Novosibirskiy Islands to Wrangel Island (140° to 178°E)—Navigation is through drifting first- and multiyear sea ice with *Arktika*-class icebreaker assistance. It is currently preferred to convoy a single cargo vessel using two icebreakers.
6. From Wrangel Island to the Bering Strait (178°E to 170°W)—Navigation is in drifting first- and multiyear sea ice under *Arktika*-class icebreaker convoy.

The above prescription shows that the critical section is from the Novosibirskiy Islands to Wrangel Island and the Longa Strait. Successful

NSR transit depends most critically on the ice conditions through this section; i.e., less consolidation and ice pressure, and the existence of leads, fractures, and polynyas.

Navigation charts

For this study, we investigated only U.S. and Russian sources for maps of the Northern Sea Route and, more specifically, hydrographic maps. Some maps of the Russian Arctic and Alaskan coastlines are produced by the Defense Mapping Agency (DMA). The Alaskan coastline is fully covered, and there is fairly good coverage of the Russian coastlines in the Chukchi, East Siberian, and western portion of the Barents Sea. Except for three large-scale maps, one each for the Kara Gate and the mouths of the Ob' and Yenisey Rivers, DMA currently has no coverage between 45° and 135°E (the White Sea to the Novosibirskiy Islands). We are not aware of any other publicly available maps for this area from U.S. sources.

According to Mikhailichenko,* Russian hydrographic charts covering the entire route are being declassified and made available for purchase from the Russian State Hydrographic Department under the Ministry of Transport. At the October 1992 Northern Sea Route Expert Meeting, held in Tromsø, Norway, Mikhailichenko provided a diagram showing 23 charts that were available at that time. We had extreme difficulty in obtaining them from Russian government sources. In November 1993, we contacted HydroCon, Ltd., a small, privately owned distributor of geographic products based in St. Petersburg, Russia. They informed us that the NSR nautical charts are actually issued by the Russian State Navigation and Oceanography Department under the Ministry of Defense, which had no policy for responding to one-time, small orders for their products. HydroCon acted as a facilitator in working through the official and unofficial bureaucracy to obtain the charts and arrange for their delivery. This exercise revealed the value of having an individual on-site in Russia to facilitate requests and negotiations. Face-to-face contact by one who speaks the language and knows the social system seems to be much more effective for producing the desired result than long-distance inquiries. Most of the maps were in Russian, with the exception of a few of the latest editions, which were bilingual. Their dates of issue ranged from 1984 to 1993, with most showing revision dates from 1990 to 1993. Their scales ranged between 1:10,000 and 1:2,000,000, with the majority scaled between 1:100,000 and 1:700,000. Figure 24 is an

* V. Mikhailichenko, 1993, Administration of the Northern Sea Route, personal communication.

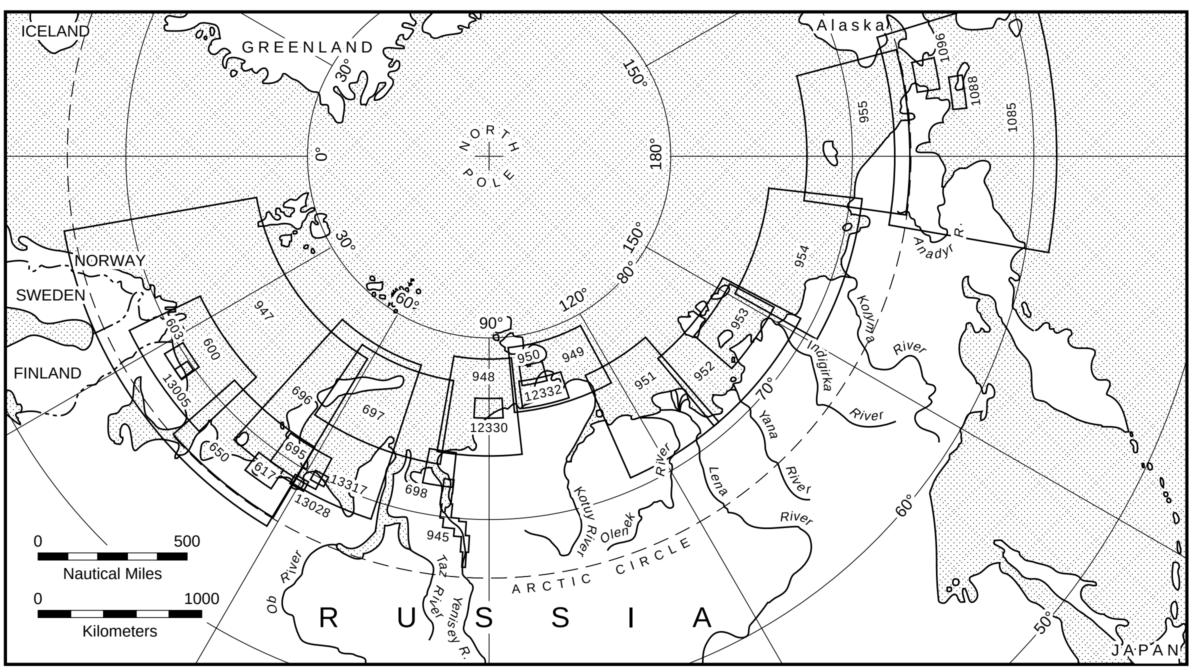


Figure 24. Declassified Russian hydrographic charts for the NSR, as of November 1993. Refer to chart number in Appendix D for a description of each map.

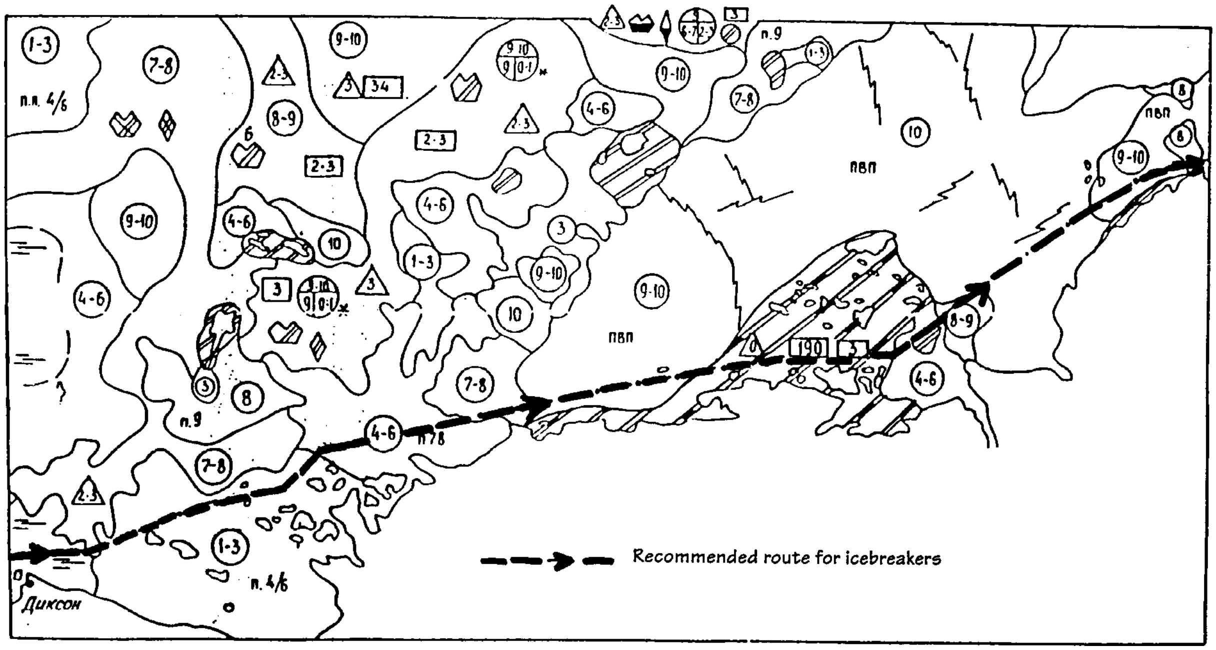


Figure 25. Russian ice chart and ship routing analysis for the coastal area between Dikson (lower left) and Cape Chelyuskin (upper right). It represents the ice conditions on 1 and 2 September 1990, and was integrated from satellite, aircraft, and icebreaker observations (from Buzuev 1991).

index map showing the coverage provided by the 1:100,000-scale and larger charts. Maps of the Yenisey River were 1:100,000, and several included inset maps of shoal and port areas with scales ranging from 1:10,000 to 1:25,000. The complete list of available hydrographic charts that were available as of November 1993 is included in this report as Appendix D.

Forecasting and routing

Russian efforts to maintain up-to-date weather, ice, and sea-state information along the Northern Sea Route include the use of satellites, shipboard helicopters, fixed-wing aircraft, shore-based and drifting ice stations, drifting buoys, and shipboard observations. The information is used in AARI models to produce both short- and long-range forecasts and ship-routing aids such as the ice map shown in Figure 25. Ice maps and routing recommendations from the Dikson and Pevek MOHQs are sent twice a week to the icebreakers and then relayed to the ships under their escort. Radio communications along the route are handled from seven communications centers located at Amderma, Dikson, Cape Chelyuskin, Tiksi, Pevek, Cape Shmidta, and Provideniya. The Provideniya center is operated by the Ministry of Merchant Marine, and the others are maintained by the State Committee for Hydrometeorology (Ushakov et al. 1991).

Ice mapping has been improved with the availability of high-resolution imagery from the European Space Agency's Earth Resources Satellite (ERS-1) platform. The Synthetic Aperture Radar (SAR) provides coverage with a resolution of 30 m that is independent of darkness and cloud cover. Nearly round-the-clock ice concentration mapping with a resolution of 30 km is possible using data from the U.S. Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I). Although these technologies are not yet in widespread use by the Russians, who rely primarily on data in the visual and infrared spectrum, SAR and SSM/I services are commercially available. Russian ice pilots can make expert use of the information if it is available aboard a foreign ship under their escort. In 1991, routing for *L'Astrolabe*'s transit voyage was the joint work of the Nansen Environmental and Remote Sensing Center (NERSC), the ESA, the Norwegian Space Center, and the Alaska SAR Facility. Ice maps made from the satellite products were telefaxed to the ship using the Inmarsat satellite telecommunications system. The time delay from satellite observation to shipboard reception of the maps ranged from 6 hours to 2 days. The quality and utility of the information was judged by the Russian ice pilots to be extremely good relative to their own products. The routing work that was done for

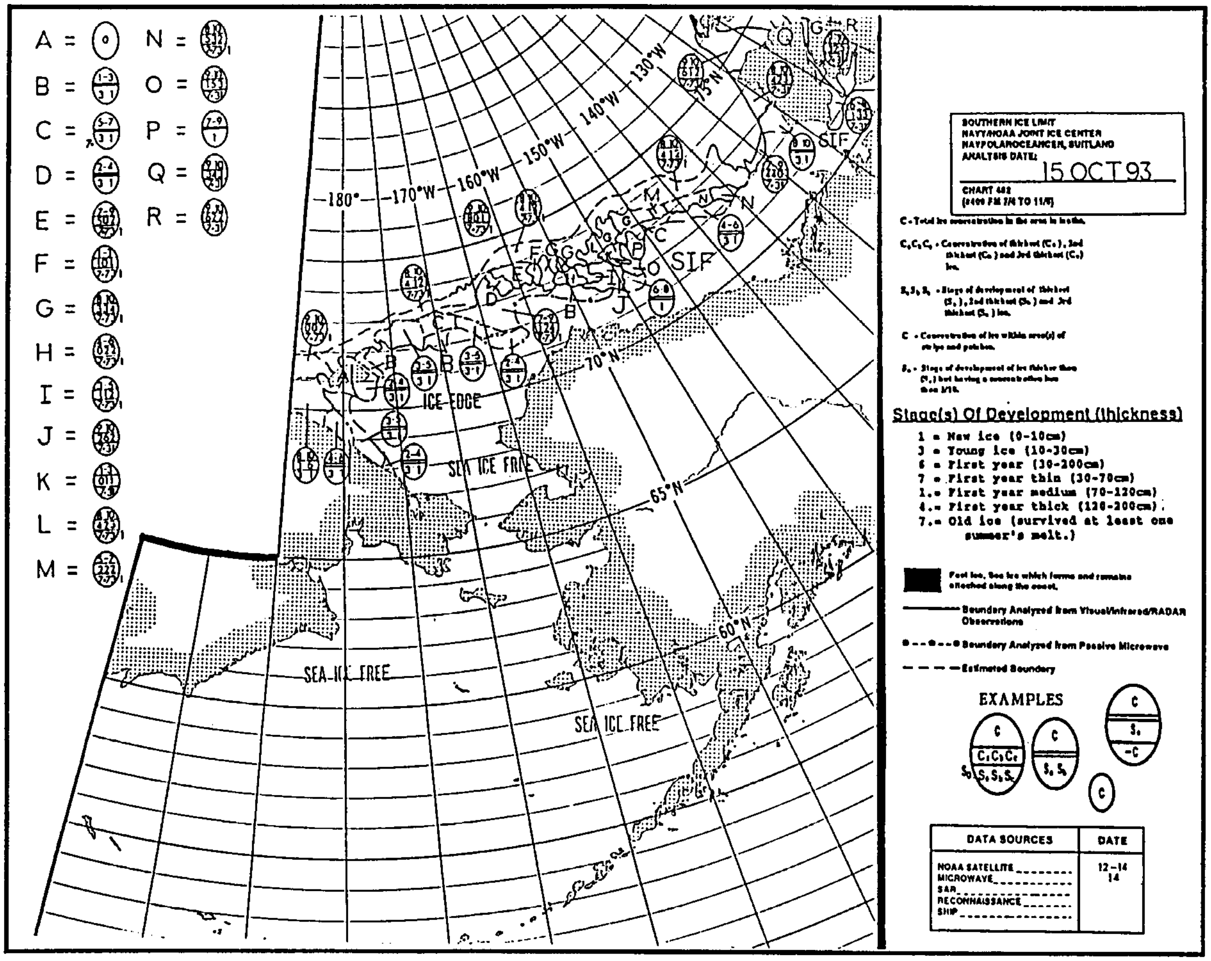


Figure 26. A portion of an Alaskan Regional Ice Analysis from the National Ice Center.

L'Astrolabe is described in a report by Johannessen et al. (1992).

The U.S. agency in charge of sea-ice analyses and forecasting is the U.S. Navy/NOAA's National Ice Center (NIC). It is the world's only organization that routinely provides global coverage, and its standard ice guidance products are available to the general public. Their data are derived from a variety of satellite-borne sensors, and their products include:

- A weekly, global-scale (1:10,000,000) analysis showing sea-ice extent, concentration, stage of development, and the location of leads and polynyas for the entire Arctic Basin;
- A biweekly, regional-scale (1:7,500,000) 30-day forecast of the above parameters;
- A long-range seasonal outlook for the west Arctic, issued each year on 15 May.

The agency maintains a convenient 24-hour, auto-polling system that subscribers can use to obtain analyses and forecasts in telefaxed form. Figure 26 shows a portion of their Alaskan Regional Ice Analysis that was produced for 15 October 1993. The NIC can also provide to any U.S. government agency more specialized guidance products, including ship routing recommendations, operational briefings, and aerial reconnaissance support. For example, Figure 27 shows a ship routing recommendation that was transmitted via satellite to the U.S. Coast Guard ship *Polar Star* en route from the Canadian archipelago to Point Barrow, Alaska, in September 1992. NIC provided latitude and longitude for each waypoint along the track and the distance and heading between each point. The figure shows several large ice floes that were avoided along the coastal route, resulting in a significant savings in time and fuel.

A complete description of NIC products and

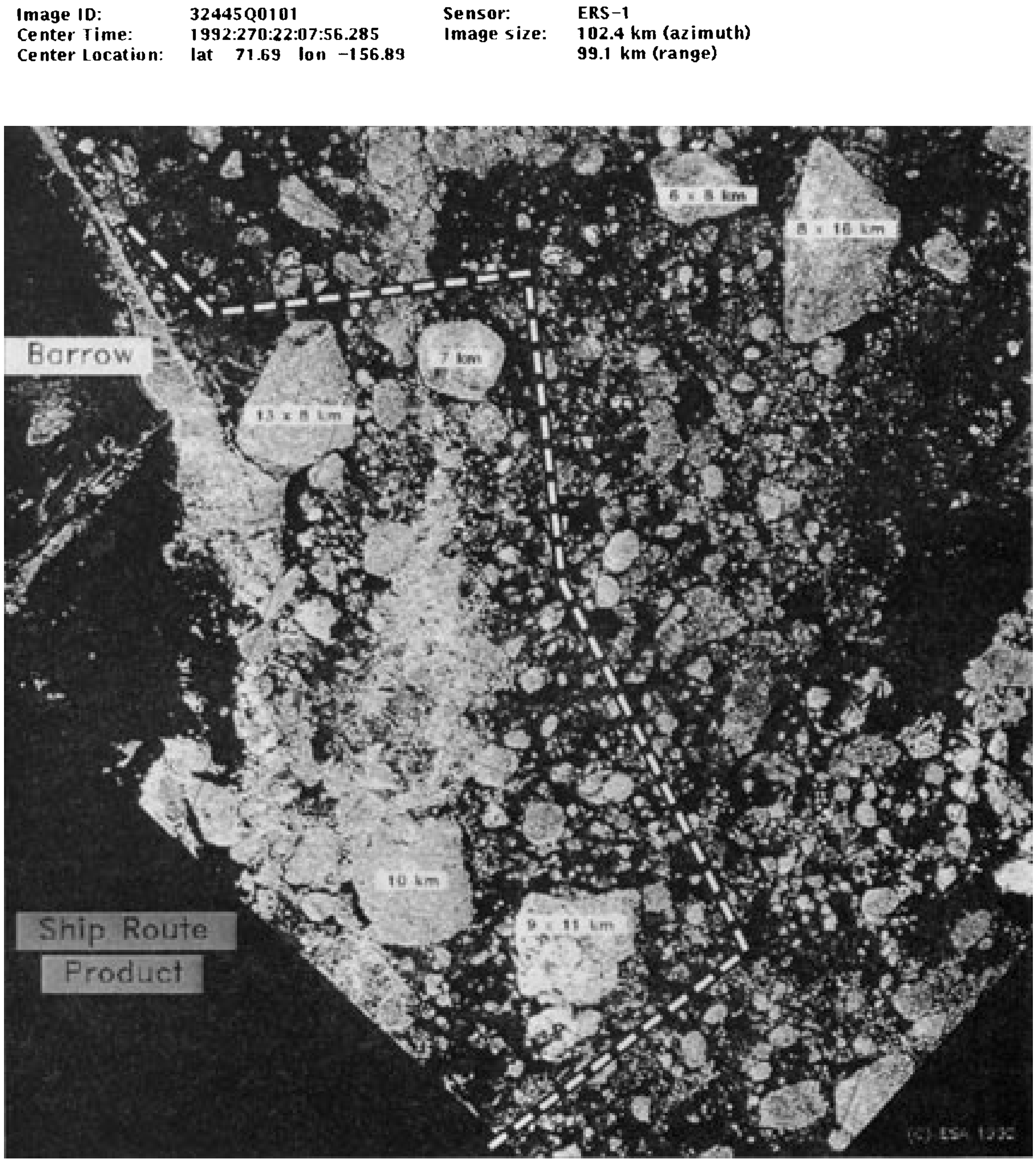


Figure 27. A specialized ship routing analysis from the Joint Ice Center. The image was produced in September 1992 using ERS-1 SAR imagery for the USCGC Polar Star, *which was en route from the Canadian archipelago to Pt. Barrow, Alaska. It was sent directly to the ship via satellite and recommends (dashed line) a route to avoid several large floes and ice consolidation areas. (Courtesy of the National Ice Center.)*

support activities can be found in USN/NOAA NIC (1993). This publication is currently undergoing revision to reflect recent transfer of weather forecasting responsibilities to other Navy centers. Weather forecasts and ship routing support to government agencies for the east and west Arctic regions have been transferred to the Naval Meteorology and Oceanography Command Centers in Norfolk, Virginia, and Pearl Harbor, Hawaii, respectively. The NIC products from previous years are archived on 9-track tape and are available upon request from either the National Climate Data Center in Asheville, North Carolina, or the National Snow and Ice Data Center in Boulder, Colorado.

