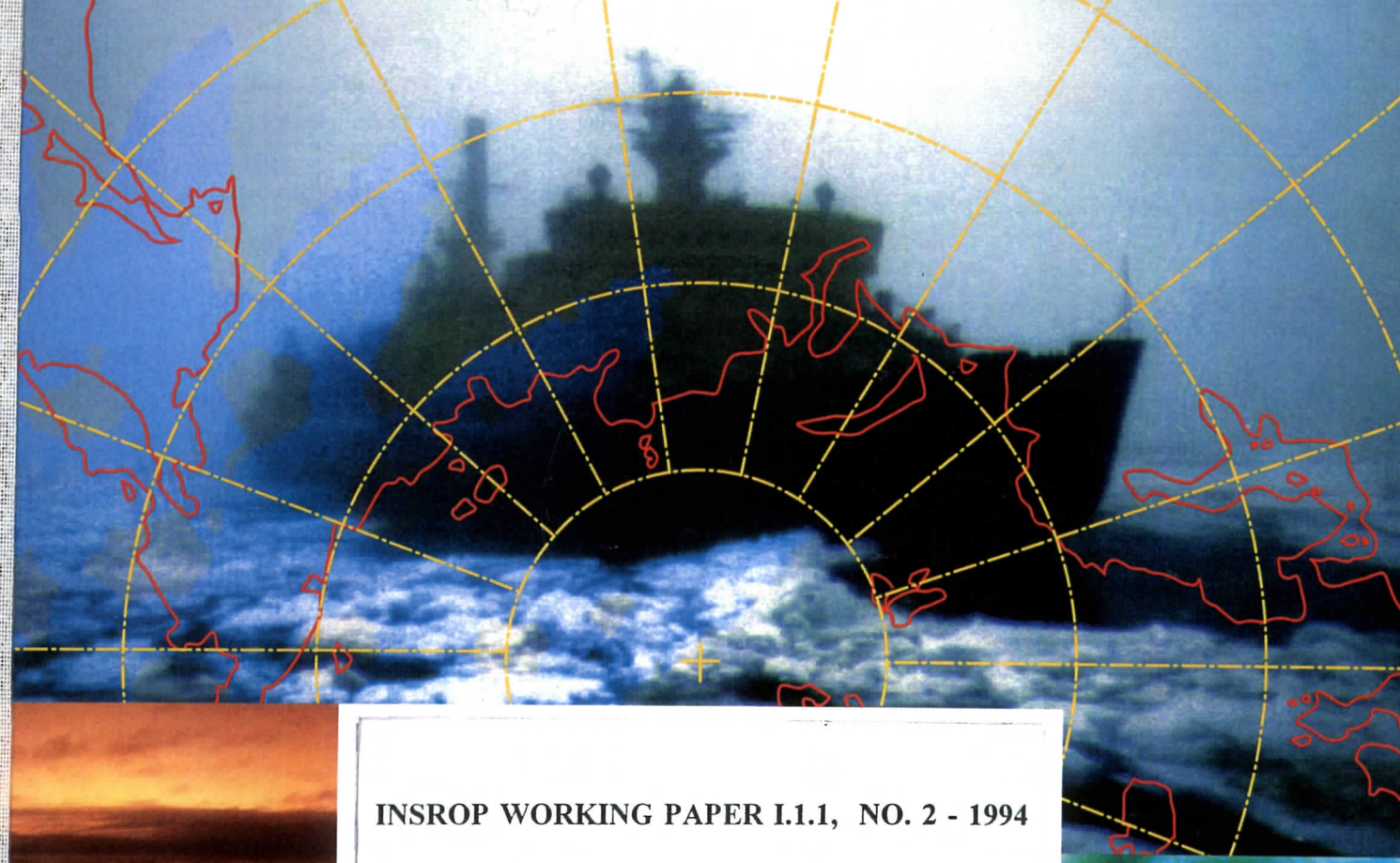
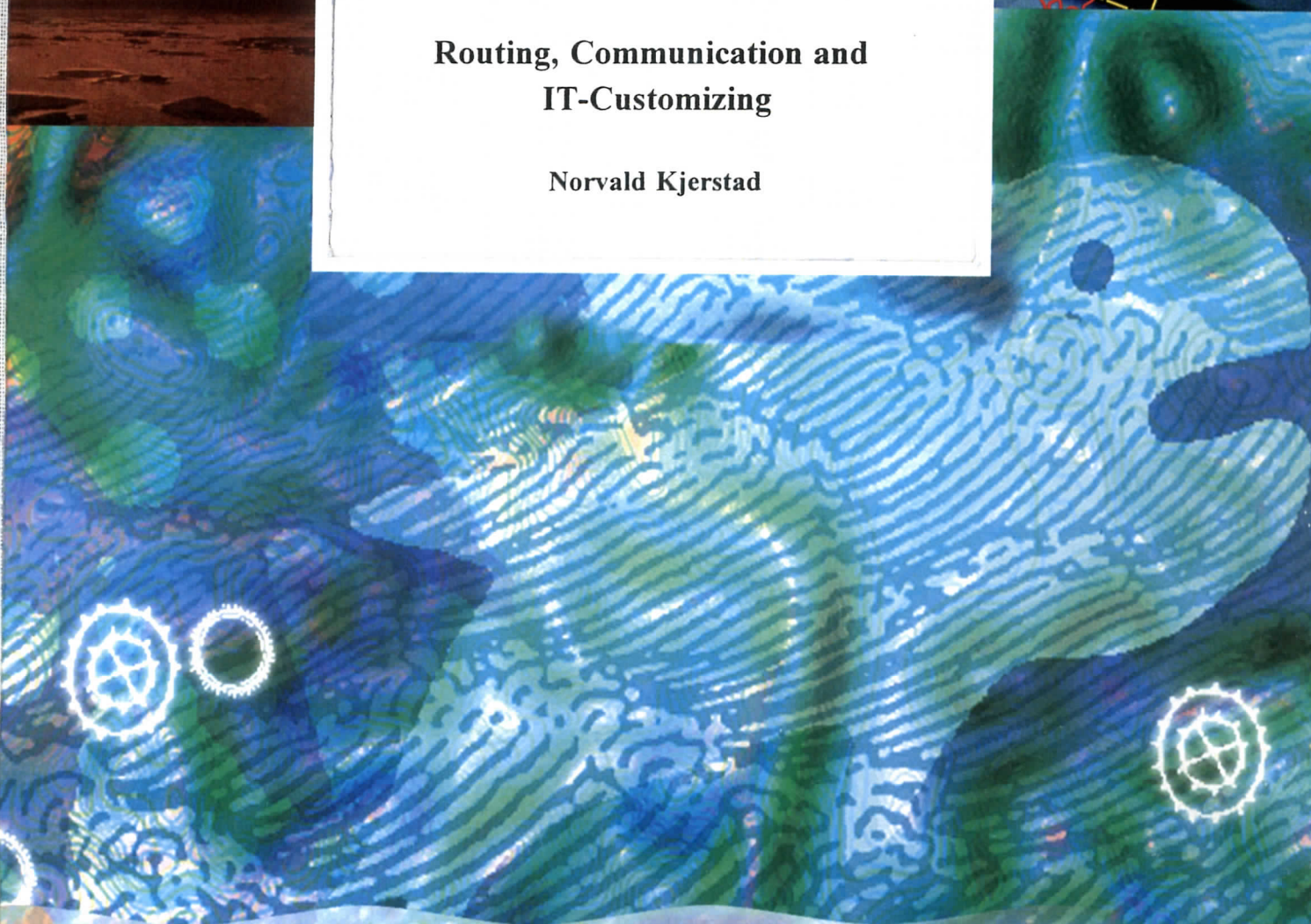


INSROP WORKING PAPER I.1.1, NO. 2 - 1994

Routing, Communication and IT-Customizing

Norvald Kjerstad



INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship & Ocean Foundation, Japan

INSROP - WORKING PAPER

Sub-programme I: Natural Conditions and Ice Navigation

Project: 1.1. Routing, Communication and IT-customizing

By supervisor: Master of Nautical Science/
Captain Norvald Kjerstad

Address: Møre and Romsdal Maritime College (M & R),
Sjømannsveien 27, 6008 Ålesund, NORWAY

Date: 30 June 1994

Reviewed by: Captain Lawson W. Brigham, US Coast Guard

What is an INSROP Working Paper and how to handle it:

FOREWORD - INSROP WORKING PAPER

INSROP is a five-year multidisciplinary and multilateral research programme, the main phase of which commenced in June 1993. The three principal cooperating partners are **Central Marine Research & Design Institute (CNIIMF)**, St. Petersburg, Russia; **Ship and Ocean Foundation (SOF)**, Tokyo, Japan; and **Fridtjof Nansen Institute (FNI)**, Lysaker, Norway. The INSROP Secretariat is shared between CNIIMF and FNI and is located at FNI.

INSROP is split into four main projects: 1) Natural Conditions and Ice Navigation; 2) Environmental Factors; 3) Trade and Commercial Shipping Aspects of the NSR; and 4) Political, Legal and Strategic Factors. The aim of INSROP is to build up a knowledge base adequate to provide a foundation for long-term planning and decision-making by state agencies as well as private companies etc., for purposes of promoting rational decisionmaking concerning the use of the Northern Sea Route for transit and regional development.

INSROP is a direct result of the normalization of the international situation and the Murmansk initiatives of the former Soviet Union in 1987, when the readiness of the USSR to open the NSR for international shipping was officially declared. The Murmansk Initiatives enabled the continuation, expansion and intensification of traditional collaboration between the states in the Arctic, including safety and efficiency of shipping. Russia, being the successor state to the USSR, supports the Murmansk Initiatives. The initiatives stimulated contact and cooperation between CNIIMF and FNI in 1988 and resulted in a pilot study of the NSR in 1991. In 1992 SOF entered INSROP as a third partner on an equal basis with CNIIMF and FNI.

The complete series of publications may be obtained from the Fridtjof Nansen Institute.

SPONSORS FOR INSROP

- Sasakawa Foundation/Ship & Ocean Foundation, Japan
- The government of the Russian Federation
- The Norwegian Research Council
- The Norwegian Ministry of Foreign Affairs
- The Norwegian Ministry of Industry and Energy
- The Norwegian Ministry of the Environment
- State Industry and Regional Development Fund, Norway
- Norsk Hydro
- Norwegian Federation of Shipowners
- Fridtjof Nansen Institute
- Kværner a.s.

PROFESSIONAL ORGANISATIONS PERMANENTLY ATTACHED TO INSROP

- Ship & Ocean Foundation, Japan
- Central Marine Research & Design Institute, Russia
- Fridtjof Nansen Institute, Norway
- National Institute of Polar Research, Japan
- Ship Research Institute, Japan
- Murmansk Shipping Company, Russia
- Northern Sea Route Administration, Russia
- Arctic & Antarctic Research Institute, Russia
- ARTEC, Norway
- Norwegian Polar Research Institute
- Norwegian School of Economics and Business Administration
- SINTEF NHL (Foundation for Scientific and Industrial Research - Norwegian Hydrotechnical Laboratory), Norway.

PROGRAMME COORDINATORS

- **Yuri Ivanov, CNIIMF**
  Krasnoy Konnitsy Str.6
  St. Petersburg 193015, Russia
  Tel: 7 812 271 5633
  Fax: 7 812 274 3864
  Telex: 12 14 58 CNIMF SU
- **Willy Østreng, FNI**
  P.O. Box 326
  N-1324 Lysaker, Norway
  Tel: 47 67 53 89 12
  Fax: 47 67 12 50 47
  Telex: 79 965 nanse n
  E-mail: Elin.Dragland @fni.wpoffice.telemax.no
- **Masaru Sakuma, SOF**
  Senpaku Shinko Building
  15-16 Toranomon 1-chome
  Minato-ku, Tokyo 105, Japan
  Tel: 81 3 3502 2371
  Fax: 81 3 3502 2033
  Telex: J 23704

Preface

The purpose of this report is to provide Sub-program I "Natural Conditions and Ice Navigation" with a nautical approach and operational aspects regarding navigation and communication on the Northern Sea Route. The work related to customizing of modern information technology (IT) has basically been carried out through consultative meetings and letters to the project leader of project I 3.1 "Design of Information System" and will not be included in this report.