Communications and positioning

Rosenberg (1993) reports that satellites make voice and fax communications available to ships in all areas of the Arctic below 80°N latitude. The Inmarsat system, for example, can be used to send and receive a variety of communications, including positioning and navigational information, ice and weather forecasts, and emergency and distress transmissions. This system enables the NIC's auto-polled products to be transmitted directly to ships. Various commercial firms also offer routing products that can be telefaxed regularly to client ships. For example, weather forecasts and route recommendations provided by OceanRoutes, Inc., were transmitted to a Finnish tanker for its three voyages from Arkhangel'sk to the Yana River in 1993. Laapio* of Neste Shipping reported that the OceanRoutes products were used and well regarded by the Russian pilot on board.

Extensive information about radio navigation and positioning systems in use on the Northern Sea Route is found in the NSR sailing guides by Kjerstad (1994) and RSMOT (in prep.). Ushakov et al. (1991) and Kjerstad (1992) state that, in the last 50 years, the Russians have installed more than 2,500 navigation markers, light buoys, light beacons, radio beacons, radar reflectors, and radar beacon responders throughout the Arctic. Radio navigation is by way of their hyperbolic MARS-75 system, which is similar in operation to the U.S. Loran-C system, though the two are not compatible. It has an operating range exceeding 1000 km from each of its three coastal links, providing essentially complete coverage of the route, and it has better than 250-m accuracy. This system is being phased out in favor of newer technology. The Chaika radio navigation system, which is compatible with Loran-S, operates for the Barents and Kara Seas.

Satellite navigation systems, such as the Navigator (U.S.) and the Glonass (Russian), which will provide continuous and global coverage, are currently in development. Their deployment is expected in 1995. Reporting on his experiments using a Global Positioning System satellite receiver aboard the SA-15 *Kapitan Danilkin*, Kjerstad (1992) concluded that coverage en route from Murmansk to the Bering Strait was continuous. He also stated that the ship had both Russian and Western navigation equipment installed. Improvements in both positioning and communications systems are ongoing.

* J. Laapio, 1993, Neste Shipping, personal communication.

RUSSIAN ARCTIC SEAPORTS

The role of ports under Soviet rule

The NSR is considered navigable year-round from Murmansk to Dudinka, except for the period May through June when the river ice is going out (DMA 1993). According to Østreng and Jørgensen-Dahl (1991), there were nine significant seaports along the NSR. These were Amderma, Dikson, Khatanga, Tiksi, Pevek, and Mys Shmidta near the coastline, and the ports of Dudinka and Igarka on the Yenisey River and Zelenyy Mys on the Kolyma River. They stated that there were also approximately 100 other locations where no permanent facilities exist but cargo is exchanged. One practice that is common along Russia's shallow Arctic coastline is on- and offloading of cargo directly from and to the ice using the ships' own lifting equipment. Where a ship's draft may be too great to enter shallow coastal waters, the fast-ice edge can serve for wharfing purposes. The ship is secured alongside or in the ice, and cargo is transferred to and from vehicles driven out to the ship.

Under the FSU, overall coordination and control of the marine and river ports systems rested with the ministries of the Merchant Marine and River Transport, respectively. These two ministries once centrally managed all water transport by determining investment decisions, service arrangements, productivity targets, and fees for services. Centralization made possible regional specialization. Most ports and cargo carriers were thus developed and managed for specific purposes in support of the overall Union plan. The day-to-day management of each port, however, was delegated to a single, regional shipping company. The Murmansk Shipping Company, for example, was responsible for the ports of Murmansk and Kandalaksha, and the Northern Shipping Company (based in Arkhangel'sk) controlled the ports of Arkhangel'sk, Amderma, Mezen, Nar'yan Mar, and Onega.

Aside from issues related to overall Union prosperity, most aspects of individual port management were the responsibility of the shipping companies. They managed and maintained everything related to water transportation in their respective regions. That is, they were responsible for port facilities, navigation aids, channel dredging, marine support, and so forth. In addition, they also provided for most of the social needs of their employees and families, such as operating schools and hospitals, providing housing, and managing farms and factories that produced goods totally unrelated to water transport. In some cases, these support services consumed a large percentage of the port's operating income. A European Bank report estimated that social benefits add approximately 40% to basic port labor costs; 35 to 40% of port operating costs went directly toward wages, and another 15% was consumed by social benefits (EBRD 1993). For example, only 15% of Arkhangel'sk's 1992 net profit of 160 million rubles remained for maintenance and investments after social expenditures had been deducted (Peters 1993).

Recent administrative changes

In January of 1991, Russia's ports were delinked from the cargo carriers in the advancement of decentralization and privatization. The new Department of Maritime Transport under the Ministry of Transport retained only a few of the port administration duties previously held by the government. The overriding assignment of each port's specialty role, the control of broad investment decisions toward that end, and the establishment of service charges officially continue to be controlled by the department. In actual practice, these reduced mandates are probably not being strictly adhered to since the department's manpower and funding shortages make enforcement relatively impossible. Port managers are frustrated that the fees for service established by the department are not keeping up with the rapid rise in the actual cost for delivering that service. It is more likely that more lucrative, albeit unofficial, business arrangements are being sought in the effort to generate desperately needed working capital.

The Department of Maritime Transport has recently established three categories of national seaports. The ten largest and most diversified ports, handling significant international trade, comprise Category I and are considered to be of the highest national importance. Forced privatization, or the turnover of port assets and operations to current port personnel, is being considered only for Category I ports. Nine of these ten ports are most likely those presented in a table of principal ports by Peters (1993), a portion of which is reproduced as Table 11. Category II is composed of 21 ports that are considered to be of regional importance, and their management will be transferred to regional jurisdiction. Most of these are located in the Pacific Rim region. Category III is composed of ten smaller ports that are considered to be of limited, local importance. Their organization and management will be placed in local hands. Most of these are found in the White, Azov, and Caspian Seas. We can only assume that the Arctic ports (with the exceptions of Murmansk and Arkhangel'sk) fall mainly into Category III due to their relatively low cargo turnover.

During the Soviet period, ports and transportation companies were supposed to cover operating costs out of revenues, and government subsidies were to be allocated to fund capital improvements and investment. Even this arrangement was unrealistic, for additional subsidies were required every year to fund basic operations. This was especially true in the Soviet Arctic where transportation is much more equipment- and labor-intensive. Now, not only have these subsidies been reduced and in some cases discontinued, but the government has also levied new taxes on port operators that are creating very difficult business conditions. None of the ports has sufficient reserves to maintain its current infrastructure, let alone invest in

Table 11. Cargo turnover, in millions of tons, and vessel traffic in Russia's largest ports for 1990 (from Peters 1993).

Port	*Total cargo*	*Liquid cargo*	*Dry cargo*	*Bulk cargo*	*Container cargo*	*Number of vessel calls*
Novorossiysk	43.6	34.5	9.1	6.9	—	1,176
Tuapse	14.6	12.0	2.6	2.2	—	851
Nakhodka	12.0	4.5	7.5	3.6	—	1,901
Vostochny	11.6	—	11.6	8.8	2.0	1,218
St. Petersburg	10.9	—	10.9	7.1	0.9	1,776
Murmansk	7.9	—	7.9	6.9	0.3	578
Kholmsk	6.7	—	6.7	0.6	—	

necessary improvements and modernization. Insufficient capital has allowed 40% of ship and cargo-handling equipment in all ports to become useless, and approximately one third of all quay walls are verging on collapse. Peters (1993) reports that about 85% of all profits would be necessary to just maintain current equipment in operating condition.

Even though all ports of the Arctic and Pacific Rim regions came under the control of Russia, several key, high-volume ports and cargo carriers in the Baltic and Black Sea regions were lost to other nations of the CIS. This reapportionment changed the national statistics dramatically, so that in 1992 a large segment of Russian sea trade was channeled through foreign ports (37%) and moved by foreign vessels (46%). Foreign handlers now require payment for services in hard currency, resulting in a serious drain of nearly US $3 billion equivalent. To stem this outflow, the Russian government responded quickly by redirecting freight shipment as much as possible through Federation ports and onto Russian ships. Approximately 50% of foreign trade is still moved on foreign vessels, which generally provide more efficient service at lower cost than domestic ships.

Privatization and profit-motivated management are not familiar concepts in Russia, and the drastic changeover is sure to cause many immediate problems. Industry analysts expect a period of upheaval and adjustment resulting in near-term lower port productivity and, in some cases, the closing of certain facilities. Viktor Miskov, president of FESCO, was recently quoted as saying "This type of privatization is totally wrong … they broke up the chain … Before taking this step, they should have taken into account the psychology of the people, traditions, even geography—the whole system we used to live in. Maybe it could be done in a few years time, but not now, not straight away." (Berenyl et al. 1994)

The government's policy to dissolve central control of port operations, eliminating state subsidies and allowing market forces to prevail, does not bode well for the industry, considering the current upheaval. Peters (1993) is especially concerned about the plan's viability for northern ports that have never been positioned to be commercially profitable. He points to high cost factors such as ice navigation, the short sailing season, sparse population, small cargo volume, and heavy non-transport-related social responsibilities as reasons for unprofitable shipping. Yet the importance of shipping in these areas is unquestioned. It is currently the only means for servicing these outlying regions, which are crucial for resource development and the hard currency it can generate in the form of exports. Though Peters' analysis of current conditions is certainly unsettling, it admits to disregard of international shipping, which could conceivably improve the regional outlook. Still, he presents a series of recommendations that appear promising for the future.

River shipping

In the Siberian North, river shipping is inextricably dependent on ocean transport. North (1991) provided the following general information on Russia's northern rivers. As important as it is for the regional economy, river navigation is limited each year by ice and low water. For example, many ports are inaccessible for most of the year due to the presence of ice, and spring ice breakup causes a two- to four-week idle period for most river ports. In general, rivers west of the Taymyr Peninsula are ice-free for an average of 120 days, and east of the peninsula the average is around 80 days. Variations of 20 days about these means are typical. Low water becomes problematic following spring runoff. Precipitation is sparse during the summer months so that watersheds are not replenished at a rate comparable to drainage. Rivers, particularly east of the Yenisey, are affected by a shallower line of permafrost that prevents the infiltration of snowmelt and rainfall. Consequently runoff is more rapid and water level fluctuations are more extreme. Small rivers are even more greatly affected. For the shallower and more upstream reaches, which comprise a large percentage of Siberia's total river mileage, the navigation season can be 30 days or less, assuming that the minimum depth needed is 0.6 m. Sporadic years of unusual dryness can limit navigation here to even a 10-day season. This inherently short season for river vessel movement coupled with its unpredictability must be considered when projecting when, how much, and what types of cargoes can be moved by water transport.

The Yenisey and Ob' are navigable by ocean-going vessels for approximately the same distance (to Igarka on the Yenisey), but the majority of the Ob's distance is a gulf. The gulf of Ob' is shallow, and transshipment to river craft takes place at roadsteads using floating cranes. Besides the inconvenience, the work is often interrupted by weather when conditions become too rough for smaller river craft. The Lena River delta is shallow, so that cargo has to be transshipped at nearby Tiksi, and then the small river craft are at risk in crossing open coastal water with uncertain weather.

Northern seaports

Sources consulted

This section summarizes information for Russia's northern ports that are currently open for foreign stopover or are scheduled to be opened at some future unspecified date. Several providers of port information were consulted, primarily Lloyd's of London in England (LLP), the U.S. Defense Mapping Agency (DMA), and the Russian State Ministry of Transport (RSMOT).

In addition, a computerized database entitled *Commercial Sea Ports of the CIS and Baltic States, and River Ports of Russia,* available from Russia's Central Marine Research and Design Institute (CNIIMF), is described in Appendix E. The CNIIMF database is currently available only in Russian and was not consulted for this study.

Ports of the World 1994 (LLP 1994) is a comprehensive directory that provides a wide range of navigational information on approximately 2,700 ports worldwide. It is updated annually, and its information includes each port's authority, physical description, navigation season, the type of cargo handled, facilities and accommodations, approach description, communication frequencies, and resident shipping agents. The directory lists altogether only 28 Russian ports, and only one, Igarka, is located on the NSR. Four of the ports are found on the White Sea (Archangel'sk, Kandalaksha, Mezen, and Onega) and two on the Barents Sea (Murmansk and Nar'yan Mar). As of July 1994, Igarka was the only port on the route that was officially open for foreign stopover. Information on northern Russian seaports from *Ports of the World* is included as Appendix F.

Another directory of ports worldwide that is published periodically is the *World Port Index* (DMA 1992a). It lists a total of 45 north coast and far eastern Russian ports (App. G). Twenty-four of these are located between the Norwegian–Russian border and the Kara Strait, and eleven more lie along the NSR (Fig. 28). Its wide array of information is presented in a table nearly 75 columns wide. The Defense Mapping Agency also publishes a series of sailing directions that provide detailed navigational information for harbors, coastlines, and passages of the entire world. These are periodically updated in regional volumes every 5 to 10 years with subsequent amendments between editions appearing in the DMA Weekly Notice to Mariners. *Sailing Directions (Enroute): Northern Coast of Russia* (DMA 1993) covers the region from the Norwegian–Russian border to the Bering Strait and was consulted for some of the information pre-

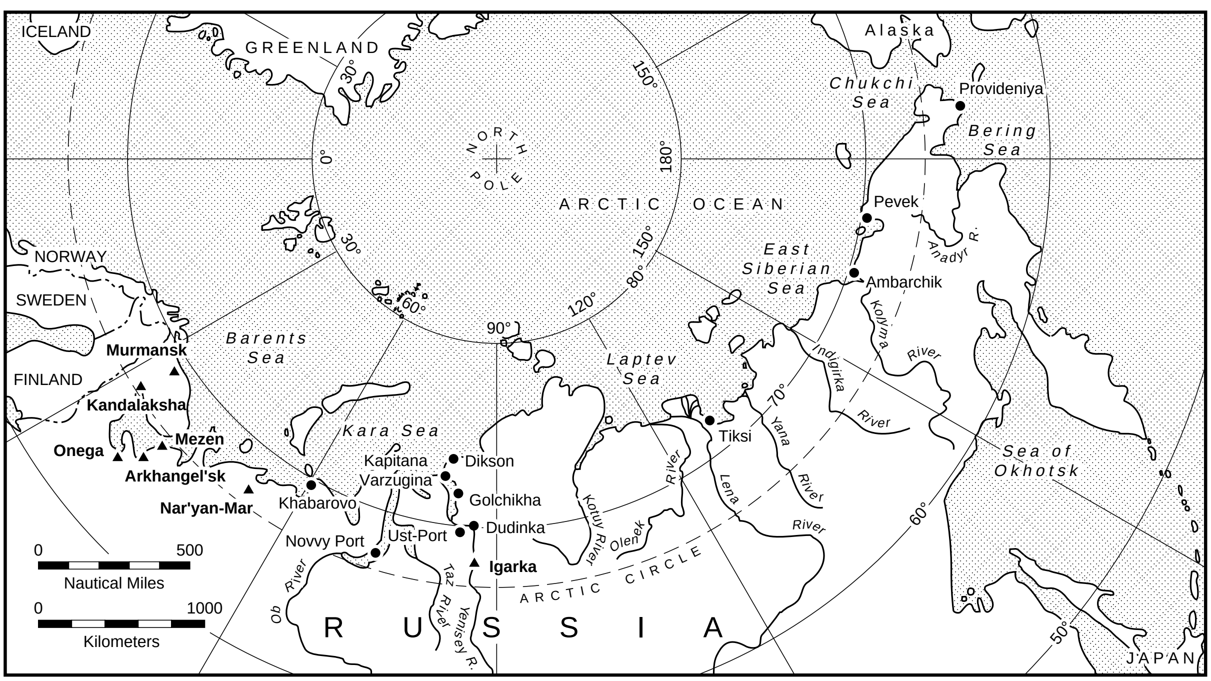


Figure 28. Russian Arctic seaports listed in DMA (1992a). Those in bold type and marked with triangular symbols are open for foreign stopover, as of July 1994.

sented in this chapter. The reader is also advised of the agency's *Sailing Directions (Enroute): East Coast of Russia* (DMA 1992b) for similar coverage from the Bering Strait to North Korea.

The scope of information provided by these LLP and DMA directories is similar although very different in format. LLP's port descriptions tend to be more literal and quantitative, and DMA's are coded and qualitative, employing indices for ranges of values. A comparison of the two descriptions for Igarka reveal differing lapses of data in each and sometimes disagreement (e.g., the location coordinates and minimum channel depth). The Igarka example indicates that both directories can provide important information that is not entirely available in either one. The LLP source book presently has little information about NSR ports. However, in time more will be learned, and this source should be much more useful in the future.

Another useful source of ports information, RSMOT's *Guide to Navigation on the Northern Sea Route*, was described in the Administration and Regulation section of this report.

Northern ports open for foreign stopover

For more than 50 years prior to 1991, the seas along Russia's northern coastline and its ports were closed to foreign shipping. In July of 1991, the first foreign ship since 1940, *L'Astrolabe*, was escorted across the entire Northeast Passage. At that time, the only Russian port that was officially open to foreign call anywhere along the official NSR was Igarka. The ANSR has been systematically easing restrictions and implementing procedures to allow greater freedom of movement of foreign ships through its territorial waters, which includes making more ports of call available along the route.

The list of Russian ports that have been officially opened to foreign stopover is published annually in issue No. 1 of the Russian *Notices to Mariners* (RSMOT 1994). The list appearing as Table 12 was reported to be valid as of July 1994.* What follows is information summarized from the above-named sources on those ports that are located along Russia's northern coastline.

Murmansk. Some sources consider the port of Murmansk to be the western terminus of the Northern Sea Route. It does play an important role as the home port of the Murmansk Shipping Company, the marine operator of the western half of the NSR. Situated on the eastern shore of the Kolskiy Gulf, approximately 24 nm from the Barents Sea, it is connected to the Baltic Sea via the White Sea–Baltic Canal. Murmansk is open year-round except for short episodes of heavy

* M. Maliavko, 1994, HydroCon, Ltd., St. Petersburg, Russia, personal communication.

Table 12. Russian ports open to foreign shipping, as of July 1994. Ports in boldface are those that have been opened since the latest edition of *Notices to Mariners* (RSMOT 1994).