Most of the activity in 1993 was dedicated to collection of relevant data for future reports concerning the field of routing and navigation on the Northern Sea Route (NSR). The report will be divided into two volumes, the present being the first. The second will fulfill the need of a comprehensive description of the NSR and the accessible technology and techniques for navigating, routing and navigation-training in Arctic waters. The report will be drawn up within the framework of future operational courses in Arctic navigation, which will probably become compulsory when the ongoing reform of the ice classification of ships has entered into force.

The first volume has been delayed by four months due to late budget agreement. However the described work of the 1994 activities (volume 2) will as far as can be seen today be completed on schedule, appearing in December 1994. A preliminary description of the contents of volume 2 appears in the present volume 1. One of the tasks of this project has been to inform actual operators of vessels in Arctic waters about the process along the NSR. This has been done through articles published in various shipping magazines in Scandinavia.

I would like to thank Murmansk Shipping Company and the Canadian Coast Guard (CCG), and in particular Victor Santos Pedro of CCG for hospitality,important information and cooperation.

Ålesund 30.06.94

Norvald Kjerstad
Project Manager

Contents of volume 1

Preliminary contents of Volume 2

(Planned completion December 1994)

Operational aspects

- Passage planning
- Ice surveillance
- Modern routing technology
- Radar navigation in ice
- High latitude problems
- Navigation in ice
- Safe speed
- Convoy operations
- Ship stability
- Contingency planning
- Critical situations

Ship Technology

- Classification rules
- Harmonization of ice-classes
- Icebreakers
- Merchant Ships
- Damage statistics and accident analysis

Terminology for Ice navigation

Abbreviations

ALRS	Admiralty List of Radio Stations
CCG	Canadian Coast Guard
CNIIMF	Central Marine Research & Design Institute, Russia
ECDIS	Electronic Chart Display and Information System
FESCO	Far East Shipping Company
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
HF	High Frequency
IALA	International Association of Lighthouse Authorities
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
INSROP	International Northern Sea Route Project
LORAN	Long Range Navigation System
MARPOL	Maritime Pollution Prevention Convention
MF	Medium Frequency
MSC	Murmansk Shipping Company
n.m.	Nautical Mile (1852 meters)
NP	Nautical Publications (British Admiralty)
NSR	Northern Sea Route (Northeast Passage)
SAR	Search And Rescue / Synthetic Aperture Radar
SOLAS	Safety Of Life At Sea (IMO-conv.)
VHF	Very High Frequency

1 Nautical Publication and reference material for navigation on the Northern Sea Route.

For professional ship navigators there is a mass of publications available as a tool for better planning and more efficient sailing. Some of them are compulsory and others optional. According to international law the officers have a duty to keep themselves updated on available information sources at all times and develop routines to ensure that the information is updated to the latest possible level.

Most of the publications covering the whole world are provided by US and British Admiralty, but when it comes to the Northern Sea Route (NSR) the published material is based on sparse and obsolete material sometimes totally lacking vital information. The international opening of the NSR will induce a timely updating and extension of nautical publications. The INSROP project is in addition to the international hydrographic- and IMO related organizations important in promoting this process. In this chapter I will now make a summary of nautical publications and focus on the NSR-updates.

1.1 Geographical Information System (GIS), developed by INSROP.

When INSROP was started in 1993 development of a GIS system for the NSR was initiated. The purpose of the system was to store , retrieve, integrate and analyze information obtained in the projects related to Natural Conditions, Ice Navigation and Environmental Factors (Løvås,94). Queries related to these issues can be analyzed and displayed on a PC-based terminal with windows-based ArcView software. Examples of queries:

What impact will a potential oil-spill have on the environment in a given area ?

What kind of facilities are accessible in a given port?

What is the probability of meeting ice in a given area at a given time ?

Detailed information on the NSR GIS-system can be obtained from :

SINTEF-NHL
N-7034 Trondheim
Norway

The system will contribute with important information both for land- and ship-based planning. An example of an initial map can be seen on figure 1.1.

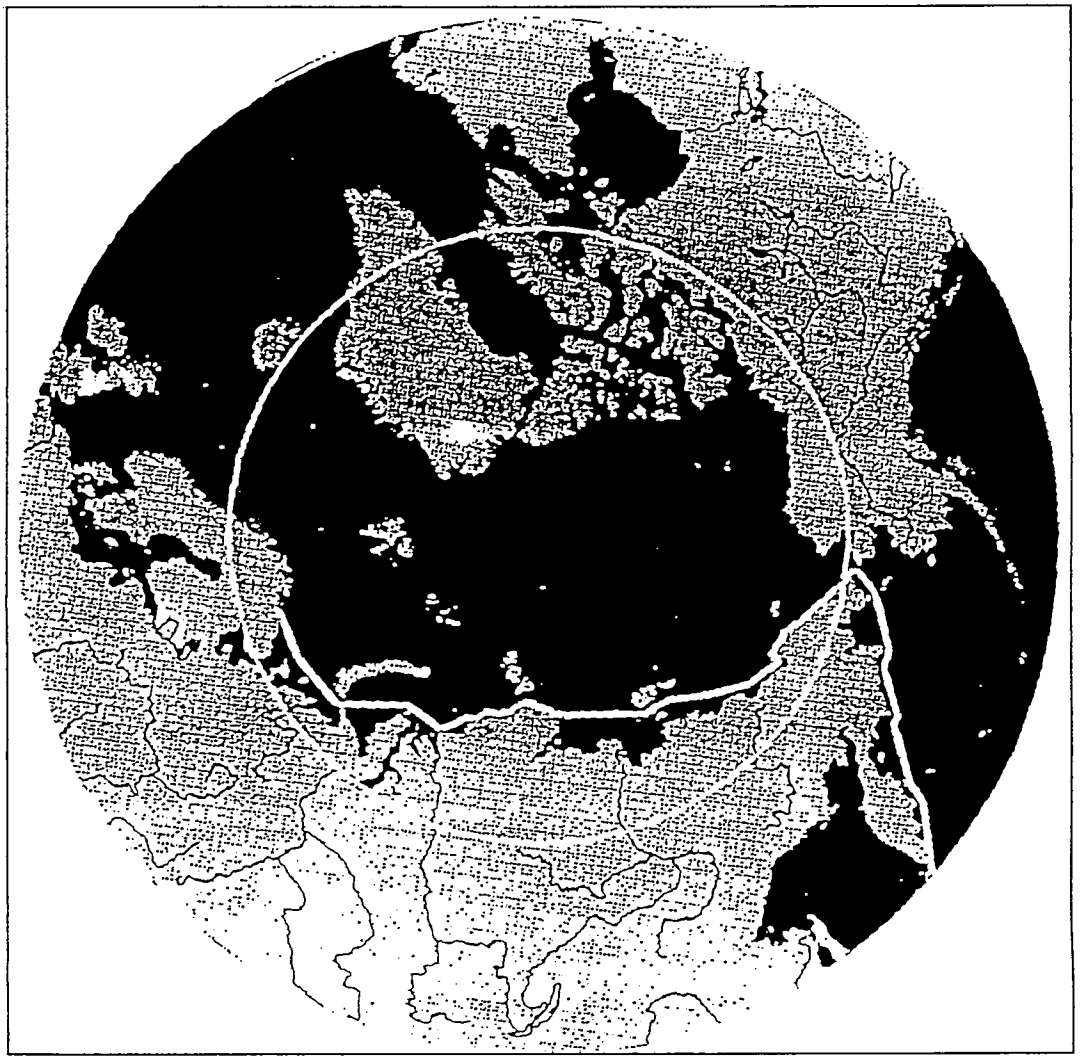


Figure 1.1 *Example on display from GIS system based on ArcView software. NSR is indicated as a white line on the initial map (Løvås,94).*

1.2 Admiralty Chart Catalogue (NP 131)

This catalogue is an integral part of a vessel's chart and publication outfit. It is published by the Hydrographer of the Navy and can be obtained through an agent. The catalogue lists all charts currently produced by the British Admiralty and displays the coverage diagrammatically. The publication will

be updated annually and also includes the development of electronic chart coverage. Similar catalogues are published byother Hydrographic offices but few are relevant to the NSR. At the present time there are few non-Russian charts available for navigation on the NSR. Their scale and quality makes them useful only for planning purposes. The following charts are accessible from the British Admiralty (ref. also fig.1.6 - 1.10):

Nr.:	Name / Nation:	Scale:
2683	Pacific Ocean	21,830,000
2961	Pechorskaya-Guba	200,000
2962	The North Cape to Uyedinyenya	2,400,000
2963	Obskaya Guba and Yenisey Zaliv	1,000,000
	Port of Dikson	75,000
2967	Karskye Vorota / Yugorskiy Shar	325,000
3181	Mys Kanin to Ostrov Belyy	1,000,000
3182	Matochkin Shar - O.Uyedinenya	1,000,000
4814	Bering Sea - northern part	3,500,000
5555	North Coast of Siberia	2,830,000

1.3 Sailing Directions (NP 1 - 72 / US 183)

When planning a passage and tracing a safe route in the chart it will normally be necessary to consult a Pilot Description. Such descriptions can be obtained through the Admiralty. One book covers a limited area and is frequently updated at intervals of 10 - 15 years. Unfortunately the existing descriptions covering the NSR currently lack the high level of information included for the rest of the world, however the following descriptions are helpful in some degree:

Nr.:	Area Covered / Nation
NP-10	Arctic Pilot Vol.I, Novaya Zemlya - Wrangel Island / British.
NP-23	Bering Sea and Strait Pilot / British.
NP-72	White Sea Pilot / British
US-183	Sailing Directions on the northern coast of the U.S.S.R.

1.4 Ocean Passages of the World (NP-183)

This publication deals with all areas not covered in the sailing descriptions and is very helpful when planning trans-ocean sailings. Information on meteorological and oceanographic conditions are included, and will of course be relevant in the approach to the NSR.

1.5 Notice to Mariners and NAVTEX

The weekly edition of Notice to Mariners is the principal method of keeping Admiralty charts and publications up to date, and is published by the British Admiralty. Information on new shoals, destroyed navigation marks, etc. can be found. An annual summary of the Notice to Mariners can be obtained. The Notice has relevance to NSR when the Russian Hydrographic Office exchanges information with the publisher. Update on electronic charts can be obtained on magnetic / optic media or by satellite communication link. The compulsory NAVTEX-system will also contribute with nautical updates in an efficient manner. The NAVTEX system receives messages from different coast-radio stations and warnings are printed automatically. The NAVTEX coverage of the NSR is still insufficient, but will in future probably be updated to the compulsory GMDSS system (Global Maritime Distress and Safety System).

1.6 Admiralty list of Lights (NP-84, vols. A-L)

This publication or equivalent publication from other countries is compulsory to carry on ships. It contains details of all navigation lights, including light buoys significant to normal navigation. Included is also information on luminous range, fog signals, etc. Different areas are covered by different volumes and volume L covers the entire Arctic except for Canadian and US territory. Unfortunately data covering the area between Dikson and the Strait of Bering has not been released from the USSR, and is consequently missing. The international development of the NSR will hopefully give access to these data for publishing in future issues. The list is normally updated every 15 months.

1.7 Admiralty List of Radio Signals (NP 281 - 286)

It is a compulsory requirement to carry these 6 volumes (or equivalent) on ships equipped according to GMDSS.

Vol.1 Coast Radio Stations. In this volume data and service from the coast radio stations are listed. Part 1 of this volume is relevant to the NSR and information on the following stations can be found:

- Murmansk UMN)
- Mezen (UZT)
- Kandalakcha (UZI)
- Amderma (UPM)
- Igarka (UFR)
- Egvekinot (UK02)
- Ust-Kamtchatsk (UOS2)
- Arkhangelsk (UGE)
- Onega (UZS)
- Narian-Mar (UOY)
- Dikson Ostrov (UPV)
- Provedenia Bukhta (UCZ / UPB)
- Anadyr (UIF2)

No information is accessible between Dikson and Provedenia.