Arctic seas:
Arkhangelsk, Igarka, Kandalaksha, Mezen, Murmansk, Nar'yan-Mar, Onega.

Baltic Sea:
Vyborg, Vysotsk, Kaliningrad, **Kaliningrad-Rechnoy, Brusnichnoye**, St. Petersburg.

Black Sea:
Anapa, Novorossiysk, Sochi, Tuapse, **Gelendzhik, Ozero Solenoye**.

Sea of Azov:
Taganrog, **Kerch, Yeysk**.

Caspian Sea:
Makhachkala.

Pacific Ocean:
Aleksandrovsk-na-Sakhaline, Beringovskiy, Vanino, Vladivostok, Vostochnyy, Korsakov, Korf, Magadan, Nakhodka, Nevel'sk, Nikolayevsk-na-Amure, Oktiabr'skiy, Okhotsk, Poronaysk, Provideniya, Reid Makarova, Bukhta Svetlaya, Uglegorsk, Khasanskiy, Kholmsk, Shakhtersk, **Sovetskaya Gavan', Petropavlovsk-Kamchatskiy, Anadyr', Bukhta Troitsy, De-Kastri, Komsomol'sk-na-Amure, Krabozavodsk, Kuril'sk, Lavrentiya, Mago, Pos'yet, Severo-Kuril'sk, Uelen, Yuzhno-Kuril'sk**.

weather and fog. November to February is generally the period with the most difficult weather conditions, but moderate gales can be expected two to four days every month of the year. Episodes of fog are heaviest from January to April. Ice normally begins forming at the beginning of January, attains its maximum thickness by the end of February, and is gone by mid-April. Icebreakers are available throughout the period to maintain ocean-going traffic. Springtime ice breakup on the Tuloma and Kola Rivers presents a brief challenge to navigation in May. The channel approach varies from 10 to 30 m, and depths alongside the 28 available berths range from 6 to 13 m. The tidal fluctuation is 3.7 m. The port can accommodate general cargo, container, and bulk cargo ships, ro-ro ("roll-on, roll-off" ship capable of transporting wheeled cargo such as trucks, trailers, or automobiles) and passenger ships, and tankers. Ships can be as large as 44,750 dwt, up to 202 m in length, and with 12 m draft. Murmansk, a city of about 500,000, offers provisions, bunkers, fresh water, and medical services; nearby highway, air, and rail transportation; and repairs for ships up 30,000 dwt. Berenyl et al. (1994) report that cargo throughput at Murmansk has decreased from 8.5 million tons per year to 6.5 million. His source states that large volumes of liquids are not handled there; only dry cargoes, including fertilizers (up to 4 million tons of apatite per annum in the early 1990s), ores, coal, grain, alumina, and containerized general cargo.

Kandalaksha. This port is located just inside the mouth of the Niva River, which empties into Kandalaksha Inlet and the White Sea. Kandalaksha Inlet forms the southern edge of the Kola Peninsula. The port is normally frozen over from early November to late May. Tides cause a depth fluctuation of 2.1 m, and tidal currents run between 0.5 and 1.5 kn. The depth of the approach channel and its berthing area is reportedly 4.9 to 6.1 m. LLP lists the maximum alongside-berthing depth as 8.5 m. Five berths with a total length of 288 m are available, the longest being 90 m. The maximum vessel size is not mentioned. Principal facilities are for dry bulk and general cargoes. Medical services, fresh water, and provisions are available, but bunkers are not. Only minor ship repairs can be performed. Rail service is available nearby, but there is no air service.

Onega. Located on the north bank of the Onega River, between 4.8 and 6.4 km upstream of its mouth on Onezhskiy Bay of the White Sea, Onega is a center for timber and sawmilling activities. Its principal export is timber, and facilities for handling general cargoes are available. The port is closed for 5 to 6 months of the year, and ships cannot winter afloat in the river as ice conditions prevail in the estuary and port area from early November to mid-May. In high water conditions, the channel will allow passage of vessels up to 124 m in length with drafts of 5.1 to 6.4 m. The tidal fluctuation is 2.7 m. The two largest berths are 470 m and 110 m in length with alongside depths of 6.1 m and 4 m, respectively. Cargo loading and handling is accomplished using the ships' own gear. There is rail but not air service nearby, and only limited ship repairs are available. Other services include medical, fresh water, and ship's provisions, but bunkers cannot be guaranteed.

Arkhangel'sk. Arkhangel'sk is situated on the east bank of the Severnaya Dvina River, about 28 nm upstream from its mouth on the White Sea. The port area extends nearly 30 nm along the river, comprising the entire navigable waterways and facilities of the river. Arkhangel'sk is one of Russia's largest and most important ports. The port is normally open from the end of April through November but can be used year-round by ice-classed vessels under icebreaker escort. Ice can occur from late October to mid-May and, depending upon the severity, the port may be closed periodically during the winter period. The river delta approach to Arkhangel'sk has three main branches among numerous islands and shoals. The channel depth is reportedly 6.4 to 7.6 m, but this is variable due to erosion and siltation. The tidal fluctuation is 0.6 m. There are a total of 35 berths with alongside depths of 7.8 to 9.6 m and facilities for tanker, container, general, and bulk cargo vessels. Ships up to 19,200 dwt, an overall length of 162 m, and a beam of 30 m can be accommodated. A wide array of stores are available by order. Bunkers and supplies of fresh water are available from offshore barges and lighters. Air and rail service is available nearby. Ship repairs are handled at floating docks for vessels up to 7000 dwt. Berenyl (1994) states that the three port areas of Arkhangel'sk can accomodate vessels with drafts of 8.0 to 9.2 m. Plans call for the construction of a methanol plant that will begin exporting up to 700,000 tons per year to the U.S. in 1995. He also reports that the construction of a new terminal is being considered to receive metals for export from the Cheropovets metallurgical plant and from Magnitogorsk.

Mezen. This port is located 35 km upstream on the Mezen River, which empties into Mezen Bay in the northeast region of the White Sea. It is only open from late May until October, and vessels may enter the port only on high water during daylight hours. The tidal fluctuation is reportedly 4.9 m. Mezen can only accommodate general cargo vessels up to 2930 dwt, 120 m in length, with 4.5 m of draft. Berthing length is limited to 200 m on pontoons near a timber mill. Vessels with 4 m of draft are usually grounded when loading timber. Loading is accomplished using the ship's own gear. Rail and air service is not available, and only minor ship repairs can be expected. A hospital is located in the town, and fresh water and provisions can be obtained. Bunkers are not guaranteed available.

Nar'yan-Mar. This commercial port is located on the south bank of the Pechora River about 70 nm upstream from its mouth on Pechorskaya Bay on the Barents Sea. It is normally open to navigation between late June and late October (120–130 days per year). Ice begins forming in the estuary in October, attains a thickness of 1 to 2 m by springtime, begins clearing in June, and is normally out by July. The permitted draft for port entry is about 4.5 m due to the bar that forms at the river's mouth, but this figure is set by the Port Authority at the beginning of each season. The tidal variation is 0.6 m. The port is primarily a timber exporting center, but other dry and bulk cargoes are handled, including grain, salt, metals, fish, coal, and cement. Four berths are available with a maximum alongside depth of 6.5 m. The maximum vessel length is 125 m. Provisions and fresh water are usually available, however, only minor ship repairs can obtained and fuel oil bunkers cannot be guaranteed available. There is medical and air service available, but no rail service.

Igarka. Igarka is situated on the east bank of the Yenisey River, 321 nm upstream from its mouth on the Yenisey Gulf. Its normal navigation season is from July to mid-November. Ice begins forming about mid-October. Igarka is the only NSR port now open for foreigner stopover; it is navigable for about 135 days per year. Interestingly, it lies 136 nm upstream from the port of Dudinka, which is navigable year-round but is not yet open to foreigners. Only those vessels with drafts less than 7.3 m can safely negotiate the river bars and enter the port. The largest vessel that can be accommodated is 14,203 dwt and 151.8 m length overall (loa). Tidal fluctuations are not a factor this far upriver, but depth fluctuations associated with runoff events can be as much as 15 to 20 m. The main wharf for the principal export, timber, is 300 m long with an alongside depth of 7.5 m where loading is accomplished using the ships' own gear. Twelve berths are available in the inner roads where vessels secure stern-on to the island. Provisions, bunkers, air, and medical services are available. Fresh water is obtained from the river outside the port area.

Northern ports slated for opening

The following section summarizes the information available on the ports of Dudinka, Dikson, Tiksi, and Pevek, which were identified by Mikhailichenko (1992) as slated for opening sometime in the future. He did not project when this would occur and, according to Maliavko,* they have yet to be opened.

Dudinka. Situated on the east bank of the Yenisey River approximately 185 nm upstream of its mouth on the Kara Sea, Dudinka is the largest Arctic port east of Arkhangel'sk. Near the port, the river is 1.25 to 1.75 nm wide, has low banks, and is subject to large fluctuations in depth. Permafrost prevents the percolation of rainfall, so runoff events are particularly flashy. Dudinka is evacuated and closed for two weeks or more during the ice breakup period in late June to early July to avoid ice and flood damage. The depth limitation for entering port is reportedly 7.6 m. The main wharf is 300 m long and is said to accommodate vessels of 10,000 gross tonnage. The main cargo facilities are primarily for minerals export. Medical and air services are available, and there is a railroad to Noril'sk. Although fuel oil is said to be available, ships' provisions, repairs, and water are not guaranteed.

Dikson. The port of Dikson, where the western Marine Operations Headquarters is based, is composed of a harbor indentation on the east side of Ostrov (Island) Dikson. The maximum permitted draft is 11 m. The general cargo wharf has two berths of 100 and 107 m with an alongside depth of 5.2 m. Including nearby Ostrov Konus, there are three coal piers of 38, 56, and 61 m in length with alongside depths of 3, 7, and 7 m, respectively. There are two petroleum berths, one 24 m long and the other 23 m. The alongside depth for both is 5.2 m. Medical facilities and air service are available, but rail service is not. Water, fuel oil, ships' provisions, and minor ship repairs can be obtained, as well as rescue service and communication equipment repair.

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* M. Maliavko, 1994, HydroCon, Ltd., St. Petersburg, Russia, personal communication.

Tiksi. The port of Tiksi is located on the west side of Tiksi Bay, an inlet just southeast of the Lena River delta. It is the largest coastal port actually situated on the NSR, and it is the transfer point for cargo going into and out of the Lena River. The port is generally closed by ice from mid-October to mid-July. Winds also have a large effect on the water depth in the bay. Strong north and east winds tend to raise the water level, and south and west winds tend to lower it; this wind-induced fluctuation can be as much as 1.2 m. Tiksi's main pier is 122 m long with 6.7 m depth alongside. Air service, water, fuel oil, and minor repairs are available, but rail service and ships' provisions are not.

Pevek. Pevek has approximately 10,000 inhabitants and is located on the northwestern side of Poluostrova (Peninsula) Pevek. It is the main outlet for extensive mining operations in that region. Its normal navigation season extends from June to September. Two wharves, one 260 m long and the other 215 m long with alongside depths of 7 m and 5.5 m, respectively, are used mainly for dry and bulk cargoes. An offshore pipeline berth services ocean-going vessels. Ships as large as 20,000 dwt have been accommodated. Air and medical services, water, fuel oil, and minor repairs are available, but ship provisioning and rail service are not.

VESSELS AND CARGOES

Types of vessels using the NSR

This section does not attempt to inventory the world's fleet of icebreakers and ice-strengthened ships that are using or might use the NSR. That task was the focus of a separate CRREL investigation (Sodhi 1995). We instead present recent and general information concerning vessels on the route.

The speed at which nonstrengthened ships would have to operate for an acceptable margin of safety practically eliminates anything but ice-strengthened vessels using the NSR competitively. In principle, only ice-strengthened vessels will be allowed to operate along the route. The ANSR regulations stipulate that vessels having at least an L1 ice classification under the Russian Register (or its equivalent rating under other registers) will be allowed to ply the route under the control of icebreakers. Special exceptions for less ice-resistant ships may be granted for transits through areas that are expected to be virtually ice-free. Regulations stipulate that vessels having an L2 classification may be permitted in areas west of 125°E longitude under favorable conditions, but they may go east of that line only into totally ice-free areas. Finally, vessels classified as L3 that were already in service and assigned to Arctic ports at the time the regulations were published (around 1991) may be permitted to operate during the summer period exclusively and only in ice-free coastal zones.

Shallow depths in several key locations effectively limit ships on the route at the current time to 20,000 dwt tons and less (Granberg 1992). Transit shippers must consider shallow waters overlying the far-reaching continental shelf, which extends seaward for hundreds of kilometers, and shallow passages between land barriers separating the various seas. The straits through the Novosibirskiy Islands, Sannikova and Dmitrya Lapteva, are 13 and 7 m deep, respectively. The high-latitude route variation to the north of the islands has no such depth limitation, but at the present time it is not reliably navigable to ensure regular passage. Cabotage and river shipping must also contend with shallow waters due to heavy silt deposition at coastal deltas and in riverine channels. Many coastal and river ports can only be approached by ships with shallow draft. Dredging is necessary at the deltas and within upriver shipping channels to maintain passage. Efficient cargo transportation in this region therefore currently favors the use of ships with high carrying capacity, reduced draft, and technological features (structural, mechanical, navigational, etc.) that allow some ability to operate independent of icebreaker escort.

The former Soviet merchant fleet was divided among the CIS such that 57% of both ships and the deadweight tonnage remained with Russia. Russia's entire fleet as of July 1992 consisted of 13.6 million dwt and 1433 ships (Table 13). Fifty-five percent of those ships and nearly 30% of the tonnage is made up of general cargo ships.

Currently the newest and most capable cargo ship in use there is the *Noril'sk*-class SA-15 (Fig. 4). It is a multipurpose icebreaking vessel of 20,000 dwt designed to carry up to 15,000 t of a variety of cargoes including containers, trailers, refrigerated cargo, and bulk material (e.g., ore, grain, coal). It is fitted with a stern ramp and 40-ton-capacity cranes (operable in –40°C ambient temperatures) that allow cargo exchange where pier facilities do not exist. The ships are 174 m long, have a maximum draft of 10.5 m, an operating range of 16,000 nm,

Table 13. Russian Federation shipping fleet as of 1 July 1992 (ships of 300 gross tons and greater) (from Holt 1993).

Ship type	*Dwt (000)*	*Number of ships*
Oil tankers	3,908.9	239
Chemical tankers	32.8	9
Liquid gas tanker	0	0
Bulk carriers	15,05.0	74
OBO carriers	16,11.6	18
Container vessels	4,84.6	40
General cargo vessels	39,23.9	793
Reefer vessels	1,055.1	190
Ro-ro ships	1,072.5	70
Total	13,594.4	1,433

and travel at 17 kn in open water when fully loaded. They are ice-classed as ULA, the highest freighter rating in the Russian Registry, and are able to operate independently and continuously at 2 kn in 1-m-thick ice. Special ice navigation features include air-bubbling and water jetting systems and a low-friction hull coating to enable easier passage. The two Finnish yards of Wartsila and Valmet produced the first 14 of these ships, the first of which, the *Noril'sk*, was completed in 1982. Five more were built between 1985 and 1987. As of July 1994, these 19 were owned by the Murmansk, Far Eastern, North Bulk, and Sahkalin shipping companies and were operating along the NSR.

Principal Arctic shipping companies

The Russian Federation's nine principal shipping companies, their respective fleets, and their trade patterns are listed in Table 14. Peters (1993) has compiled a paragraph of specifics on each of those listed. His descriptions, with additional information extracted from Berenyl et al. (1992, 1994), for those companies that operate in the Arctic and Far East follow.

Arctic Shipping Company

The Yakutsk Production Organization was reorganized in March 1991 and became known as the Arctic Shipping Company. The company's headquarters are in Tiksi, which is located near the Lena River estuary on the Laptev Sea. Its gross revenues in 1990 were 40 million rubles. Payroll staff involved in transport operations and cargo management comprises 1660 employees. The fleet consists mainly of general cargo ships, many of which are "ice-class." The average vessel cargo-carrying capacity is under 4000 dwt.

Far Eastern Shipping Company (FESCO)

The Far Eastern Shipping Company is involved in domestic sea transportation service along the Pacific coast from Posyet in the south to Pevek on the East Siberian Sea (28% of all activities), in bilateral trade (65%), and in regular liner cross trade (10%). The company is a well-established and well-regarded carrier with a diversified organization and service network. Its headquarters are in Vladivostok, and it employs a staff of close to 19,000. FESCO is the largest of Russia's Far East ship owners, having a fleet of over 225 vessels totalling 1.8 million dwt. Universal cargo vessels make up 40% of its fleet, and timber carriers another 20%. The fleet includes 21 container vessels (less than 15,000 dwt average capacity), 88 general cargo ships (3000–12,000 dwt), 39 timber carriers (4000–6000 dwt), 15 reefer vessels (5500 dwt average), and seven dry bulk carriers (12,000–15,000 dwt). Until 1991, the company was functionally responsible for the ports of Nakhodka, Vladivo-

Table 14. Russia's principal shipping companies, their fleet composition, and trade patterns as of 1991 (from Peters 1993).

	Fleet composition		*Trade distribution*	
Company	*Tonnage (000 dwt)*	*Number of ships*	*International (000 tons)*	*Cabotage (000 tons)*
Arctic	94.4	25	223	452
Baltic	1,920.6	178	11,509	Negligible
Far Eastern	1,846.2	228	10,243	6,584
Kamchatka	220.4	53	330	2,939
Murmansk	929.3	78	5,675	2,895
Northern	673.0	135	5,299	660
Novorossiysk	5,321.8	112	46,093	790
Primorsk	597.8	53	2,171	4,887
Sakhalin	419.4	88	2,574	10,231

stok, and Vostochny, and it continues to maintain managerial links with the Nakhodka, Slavyanka, and Vladivostok ship repair yards.

Kamchatka Shipping Company

The Kamchatka Shipping Company's fleet has declined to 45 to 50 ships totalling 220 million dwt. It provides regular liner service from the Kamchatka Peninsula to Japan (timber) and the Koreas (cement). However, its main activities involve services to and from ports in the Federation's northeastern region. The company is headquartered in Petropavlovsk–Kamchatsky and employs about 4500. The fleet consists mainly of general cargo ships with ice-strengthened hulls and an average carrying capacity of under 4000 dwt. Although officially freed from port responsibilities, the carrier continues to be managerially involved in the ports of Petropavlovsk–Kamchatsky and Ust-Kamchatsk, as well as in the Petropavlovsk ship repair yard. The company faced closure sometime in late 1994 or early 1995, but that has been forestalled by a recent agreement with a South Korean company to lease some of Kamchatka's idle ships. It is also trying to branch out from its previous nearly exclusive role as a cabotageur and develop cross-trading with Japan and South Korea.