The accessible coast stations and services appears in figure 1.2, below.

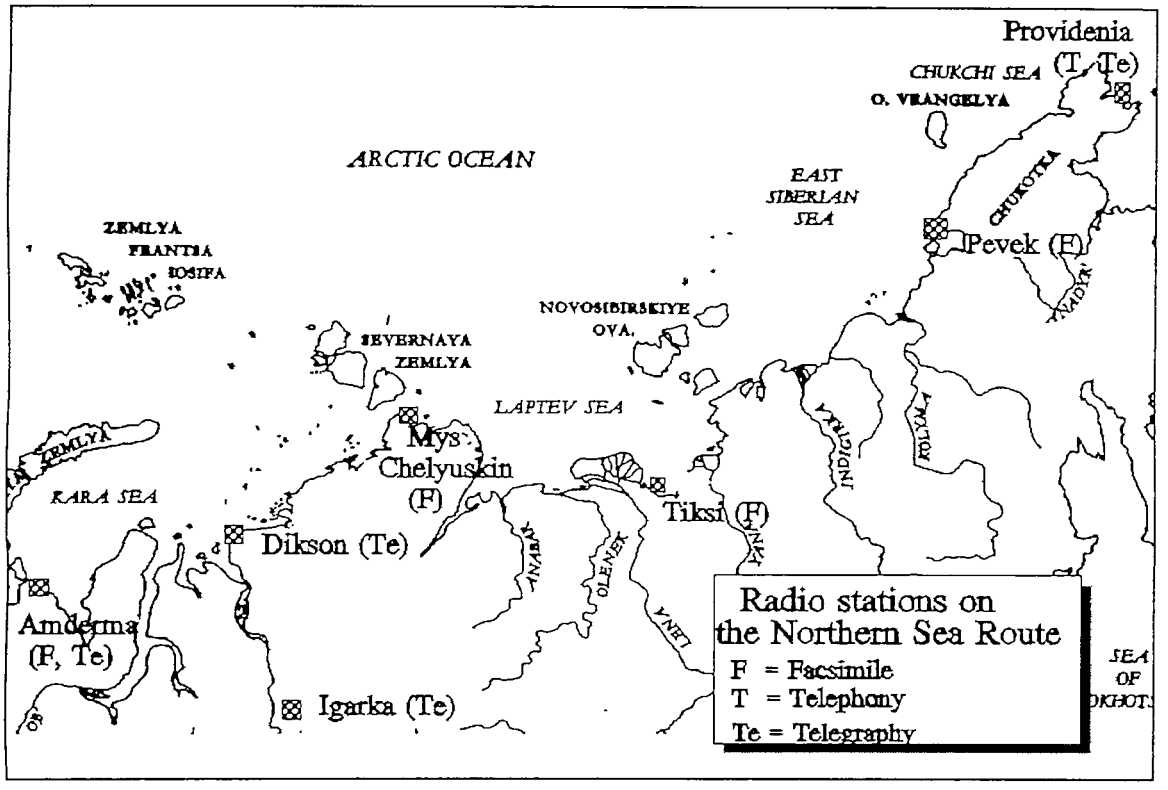


Figure 1.2 *Radio stations on the NSR, referred to in the Admiralty List of Radio Stations. Coverage and range vil depend on the atmospheric conditions. (F = Facsimile, T = telephony, Te = telegraphy).*

Vol.2 Rdo. Navigational Aids, Electronic Position-Fixing systems and Radio Time signals. This volume gives information on radiobeacons, racons (Radar beacons) and other electronic navigation systems. Information related to the Kara Sea and the approaches to the NSR are quite good, but between Ostrov Baranova (E84°14′) and Mys Dezhneva (W169°43′) there is no information, ref. figures 1.3 and 1.4.

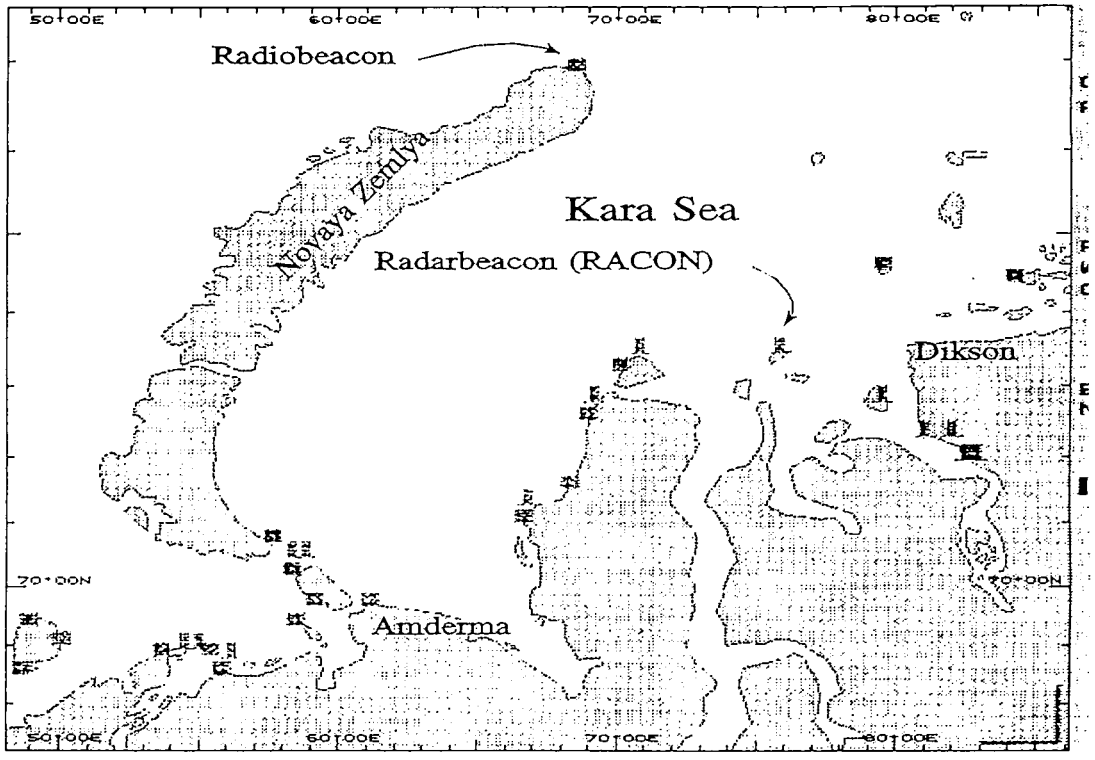


Figure 1.3 *Radiobeacons and Racons in the Kara Sea. (squares = Radiobeacon, underlined rectangles = Racon).*

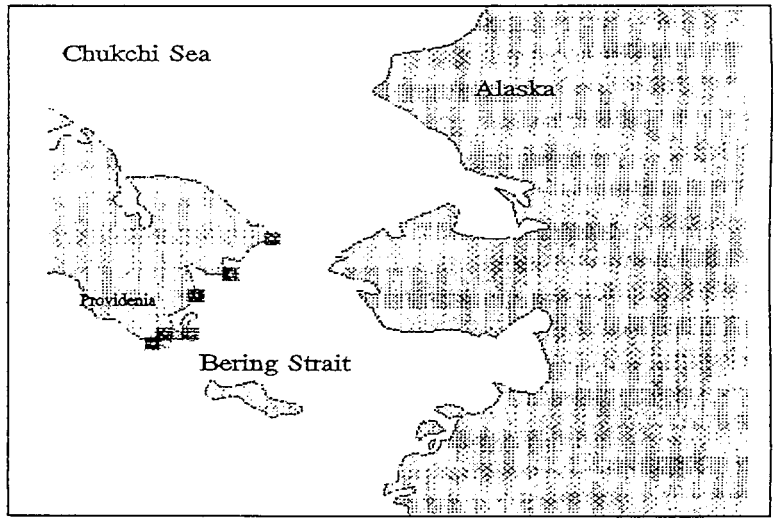


Figure 1.4 *Russian radiobeacons in the Strait of Bering (there are no Racons).*

Vol.3 Radio Weather services and Navigational Warnings. This volume gives important information on the schedule and meteorological services transmitted from different stations. Navigational warnings on NAVTEX are also described. For the NSR there is information on meteorological services from the following stations:

- Beringovskiy
- Provedenia Bukhta
- Pevek
- Tiksi Bukhta
- Mys Chelyuskina
- Dikson
- Amderma
- Arkhangelsk

Information on NAVTEX transmission is not currently available between Arkhangelsk and the Strait of Bering. In fact a planned station is indicated in Provedenia Bukhta, close to the Strait of Bering. In this area the ships will also have access to US-stations in Alaska.

Vol.4 Meteorological Observation Stations. This volume gives an account of the meteorological observation stations around the world. In the coastal regions of the NSR there is information on more than 20 stations, as indicated on figure 1.5.

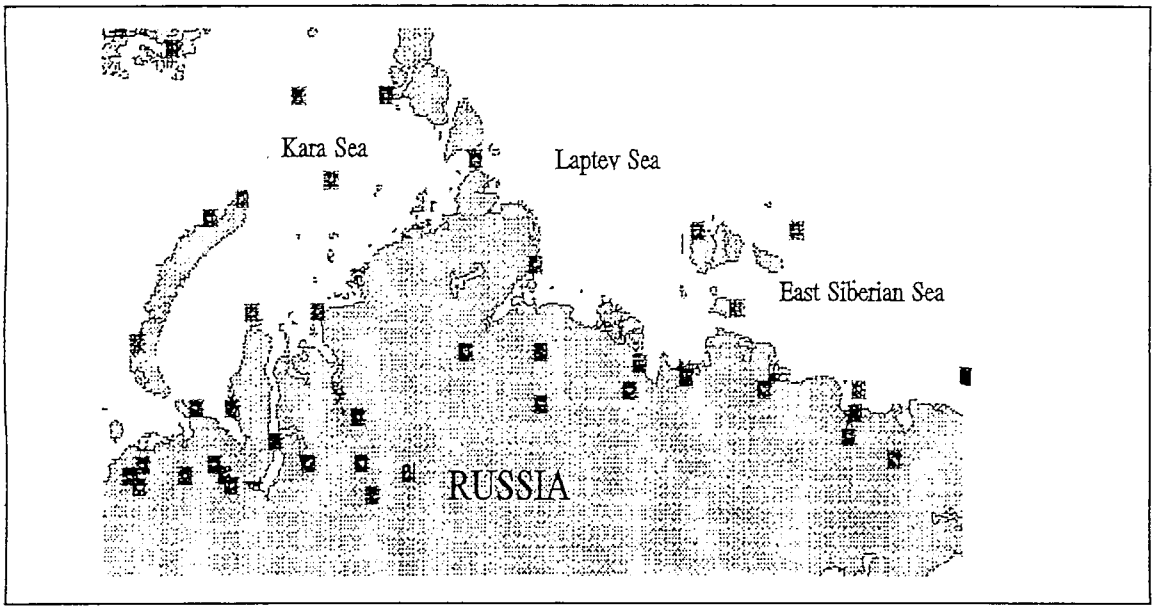


Figure 1.5 *The dark squares indicates Meteorological Observation stations on the NSR.*

Vol.6 Vessel traffic services, port operations and pilot stations. This volume provides particulars of radio stations working in the port operations and information services, services to assist vessels requiring pilots, and services related to traffic control. Diagrams to be used are also included. For the NSR information on the following areas/ports can be found:

- Yugorskiy Shar
- Yenisey River
- Igarka
- Port Provideniya

There is no information on the intermediate area from Yenisey river to the Bering Strait.

1.8 Admiralty Tide Tables (NP 201-203).

Volume 1 (NP-201), covering European waters and the entire NSR, is an annual publication giving daily prediction of high and low water for a number of standard ports / locations. For locations between the standard ports, predictions are based on various corrections to the standard ports. Harmonic constants for the theoretical calculations are also listed for the different locations. Along the NSR and the adjacent areas there are approximately 30 locations for tidal prediction. The tidal predictions tend to move towards electronic means, like PC-based chart and planning programs. Such programs are also available on the NSR.

1.9 Sea Charts, including Electronic Charts.

The sea chart is probably the most important planning tool for safe navigation. For the NSR there are very few non-Russian charts usable for navigation. On the other hand there are quite a lot of good Russian charts. Unfortunately not all of the Russian charts are released for international shipping. For planning and open water sailing purposes the 600 and 900 series (most of them in 1:750,000 scale) are good. In narrow straits, rivers and close to the coast more detailed charts in scales down to 1:50,000 are required. Frames on the accessible Russian charts (1994 / 1995) are shown in figures 1.6 - 1.10. (CNIIMF,94).

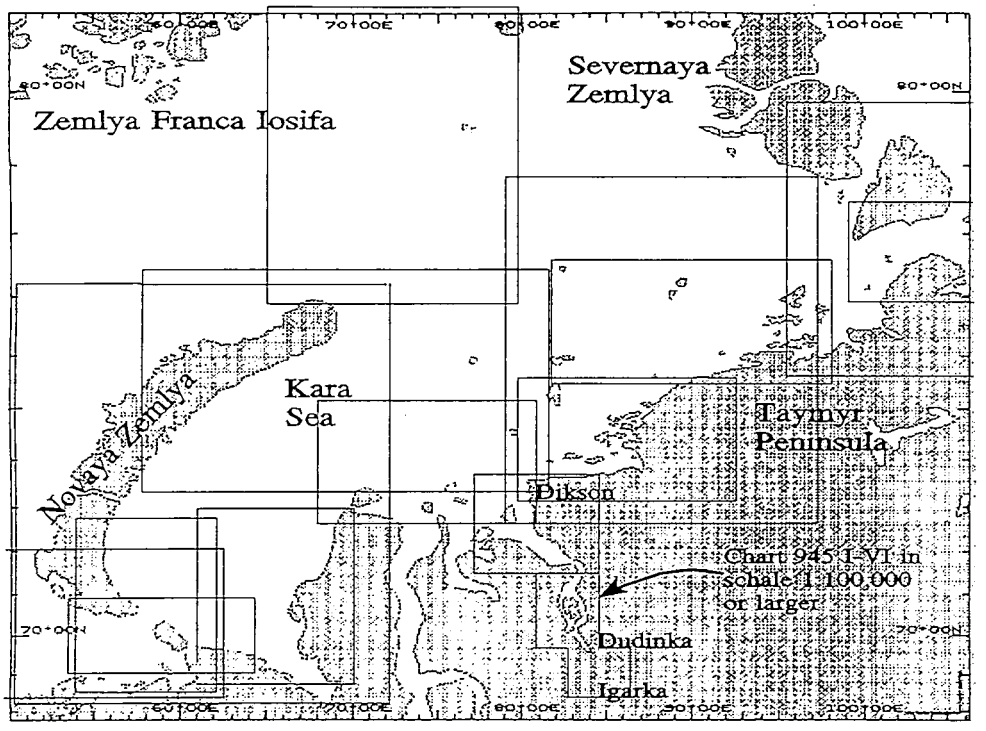


Figure 1.6 *Coverage of Russian charts released for international shipping in the Kara Sea *).*

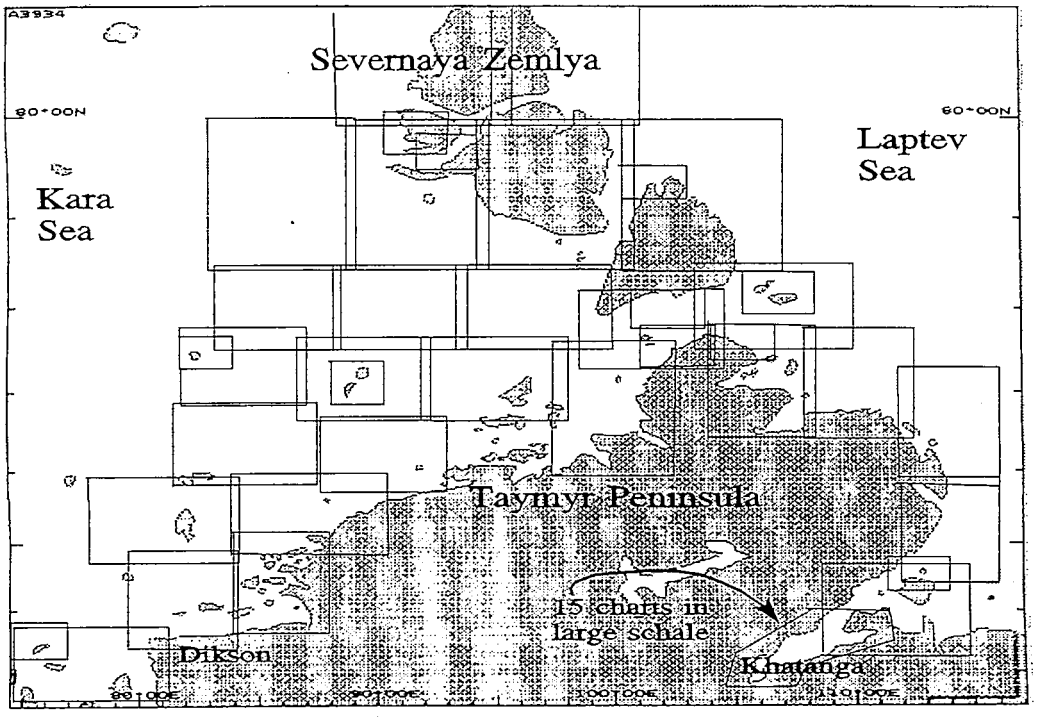


Figure 1.7 *Coverage of Russian charts released for international shipping off Taymyr Peninsula *).*

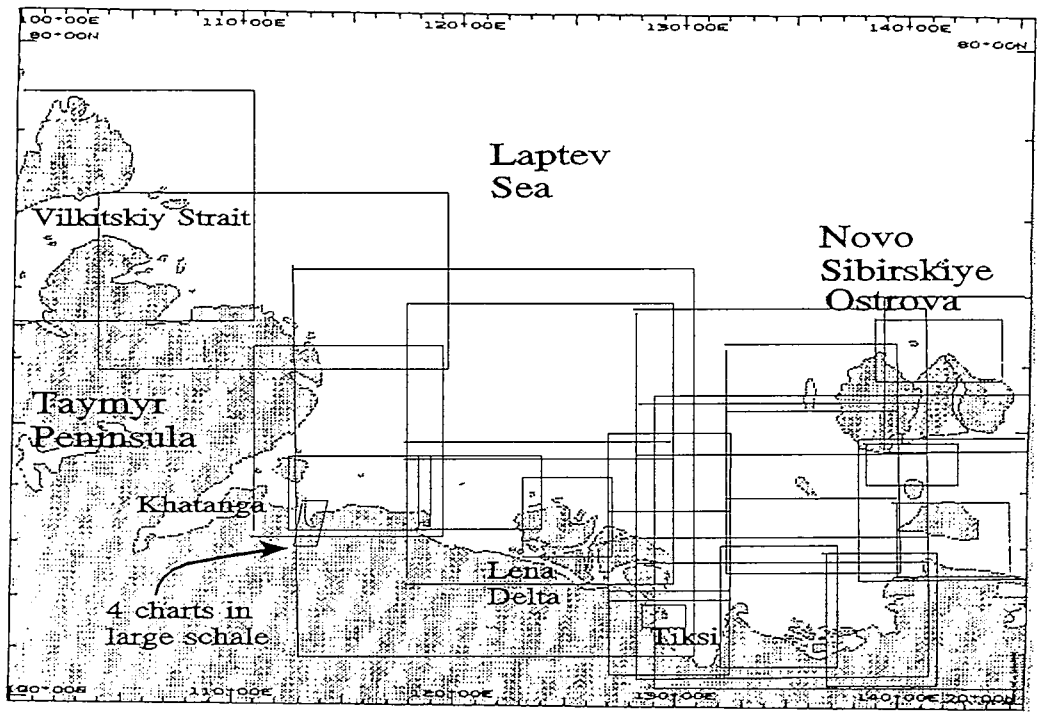


Figure 1.8 *Coverage of Russian charts released for international shipping in the Laptev Sea *).*

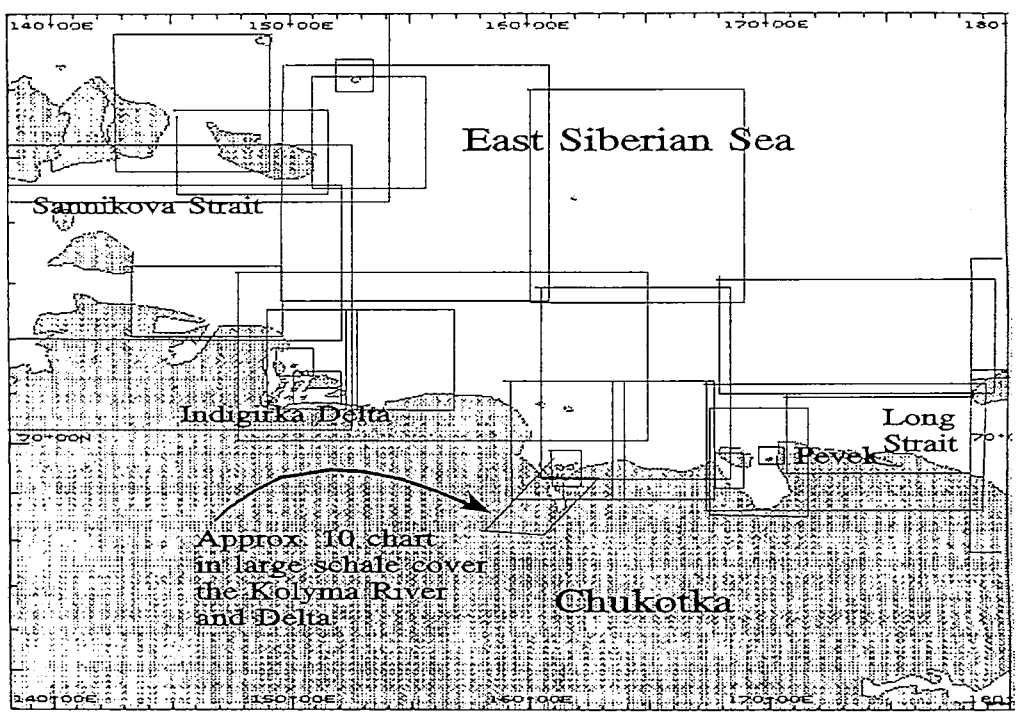


Figure 1.9 *Coverage of Russian charts released for international shipping in the East Siberian Sea *).*

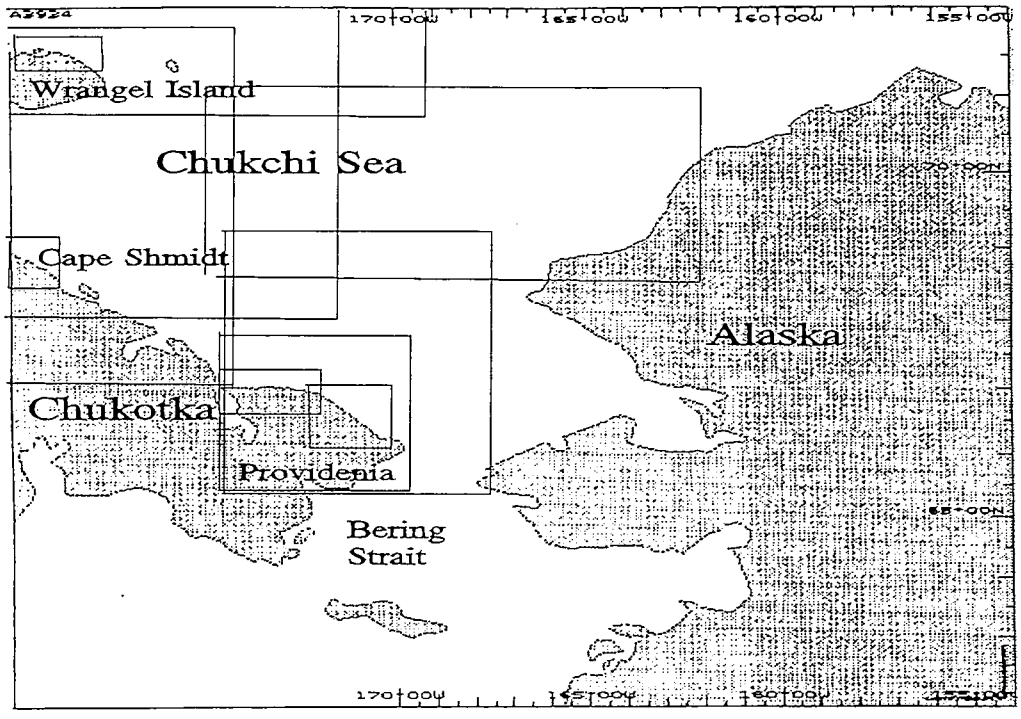


Figure 1.10 *Coverage of Russian charts released for international shipping in the Bering Strait area *).*

***) NOTE** that some of the charts framed in figures 1.6 - 1.10 are under consideration for international release in 1995 (CNIIMF, 94).