Murmansk Shipping Company (MSC)

The Murmansk Shipping Company has a sizable fleet of ice-class vessels that provide supply services to the Arctic region. It also assists in keeping sea routes open. The company has a diversified service network that extends all over Western Europe and the Mediterranean. It is headquartered in the city of Murmansk, and has about 9000 on its payroll. The fleet does not include cellular container tonnage, but nine rather large ro-ro carriers (about 20,000 dwt average) provide container carrying facility. The fleet distinguishes itself also by having 31 dry bulkers of 18,000–22,000 dwt, which are large by Russian standards. Furthermore, there are 24 general-cargo ships in the 4000 dwt range. Before 1991, Murmansk Shipping was functionally responsible for the ports of Kandalaksha and Murmansk, and the ties with both ports remain strong. MSC's trade has recently fallen off three-and-a-half-fold due to the high cost of Arctic shipping and the closing of Russia's Arctic research and meteorological stations, which it kept supplied. The company entered into a joint arrangement, known as Arctic Shipping Services, with Neste Shipping of Finland in 1993 to ship petroleum products and move equipment for oil and gas exploration activities to northern settlements.

Northern Shipping Company

The Northern Shipping Company, one of Russia's oldest shipowners, is mainly involved in the transport of sawn timber, cardboard, and pulpwood from northern latitudes to Western Europe, the Mediterranean, Africa, and the U.S.A. It has a fleet of 106 timber carriers ranging from 1 to 17 years old. Limited quantities of dry bulk and general cargo are also carried. Its cabotage trade was once at 6 million tons per year but that is down threefold and now its primary trade is international. More recently, the company has begun engaging regular container services to Western Europe. Northern Shipping's homeport is Arkhangel'sk, where it employs about 9800 in transport operations and cargo management. Its fleet is relatively large, including nine dry bulkers of around 14,000 dwt and more than 100 general cargo ships in the 2500–6000 dwt range, which is typical of the Russian multipurpose fleet. Before 1991, the company was responsible for the ports of Amderma, Arkhangel'sk, Mezen, Nar'yan Mar, and Onega. With the exception of Arkhangel'sk, it remains closely involved in the management of the ports, as well as in the operations of the Krasnaya-knuznitsa and Layskiydok ship repair yards.

Primorsk Shipping Company (PSC)

The Primorsk Shipping Company, established in 1969 as the tanker division of FESCO, became independent three years later. Though its main activities were once related to cabotage services along Russia's Pacific Rim, it has been freed to pursue international, or cross, trade, particularly with the Far East. PSC's fleet consists exclusively of oil and liquid product tankers. It is a carrier of oil and petroleum products, vegetable oils, molasses, and similar cargoes to Japan and South Asia, East Africa, and Europe. PSC's headquarters are in Nakhodka, with about 4500 staff involved in transport operations and cargo management. Of these vessels, 20 have a capacity between 14,000 and 20,000 dwt, and the balance is in the 4000 to 6000 dwt range. The average age of its 40 tankers is only 12 years.

Sakhalin Shipping Company (SASCO)

The Sakhalin Shipping Company, founded in 1945, is the Federation's key cabotage operator, with much emphasis on sea–rail ferry services. Its service network includes all of Russia's Far Eastern provinces and the Arctic region. The company is also competing with FESCO for international cargo, providing regular services to ports in China, Japan, and Southeast Asia. Its administrative seat and home base are in Kholmsk, on Sakhalin Island. Payroll staff comprises almost 6250 employees, of whom only 1455 are assigned to transport and cargo management functions. The fleet includes several gas carriers of 1500 dwt, a variety of vessels with mixed cargo–passenger configurations (usually less than 3000 dwt), two 20,000 dwt ro-ro vessels, and a pool of general cargo ships in the usual 3000 to 5000 dwt range. Although nominally freed from port responsibilities in 1991, Sakhalin Shipping continues to provide much management cohesion in the ports of Alexandrovsk, Kholmsk, Korsakov, Krasnogorsk, Nikolayevsk, Poronaysk, Uglegorsk, and Vanino.

Cargoes

Alexander Granberg, an economic advisor to the Office of the President of the Russian Federation, provided the following encapsulated observation on both the importance of the NSR for the Russian economy and the type of products that are being shipped from the region:

> The Northern Sea Route is instrumental in the flow of goods into and out of Russia's northern regions, which are estimated to bring in 60% of the entire country's hard currency revenue. In 1988 the northern deposits accounted for the Soviet Union's entire production of diamonds and apatite and more than half of its production of gold, nickel and tin. The oil and gas fields of northwestern Siberia supplied 65% and 62%, respectively, of the Soviet Union's entire oil and gas production. Today, the shipping of raw timber and nickel ore from the Yenisey River ports of Igarka and Dudinka, respectively, makes up the bulk of tonnage in transit along the western NSR. (Granberg 1992)

A recent study for the Finnish shipping industry (Arpiainen 1994) estimated the potential cargo volumes that might be shipped via the NSR based on current trade flows. That study's region of interest was limited to routes having at least a 20% distance advantage over the canal routes. This criterion allowed consideration of the European locations of Great Britain, Germany, The Netherlands, and Scandinavia; Far Eastern locations of Japan, the Koreas, and northern China; and West Coast North American ports lying north of the U.S.–Canadian border. The study estimated that the total cargo potential between northern Europe, the Far East, and North America is approximately 20 mt. Arpiainen further estimates that this tonnage would employ a fleet of 100 dedicated ships, assuming an average vessel size of 20,000 dwt and five round-trips annually per ship. These figures reflect the total cargo currently moving between these regions and perhaps unrealistically assumes all of it would be diverted to the NSR. It does, however, provide a planning estimate. Not reflected in the estimate is the additional cargo traffic that might be generated by increased NSR shipping, increased competition, and decreased costs due to economies of scale. Another speculation by Arpiainen is the extent to which established trading patterns will be altered by the availability of the new route. It is likely that increased traffic along the NSR would generate new trade agreements for Russian products that have not been widely available to world markets in the past. For example, shipments of coal and timber to Europe from Canada would be replaced to some degree by Siberian shipments due to their greater proximity.

There are four broad categories of trade that will ply the route, and each has its own set of cargoes. These are exports, imports, cabotage, and transit cargoes.

Exports

Exports are domestic Russian products shipped from NSR ports to other countries for consumption. These consist mainly of raw and intermediate materials that will be processed into finished goods in other countries. Exports most significant to the Northern Sea Route are from Siberia's storehouse of raw wealth. These include raw fuels (coal, oil, natural gas, oil shale, peat), bulk ores (iron, copper, nickel, bauxite, titanium, cobalt), bulk minerals (apatite, sulphur, sodium chloride, mica), raw materials (timber, building stone, alumina, calcite, other materials used for making glass, cement, and brick), and precious metals (gold, diamonds, rare earths). Cruise tourism, which has great potential for the region, can also be considered an export because it brings foreign currency into the country.

Imports

Imports coming into the Russian Arctic and Pacific Rim ports via the NSR will be a relatively minor segment of total cargo flow. The low population density and lack of hard currency will be an impediment to foreign imports to this region. Modest shipments of construction equipment, oil and gas exploration equipment, general, and containerized cargo are necessary for the raw material extraction activities of the region. The majority of these supply shipments will be cabotage; any imported cargoes will have been broken down into smaller loads at domestic ports for distribution to the settlements.

Cabotage

Cabotage cargoes are products that are transported from one Russian coastal port to another. Cabotage consists of both materials bound for export that are shipped to larger domestic ports for consolidation, and imports that are distributed from domestic break-bulk points to smaller ports. These products are typically raw or bulk materials bound for industrial processing centers, fuels (both raw and finished), construction equipment and housing materials, finished goods, foodstuffs, and general cargo to supply outer settlements. Sand and gravel, grain, coal, and fertilizer are major cabotage goods. Fish and reindeer meat are northern food exports that are important to the indigenous economies. The transfer of railway freight to large, Pacific Rim island population centers (Sahkalin and the Kurils) via ferry transport accounted for 73% of all Federation cabotage in 1992.

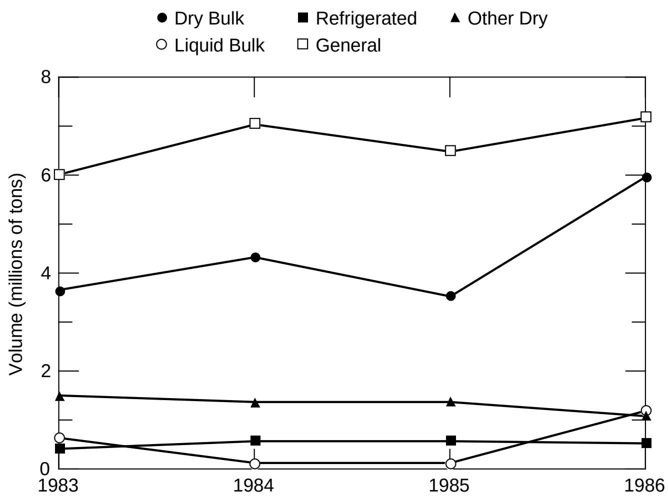

Figure 29. Trade volume from Europe to the North Pacific region by cargo type (from Arpiainen 1994).

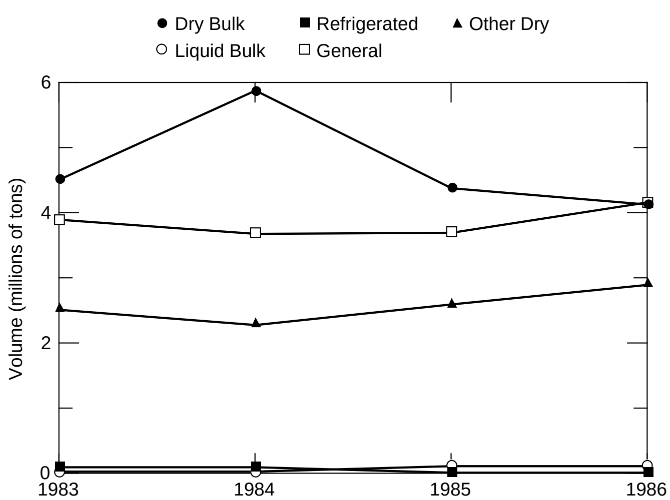

Figure 30. Trade volume from the North Pacific region to Europe by cargo type (from Arpiainen 1994).

Transit cargo

Transit shipments are those that traverse the NSR but originate and end outside its bounds. They utilize the route only as a convenient path of progress between the North Atlantic and North Pacific regions. Ideally, they would bypass all intermediate ports in the interest of saving time, but they would still require icebreaker escort and rely on Russian facilities or services along the way in an emergency.

Arpiainen estimates that potentially 10 mt of cargo would transit the route annually, including 4 to 5 mt of dry bulk cargo, 2 mt of container cargo, and 1 to 2 mt of other cargo. This is a small figure compared with the cargo that moves through the Suez Canal (280 mt) and the Panama Canal (160 mt), so it is unlikely that canal authorities would adjust their passage fees to appreciably alter traffic flows to the NSR.

Figures 29 and 30 show the composition of trade between Europe and the North Pacific as reported by Arpiainen (1994). Potential cargoes from the North Pacific to the North Atlantic include coal, ores, grain, timber (logs and sawn), automobiles, pulp and paper waste, and container goods. Potential cargoes in the reverse direction include container and general cargoes, foodstuffs (raw and processed), and refrigerated food products (seafood, meat, dairy products, fruit, and vegetables).

SHIPPING COSTS

It should be emphasized that few foreign ships have undertaken an NSR voyage, so

Table 15. Recent voyages with foreign involvement (from Armstrong 1991, Kjerstad 1992, Brigham 1991a, Matyushenko 1992).

Year	*Ship/flag*	*Begin – end*	*Comments*
1967	*Novovoronezh* USSR	No. Europe – Yokohama	Soviet ship with foreign cargo
1967	*Dubno* USSR	No. Europe – Japan	Soviet ship with foreign cargo
1967	*Ustyuzhna* USSR	No. Europe – Japan	Soviet ship with foreign cargo
1989	Several transits USSR	Hamburg – Osaka	Soviet ships with foreign cargo
1990	6 transits USSR	No. Europe – Far East	Soviet ships with foreign cargo
1990	*Rossiya* USSR	North Pole trip	Foreign tourists on Soviet icebreaker
1991	*L'Astrolabe* France	Murmansk – Provideniya	1st foreign ship transit allowed since 1940
1991	*Dagmar Aen* FRG	Nar'yan-Mar – Igarka	Foreign ship with no ice classification
1991	*Kapitan Danilkin* USSR	Norway – Hong Kong	Soviet SA-15 with Norwegian cargo
1991	*Kapitan Danilkin* USSR	Malaysia – Murmansk	Soviet SA-15 with foreign cargo
1991	*Tiksi* USSR	Hamburg – Chiba, Japan	Soviet ship with foreign cargo
1991	*Sovietskiy Soyuz* USSR	North Pole trip	Foreign tourists on Soviet icebreaker
1991	8 other voyages USSR	Various	Russian ships with foreign cargo
1992	*Sovietskiy Soyuz* Russia	North Pole trip	Foreign tourists on Russian icebreaker
1992	Freighter Russia	Vancouver – Tiksi	Russian ship with foreign cargo
1992	*Sovietskiy Soyuz* Russia	2 North Pole trips	Foreign tourists on Russian icebreaker
1993	3 round-trip voyages Finland	Arkhangel'sk – Yana River	Foreign tankers with Russian cargo
1993	SA-15 Russia	New Westminster, BC – Novvy Port	Russian ship with foreign cargo
1993	SA-15 Russia	Hamina, Finland – Japan	Russian ship with foreign cargo
1993	*Yamal* Russia	3 North Pole trips	Foreign tourists on Russian icebreaker
1994	*Yamal* and *Kapitan Dranitsyn* Russia	North Pole trip	Foreign tourists on Russian icebreaker
1994	*Yamal* Russia	2 North Pole trips	Foreign tourists on Russian icebreaker

there is little international experience to draw upon. Further, the economic, social, and political instability in Russia makes the future uncertain: past experience does not necessarily reflect the future. There are reports that the fees are highly negotiable and depend more on the type of cargo than on actual cost of services (Armstrong 1989).

Armstrong (1990) reported complaints of flat rate charges for icebreaking services without regard to the amount of work done. He has reported more recently on wage and labor disputes (1990, 1991, 1992b) and difficulties in arranging resupply voyages due to lack of operating funds and "enormous" insurance rates (1993).

There does not appear to be an established protocol at this time. Arrangements between foreign parties and the Russian shipping companies (MSC and FESCO) are negotiated on a case-by-case basis. ANSR officials, when questioned at the 1992 Northern Sea Route Expert Meeting, replied that the transit tariffs were open to negotiation, depending on the specific shipping task, and would compare favorably with alternative canal routes and transport by rail. Although there are problems to be overcome, and the costs appear to be in a state of flux, Administration officials were clearly open to and inviting of cooperative discussion. That being the case, it might be useful for potential NSR users to obtain information from other foreign parties that have already used the route (refer to Table 15). The annual summaries of NSR activities that are published in *Polar Record* by Terence Armstrong following each shipping season are another source of information. These usually include reports of foreign involvement.

Proposed Russian fee structure

Some economic information can be found in Wergeland (1991), who was relied on for the following. Prices are in U.S. dollars as of July 1991.

The guiding principles used by MSC and FESCO in determining fees for their services are that:

- Rates should not be lower than the actual cost of services rendered;
- Rates should be low enough that an economic advantage is maintained over the alternative canal routes.

That said, "icebreaker fees," more specifically, depend on the vessel's displacement (size), its ice classification, the route chosen, and the level of escort or support required. In addition to icebreaking, this fee includes guiding by reconnaissance aircraft, hydrographic and meteorological services, and the use of communication systems. To arrive at a specific rate, a three-step process is used. First, the basis fee is determined for the size of the ship. This fee is derived from the rate set for guiding a cargo ship having the highest ice classification (ULA) through the NSR. Table 16 shows the sliding scale that is used to determine the basis fee: the larger the ship, the lower the per-ton tariff.

Second, the NSR has been divided into three different tariff regions based on their historically known difficulty of transit:

- Region A, from Novaya Zemlya to Severnaya Zemlya (60°E to 90°E);
- Region B, from Severnaya Zemlya to the Bering Strait (90°E to 169°W);
- Region C, which includes all areas north of the 78°N parallel.

Table 16. Icebreaker basis fees for escorting vessels through the NSR (from Wergeland 1991).

Total displacement (tons)		*Basis fee*
From	*To*	*(US$/ton)*
100	1,000	15.20
1,001	2,000	9.16
2,001	5,000	5.51
5,001	8,000	4.73
8,001	11,000	4.21
11,001	14,000	3.98
14,001	17,000	3.82
17,001	20,000	3.72
20,001	23,000	3.64
23,001	27,000	3.56
27,001	30,000	3.26

The tariff for Region A is set at 70% of Region C, and for B it is 80% of Region C. The tariff for Region C (from Table 16) is assessed for any full-transit voyage or one that traverses two or more of these regions.

Third, ships of lesser ice classification are required to pay the following relatively higher surcharges: UL = 20% more, L = 44%, and B/kl = 73%. Wergeland calculated the icebreaker fee for an L-class vessel of 15,000 displacement tons sailing in Region B at $66,000 (that is, 15,000 tons × $3.82/ton × 0.8 × 1.44). The transit tariff for a foreign icebreaker, on the other hand, is 33% less than that for the ULA-class vessel.

Fees for compulsory piloting are assessed separately. The pilot fee is for having a Russian ice pilot onboard during operations in ice. It is $1.01 per nautical mile, based on the ship's "tariff distance" or shortest recommended route. The cost to transport the pilot out to the ship is also assessed. Wergeland listed the following additional cost elements that might be encountered during the voyage, citing a regulatory manual entitled *Port Dues and Charges for Commercial Soviet Seaports* (the prices are as of the manual's 1988 effective date):

- Route recommendation based on meteorological and ice forecasts where, for example, a one-day forecast is $90 and a three-day forecast is $231;
- Communication services billed at the rate of $2.20 per minute for telex and $4.50 per minute for telephone;
- Salary for a Russian helmsman at $33.33 per day if the vessel doesn't have one qualified for ice navigation;

- Maps, guidebooks, tide tables, signals book, and such can total $700 to $900 for the route;
- Special vessel steerage can be required by local authorities in various ports of call for safety considerations; unstated local rates probably apply;
- Bunker-filling fee is $6.30 per ton, and the bunker itself is priced at "world market rates";
- Supply of fresh water en route ranges between $0.99 and $11.69 per ton, depending on location and its quality.

The fees used for analysis in Wergeland (1993b) are the same as those listed above, indicating that no new figures have been supplied to INSROP by FESCO and MSC since 1991.

Marine insurance

Marine insurance is a significant issue for shipping along the NSR. The insurance premium protecting the shipowner is another cost factor to be considered to determine whether a shipment can be accomplished profitably. There are three different components of a marine insurance policy: 1) hull, machinery, and equipment coverage on the vessel itself, 2) protection and indemnity insurance to cover damages caused to others by the vessel or its operator, and 3) damage coverage for the cargo. Because there have been few voyages in that area, there is presently no statistically based assessment of the risk involved. Until there is, insurers will no doubt be conservative and charge rates that reflect a higher than actual degree of risk. Regardless of the risk, the premiums will be custom tailored to the particular situation based on the following factors:

- The gross tonnage of the vessel
- The insured value
- The level of deductible damages
- Time of season and expected environmental conditions
- The client's past relationship with the insurer
- The competition between rival insurers.