Electronic charts are rapidly being developed for use in computerized chart systems. The Russian company Transas Marine is at present the only company providing PC-based seacharts for the NSR. The program is also an excellent planning tool for navigation in all parts of the World. The Transas system is marketed in Europe by RACAL Ltd. Accessible charts are the same as the released paper charts. They are prepared in a format compatible to ECDIS standard (DX-90), described in the nautical class notation in the classification societies. The Transas system can be interfaced to an electronic navigation aid like GPS and present a picture like the one on figure 1.11. The British Admiralty will also offer most of their seacharts in a scanned, electronic format, prepared for raster-scan electronic chart system. There is in fact reason to believe that such scanned charts will not be accepted as full ECDIS.

When navigating by means of Electronic charts interfaced to an electronic navigation systems a paper chart should be used as redundancy.

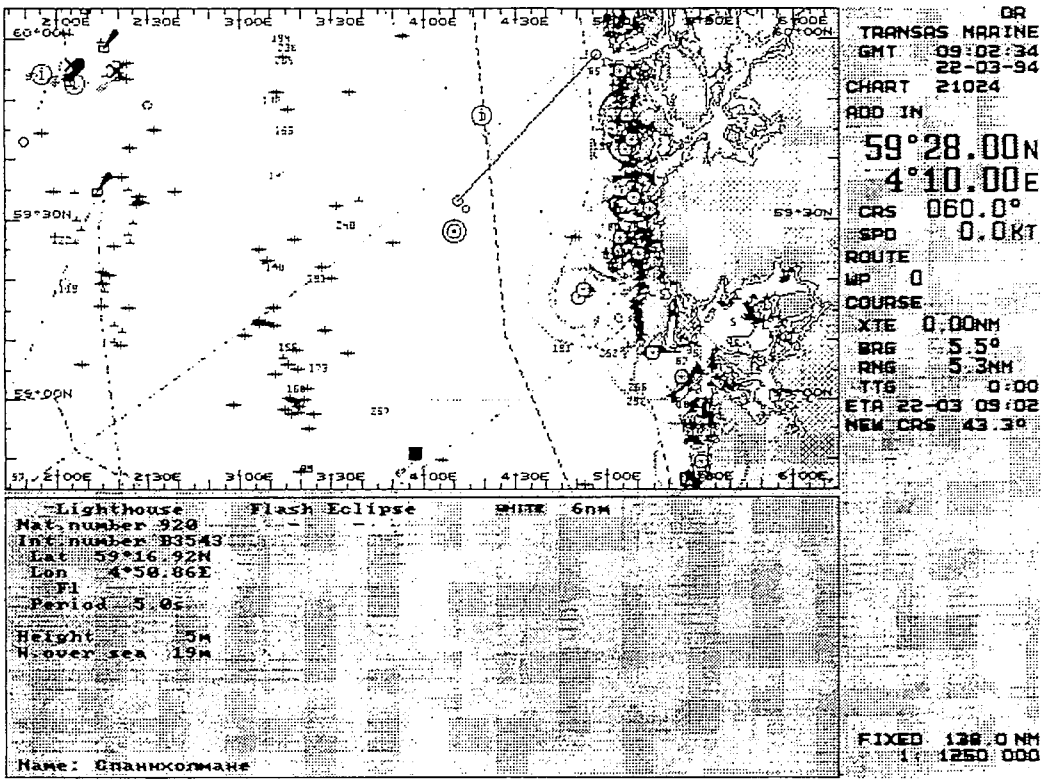


Figure 1.11 *Typical display from the Transas Electronic chart system. This company is at present the only company issuing electronic seacharts from the NSR (1994). Position from a Navigation system can be projected onto the chart. This illustration is from the Southwest Coast of Norway and additional information is presented in the bottom window.*

1.10 Other relevant publications for Arctic Navigation.

- Arctic Survival Equipment Standard (CCG)
- The Mariner's Handbook (NP-100)
- SOLAS- Convention (IMO)
- MARPOL- Convention (IMO)
- Mersar Manual (IMO)
- The Nautical Almanac (NP-134)
- Ice Navigation in Canadian Waters (CCG)
- Arctic Water Pollution Prevention Act (CCG)

In addition to these publications tutorial computer-based training courses have been developed. One is the "IceXpert", an interactive approach to instruction in interpreting sea ice information from synthetic aperture radar (SAR) imagery. One of the display modes from IceXpert is shown in figure 1.12.

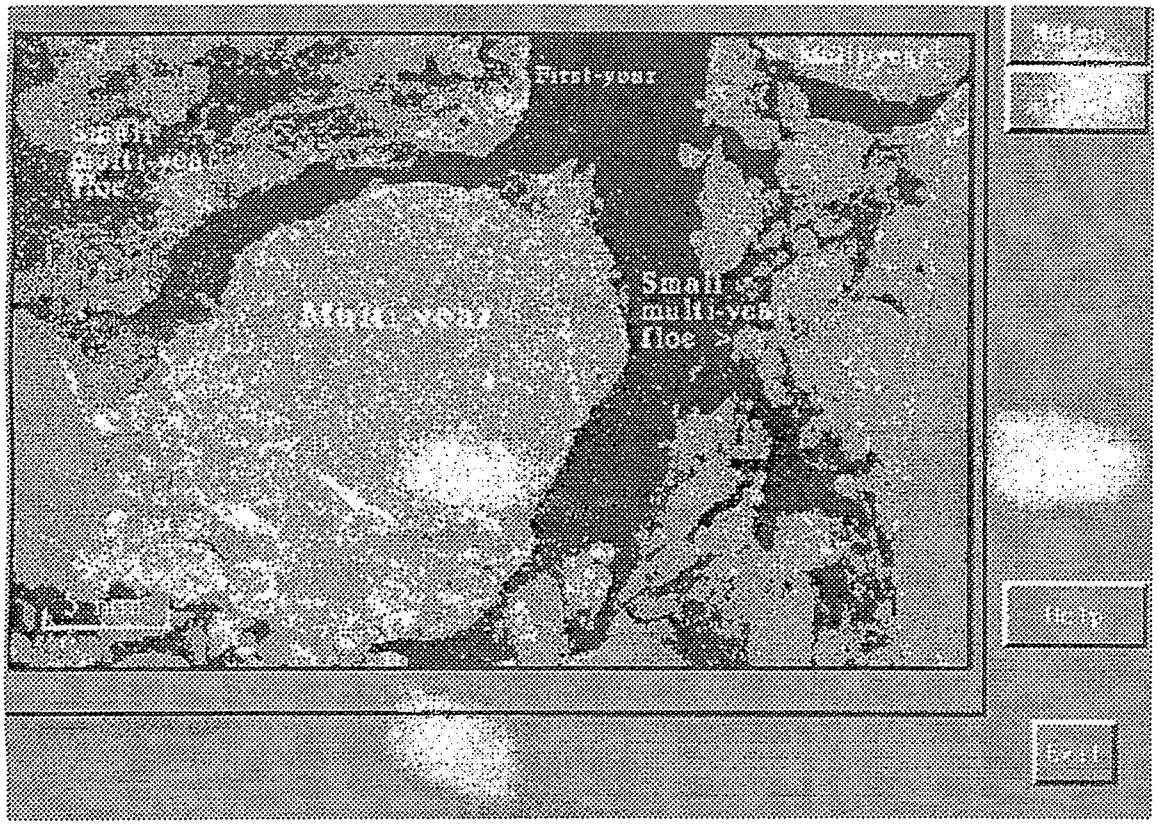


Figure 1.8 *A SAR image from the tutorial SAR-interpretation program IceXpert. Through a PC-program ship operators can learn basic theory and practise ice-image interpretation.*

The IceXpert program is developed by :

Norland Science & Engineering Ltd.
904-280 Albert Street, Ottawa
Ontario K1P 5G8, Canada.

Additional information on "IceXpert" can be obtained from Nordland Science Ltd.

2 Regulations for navigation on the Northern Sea Route

After Michail Gorbachev's Murmansk Initiative in 1987 to open the Northern Sea Route (NSR) for international shipping, regulations for navigation have been worked out by the NSR-administration. The regulations give a definition of the NSR as a national transportation artery situated within the economic zone of Russia. The route is limited to the west by the entrances to the Kara Sea and the meridian running north from Mys Zheleniya (Northern Novaya Zemlya). To the east the route is limited by the parallel of 66°N latitude and the meridian of 168°58'37''W longitude. The northern boundary is the economic zone of Russia.

2.1 The NSR-regulations

The present regulations were approved by the Ministry of Merchant Marine in September 1990, entered into force on july 1, 1991 and were published in Notice to Mariners # 29, june 13, 1991.

Application for preliminary permission for navigation on the NSR can be submitted to :

Northern Sea Route Administration
1/4 Rozhdestvenka, Moscow
103759 Russia
(Telex 411134 BUNK SU or 411197)

Application shall include detailed data of vessel and owner including:

1 Name of ship, Flag, Port of Registry, Shipowner (full name and address).

2 Gross / Net tonnage Reg.T.

2.1 Full displacement figures.

3 Main dimensions (length, breadth, draft), output of main engines, speed, delivery year from shipyard.

4 Ice-class and classification society, date of last examination.

4.1 Construction of bow (Ice-knife or bulb)

5 Expected time of sailing through the NSR

6 Issue of certificate of insurance or other financial security in respect of civil liability for environmental pollution damage.

7 Aim of sailing (commercial voyage, tourism, scientific research, etc.)

The final permission to pass through NSR, such as dates, region of navigation and conditions of ice-pilotage will be given by an NSR-administration representative after a survey of the vessel. The survey can take place in any suitable port, and costs will be covered by the vessel concerned. Details of the responsible escort must be clarified by the Murmansk Shipping Co. (MSC) (if eastbound) or the Far-East Shipping Co. (FESCO) (if westbound).

If the ship's activity includes fishing, tourism or scientific research a special request has to be sent through the Ministry of Foreign Affairs of Russia. Payment for ice-breaker escort and pilotage is stipulated in the contract and are normally based on the displacement of the ship.

To obtain permission the vessel has to satisfy the "Requirement for the design, equipment and supply of vessel navigating the Northern Sea Route". These requirements will depend on region and time of passage, but for transit sailings the ship will normally have to have minimum Ice-class **UL or L1** in the Russian register or equivalent (details of ice-classes will be described in volume 2 of this report). Ports calls on the NSR can be permitted with lower ice-classes in the summer season. The only ports currently (1994) open for calls by foreign flag vessels are Igarka, Dikson, Tiksi and Pevek. In the absence of crew practically experienced in plying icy-water the navigation shall be performed with a State Ice-Pilot on board. Since all ports in the Russian Arctic have limited capability to cater foreign ships with food, tugs, fresh water, fuel and repairs, the regulations recommend the vessel to have a 30-day fuel supply, a 60-day food supply and a distilling plant for water.

The period of navigation on a certain part of the NSR is determined by the NSR-Administration or by the Marine Operation Headquarters, normally the MSC or the FESCO. When navigating the NSR the vessel shall follow the route assigned by the Marine Operations. Compulsory icebreaker assisted

pilotage is established in the Proliv Vil'kitskogo, Proliv Shokal'skogo, Proliv Dmitriya Lapteva and Proliv Sannikova. In other regions other types of pilotage can be determined by the Headquarters, depending on the circumstances. Such pilotage can be aircraft-led, icebreaker or conventional pilotage.

It should be borne in mind that vessels violating the "Regulations for Navigation on the Seaways of the NSR" could be ordered to leave the route.

2.2 The MARPOL Convention.

The International Convention for the Prevention of Pollution from Ships is called the MARPOL Convention, and came first into force in 1973, and has later been modified. The Convention regulates pollution by oil, noxious liquid substances, harmful substances in package form, sewage and garbage on a worldwide basis. Areas covered by the Convention are normally defined as a certain distance from land and a certain depth. In addition to this there are defined special areas, more restrictive to pollution than other areas. Such special areas are various gulf areas like the Black Sea, Gulf of Bothnia, and the Persian Gulf, etc. Since 1992 Antarctica, south of latitude 60° south, is defined as a special area. Other Polar areas like the NSR has been suggested but are not defined as special areas, and discharge from ships in these areas is consequently restricted under the general regulations.

The hazard rating of individual pollutants and transportation precautions can be found in the IMDG-code (International Maritime Dangerous Goods Code) which is a IMO-document.

2.3 The SOLAS Convention.

Of all the international conventions dealing with maritime safety the most important is the International Convention on the Safety of Life at Sea, better known as the SOLAS-convention whitch covers a wide range of measures to improve the safety of shipping. The first edition was adopted in 1914 after the sinking of the *Titanic*, with the loss of more than 1,500 lives. The present version was adopted in 1994 and entered into force in 1980. Concerning navigation in ice or in

areas where ice can be expected the Convention is focused specially on the dangerous area in the Northwest Atlantic, off Newfoundland. Regarding ice patrol services the text in the Convention is also based on the area adjacent to the US and Canadian coast - nothing is specified regarding the NSR. In general terms the Convention describes the duties of a master of a ship navigating in or near ice-infested waters. Such sailing are to proceed at a moderate speed in night time and dangerous ice-conditions shall be reported.

2.4 The Load Line convention.

This Convention describes the draft the ship can be loaded to in different areas and at different times of the year (ref. figure 2.1). This is done to ensure the safety of ships sailing in areas exposed to varying environmental conditions, like storms and icing. The practical consequence of the regulations is that the loading capacity on a given ship will be restricted when sailing in northern regions in the winter season. Three lines, according to the figure will apply.

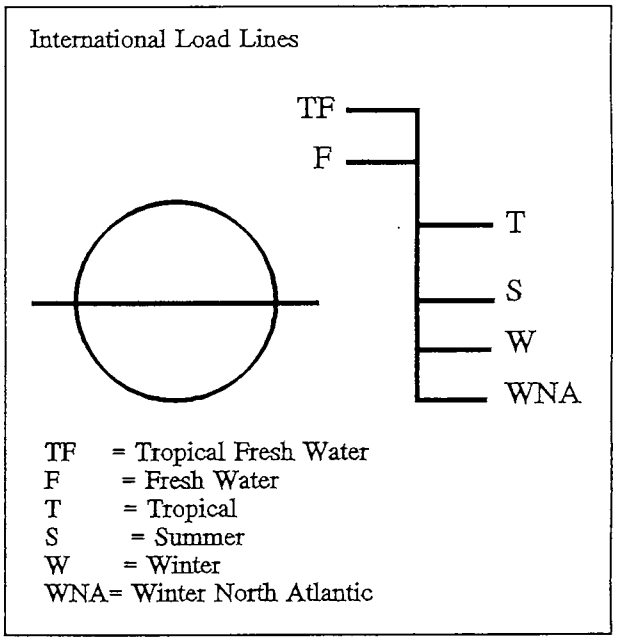


Figure 2.1
The international load line symbol describes to which draft a ship can be loaded in different areas and at different times of the year.

The Summer line applies in the Kara Sea between 1 April and 31 October. In the east, from the Lena Delta to the Strait of Bering the summer line applies from 16 April to 15 October.

The Winter Line applies from the Lena Delta to the Strait of Bering between 16 October and 15 April.

The Winter North Atlantic Line applies to ships of length less than 100 meters in the Kara Sea from 1 November to 31 March.

The area between the Yenisey Delta and the Lena Delta are not formally delineated, but it will be reasonable to use the Summer line and the Winter North Atlantic Line in the same period as described for the western part of the Kara Sea. For example the difference between the Summer- and the Winter - line represents a capacity reduction in winter of 970 tons on a 40,000 ton bulk carrier like the M/V *Arctic*, used in the Canadian Arctic.

Since all parts of Northern Europe have the same regulations as the Kara Sea the loading capacity reductions required in different areas will have a negligible effect when comparing the northern and the southern sailing alternatives.

3 Navigation and position systems

In the Russian Arctic we have to pay special attention to three major concerns related to the applicable seacharts. They are the projection, the coordinate systems (datum) and the accuracy.

3.1 Charts, datum and projections.

The Chart Projection in the polar region is affected by the convergence of the meridians near the pole. Therefore normal Mercator seacharts used in lower latitudes will suffer much distortion in the latitude direction. Mercator projections are consequently only used for large scale charts. Small scale charts made for planning etc., are normally based on a polar Stereographich projection. The Mercator projection is preferred by navigators due to the fact that angles/bearings and distances on rumb lines can be taken directly from the chart. If this is taken from a polar projection the distance and angle will be wrong. Therefore:

BE AWARE OF ERRORS CAUSED BY DIFFERING CHART PROJECTIONS

The chart projection must be checked especially when changing over from small- to large scale charts and vica versa. The convergence of the meridians will also affect visual-, radar and astronomical bearings.

The coordinate system (datum) has changed significantly over the years, from the time Moscow was used as 0° longitude reference to the present coordinate references based on global positioning from satellite systems. Over the last decades a local datum based on a Krassowski ellipsoid has been used to fit the Russian territory. This datum has also been named Pulkova 1942. Old possitions reffered to in Russian publication can use the previous datum, Pulkova-32. As an example it can be mentioned that the Russian/Norwegian border is by Russia defined by the Pulkova-32 datum. After global positioning systems have been adopted the chart datum has relevance for optimal accuracy of positioning. Global systems normally use a global datum like the "World Geodetic System

1984" (WGS-84). If positions are taken from WGS-84 and applied on a chart with local datum, e.g. the Pulkova-1942, an error will arise represented by a shift in latitude, longitude and altitude. The problem is visualized in figure 3.1. The inaccuracy is significant and should not be assumed to be only negligible.

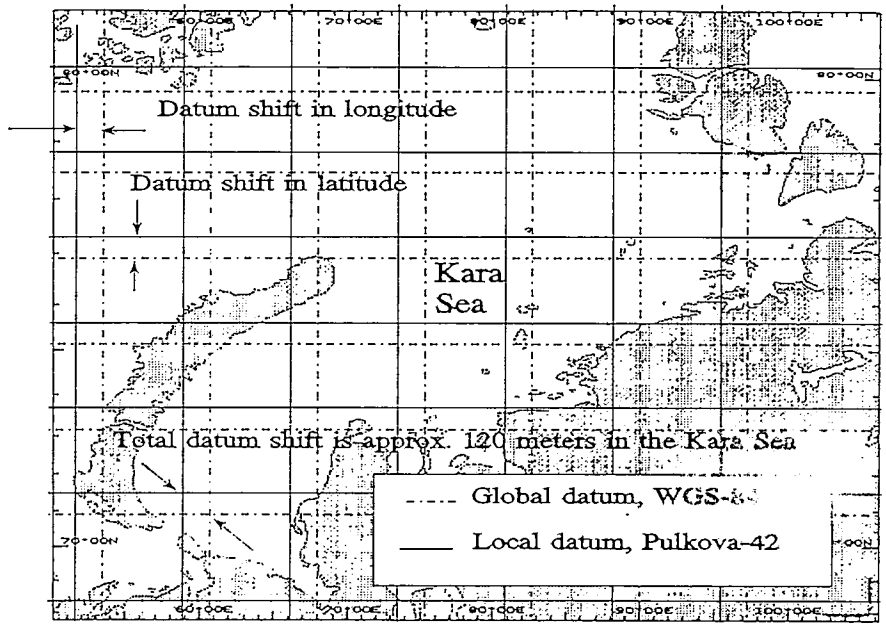


Figure 3.1 For precise electronic positioning the datum shift has to be calculated. The figure indicates a shift between a global and a local datum. The chart and the shift are not on equal scale.

The size of the shift will depend on the location and is not equal over a large area. In modern navigation receivers a datum transformation can be performed automatically and presents the coordinates in a given datum. However there are no non-Russian receivers at the present time prepared for Pulkova 1942. Therefore:

POSITIONS FROM GLOBAL SATELLITE SYSTEMS WILL BE EFFECTED BY A DATUM SHIFT WHEN APPLIED TO MOST RUSSIAN CHARTS.

Table 3.1 exemplifies shift dimension between WGS-84 and Pulkova-42 in 4 different straits along the NSR. The calculations are based on series calculation method from a few reference positions. The approximation gives a fairly good estimate for shipping but must not be used for geodetic purposes.

Area / Strait	WGS-84	Pulkova-42	Shift [m]
Kara Gate	N 70°30' E 58°00'	N 70°29'57.8" E 58°00'09.2"	119
Vilkitskiy Strait	N 78°00' E103°00'	N 77°59'56.2" E102°59'59.4"	117
Sannikova Strait	N 74°30' E140°00'	N 74°29'57.3" E139°59'49.6"	120
Long Strait	N 70°00' E180°00'	N 70°00'00.1" E179°59'47.2"	135

Table 3.1 The figures indicates the datum shift between the global WGS-84 and the local Russian Pulkova-42 coordinate systems in 4 different straits along the NSR.

On newer editions of Russian charts the datum is WGS-84, and consequently there will be no datum-shift. All newly released charts mentioned in chapter 1.9 are published in WGS-84 datum. When using electronic charts with navigation interphase (ref. figure 1.7) check that the chart and the navigation system run in the same coordinate mode (datum).

Accuracy of seachart is normally limited in the Arctic regions, the Russian Arctic is no exception in this respect. Historically the latitude accuracy was better than the longitude accuracy due to the fact that latitude observations could be performed by an observation of the culmination of an astronomic body, while the latitude observation also had to rely on a relatively imprecise chronometer.

The modern accuracy problem is dual. The first problem is the accuracy of the datum transformation between global and local coordinate systems. Due to limited geodetic surveying large areas can be affected by relatively uncertain coordinate fitting. The problem is well known from Svalbard in the Norwegian Arctic. The second problem is the uncertainty of soundings and depth contours. Since surveying in the Russian Arctic has for several years been based on positioning by the system alsoused in the rest of the world, there is no reason to believe that the location of the soundings are effected with less accuracy than usual on Admiralty charts from other parts of the world. Beware of probable uncertainty on charts based on old surveys.

The important limitation is the distance between the sounding profiles used in the area. The hydrographic standard on profile spacing is related to water depth, and normally 25 - 50 meters in shallow waters. The profile spacing in the

Russian Arctic varies between 250 - 2000 meters (ref. figure 3.2) and consequently the probability of grounding on "new" banks is higher than in comparable waters, like e.g. on the coast of Norway (excluding Svalbard).