This is a complex issue that is outside our sphere of expertise, so we will not attempt to be more specific on these costs. Instead we refer the interested reader to Torrens (1994) and Arpiainen (1994), two publications that contain very recent insurance information specific to the Northern Sea Route.

PRACTICAL CONSIDERATIONS

Social, economic, and political

Social, economic, and political instability are the fundamental obstacles to developing the NSR (Franzen 1993, Granberg 1993a,b). When Boris Yeltsin assumed the Russian presidency in 1991, he inherited an economy on the verge of widespread collapse. The shortage of basic goods led to social and political unrest that in turn produced further chaos in the supply system. Drastic emergency reforms were instituted in 1992 to stem the tide, but during the three previous years, virtually every economic indicator was showing the strain. In 1991 alone, the Russian gross national product dropped 17% and retail prices increased by 189%. Although salaries increased by 80% in response to inflation, purchasing power fell an estimated two- to threefold. The government's response to the crisis has been to print more rubles, fueling inflation. Granberg cites many examples of economic distress that may adversely affect NSR operations.

The Russians declare that the Northern Sea Route is now open and the obstacles of the past are disappearing. Actual experience appears to indicate otherwise. Total cargo figures, which showed a steady annual increase to about 6,600,000 tons in 1987, dropped to 4,900,000 tons in 1991 (Granberg 1992). The fact that both traffic and tonnage along the route have dramatically decreased since 1990 in the face of shortages testifies to the current problems with moving freight in that area of the world. Reports of protests and labor strikes, stemming from poor wages and living conditions, are common. With producer privatization measures, the government is attempting to introduce profit incentives for its citizens. However, eliminating the old way of doing business has severely disrupted the producers' industry-to-industry connections and their ability to bring goods to market. It will take time to re-establish these networks (Arikaynen 1991).

In addition to the overall national problems, Arikaynen discusses numerous problems between the administrative and operations entities in carrying out the Arctic maritime transportation plan. While MSC and FESCO perform all icebreaking tasks and move most of the cargo, they do not appear to be working together to achieve an overall cargo transport plan. Together, they effectively make up the complete operations arm for the plan, and yet they have been forced to pursue their own respective economic interests due to reduced subsidies from Moscow.

The most pressing and difficult problem to address may be the lack of incentive to deliver freight in the most efficient and economical manner. Inefficiencies plague virtually all aspects of the system. Labor discontent is reported aboard icebreakers and cargo ships (Armstrong 1990, 1991, 1992b). Several experts contacted for this study speculated that the shipping companies have an endemic preference for dealing with large bureaucratic entities, giving low priority to small business transactions where the profit potential for each is less. This may be a cultural artifact stemming from decades of state-mandated controls over the distribution of goods and services.

Negative social and ecological effects from uncontrolled Arctic development have been identified as a potential risk. The Arctic regions form a delicate ecosystem that recovers very slowly after change is introduced. Arikaynen (1991), Young and Osherenko (1991), Roginko (1991, 1993), Stokke (1992), Hansson (1992, 1993), and Osherenko (1993), for example, advocate international vigilance and strong cooperative agreement for environmental protection. Indeed, one of the four main focuses of INSROP is to inventory the indigenous human, animal, and plant populations of the Arctic to create a baseline for assessing the impacts of development (Brekke and Fjeld 1991). Though several authors point out that environmental protection has not been emphasized in the Soviet past (for example, Hansson 1993, Osherenko 1993, Hume 1984), there appears today to be a shared international awareness and concern, which these authors and others hope will translate into adequate safeguards.

Another related problem is the difficulty of finding return cargo, which can lead to slow turnaround for ships or costly return voyages without cargo (Wergeland 1992, Armstrong 1993). This problem should diminish with increased import–export activity along the route. Greater international effort to promote awareness of the route, more demonstration voyages, and gradual elimination of the unknowns will help to expand the NSR cargo base.

Infrastructural

The language barrier may be of some concern to potential users of the NSR, but our experience in contacting various Russian agencies and businesses for this project did not reveal any serious communication problems, once we were able to establish contact. The ANSR, the shipping companies, and almost all other agencies we contacted had a staff member nearby who understood and spoke English.

On the other hand, Russia's telecommunications equipment is outdated and often unreliable (Franzen 1993). Telephone lines into Russia are overloaded and very often busy. The quality of the connection is sometimes poor, which can be detrimental for facsimile transmission. There were no apparent difficulties in our receiving telefaxes, but we experienced much difficulty in trying to send fax messages to Russia.

Franzen (1993) presents a recent evaluation of the communications systems servicing Russia and several alternatives to avoid the unreliable telephone and telefax systems. Due to these problems, many Russian businesses are setting up subsidiaries in neighboring European and Scandinavian countries to take advantage of modern and/or more reliable communications technology to the outside world. We learned from more than one knowledgeable U.S. source that fax machines in Russia are often shut off after business hours, which is a problem (though easily remedied) for potential clients half a world away. Many Russian businesses limit incoming faxes to a single page to conserve paper. The unwary sender, in the habit of preceding his message with a cover page, would thus not be in communication.

Electronic mail is in the early stages of development in Russia. Although AARI is connected to the Internet, no other agencies or companies we contacted were. Franzen (1993) reports that although e-mail allows electronic communication via modem from a desktop computer to any telex terminal worldwide, error correction software is required to help ensure clear messages.

Although the infrastructure is already in place to fully support NSR traffic during the summer season, it has been suggested (Wergeland 1991, Østreng 1991) that it will be difficult to attract greater foreign interest unless the navigation season can be extended. The additional investment for building ice-class ships is considerable. These ships are not ideal for use in other parts of the world when the Arctic passage is closed for the winter, and they are less efficient and more costly to run in open water than conventional vessels. An ice-strengthened vessel costs 15 to 20% more to build, according to Wergeland (1993b). To offset the greater construction, operating, and maintenance costs, shipowners rely on the ships providing year-round service. Since depth limitations in some straits prevent passage of ships greater than 20,000 dwt, the shallow-draft fleet of the Northern

Sea Route may not be desirable for use where larger ships can move cargo more efficiently. More northerly route options would enable larger and perhaps more efficient ship passage but would also require greater icebreaking capabilities than are currently available. As recently as 1988, there was discussion that the Soviets were considering the construction of a new 150,000-shp icebreaker, which was seen as a necessary step for expanding NSR shipping through the winter (Østreng 1992). Although those plans have been deemed premature in light of current cargo volume, costs, and revenue possibilities, we are left to wonder which must first occur—improvements in icebreaking capacity that will allow more economical cargo transportation, or the development of markets for trade goods that will spur technological advance.

It is likely that advances on both fronts must occur simultaneously to effect real progress. Import and export industries depend heavily on reliable, year-round transportation of goods. Few businesses can afford the limitation of a seasonal supply of raw materials or seasonal distribution of their finished products. Attracting year-round trade will encourage the establishment of alternative transportation modes for the off-season, such as overland rail or air freight service. These will introduce another source of competitive pressure on marine shipping that is perceived as negative.

According to Makinen (1993), average ship speeds along the Northern Sea Route need to be increased from 6–13 to 10–15 knots to make the route more competitive with the alternative canal routes. Wergeland's economic analysis shows that the NSR advantage in transit time diminishes to only two days by assuming an average transit speed of 12 knots vs. the 21-knot speed possible on the canal routes. When other costs associated with the NSR are then considered (greater insurance and political risk, higher maintenance and operating costs, smaller vessel capacity), the NSR advantage disappears. It isn't likely that ship speeds will be substantially increased in the near future. The NSR's economic advantage in the near term may perhaps only be realized by Russia offering attractive rates for chartering and services to bring the overall cost down.

Use of the Northern Sea Route will also depend on wider availability of emergency services. Personal safety demands greater access to rescue and medical services, whereas equipment emergencies might include ship repairs, refueling sites, and pollution abatement response. At the present time, the MOHQs and icebreaker escorts must be relied upon for these emergency services. Only the port of Igarka is now open as a stopover for foreign ships. Other ports slated to be opened are Dudinka, Dikson, Tiksi, and Pevek. Another advantage to opening more ports would be the stimulation of spinoff support services that could bring additional foreign revenue into the northern economy, from tourism and lodging facilities, for example (Brigham 1993).

The ability to respond to an environmental disaster at sea in this harsh and remote region is of concern to the northern populations of Russia as well as to the international community. The need for a coordination center and establishment of standard emergency procedures is widely acknowledged (for example, Roginko 1993, Sandkvist 1993). A funding source to achieve these goals is needed but is not immediately apparent. Until more experience is gained and more facilities become established, NSR shipping will continue to be perceived as riskier than the traditional canal routes.

Other needed improvements to navigation are

- Better communication between ships and MOHQs (Mikhailichenko and Ushakov 1993);
- Better ice-imaging tools (Østreng 1991);
- Modern hardware for positioning and communication;
- Dredging of ports (Brigham 1993).

The hardware that allows for global communications from virtually any Arctic location is already in place, although better coordination in the use of that hardware may be needed. The technology to receive ice data from satellite-based sensors that do not require clear sky or daylight would enable the Russian experts to substantially improve their forecasting and ship-routing capabilities.

CONCLUSIONS

Our study of the history and current conditions related to international use of the Northern Sea Route brings us to the following general conclusions:

- The Northern Sea Route is a substantially shorter passage for shipping between northern European ports and those of the Far East and Alaska than routes through the Suez and Panama Canals. Comparisons show a 35 to 60% savings in distance.

- The Russians have a highly developed maritime infrastructure along the Northern Sea Route and specialized ice navigation experience that spans many decades. Their Arctic marine system has been used primarily to develop Russia's northern regions, extract raw materials, and resupply their coastal settlements. They have a fleet of the world's most powerful icebreaking ships and specialized, ice-strengthened ships for moving most types of cargo. Their cargo ships are small, however, relative to ships plying the canal routes.
- Overall responsibility for shipping activities on the route currently resides with the Administration of the Northern Sea Route (ANSR) in Moscow. Actual sea operations are directly controlled by two marine operations headquarters: the Murmansk Shipping Company (MSC) operates the icebreakers and controls shipping through the western half of the route, and the Far Eastern Shipping Company (FESCO) controls the eastern half.
- A western segment of the route, from Murmansk to Dudinka, has been open year-round since 1980. The remainder is normally kept open for both transit and local freighting from the beginning of July through October. For the Northern Sea Route to be more attractive as an international trade route, the length of the shipping season will have to be extended, if the route is not actually kept open year-round. Average transit speeds need to be increased as well. While the former requirement can be immediately addressed, at least partially, by enlisting the underutilized icebreaking and transport capacity of the Russian fleet, the latter will likely require better ice forecasting tools and advances in ship technology.
- There is currently much international interest and momentum toward expanded shipping development. Since 1987, when the Soviet Union's new spirit of openness and international cooperation was announced, much has been made of the possible use of the Northern Sea Route as a major marine trade corridor. Several international organizations and regional government bodies have endorsed the idea, formulated agenda, and begun promotional activities.
- The USSR's dissolution into the Commonwealth of Independent States was accompanied by social and economic hardship. Shortages, inflation, and unemployment have extended even to the Arctic fleet and the maritime trade setting. Now, more than at any other time in history, Russia is open to discussion of the many ways to employ their marine infrastructure to raise much-needed foreign capital, such as providing icebreaker support for foreign ships, leasing Russian cargo ships to transport foreign goods over the NSR and elsewhere, joint venturing with foreign companies in Russian marine trade, leasing out idle Russian icebreakers in the U.S. and Canadian Arctic, and Arctic tourism.
- Social instability may be the greatest impediment to the development of the Northern Sea Route. Labor discontent, currency devaluation, cutbacks in personnel and services, and the inability to maintain the fleet and navigation equipment are all problems that directly affect future development. Communication between foreign parties, the NSR Administration, and the shipping companies is made difficult by outdated equipment. The result is a climate of uncertainty for potential users of the route, which, accordingly, diminishes foreign interest. The Murmansk Shipping Company and the Far Eastern Shipping Company must be willing to offer rate guarantees so that the Northern Sea Route maintains an economic advantage over other route and transit options. Finally, the NSR Administration and the shipping companies need to be more reliable and responsive to inquiries from potential foreign clients.

The technological advances necessary to enable year-round traffic along the Northern Sea Route will occur more rapidly if the international community perceives a need for them. This would help to promote the growth of the Russian economy and encourage a cooperative and constructive posture for that nation, both domestically and internationally.

There is a large degree of skepticism as to whether the Russians can sufficiently reorganize their operations and develop a credible continuity to the extent that foreign shippers will have faith in the system. At this time, there is considerable perceived risk. To increase credibility, more success stories will be required. As more successes are reported, greater interest is sure to follow, and the need for technological advance will be recognized.

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APPENDIX A: CARGO SHIP AND ICEBREAKER CLASSIFICATION EQUIVALENCIES (FROM TORRENS 1994)

Cargo ship classes:

		Ice class				
Organization	*Class symbol*	*High*		*Medium*		*Low*
Det norske Veritas (post-1971)	1A1	1A*	1A	1B	1C	
Finnish/Swedish rules (toll classes as per 1985)		IA Super	IA	IB	IC	II
American Bureau of Shipping (post-1971)	A1 (E)	IAA	IA	IB	IC	
Bureau Veritas (pre-1971)	I 3/3 E	I-Super	I	II	III	
Bureau Veritas (post-1971)	I 3/3 E	IA-Super	IA	IB	IC	
Bulgarian Register of Shipping	KM	ULA, UA	L1	L2	L3	L4
DDR Schiffs-Rev. und Klassif.	DSRK KM	Eis Arktis, Eis Super	Eis 1	Eis 2	Eis 3	Eis 4
Germanischer Lloyd	100 A4	E4	E3	E2	E1	
Lloyd's Register of Shipping (post-1971)	100 A1	1AS	1A	1B	1C	1D
Polski Register Statkow	KM	L1A, UL	L1	L2	L3	L4
Nippon Kaiji Kyokai	NS	IA Super	IA	IB	IC	
Register of Shipping People's Republic of China	ZCA	B1*	B1	B2	B3	
Register of Shipping of the USSR*	KM	ULA, UL	L1	L2	L3	L4
Registro Italiano Navale	100A-1.1	RG 1*	RG 1	RG 2	RG 3	
Registrul Naval Roman	RNR+M CM O	G 60, G 50	G40	G 30	G 20	G10
Canadian ASPPR rules/zones		A	B	C	D	E

Icebreaker classes:

	Ice class					
Organization	*High*					*Low*
Register of Shipping of the USSR	LL1	LL2	LL3	LL4		
Det norske Veritas (includes "Sealer" class)	Polar-30	Polar-20	Polar-10 Ice-15	Ice-10	Ice-05	
Lloyd's Register of Shipping	AC3	AC2	AAC1.5	AC1		
Canadian ASPPR rules/zones	Classes not available.					

*For Russian classes: L = ice; U = reinforced, A = Arctic.

APPENDIX B: TRANSLATED TABLE OF CONTENTS FOR THE NSR SAILING GUIDE ENTITLED *GUIDE TO NAVIGATION THROUGH THE NORTHERN SEA ROUTE,* SCHEDULED FOR RELEASE IN 1995

GENERAL INFORMATION

NAVIGATIONAL INFORMATION

REFERENCE SECTION

APPENDIX C: SELECTED SEA-ICE DATA AND SEVERITY INDEX FOR THE NORTH COAST OF ALASKA, 1953–1993 (FROM USN/NOAA NIC 1994)

Rank	Year	nm	nm	nm	nm	Date	Date	Days	Days	Meters	Outlook
1	1958	50	150	50	210	07/19	10/25	92	99+	285	fav
2	1968	25	165	30	200	07/19	10/18	86	91	275	fav
3	1993	0	130	5	185	07/18	11/07	64	112	358	unfav
4	1962	25	150	30	150	07/19	09/30	49+	68+	265	fav
5	1973	5	80	5	190	07/31	10/20	73	82	280	fav
6	1954	20	115	20	210	08/01	09/30	38+	61+	285	fav
7	1963	5	130	5	130	08/13	10/18	67	67	300	unfav
8	1960	0	90	40	90	07/23	10/12	75	105	289	fav
9	1961	15	105	15	135	07/25	09/24	49+	62+	255	fav
10	1979	0	125	0	125	08/04	10/08	31	56	309	unfav
11	1989	10	70	55	110	07/19	10/22	34	95	296	unfav
12	1974	10	100	10	100	08/06	10/05	35	61	255	fav
13	1978	5	70	30	95	07/25	10/09	35	76	231	fav
14	1986	10	80	10	110	07/29	10/21	30	58	298	unfav
15	1977	5	55	25	85	08/02	10/15	63	74	251	fav
16	1959	20	65	20	65	07/19	10/06	42	86	250	fav
17	1982	0	85	0	95	08/03	10/10	21	69	268	fav
18	1972	0	60	30	90	07/31	10/01	45	63	270	fav
19	1957	5	45	70	60	08/01	10/06	18	67	255	fav
20	1987	0	10	0	85	08/05	10/30	35	59	287	fav
21	1981	0	0	35	100	07/26	10/01	0	66+	221	fav
22	1985	0	35	0	55	08/01	10/15	22	52	301	unfav
23	1967	15	0	30	50	07/25	10/12	Unk	68	275	fav
24	1984	0	25	0	50	08/11	10/15	21	42	309	unfav
25	1966	5	0	5	45	08/01	10/22	24	65	375	unfav
26	1992	15	0	15	75	08/09	09/19	24	37	297	unfav
27	1965	0	10	0	70+	08/25	09/25	25	32	300	unfav
28	1980	15	25	15	25	08/05	09/30	11	42	359	unfav
29	1953	0	0	5	35	07/27	09/16	5	52+	330	unfav
30	1976	0	15	0	15	08/15	10/07	21	53	307	unfav
31	1971	0	0	0	30	08/23	11/01	8	71	295	unfav
32	1991	0	0	0	20	08/16	10/02	0	46	304	unfav
33	1960	0	0	20+	20	08/05	09/07	0	34	290	unfav
34	1988	0	0	0	25	08/09	09/20	0	32	236	fav
35	1983	0	10	0	10	08/08	09/16	0	21	277	fav
36	1964	0	0	0	5	08/13	09/20	0	39	310	unfav
37	1970	0	0	5	0	08/06	09/14	0	32	295	unfav
38	1956	0	0	0	40	09/07	09/30	0	24	300	unfav
39	1969	0	0	0	30	09/07	09/18	5	12	240	fav
40	1955	0	0	5	15	09/13	09/24	0	12	310	unfav
41	1975	5	0	5	0	Never	Never	0	0	290	unfav

NOTES:
Column 3—Distance from Point Barrow northward to ice edge (10 Aug)
Column 4—Distance from Point Barrow northward to ice edge (15 Sep)
Column 5—Distance from Point Barrow northward to boundary of five tenths ice concentration (10 Aug)
Column 6—Distance from Point Barrow northward to boundary of five tenths ice concentration (15 Sep)
Column 7—Initial date entire sea route to Prudhoe Bay less than/equal to five tenths ice concentration
Column 8—Date that combined ice concentration and thickness dictate end of prudent navigation
Column 9—Number of days entire sea route to Prudhoe Bay ice free
Column 10—Number of days entire sea route to Prudhoe Bay less than/equal to five tenths ice concentration
Column 11—Primary indicator of ice season severity...sum of values for 1000 mb heights at point A (52°N/100°E) and point B (70°N/140°E).
Column 12—Value in column 11 indicating favorable/unfavorable summer ice conditions (<290 m = favorable; >290 m = unfavorable).