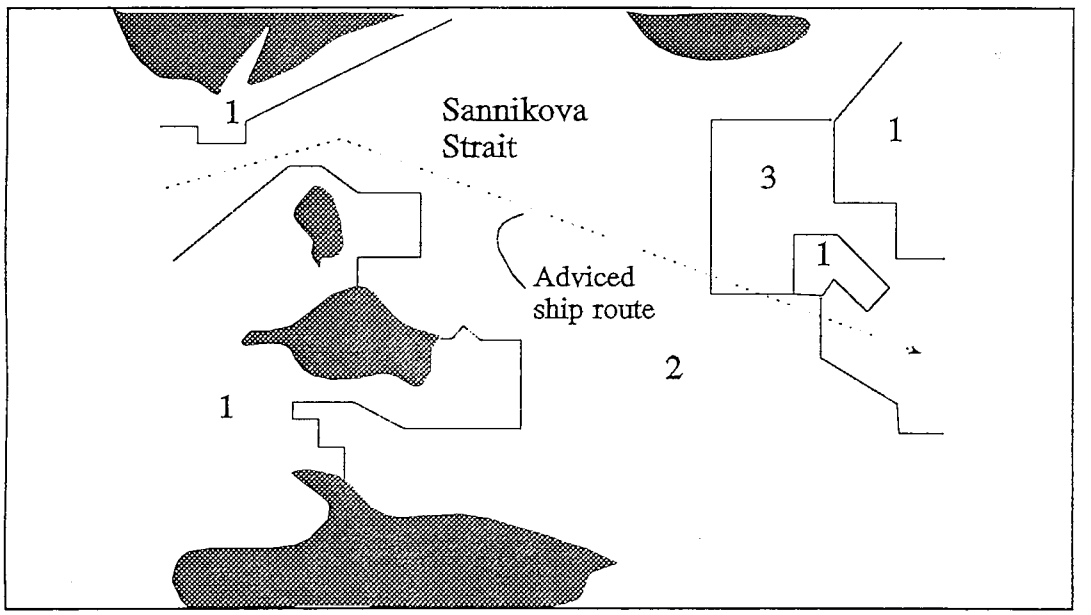


Figure 3.2 *The line spacing between survey profiles is an important scale on sea chart quality, because the areas between are more or less "white spots". The numbers indicate area with different profile spacing in the Strait of Sannikova. Area 1 - surveyed with 250 - 500 meter spacing, area 2 with 1000 - 2000 meter spacing and area 3 with 5000 meter spacing. (Source: Russian chart # 953)*

Information on profile spacing and time of surveying can normally be found in the chart.

Note that:

DUE TO GAPS BETWEEN SOUNDINGS, HIGH PROBABILITY FOR "NEW" SHOALS MUST BE CONSIDERED WHEN ALLOWING FOR UNDERKEEL CLEARANCE.

3.2 Electronic Navigation Aids

Electronic navigation aids play a more and more significant role in modern shipping operations, and it is therefore important to have information on the system performance in a given region. Performance of the different systems is discussed below.

3.2.1 NAVSTAR Global Positioning System (GPS)

GPS was declared "initially operational" in December 1993 and will probably be the most important navigation system in the years to come. The system is under US-military control and service provided for civil users is effected by accuracy degrading (c/a-code). The absolute accuracy for civil users will normally be within 100 meters, with a probability of 95%. An additional error can be added on at 48 hours notice if US-authorities find it necessary for strategic reasons. The above mentioned 100 meter system-accuracy is considered as equal all over the globe. Due to relatively uncertain geodetic data in the Arctic there will most probably be slightly poorer probability when transforming the position to the chart (Kjerstad, 92). Ionospheric refraction in the auroral zone will also cause a minor additional uncertainty to the system along the Northern Sea Route (NSR). Severe ionospheric influence will be related to the sunspot activity and vary on an 11 year cycle.

Therefore:

DUE TO UNCERTAIN PERFORMANCE ON GPS AND LIMITED GEODETIC ACCURACY SPECIAL CAUTION MUST BE TAKEN WHEN NAVIGATING BY ELECTRONIC MEANS IN THE ARCTIC.

The 100 meter accuracy is also based on a certain satellite constellation (HDOP). On certain latitudes the HDOP-limit will be exceeded for a limited time during the day, but this will not cause any problem along the NSR.

3.2.2 Loran-C / Chayka

In the North Atlantic and the North Pacific the landbased radinavigation system, Loran-C, has been under US-Coastguard control for several years. Russia controls a fully compatible system called Chayka. In the Northern Pacific Loran-C and Chayka are linked together for better performance. The North Atlantic Chain is at the present time renewed for better

performance, and will after January 1995 be under European control. Positions from the new stations are based on the WGS-84 datum. New stations in Northern Norway makes the coverage much better in the Barents Sea, and open for cooperation against the existing North West Russian chain (ref. figure 3.3). This Russian chain, which covers the Eastern Barents Sea and the Kara Sea, is not running on a regular basis at the present time. If the cooperative initiative between these two chains succeeds there will be a very good coverage and high accuracy in the mentioned area. Repeatable accuracy of approx. 50 - 100 meters can be obtained. Extreme icing and meteorological conditions can reduce the range and performance of the transmitting stations. With the existing stations there will be no Loran/Chayka coverage from The Vilkitskiy Strait to 130° East longitude.

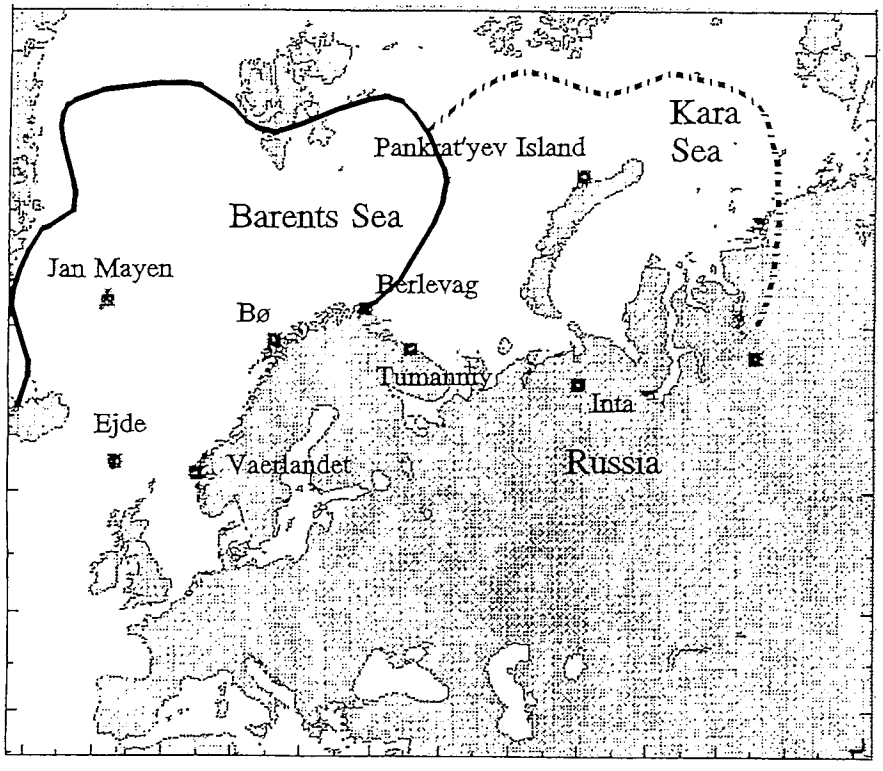


Figure 3.3

The dark squares indicate Chayka stations in Barents Sea - and Kara Sea region. The continuous line in the Barents Sea indicates the coverage of the new Loran-C chain. The dashed line gives an approximate coverage if Russian Chayka stations are linked to the Norwegian stations. The Russian stations Inta and Tumanniy will most probable be the first stations to be linked to the Loran-C system.

3.2.3 Mars-75

"Mars-75" is the name of what the Russians for several years have considered as the prime navigation system along the NSR. Three chains are operating along the coast and provide ships with a navigation accuracy better than 250 meters along the entire NSR. System coverage is indicated on figure 3.4. In small areas line of position from Mars-75 can be used together with bearings from radiobeacons. Since Mars-75 has for several years been considered secret there are few technical details on the system, but it is known that it is a medium frequency, hyperbolic system. The hyperbolic lines of position can either be used in special maps or converted automatically in the receivers. The future plans for Mars-75 are not known but there is reason to believe that the very limited number of receivers will be the limiting factor for a wide use of the system.

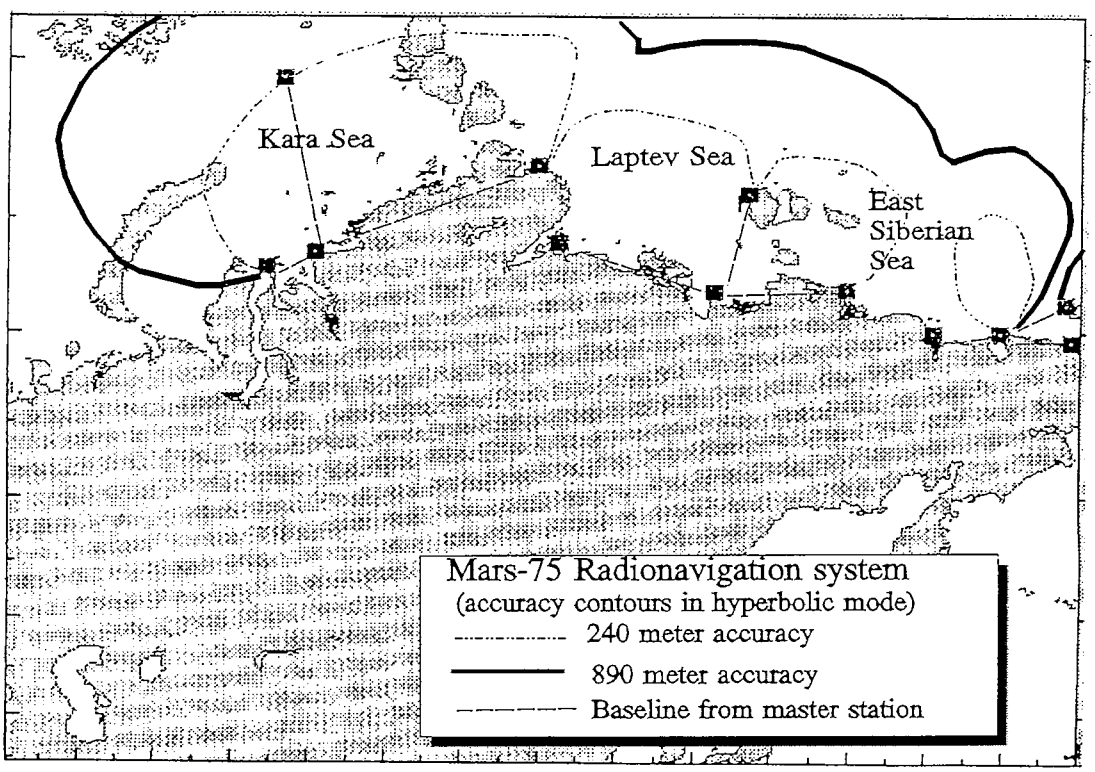


Figure 3.4 *Mars-75 coverage chart. The stations are indicated with dark squares and the accuracy is indicated by the curved lines. The 890 meter accuracy contour will also indicate system maximum-range (Source: CNIIMF,91).*

3.2.4 Other Electronic Navigation systems.

Several systems are operating on a global or local basis. Satellite systems like the US Transit and the Russian Tsikada are based on position fixing from polar orbit satellites through doppler measurements. Accessibility is unfortunately rather limited and the longitudinal accuracy is reduced in high latitudes. The Transit system operation will be terminated by the end of 1996 according to the US Federal Radinavigation Plan. The future plans for the Tsikada system is not known but will probably depend on the date when the new Russian system, GLONASS, is considered operational. GLONASS is comparable to the US, GPS, system and will provide users with continuous high accuracy positioning all over the world (including NSR). At the present time few GLONASS-receivers are accessible and not all space segments are in orbit. The GLONASS system will not have degraded accuracy for civil users like the GPS and initial tests indicate an accuracy of approximately 20 meters (95% probability). The global, very low frequency system, Omega, covers the NSR. Due to rather poor accuracy of up to 10,000 meters the Omega is not widely used by merchant vessels sailing in Arctic waters. Omega will according to the US Federal Radionavigation Plan be phased out of use from 1995. The DECCA system is not accessible on the NSR, and will probably be phased out in the rest of the world before the year 2000. Short range, high accuracy systems for surveying are not operating on the NSR on a regular basis. Such a system, like e.g. the Trisponder, is used only for short periods in the surveying season.