APPENDIX D: DECLASSIFIED, GENERAL-DISTRIBUTION RUSSIAN HYDROGRAPHIC CHARTS FOR THE NSR, AS OF NOVEMBER 1993

Map no.	Map name (translated)	Revision date	Scale (1:_____)	Areal coverage	
				Latitude	Longitude*
600	*Arctic Ocean; Barents Sea–Cape Nordkap to Cape Kanin Nos*	1990	750,000	72°20′ 68°00′	25°50′ 43°30′
603	*Barents Sea–Murmansk Shore, Pechenega Bay to Gavrilovskie Islands*	1990	200,000	70°16′ 69°05′	31°20′ 36°00′
617	*Barents Sea; Southeastern Part–Kolokolkovaya Bay to Cape Cheornaya Lopatka with Pecheorekaya Bay*	1984	200,000	69°21′ 68°07′	52°08′ 56°45′
620	*Barents Sea; Murmansk Shore; Kola Peninsula*	1984	50,000	69°24′24″ 68°55′06″	32°57′00″ 33°47′30″
624	*Barents Sea; Kola Peninsula; Murmansk Harbor*	1990	25,000	69°04′12″ 68°55′06″	32°54′00″ 33°10′00″
650	*Arctic Ocean; Barents Sea–Cape Orlov-Terskiy Tolstyi to Karskiye Vorota Strait*	1986	750,000	71°22′ 66°48′	41°18′ 59°06′
695	*Arctic Ocean, Barents and Kara Seas–Approaches to Karskiye Vorota and Yugorskiye Shar Straits*	1990	250,000	71°13′ 69°20′	54°20′ 62°30′
696	*Barents and Kara Seas–Novaya Zemlya*	1986	1,000,000	77°56′ 69°00′	48°00′ 72°00′
697†	*Arctic Ocean; Kara Sea–Novaya Zemlya to Dikson Island*	1991	700,000	77°30′ 72°50′	56°00′ 81°00′
698	*Kara Sea; Yenisey Bay–Golchina River to Dikson Harbor*	1989	200,000	73°35′ 71°41′	78°31′ 83°40′
	with expanded region*: Moscow and Kristovskiy Straits*		50,000	72°28′00″ 72°17′00″	80°40′00″ 81°10′30″
940	*Yenisey River–Igarka Harbor*	1980	25,000	not shown	not shown
945i	*Kara Sea; Yenisey River–Cape Sopochnaya Karga to Cape Dorofeyevskiye*	1991	100,000	72°07′ 71°22′	82°03′ 83°50′
945ii	*Yenisey River–Cape Dorofeyevskiye to Baykalovo Village*	1984	100,000	71°27′ 70°40′	82°00′ 83°45′
945iii	*Yenisey River–Baykalovo Village to Bolshoy Island*	1986	100,000	70°46′ 69°57′	82°15′ 84°00′
	with expanded region*: Turushinskiy Shoal*		25,000	70°40′12″ 70°33′42″	83°24′00″ 83°32′18″
945iv	*Yenisey River–Bolshoy Island to Tochino Village*	1985	100,000	70°02′ 69°25′	82°50′ 85°15′
	with expanded region*: Navigating channel to the*		25,000	69°57′00″ 69°53′00″	83°25′00″ 83°35′00″
945v	*Yenisey River–Tochino Village to Nikolskoye Village*	1984	100,000	69°51′ 69°00′	84°40′ 86°25′
945vi	*Yenisey River–Nikolskoye Village to Port Igarka* (North-ern part)	1990	100,000	69°05′ 68°12′	85°49′ 87°02′
	(Southern part)		100,000	68°12′ 67°21′	86°12′ 86°42′
	with expanded region*: Lipatnikovsky Shoal*		25,000	68°33′48″ 68°25′54″	86°17′00″ 87°02′00″
947	*Arctic Ocean–Southern part of Barents Sea*	1990	2,000,000	77°00′ 66°15′	10°00′ 59°00′
948	*Kara Sea–Dikson Harbor to Russkiy Island*	1991	700,000	78°52′ 73°30′	80°00′ 96°20′
949	*Kara and Laptev Seas–Russkiy Island to Petra Island*	1991	700,000	79°26′ 75°52′	95°40′ 118°20′
950	*Kara Sea–Vil'kitskogo Strait*	1991	200,000	78°18′ 77°17′	98°10′ 104°32′
951	*Laptev Sea–Ahabaskogo Strait to Buor-Haya Bay*	1991	700,000	76°50′ 70°40′	113°44′ 130°50′
952	*Laptev and East Siberian Seas–Buor-Haya Bay to Indigirka River delta*	1991	700,000	75°30′ 70°40′	129°50′ 152°30′

Map no.	Map name (translated)	Revision date	Scale (1:_____)	Areal coverage	
				Latitude	Longitude*
953	*East Siberian Sea–Novosibirskiye Islands, Sannikova and Dmitriya Lapteva Straits*	1991	500,000	75°00′ 72°16′	138°50′ 152°05′
954	*East Siberian Sea–Indigirka River delta to Shalaupova Island*	1991	700,000	74°29′ 69°20′	150°50′ 173°30′
955	*East Siberian and Chukchi Seas–Schapovalov Island to Cape Golovin*	1991	700,000	72°30′ 66°50′	172°00′ W165°20′
1085	*Pacific Ocean–Northern part of Bering Strait*	1978	2,000,000	67°38′ 58°45′	170°15′ W163°00′
1088	*Bering Sea; Chukotskiy Peninsula–Cape Yakun to Cape Mertensa with St. Lawrence Island*	1978	250,000	64°36′ 63°18′	W174°15′ W170°15′
1089	*Bering Sea; Chukotskiy Peninsula–Provideniya Harbor*	1979	50,000	64°35′00″ 64°14′10″	W173°39′21″ W173°03′51″
1096	*Bering Sea, northern part; Bering Strait*	1979	250,000	66°10′ 64°56′	W171°30′ W167°30′
12330†	*Kara Sea–Ringnes Island to Gavrilova Island*	1993	200,000	76°42′ 75°35′	86°42′ 93°06′
12332†	*Kara Sea; Taymyr Peninsula–Knipovicha Bay to Cape Poluostrovnoy*	1993	200,000	77°30′ 76°02′	97°34′ 108°18′
13005	*Barents Sea–Murmansk Shore, Kildin Island to Voroni Luki Islands*	1993	100,000	69°56′ 69°07′	34°08′ 35°51′
13028	*Barents Sea, Southeastern part–Cape Medynski Zavorot to Cape Chayka with Dolgiy Island*	1993	100,000	69°32′ 68°56′	58°42′ 61°01′
13317	*Kara Sea; Yugor Peninsula–Mestnyi Island to Svyaschenyi Znak Schpindlera*	1993	100,000	70°13′ 69°38′	61°04′ 63°25′
15352	*River Yenisey; Channel Golovin–Approaches to Nosok Village*	1993	25,000	70°15′12″ 70°06′00″	82°20′00″ 83°50′00″
18389	*River Yenisey–Fairway to the south from Bolshoy Island*	1993	10,000	69°57′40″ 69°52′40″	83°24′45″ 83°35′24″

* All latitudes are east of the prime meridian through Greenwich, England, unless otherwise listed.
† Map has both Russian and English labeling.

APPENDIX E: A CONTENTS OF A COMPUTERIZED RUSSIAN SEAPORTS DATABASE

A computerized database, entitled *Commercial Sea Ports of the CIS and Baltic States, and River Ports of Russia* is commercially available from the Central Marine Research and Design Institute (CNIIMF) in St Petersburg, Russia. It is compatible with an IBM PC/AT and requires 2.1 MB of hard disk. The database is currently available only in Russian; however, it could be translated for the foreign market if there is sufficient interest. Developed and periodically updated by CNIIMF, it currently contains detailed information on 67 commercial seaports and 125 river ports. The user can select ports of one, several, or all states of the CIS as well as Lithuania, Estonia, and Latvia by type of cargo; maximum item weight of cargo; limiting ships' draft; or various wharf specifications (for example, depth at the wharf, wharf length, and type of cargo handled). It is said to contain the following information:

1. General information on each port:
   - full mailing address, telephone, fax, and telex numbers of port administration;
   - telephone numbers for port master, deputy port master, and principal subdivisions for services;
   - port location and general description;
   - period of navigation;
   - draft limitations;
   - maximum ship length;
   - maximum ship breadth;
   - loading/unloading/transshipment facilities;
   - number and specialization of transshipment complexes;
   - cargoes handled;
   - maximum weight of heavy cargo item;
   - yearly cargo turnover;
   - number and purpose of harbour craft;
   - services available;
   - ship agents;
   - transportation organizations;
   - port railway address (for cargo);
   - plan of each port (wharfs with their numbers, main administrative buildings, etc.);
2. Port transshipment capacities:
   - total number of loading wharfs (berths);
   - number of loading berths for local shipping lines;
   - number of passenger wharfs;
   - total number of auxiliary wharfs;
   - number of (auxiliary) bunkering wharfs;
   - total length of berthage;
   - cargo handling capacity;

3. Port storage space:
   (i) total area of roofed depots, and, in particular:
      - for containers;
      - for bulk cargo;
      - for dangerous cargo;
      - for perishable cargo;

   (ii) total area of open air depots, and, in particular:
      - for containers and ro–ro;
      - for timber;

- for bulk cargo;
- for perishable cargo;

4. Wharfs' characteristics:
   - name of the port;
   - number of the transshipment complex (a "complex" may include a certain number of wharfs grouped by territory, or by purpose);
   - wharf number;
   - wharf length;
   - depth at wharf;
   - purpose of wharf;
   - number of the overhead travelling cranes at the waterfront/at the rear/total;
   - number of the 5/6 tons overhead travelling cranes at the water front/at the rear/total;
   - number of the 10/20 tons overhead travelling cranes at the water front/at the rear/total;
   - number of the 16/20/32 tons overhead travelling cranes at the water front/at the rear/total;
   - number of the 16/32/40 tons overhead travelling cranes at the water front/at the rear/total;
   - loading units for particular types of cargo;
   - area (m^2) of roofed depots on the wharf;
   - area (m^2) of open air depots on the wharf;
   - cargo handling capacity.
5. Characteristics of specialized container handling complexes:
   - name of the port with container terminal;
   - container terminal wharf numbers;
   - year the terminal was put into service;
   - typical ship for which the terminal was designed;
   - frontage;
   - depths at wharf;
   - total area;
   - size of container sorting and filling areas;
   - number of 20-ft. containers stored;
   - number of reloaders on a wharf;
   - number of gantry rail cranes;
   - number of depot reloaders;
   - number of overhead truck loaders;
   - number of specialized tractors;
   - annual handling capacity (in thousands of containers).

APPENDIX F. RUSSIAN ARCTIC SEAPORTS DATA FROM LLOYD'S OF LONDON'S *PORTS OF THE WORLD* (LLP 1994)

ARCHANGEL, White Sea

Lat 64° 32′ N; Long 40° 30′ E. Situated at the mouth of the River Severnaya Dvina, in the SE corner of Dvina Bay. Navigation season is from the end of April to early November, but for ice-classed vessels year-round navigation is normally possible with icebreaker assistance

Admiralty Chart: 2280 **Admiralty Pilot:** 72
Time Zone: GMT + 4 h **UNCTAD Locode:** RU ARK
Principal Facilities:

P	Q	Y	G	C	B	D	T	A		

Authority: Port of Archangel Authority, Naberezhnaya V.I. Lenina 36, Archangel 163010, *Tel:* 37840
Approach: The main channel for ocean-going vessels is over the Berozovyy Bar. The length of vessels is normally limited to 160 m and the draught to 8 m at HWNT. There are also secondary channels to the port. Vessels proceeding to the timber mills No 2 and 3 and to the Bakaritsa cargo area have to pass under a rail bridge, the central span of which is only open once a day from 0100 to 0330 hours
Anchorages: Anchorage for foreign vessels can be obtained in several places. The outer roads to the N and NW of the Mudyugskiy No 1 Reception Buoy have a depth of 10 m. Other anchorage areas include the Solombala roadstead with depths ranging from 59 m; Maymaksa roadstead, depth also 5–9 m and the town roadsteads with depths of 6–9 m. Vessels awaiting Customs and Quarantine formalities must anchor in the N part of Maymaksa roadstead off Ostrov Chizhov. The holding ground at all roadsteads is mud and sand. Anchoring of vessels is performed to the recommendations of the pilot. Anchoorage for vessels awaiting passage is obtained in the Krasnoflotskiy roadstead in a depth of 9 m
Pilotage: Compulsory. Masters of vessels should order a pilot through the Inflot Shipping Agency 24 hours before expected arrival and confirm 4 h prior to ETA. Pilot boards in the vicinity of Mudyugskiy No 1 Reception Buoy. During rough weather a pilot boat will direct the Master of a vessel to a suitable boarding place. For leaving the port or shifting berth, pilot should be ordered 4 h in advance through the Pilot Station. 24 hour service is available
Radio Frequency Information: Port call sign UGE. Navigation frequencies: 500 kHz & 480 kHz (calling), 500 kHz & 476 kHz (working). Archangel Radio 1, Port Controller: VHF Channel 16, 156·8 mHz. Movements Control: VHF Channel 9, 156·45 mHz
Weather: Ice conditions may occur from the end of October until mid May. The port is officially opened and closed at intervals throughout this period, according to the state of the ice
Largest Vessel: 19 240 dwt, 162·3 m loa
Accommodation: The port complex has a total of 35 berths with depths alongside ranging between 7·75 m to 9·6 m. There is a fishing harbour with cold store facility
NOVODVINSK: Port area located up-river from Archange to serve a pulp and paper complex. Packaged timber is loaded at quays adjacent to timber mills by shore portal cranes or by vessels own gear
Storage: Enclosed warehouse space available and concreted open storage areas
Cranes: Mobile electric portal cranes of up to 32 t cap, floating portal cranes up to 50 t cap
Provisions: A wide range of stores can be supplied on order. ISSA members available
Water: Fresh water usually available by barge. A few berths are equipped with shore lines
Container Facilities: Container terminal, berthing length of 270 m, with container handling equipment of up to 30 t cap
Bulk Cargo Facilities: Handling equipment available for bulk cargoes, including coal, minerals, cement and building materials
Tanker Terminals: Facilities exist for tankers carrying oil and oil products
Bunkers: Available from barges stationed at the town roadstead or from lighters
Shiprepairs: All types of repairs can be effected in floating docks for vessels of up to 7000 dwt
Towage: Tugs are available for berthing and unberthing. Salvage vessels and icebreakers are stationed at the port
Airport: Situated near the town
Shipping Agents: Archangel Inflot Shipping Agency, Vinogradova Pr. 61, Archangel 163061, *Tel:* 35874 & 38573 (24 hours), *Telex:* 242115 & 242231
Lloyd's Agents: Ingosstrakh Ltd., Pjatnitskaja ul. 12, Moscow M-35, *Tel:* (095) 231 1677, *Fax:* (095) 2302518, *Telex:* 411144 INGS SU

KANDALAKSHA, White Sea

Lat 67° 08′ N; Long 36° 26′ E. Situated in the S part of the Kola Peninsular at the Kandalaksha Inlet. Year-round navigation

Admiralty Chart: 3180 **Admiralty Pilot:** 72
Time Zone: GMT + 3 h **UNCTAD Locode:** RU KAN
Principal Facilities:

Y	G									

Accommodation: 495 m of berthing with depth alongside of 8·5 m
Storage: Warehouse of 4500 m² and open storage of approx 74 000 m²
Cranes: Nineteen gantry cranes of 5–20 t cap
Provisions and Water: Available
Shiprepairs: Minor repairs available
Lloyd's Agents: Ingosstrakh Ltd., Pjatnitskaja ul. 12, Moscow M-35, *Tel:* (095) 231 1677, *Fax:* (095) 2302518, *Telex:* 411144 INGS SU

MEZEN, White Sea

Lat 65° 51′ N; Long 44° 15′ E. Situated on the Mezen River, 35 km from the mouth flowing into Mezen Bay. Navigation period from end of May to October

Admiralty Chart: 3180 **Admiralty Pilot:** 72
Time Zone: GMT + 4 h **UNCTAD Locode:** RU MEZ
Principal Facilities:

G	T									

Authority: Port of Mezen Authority, Morport, Kamenka Settlement, Mezen 164, *Tel:* 94341 (Chief of the Port), 94081 (Harbour Master)
Approach: Recommended approach is through the Morzhovskaya Channel
Anchorages: Anchorage can be obtained in the outer roads at the mouth of the Mezen River in depths of about 7 m; holding ground sand, mud and rocks. There are also anchorage areas in the Mezen River by the Kamenka settlement, or at the inner roads further up river, which have depths at LW of 4·5–5 m. The outer roads are exposed to winds veering from NW to NNE, making the sea very rough
Pilotage: Compulsory. Pilot boards at the Anchorage Buoy at the mouth of the Mezen River in position 66° 12′ N; 44° 04′ E. In the event of bad weather, the pilot at his discretion may board in the outer roads. If this is not possible, the vessel should follow the pilot boat to Tolstik Point, where pilot will board. Masters of vessels should advise the Harbour Master and Inflot Shipping Agency their ETA at least 24 hours prior to arrival. Pilotage is only carried out during daylight hours and cannot be effected earlier than 2 h before HW in the Semzha River. A vessel is piloted into port not later than 1 h before HW at the berths. Movement of vessels is not permitted if wind is over force 6 on the Beaufort Scale
Radio Frequency Information: Port call sign UZT. Mezen Radio: 500, 454 & 2182 kHz (calling), 500, 487 & 2182 kHz (working). Port Controller: call sign "Kamenka", VHF Channel 16, 156·8 mHz; VHF Channel 9, 156·45 mHz. Harbour Master: call sign "Kamenka 5", VHF Channel 12, 156·6 mHz
Largest Vessel: 2930 dwt, 98·3 m loa
Accommodation: Timber export berths on pontoons near to timber mill; at least 200 m of berthing space. Vessels drawing 3·9 to 4·2 m are usually grounded at LW when loading timber. Loading is carried out by ships own gear. Other cargoes can be handled, and there is also a small passenger terminal
Storage: Enclosed warehouses and concreted open storage areas are available
Cranes: Mobile cranes are available; floating diesel-electric cranes of up to 5 t cap can be used when loading timber
Water: Fresh water is available at the berths or delivered by road tanker
Bunkers: Supplies of fuel are not guaranteed
Shiprepairs: Only minor repairs can be effected
Towage: Tug assistance for berthing and unberthing is available if required, but is not compulsory
Medical Facilities: There is a hospital in the town
Shipping Agents: Archangel Inflot Shipping Agency, Vinogradova Pr. 61, Archangel 163061, *Tel:* 35874 & 38573 (24 hours), *Telex:* 242115 & 242231

ONEGA, White Sea

Lat 63° 55′ N; Long 38° 06′ E. Situated on the right bank of the Onega River, 4·8 to 6·4 km up from the mouth at the Onezhskiy Bay. Navigation period from May to October or November. The port is closed for foreign flag vessels from September 1 to December 31 every year

Admiralty Chart: 2097 **Admiralty Pilot:** 72
Time Zone: GMT + 3 h **UNCTAD Locode:** RU ONG
Principal Facilities:

G	T									

Authority: Port of Onega Authority, Oktyabrsky Pr. 198, Onega, *Tel:* 2491 & 2151
Officials: Harbour Master: *Tel:* 2133
Approach: Channel to port marked by leading lights and buoys. The depth allows vessels of up to 3 m d to enter or leave the port at any time of day or night. Vessels having a larger draught can only enter or leave within 1 hour before HW. The maximum permitted draught varies between 5·1 m and 6·4 m according to the state of tide. Vessels of maximum draught should not exceed a speed of 8 knots in the channel
Anchorages: Anchorage can be obtained opposite the timber berths for vessels up to 3·55 m d and for larger vessels in Onezhskiy Bay in depths of up to 10 m. During strong winds, certain anchorage areas in the bay offer better protection and masters of vessels shall cast anchor according to the recommendation of the pilot
Pilotage: Compulsory. Masters of vessels must give 24 h prior notice of arrival at Mys Letniy Orlov Pilot Station. Pilots board 0·7 miles W of the Letniy Orlov point
Radio Frequency Information: Port call sign UZS. Onega Radio 2, Port Controller: 500 & 425 kHz (calling), 500 & 441 kHz (working); VHF Channel 16, 156·8 mHz. Onega Radio 5, Harbour Master: VHF Channel 16, 156·8 mHz; VHF Channel 9, 156·45 mHz
Weather: Ice conditions prevail from the beginning of November until the middle of May, covering the port area and estuary. No vessel can winter afloat in the river
Tides: Range of tide 2·7 m
Largest Vessel: 124 m loa, 6·4 m d
Accommodation: Timber export berths fronting Sawmill Nos 32 & 33. Export Wharf No 32 has a berthing length of 470 m, with a depth alongside of 4·6 m. Pontoons are secured to the wharf enabling vessels with a draught of 6·1 m to be accommodated. Export Wharf No 33 has a berthing length of 110 m, with a depth alongside of 4 m. Loading is by ships own gear. There are berthing areas situated up river from the timber wharves, accommodating smaller vessels and harbour craft
Storage: Warehousing and open storage areas are available
Provisions: Fresh provisions can be obtained
Water: Fresh water is delivered by tugboat
Bunkers: Supplies of fuel oil are not guaranteed
Shiprepairs: Only minor repairs can be effected
Towage: Available for berthing and unberthing. Tugs should be ordered 6 h prior to leaving the port
Principal Exports: Timber
Shipping Agents: Archangel Inflot Shipping Agency, Vinogradova Pr. 61, Archangel 163061, *Tel:* 38573/4 & 34040, *Telex:* 242231 & 242115
Lloyd's Agents: Ingosstrakh Ltd., Pjatnitskaja ul. 12, Moscow M-35, *Tel:* (095) 231 1677, *Fax:* (095) 2302518, *Telex:* 411144 INGS SU

MURMANSK, Barents Sea

Lat 68° 58′ N; Long 33° 05′ E. Situated on the E shore of the Kolskiy Gulf, 45 km from the sea. Year-round navigation with icebreaker assistance if necessary. Connected to Baltic Sea through White Sea-Baltic Canal

Admiralty Chart: 2966 **Admiralty Pilot:** 72
Time Zone: GMT + 3 h **UNCTAD Locode:** RU MMK
Principal Facilities:

P	Y	G	C	R	B	D	T			

Authority: Port of Murmansk Authority, Portovy Pr. 19, Murmansk 183038, *Tel:* 22260, 22310, 25565 (Harbour Master)
Officials: Port Manager: V. Strizh. Technical Director: V. Moklyak. Harbour Master: V. Avdyukov. Chief Port Controller: A. Podoprigora
Documentation: General declaration (5 copies), crew list (6 copies), crew's effects declaration (2 copies), cargo declaration (2 copies), passenger list (6 copies)
Approach: Foreign flag vessels should request permission to enter the Gulf of Kolskiy from the Toros Island Signal Station. Depth in mid-stream at the port is about 27·4 m. There are certain speed limits in operation for vessels navigating in the Gulf of Kolskiy, which must be strictly adhered to
Anchorages: Anchorage can be obtained off the port area between Abram Point and Mishchukov Point in depths ranging from 20 m to 35 m; good holding ground. Vessels must anchor W of the Kiyevarakskiy Leading Line; it is prohibited to anchor to the E of this line. The anchorage area is exposed to NE gales
Pilotage: Compulsory. Pilot boards off the Kislaya Inlet in position 69° 11′ 30″ N; 33° 31′ 30″ E. Masters of vessels should advise the Port Authority of their ETA 24 hours prior to arrival. When leaving the port a pilot should be ordered 6 h prior to departure through the Ship's Agent and confirmed 2 h prior. Navigation is permitted at any time of the day or night. When winds are over force 6 on the Beaufort Scale, movements of vessels within the port basin and roads may be carried out with permission from the Port Authority
Radio Frequency Information: Port call sign UMN. Murmansk Radio: 500 & 2182 kHz (calling and working). Murmansk Radio 1, Port Controller: VHF Channel 16, 156·8 mHz. Murmansk Radio 9, Movements Control: VHF Channel 12, 156·6 mHz
Weather: Ice conditions occur in the vicinity of the port at the beginning of January, attaining maximum thickness by the end of February, usually disappearing by mid April. However, broken ice can be seen in the Gulf of Kolskiy during May, owing to the flo from the Tuloma and Kola Rivers. Prevailing winds; SW in Winter, NW in Summer, ENE in Autumn, SSW in Spring
Tides: Range of tide 3·66 m
Largest Vessel: 44 750 dwt, 201·6 m loa
Accommodation: The Commercial Port has a total of 20 berths with depths alongside ranging between 6 m and 13 m. The berths are equipped to handle a variety of cargoes, including bulk, timber, metals, bagged cement and other general cargo. During winter months work occasionally has to stop because of exceptionally low temperatures. There is a passenger terminal and also facilities for LASH vessels
A fishing harbour is situated to the south of the main berths
Cranes: Mobile electric portal cranes of up to 40 t cap; floating cranes up to 90 t cap and various other cargo handling equipment
Provisions: ISSA members available
Water: Fresh water available at the quays or delivered by barge
Container and Ro/Ro Facilities: Containers can be handled and also vehicles
Ore and Bulk Cargo Facilities: Two ore berths; one capable of accommodating vessels of 40 000 dwt, 11·4 m d and the other for vessels up to 180 m loa, 9 m d. Loading rate for ores up to 3000 t/day. Cargoes handled include apatites, ores, coal, minerals, grain and raw sugar
Tanker Terminals: Facilities exist for tankers
Bunkers: Available by lighters
Shiprepairs: All kinds of repairs can be effected for vessels up to 30 000 dwt. Floating dock 190·5 m by 30·5 m
Towage: Compulsory for berthing and unberthing. The number of tugs to be used is determined by the pilot with agreement from the vessels Master. Four tugs of 1200 hp and two of 2300 hp are available, together with icebreakers
Medical Facilities: First aid in port area; various city medical centres
Airport: Murmashi, about 30 km
Railway: Railway terminal, about 1 km
Local Holidays: January 1 and 2, January 7, March 8, May 1 and 2, May 9, June 12, November 7 (no affect on port working)
Working Hours: 0800–1700
Shipping Agents: Murmansk Inflot Shipping Agency, Portovy Pr. 19, Murmansk 183038, *Tel:* 22757 & 25197, *Telex:* 126116
Polar Sea Terminal Ltd., 19 Portovy Proezd, 183024 Murmansk, *Tel:* 26514 & 22370, *Telex:* 126113
Lloyd's Agents: Ingosstrakh Ltd., Pjatnitskaja ul. 12, Moscow M-35, *Tel:* (095) 231 1677, *Fax:* (095) 2302518, *Telex:* 411144 INGS SU

NARYAN MAR, Barents Sea

Lat 67° 39′ N; Long 53° 01′ E. Situated on the S bank of the Pechora River on the Gorodetskiy Shar Creek, 70 miles from the mouth at the Pechorskaya Bay. Navigation period of 120 to 130 days per year

Admiralty Chart: 3181 **Admiralty Pilot:** 72
Time Zone: GMT + 4·5 h **UNCTAD Locode:** RU NRM
Principal Facilities:

Y	G	T								

Authority: Port of Naryan-Mar Authority, Portovaya ul. 11, Naryan Mar, *Tel:* 2695 & 2825
Approach: Channel to port from the pilot anchorage is marked by leading lights and buoys. The buoys are moved as necessary to conform with the constantly changing channel. There is a bar which fronts the mouth of the river and has a maximum depth of water over it ranging from 3 m to 4·3 m at HW. Vessels can enter or leave the port at any time of day or night. All vessels arriving from a foreign port, or leaving for a foreign port, must anchor opposite Zakhrebetnyy Bay for the performance of port formalities
Anchorages: Anchorage for foreign flag vessels is recommended around position 68° 30′ N; 54° 33′ E in depths ranging from 5·4 m to 6·6 m. There are anchorage areas in the inner roads which may be pointed out by the pilot for use, and also elsewhere in the river

NARYAN MAR, Barents Sea (cont'd).

Pilotage: Compulsory. Pilot boards near Lotsmanskiy Yakornyy light buoy, 24 hour service available. Masters of vessels should inform the Port Captain 24 h prior to their expected time of arrival at the outer roadstead and confirm 4 h before ETA
Radio Frequency Information: Port call sign UOY. Naryan-Mar Radio: 500 kHz (calling and working), VHF Channel 16, 156·8 mHz, during periods of navigation only. Port controller: VHF Channel 14, 156·7 mHz
Weather: Ice conditions occur during October, when the estuary begins to freeze over, attaining a thickness of 1·2 m in the spring. The clearing of ice depends principally on the direction of the wind, and usually begins to break up during June and is normally clear by early July
Tides: Range of tide 1·8 m
Largest Vessel: Max 125 m loa, 4·5 m d
Accommodation: Four berths in the main port with depths alongside of 6·5 m. There are wharves for the handling of coal at Zakhrebetnyy Bay, 1·5 miles downstream
Storage: Warehouses are available and there are concreted open storage areas
Cranes: Portal cranes of up to 20 t cap and floating cranes of up to 50 t cap
Water: Fresh water is available
Bunkers: Supplies of fuel oil are not guaranteed
Shiprepairs: Only minor repairs can be effected
Towage: Compulsory for berthing and unberthing. Two tugs of 2300 hp and four tugs of 1200 hp are available
Principal Imports and Exports: Exports: Timber. Other cargoes handled include grain, salt, fish, metals, coal and cement
Shipping Agents: Archangel Inflot Shipping Agency, Vinogradova Pr. 61, Archangel 163061, *Tel:* 38573/4 & 34040, *Telex:* 242231 & 242115
Lloyd's Agents: Ingosstrakh Ltd., Pjatnitskaja ul. 12, Moscow M-35, *Tel:* (095) 231 1677, *Fax:* (095) 2302518, *Telex:* 411144 INGS SU

IGARKA, Kara Sea

Lat 67° 30′ N; Long 86° 40′ E. Situated on the Yenisei River. 689 km S of the estuary at the Yenisei Gulf. Navigation period from July to mid November

Admiralty Chart: 2962 **Admiralty Pilot:** 10
Time Zone: GMT + 6 h **UNCTAD Locode:** RU IGX
Principal Facilities:

G	T									

Authority: Port of Igarka Authority, Gorky ul. 47, Igarka 663200, *Tel:* 410 & 082
Approach: Safe draught for vessels across the Lipatnikovskiy and Turushinskiy bars in the Yenisei River is 7·3 m
Pilotage: Compulsory. Masters of vessels approaching from seaward have to order pilots through the Chief of Igarka Hydrobase and the Pilot Master 48 h prior to arrival at Oshmarino Point, where the river pilots usually meet vessels, and also confirm ETA 6 h prior to arrival. Two pilots are normally employed per vessel; 24 h service. In case of bad weather the pilots will board vessel at a place as directed by the Pilot Master. After navigating the river, vessels will normally be required to cast anchor in the outer roads, according to the Pilot Master's advice. Vessels can enter or leave the port at any time of the day
Radio Frequency Information: Port call sign UFR. Navigation frequencies: 500 kHz (calling), 470 kHz (working). Sever Radio, Port Controller: VHF Channel 14, 156·7 mHz
Largest Vessel: 14 203 dwt, 151·8 m loa
Accommodation: Twelve berths for vessels in the inner roads, secured stern-on to the island. Ocean-going vessels can also be handled at the timber wharf, as directed by the Port Authority. When at alongside berth, loading is by vessels own gear; and when at mooring berth, timber is carried out to vessels by floating cranes. Max loa permitted is 150 m
Storage: Warehousing and covered sheds are available
Cranes: Mobile cranes are available
Provisions: Available
Water: Fresh water is obtainable from the river at places designated by the river pilot. Not available in the port area

APPENDIX G: SEAPORTS DATA FROM DEFENSE MAPPING AGENCY'S *WORLD PORT INDEX* (DMA 1992a)

EXPLANATION OF DATA COLUMNS

In the data listing for each port, the letter "Y" indicates Yes and "N" No; where there is a blank, no information is available, By tabulation and codification, specific information for each port is confined to a single line. The data is listed under the column headings described below:

INDEX NUMBER—Each port and place listed in the text of this publication is numbered consecutively. Ports and places can be located by referring to the alphabetical index to find the index number. The page number will not be listed. In cases where there is an alternate and/or more familiar name, that name will have the same index number. However, only the approved name will appear in the text.

PORTS—Ports are grouped according to country and locality, and are listed in geographic sequence as shown on the chartlets in the fore part of the volume, following, in general, the coastal trend. The listing of ports in off-lying islands normally interrupts the coastal listing at some convenient place abreast of the island. River ports are listed toward the head of navigation, alternating from bank to bank, except where local considerations make other arrangements more practicable.

In general, ports are listed under the names approved by the U.S. Board on Geographic Names. Alternate or more familiar names, however, are also included in the index, under the same index number.

LATITUDE AND LONGITUDE—The position of each port, expressed in degrees and minutes, is generally obtained from the best-scale chart available.

SAILING DIRECTIONS—The publication number of the Defense Mapping Agency Hydrographic/Topographic Center Sailing Directions, describing the port or area in which the port is located, is normally given. For ports in other areas, however, other publications are shown under the following abbreviations:

USCP—United States Coast Pilot, published by the National Ocean Service, NOAA, Department of Commerce, for United States continental and territorial ports, including the Canadian Ports on the Great Lakes.

SCOR—Small Craft Guide, Ottawa River, published by the Canadian Hydrographic Service.

GLVI—Great Lakes Sailing Directions, Volume 1, published by the Canadian Hydrographic Service, covers the St. Lawrence River from Montreal to Lake Ontario, the waters of Lake Ontario, Lake Erie, Lake St. Clair and the connecting waterways including the Welland Canal, Detroit River and the St. Clair River.

PAC—Pilot of Arctic Canada, Volumes 1, 11 and 111, published by the Canadian Hydrographic Service, covers coasts and adjacent sea areas of the Canadian eastern and western arctic, northward of Hudson Bay.

BA—Black Sea Pilot, published by the Hydrographic Department of the British Admiralty for ports in the Black Sea.

CHARTS—The number of the best-scale chart issued by the Defense Mapping Agency Hydrographic/Topographic Center is listed with no prefix. In some cases, foreign charts are listed when this Center does not provide coverage. These charts can be obtained from the Hydrographic departments or services of the countries concerned or their authorized agents.

SIZE—The classification of port size is based on several applicable factors, including area, facilities, and wharf space. It is not based on area alone or on any other single factor.

TYPE HARBOR—The term "harbor" is used for the principal water area of the port. Harbors are classified as being coastal natural, coastal breakwater, open roadstead, etc. Typical harbor types are illustrated in the forepart of this volume.

SHELTER AFFORDED—The shelter afforded from wind, sea, and swell refers to the area where normal port operations are conducted, usually the wharf area. Shelter afforded the anchorage area is given for ports where cargo is handled by lighters,

ENTRANCE RESTRICTIONS—Natural factors restricting the entrance of vessels, such as ice, heavy swell, etc., are listed.

OVERHEAD LIMITATIONS—This entry is shown only to indicate that bridge and overhead power cables exist. It is advisable to refer to the chart for particulars.

DEPTHS—Depth information generalized into 5 foot units, equivalents in meters, is given for the main channel, the main anchorage, and the principal cargo pier and/or oil terminal. Depths refer to chart datum.

Depths are given in increments of 5 feet in order to lessen the number of changes when a small change in depth occurs.

A depth of 31 feet would use letter "K", a depth of 36 feet would use "J", etc. The letter "K" means a least depth of 31 feet or greater but not as great as 36 feet.

Channel (controlling)—The controlling depth of the principal or deepest channel at chart datum is given. The channel selected should lead up to the anchorage if within the harbor or to the wharf/pier. If the channel depth decreases from the anchorage to the wharf/pier and cargo can be worked at the anchorage, then the depth leading to the anchorage is taken.

Anchorage—The depth in the anchorage is the least depth in the best or principal anchorage. The depth listed reflects a general depth in the anchorage rather than an isolated shoal spot. A shoal which does not necessarily obstruct the anchorage is not considered for the least depth if the rest of the anchorage is safe and practicable.

Wharf/Pier—The greatest depth at chart datum alongside the respective wharf/pier is given. If there is more than one wharf/pier, then the one which has greatest usable depth is shown.

TIDE—The mean range in feet is normally given, but the mean rise is substituted if range data is not available. It is felt that the distinction between range and rise can be disregarded without affecting the general utility of this publication.

MAXIMUM SIZE VESSEL—"L" indicates that a ship of over 500 feet may be accommodated and "M" indicates ships less than 500 feet.

GOOD HOLDING GROUND—This is indicated only where actual anchorage conditions have been reported.

TURNING AREA—An indication that a turning basin or other water area for vessels is available in the port.

FIRST PORT OF ENTRY—A port where a vessel may enter and clear foreign goods and personnel through Customs and Immigration. For vessels arriving from overseas a quarantine clearance is required by the First Port of Entry.

U.S. REPRESENTATIVE—Indicates whether the United States maintains civilian/military representation in that port.

ETA (Estimated Time of Arrival) MESSAGE—Indicates whether ETA message is required for that port.

PILOTAGE—The necessity or advisability of taking a pilot is given. In some cases, pilot may be compulsory, although pilots are not actually stationed at the port in question and must be obtained elsewhere.

TUGS—Indicates whether tugs are available for docking or anchorage assistance.

QUARANTINE—Indicates if regular quarantine procedures are required or if further details must be found in other publications.

COMMUNICATIONS—Indicates what types of communications are available in the port and/or near-by area.

LOAD–OFF-LOAD—Refers to the area where normal port operations are conducted.

MEDICAL FACILITIES—An indication that there is some form of medical facilities in the port that will accommodate seamen.

GARBAGE DISPOSAL—Indicates whether garbage can be disposed of at the pier or by lighters at the anchorage or mooring.

DEGAUSSING—Indicates whether degaussing facilities are available.

DIRTY BALLAST—Pertains to a port that has sufficient facilities for receiving oily and/or chemically contaminated dirty ballast.

CRANES–LIFTS—Indicates whether there are cranes available and what type, and indicates its lifting power in tons.

SERVICES—Indicates whether normal port services are available.

SUPPLIES—The availability of provisions, water, and fuel oil is listed. Fuel oil and diesel oil are listed separately, but in cases of original source information falling to distinguish between the two, both kinds are presumed to be available and are so listed.

REPAIRS—Repairs that can be made to oceangoing vessels are classified as follows:

A–Major—Extensive overhauling and rebuilding in well equipped shipyards.

B–Moderate—Extensive overhauling and rebuilding that does not require drydocking. Suitable drydocking facilities are usually lacking or inadequate.

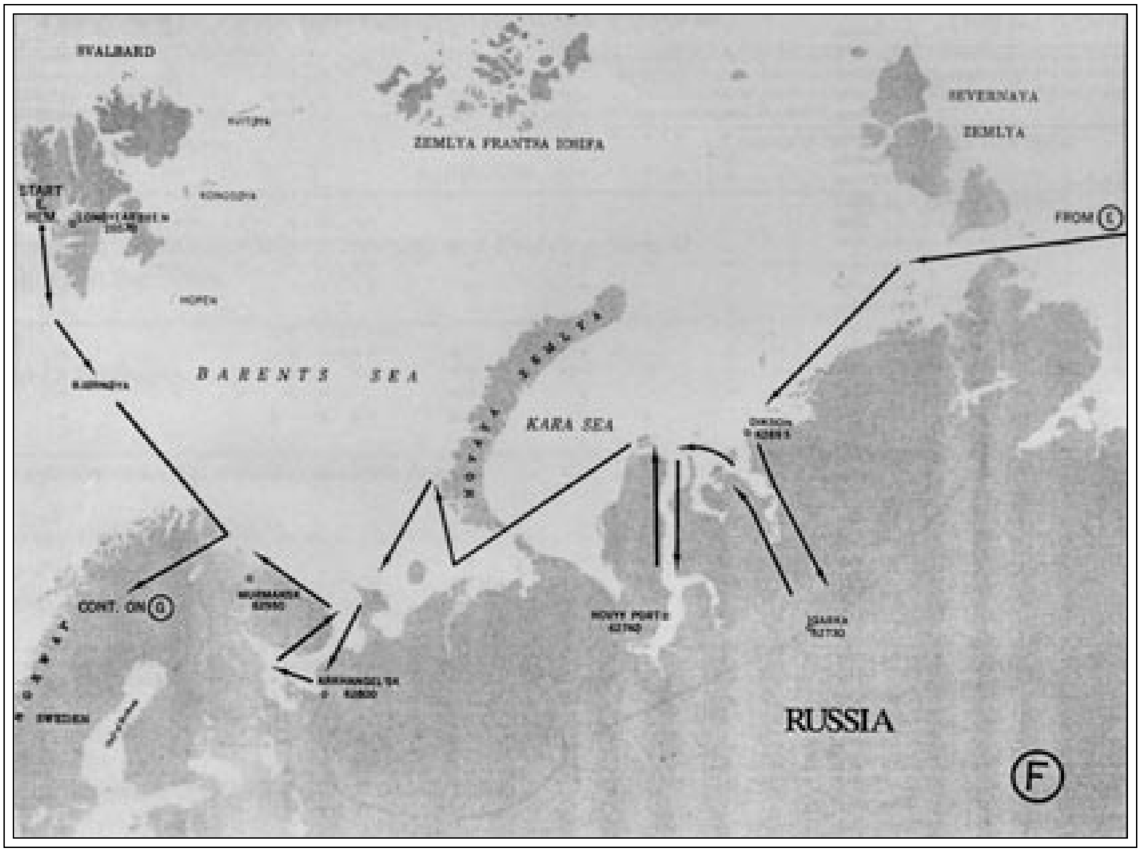
C–Limited—Small repair work in independent machine shops or foundries.

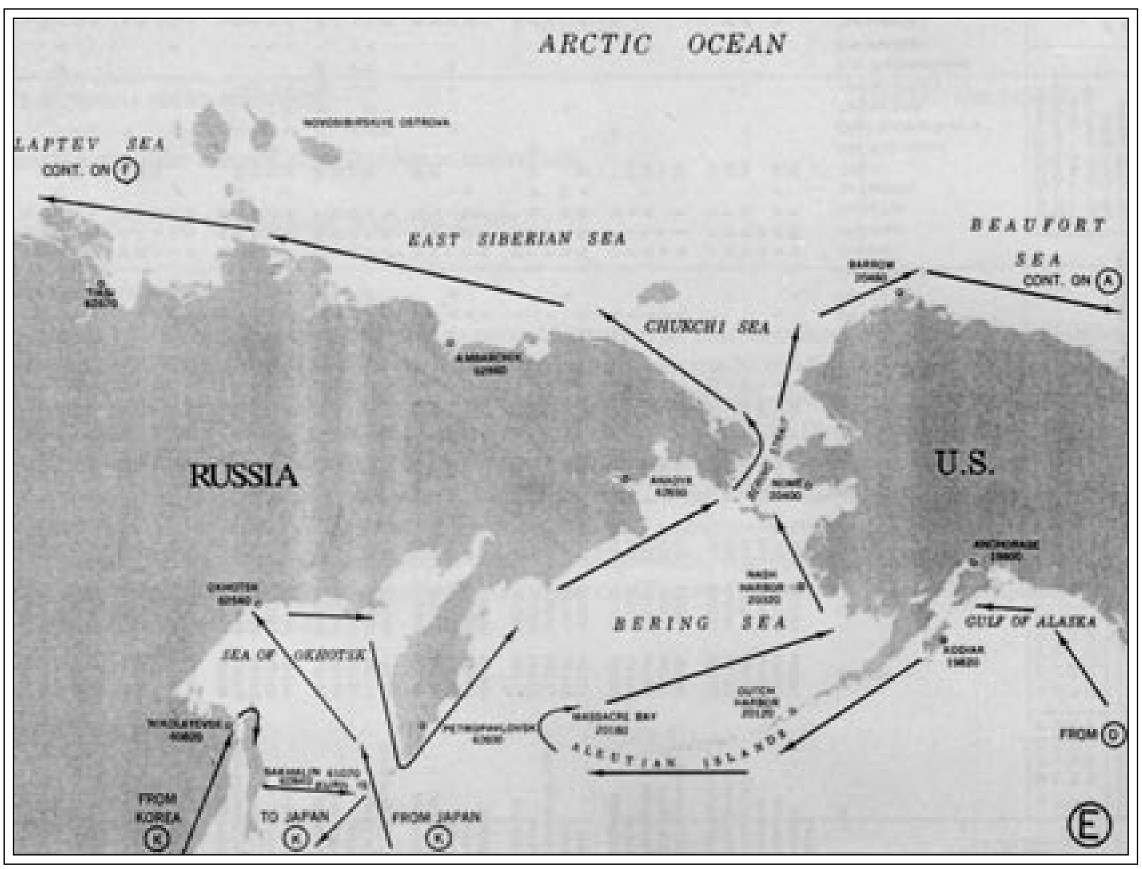
D–Emergency only.

N–None.

DRYDOCK–MARINE RAILWAY—The general size and type of the largest underwater repair facility in the port is listed.

Drydock	**Marine Railways**
Up to 656 feet—S—Up to 200 meters	Up to 200 tons—S
657 feet to 984 feet—M—201 to 300 meters	201 to 1000 tons—M
985 feet and over—L—301 meters and over	Over 1000 tons—L





Arrows show the geographic sequence, and numbers abreast selected ports indicate the numerical sequence of ports listed.

FEET				
	A 76–Over	E 56–60	J 36–40	N 16–20
	B 71–75	F 51–55	K 31–35	O 11–15
	C 66–70	G 46–50	L 26–30	P 6–10
	D 61–65	H 41–45	M 21–25	Q 0–5
METERS	A 23.2–Over	E 17.1–18.2	J 11.0–12.2	N 4.9–6.1
	B 21.6–22.9	F 15.6–17.0	K 9.4–10.7	O 3.4–4.6
	C 20.1–21.3	G 14.0–15.2	L 7.9–9.1	P 1.8–3.0
	D 18.6–19.6	H 12.5–13.7	M 6.4–7.6	Q 0–1.5

Harbor Size	Harbor Type	Shelter Afforded	Max Size Vessel
L—Large M—Medium S—Small V—Very Small	CN—Coastal Natural CB—Coastal Breakwater CT—Coastal Tide Gate RN—River Natural RB—River Basin RT—River Tide Gate LC—Lake or Canal OR—Open Roadstead TH—Typhoon Harbor	E—Excellent G—Good F—Fair P—Poor N—None	L—Over 500' Length M—Up to 500' Length

Repairs	Drydock and Marine Railway
A—Major B—Moderate C—Limited D—Emergency Only N—None	L—Large M—Medium S—Small

Index No.	Port	Latitude	Longitude	Sailing Directions	Chart	Harbor Size	Harbor Type	Shelter	Entrance Restrictions: Tide	Entrance Restrictions: Swell	Entrance Restrictions: Ice	Entrance Restrictions: Other	Overhead Limits	Channel	Anchorage	Cargo Pier	Oil Terminal	Tide	Max Size Vessel	Good Holding Ground	Turning Area	1st Port of Entry	U.S. Representative	ETA Message	Pilotage: Compulsory	Pilotage: Available	Pilotage: Local Assist.	Pilotage: Advisable	Tugs Salvage	Tugs Assist.	Quarantine: Pratique	Quarantine: Deratt Cert.	Quarantine: Other	Communications: Telephone	Communications: Telegraph	Communications: Radio	Communications: Radio Tel.	Communications: Air	Communications: R&R	Load/Off Load: Wharves	Load/Off Load: Anchor	Load/Off Load: Med Moor	Load/Off Load: Beach Moor	Load/Off Load: Ice Moor	Medical Facilities	Garbage Disposal	DeGauss	Dirty Ballast	Cranes: Fixed	Cranes: Mobile	Cranes: Floating	Lifts: 100 tons Plus	Lifts: 50–100 Tons	Lifts: 25–49 Tons	Lifts: 0–24 Tons	Services: Longshore	Services: Elect	Services: Steam	Services: Navg Equip	Services: Elect Repair	Supplies: Provisions	Supplies: Water	Supplies: Fuel Oil	Supplies: Diesel Oil	Supplies: Deck	Supplies: Engine	Repair	Drydock	Railway
62530	Russia																																																																				
62540	Okhotsk	5922N	14312E	155	96441	V	RN	F				Y		P	M	P		07								Y									Y	Y		Y			Y				Y					Y					Y							Y					D		
62550	Nagayeva	5934N	15043E	155	96441	M	CN	E			Y			A	H	K	L	09						Y	Y			Y				Y		Y		Y		Y	Y	Y					Y					Y	Y				Y							Y	Y	Y			B		M
62560	Nayakhan	6154N	15900E	155	94640	V	RN	P						P	N																				Y						Y																										C		
62590	Novaya Tarya	5254N	15832E	155	96500	V	CN	G						B	B	O		05		Y					Y																Y																					Y	Y				D		
62800	Petropavlovsk	5301N	15839E	155	96500	M	CN	E				Y		K	D	L		05				Y			Y			Y			Y	Y			Y	Y			Y	Y			Y		Y				Y	Y	Y	Y	Y	Y	Y				Y	Y	Y	Y	Y		Y	Y	A	M	
62610	Bukhta Kryugera	5601N	16158E	155	96520	V	CN	G			Y			H	H	P		04																							Y				Y																	Y					C		
62620	Ust Kamchatsk	5613N	16225E	155	96520	S	RN	F			Y			P	J	P		03													Y					Y					Y				Y																Y						D		
62630	Nikol Skoye	5512N	16559E	155	95740	V	RN	F			Y			H	J			04																		Y					Y				Y																Y	Y					D		
62640	Provideniya	6423N	17318W	155	532	S	CN	G			Y			B	J	K	L	02						Y				Y		Y						Y				Y								N		Y					Y	Y					Y	Y	Y	Y			C		
62650	Anaoyr	6444N	17730E	155	96621	V	RN	G			Y			N	J	P		04																		Y		Y			Y				Y																						D		
62660	Ambarckik	6938N	18219E	183	41100	V	CN	F			Y			O	L	P				Y					Y														Y		Y				Y																Y	Y	Y				B		
62670	Tiksi	7138N	12852E	183	BA 2683	S	CN	F			Y			M	M	M	P	01							Y											Y		Y		Y	Y				Y				Y	Y	Y			Y	Y							Y	Y				C		
62680	Pevek	6943N	17018E	183	41060	V	CN	G				Y		K	J	M	M				Y														Y			Y		Y					Y					Y					Y							Y	Y				C		
62690	Kapitana Varzugina	7233N	08050E	183	BA 2693	V	CN	F			Y			K	J										Y																Y																					Y					D		
62695	Dikson	7330N	08027E	183	42141	V	CN	F			Y			L	M	N	N	01	M						Y			Y								Y		Y		Y	Y				Y																Y	Y	Y				C	S	
62700	Golchikha	7143N	08330E	183	BA 2693	V	CN	P			Y			M	M										Y																Y																				Y						D		
62710	Ust-Port	6940N	08426E	183	800	V	RN	G			Y			M	K	L									Y															Y																											D		
62720	Dudinka	6924N	08610E	183	800	M	RN	G			Y			L	L	M	P								Y			Y								Y		Y	Y	Y	Y				Y				Y	Y				Y	Y								Y				C		
62730	Igarka	6728N	08635E	183	800	M	RN	G	N	N	Y	Y		L	K	J	J			Y		Y	N	Y	Y	Y				Y	Y			Y	Y	Y		Y		Y		Y						N	Y	Y	Y					Y					Y	Y	Y	Y	N	N	C		
62740	Novyy Port	6740N	07254E	183	804	V	RN	F			Y			M	N	P		02							Y											Y					Y				Y																								
62750	Khabarovo	6939N	06025E	183	42301	V	CN	F			Y			H	J	P		01							Y											Y					Y																				Y	Y							
62760	Malyye Karmakuly	7223N	05243E	183	804	V	CN	F			Y			H	G	P				N					Y											Y					Y				Y																	Y							
62770	Nar Yan-Mar	6739N	05300E	183	804	V	RN	F	N	N	Y	Y		N	N	N		02		Y	Y	Y	N	Y	Y	Y		Y			Y	Y	Y	Y	Y	Y	Y	Y		Y					Y			N		Y	Y			Y	Y	Y	Y				Y	Y					C	S	
62775	Mezen	6610N	04400E	183	BA 2271	S	CN	G	Y	N	Y	Y		O	N	O		16		Y		Y	N	Y	Y	Y		Y		Y		Y	Y	Y	Y	Y				Y					Y			N		Y	Y				Y	Y	Y				Y	Y	Y				C		
62790	Solombala	6435N	04030E	183	BA 2280	S	RN	F			Y			L	M	M		02							Y					Y						Y		Y		Y					Y						Y	Y															A	S	
62800	Arkhangel'sk	6432N	04031E	183	BA 2280	M	RN	G	Y	N	Y	Y	Y	M	M	L		02		Y	Y	Y	N	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y					Y			N	Y	Y	Y		Y	Y		Y	Y				Y	Y	Y	Y	Y	Y	A	S	
62810	Severodvinsk	6434N	03947E	183	BA 2273	S	CN	F			Y			L	K	K	L	02		Y	Y	Y		Y	Y			Y		Y	Y			Y	Y	Y		Y	Y	Y					Y				Y	Y	Y	Y			Y	Y	Y				Y	Y	Y	Y			A	S	
62820	Onega	6354N	03806E	183	BA 2097	V	RN	F	Y	N	Y	Y		O	N	O		04	M	Y				Y	Y			Y		Y		Y	Y			Y			Y	Y					Y			N								Y					Y	Y	Y				C		
62830	Belomorsk	6432N	03448E	183	BA 2275	S	CN	F			Y			N	N	N		04		Y		Y		Y	Y						Y	Y	Y			Y			Y	Y					Y											Y	Y										C		
62840	Rabocheostrovsk	6459N	03447E	183	BA 2274	S	CN	F			Y			N	M	K	N	05		Y					Y			Y								Y			Y	Y					Y				Y						Y	Y	Y					Y					C		
62850	Gavan Blagopoluchiya	6502N	03542E	183	BA 2274	S	CN	F			Y			O	M	N				Y					Y											Y				Y					Y																						C	S	
62860	Keret	6617N	03334E	183	BA 3180	S	CN	F			Y			K	K	M				Y					Y										Y					Y					Y											Y	Y										C		
62870	Kovda	6641N	03252E	183	BA 3180	S	CN	G			Y			J	N	N				Y				Y	Y			Y							Y										Y				Y						Y	Y	Y												
62890	Kandalaksha	6708N	03225E	183	BA 3180	S	CN	G			Y			K	J	M		07							Y											Y			Y	Y					Y					Y					Y	Y	Y										C		
62900	Bolshaya Piryu Guba	6840N	03422E	183	BA 3180	S	CN	G			Y			N	J	N		05							Y			Y								Y				Y					Y											Y											C	S	
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62930	Gavrilovo	6911N	03551E	183	42740	V	CN	F			Y			H	K	P				Y					Y									Y		Y					Y				Y																								
62940	Vayenga	6905N	03327E	183	42760	S	CN	G			Y			A	H	M		07		Y					Y											Y				Y					Y																						B	M	
62950	Murmansk	6859N	03303E	183	42760	M	CN	G	N	N	Y	N		E	K	K	M	10	L	Y	Y	Y	N	Y	Y	Y	Y		Y		Y	Y		Y	Y	Y	Y	Y	Y	Y					Y			Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	A	L	S
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62970	Mys Abram	6859N	03302E	183	42760	V	CN	F			Y			H	H	N									Y											Y				Y					Y					Y						Y	Y				Y								
62980	Lavna	6902N	03301E	183	42760	V	CN	F			Y			Q	H	Q				Y					Y																Y																												
62990	Polyarinyy	6912N	03328E	183	42762	S	CN	G			Y			J	A	L		07		Y					Y										Y	Y				Y					Y																Y						B		
62000	Ostrov Sedlovatyy	6915N	03328E	183	42762	V	CN	F						A	A	P				Y					Y																Y																												
63010	Port Vladimir	6925N	03309E	183	42762	S	CN	G						H	H	P		07							Y																Y																												

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The summer of 1991 marked the first time in recent history that Russia offered to escort ships of other countries across the Northern Sea Route (NSR). For moving cargo between the North Pacific region and Northern European ports, the NSR, along Russia's northern coastline, is between 35 and 60% shorter than the traditionally used routes through the Suez and Panama Canals. In addition to its shorter distance, there already exists an extensive ports and shipping infrastructure, a current cargo base, and the potential for developing new markets in Russia and other northern areas. These incentives are attracting considerable attention from the international shipping community, including that portion servicing Alaskan and northwestern U.S. ports. This report is a general compilation of the historical usage, recent trade developments, the current regulatory climate, the physical environment, the ports and navigational infrastructure, cost factors, and practical considerations that may shape future U.S. interests in the route.

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