3.3 Radio and Radar beacons.

Several Radiobeacons providing service for maritime users are located along the Northern Sea Route (ref. figure 1.3 and 1.4 in chapter 1). Two or more bearings from these beacons can be used for positioning or one bearing can be used for additional information together with other navigation aids. The accuracy depends on distance from the receiver and on the corrections applied on the ship. It must be borne in mind that applying bearings into a Mercator chart will be affected by the "half convergency", which represents the difference between the rhumb-line and the great circle. This error can be significant in high latitudes with only a few degrees of change in the longitude between the ship and the radio station. Some of the radiobeacons are only in service during the navigation season. Since the new Global Maritime Distress and Safety System doesn't demand radiodetecting devices it is uncertain how long the beacons will be operated.

During the last two decades Radar Beacons (RACON) have played an increasingly important role in coastal navigation. On the NSR a few beacons are located which are very helpful during

radar navigation. These stations provide service in the Kara Gate and in the approach to the Yenisey River (ref. figure 1.3 in chapter 1). A real problem with radar in the Arctic concerns the interpretation of the screen for purposes of position fixing. Problems encountered from either mistaken identification of shore features or inaccurate surveys, low relief of some coastal areas make it hard to identify landmarks. Additionally, ice piled up on the shore or fast ice may obscure the coastline. Radar Beacons can easily be identified even under such conditions.

3.4 Buoyage system

Due to the short open water season on the NSR, the use of floating buoys is very limited. The buoys used are normally taken ashore before the ice destroys them. The color coding on the buoys is based on the international IALA-system (category A) with red to port and green to starboard, equivalent to the system used in European waters and the opposite of the US-system. Details on the different marks can be found in Admiralty List of Lights, Vol.L.

4 Radiocommunication Systems

Long- and medium range radio communication in the Arctic area is normally subject to ionospheric disturbance. This communication obstacle is caused by the auroral zone. The consequence of this is that the communication range will normally be limited compared to what is usual at lower latitudes. This effect is rather crucial since most modern ships are very dependent on good communication systems for voice, telex and other data transmission.

4.1 Coast Stations and ports.

On the Northern Sea Route there are 4 regular coast Radio Stations ; Amderma, Dikson, Igarka and Providenia. Unfortunately the stations at Amderma, Igarka and Dikson are not open for public correspondence yet. All frequencies listed below are in kHz. In addition there is VHF - communication in the ports and on observation points like Pevek, Tiksi, Mys Chelyuskina, Mys Schmidta and Mys Dezhneva (ref. figure 1.2 in chapter 1).

At the present time there is reason to believe that all stations are unfamiliar with international traffic and language problems will occur on telephony. Other services such as transmission of NAVTEX, Ice Reports and weather messages are transmitted from some of the stations. Schedules for the different services can be found in the Admiralty list of Radio Signals, Vols. 1 and 3. The Russian Coast Radio stations on the Kola Peninsula and in the White Sea region can also provide service on the western approach to the NSR and in parts of the Kara Sea.

Amderma Radio (UPM) covers the Eastern Barents Sea and the Kara Sea. Public communication is not accepted but Weather Reports can be transmitted by telegraphy.

Transmits	Receives	Modulation	Power[kW]
344.8 500	468 500	A1A	1.0

Facsimile transmission on 4270, 6380, 8463.

Weather Messages and Navigational Warnings from Kara Sea to 125° East longitude.

Dikson Radio (UPV) covers the Kara Sea and the Laptev Sea. Public communication is not accepted but Weather Reports can be transmitted by telegraphy.

Transmits	Receives	Modulation	Power[kW]
322.6 500	454 500	A1A	1.0

Weather Messages in Kara Sea and in the Laptev to 115° east longitude. Navigational Warnings for the entire NSR.

Igarka Radio (UFR) covers the Kara Sea and the Yenisey River. Public communication is not accepted but Weather Reports can be transmitted by telegraphy.

Transmits	Receives	Modulation	Power[kW]
470 500	468 500	A1A	

Port Authorities can be contacted on VHF Ch.14.

Mys Chelyuskina transmits facsimile with ice charts

Freq. : 3230 and 5315.
Scanning : 90/576

Tiksi Bukhta transmits facsimile related to ice-conditions and weather progn./analyses.

Freq. : 227
Scanning : 90/576 or 120/576

Pevek transmits facsimile related to ice-conditions.

Freq. : 148
Scanning : 90/576

Providenia Radio (UCZ / UPB) covers the East Siberian Sea, The Chukchi Sea and the Bering Sea. This is the only coaststation on the NSR providing public service and telephony communication on high frequency and VHF. The used frequencies are listed on next page.

	Transmits	Receives	Modulation	Power[kW]
HF	4357.4	4063	J3E/R3E	10
	8731.3	8207.4	J3E/R3E	10
VHF	Ch.16	Ch.16		0.04

NAVTEX are transmitted with identifier [F] in addition to ordinary navigational warnings.

Port authorities can be contacted on VHF Ch.16.

In addition to the telephony there are several telegraphy frequencies.

4.2 Relevant Non-Russian Stations.

Radiostations in the adjacent area on the US and Norwegian side will be of specific interest, even if they are interferred by ionospheric disturbance in large areas on the NSR.

On the US-side there are several coast stations located in Alaska. The west-and northernmost station is located in Nome and provides a 1 kW MF radio telephony service. For short wave communication (HF) the station in Kodiak is available. This station has a wide range of services like facsimile and NAVTEX and is equipped with a 10 kW transmitter.

On the Norwegian side the MF station at Vardø can provide service to ships approaching the NSR from the west. This is a MF station with a 1 kW transmitter. The only accessible HF-station is located at Rogaland in the southwest coast of Norway. This is a powerful station with a wide range of services. Facsimile service is at the present time not provided from Norwegian coast stations. The Norwegian Telecom will probably start testing an HF transmitter at Vardø during 1994 and there will hopefully be a facsimile service. This new HF station will probably cover the western part of the NSR.

For detailed information on the US and Norwegian stations Admiralty list of Radio Signals, see Vols.1 and 3.

4.3 Satellite Communication System.

For maritime purposes the INMARSAT system is the most used. At the present time the system consists of 4 geostationary satellites and provides service on 4 different formats including telephony, telex and other data transmissions. The most used formats are the Standard-A (telephony) and Standard-C (telex and data). The Standard-A can be used as an ordinary telephone, including telefax. Since the satellites are in geostationary orbits the elevation angle will decrease towards the poles. The INMARSAT administration guarantee coverage in areas with elevation angle higher than 5°, see figure 4.1. Under such circumstances most of the Arctic will be beyond coverage limit. In spite of the guaranteed coverage field experience has proved that communication is possible to elevation angles close to 0°, depending on antenna arrangements. If we consider an intermediate coverage limit the area between the Nordenskiøld Archipelago in the Kara Sea and the Lena Delta will be out of INMARSAT coverage. In terms of nautical miles this will mean that a ship in transit on the Northern Sea Route will be missing INMARSAT for almost 1000 n.m. If this area should be covered a satellite would have to be located at a longitude between 100°- 120° East (above Malaysia), but unfortunately no such plans are known.

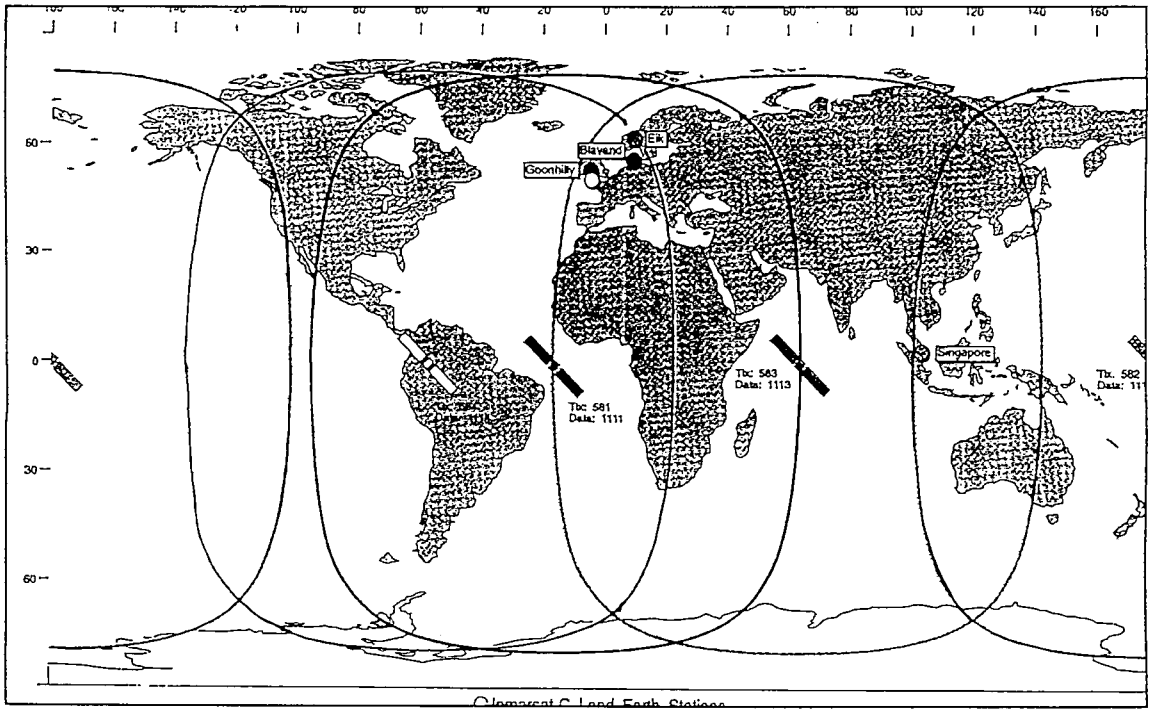


Figure 4.1 *INMARSAT communication satellite coverage. As indicated there will be a coverage gap from the eastern Kara Sea to the New Siberian Islands. (Source: INMARSAT).*

In addition to providing ordinary communication services INMARSAT has proven to be suitable for a variety of special services like transferring differential corrections to the GPS navigation system for accurate positioning in survey operations. Transmission of seachart corrections and updates has also been tested. Standard-A facsimile service has also been tested for transmission of ERS-1 SAR data to ships navigating on the Northern Sea Route with promising results (Johannessen, 92).

Future satellite communication systems are designed in non-geostationary orbit configurations. Such a system is the so called "Iridium-77". 77 satellites are meant to cover the entire globe with communication services for lightweight mobile equipment. The time perspective for such system is well beyond year 2000.

5 Routes and distances.

The Northeast passage has for centuries been attractive as a shortcut between the Northern Atlantic and The Pacific Ocean. In this chapter I will try to discuss different routes and relate them to different operational circumstances.

5.1 Transit Routes

The focus on the short distance between the Northern Atlantic and the Northern Pacific Ocean make it interesting to do some comparison between the Northern Sea Route and the Canal alternatives like the Suez- and the Panama Canals. Some relevant distances are compared in the table 5.1.

Murmansk	: Murmansk					
Rotterdam	: 1628	Rotterdam				
New York	: 3845	3270	New York			
Vancouver	: 9710	8917	6056	Vancouver		
(NSR-Alt.)	5406	6985				
San Francisco:	8915	8117	5307	812	San Francisco	
(NSR-Alt.)	5902	7480				
Yokohama	: 12840	11205	9699	4262	4536	Yokohama
(NSR-Alt.)	5767	7345	9562			
Hong Kong	: 11400	9785	11230	5777	6050	1584
(NSR-Alt.)	7320	8900	11115			

Table 5.1 Some distances on relevant northern routes are compared with southern, "traditional" routes. Distances are in Nautical Miles (1852 meters). Where only 1 distance is listed there is no relevant alternative.

If ship size exceeds the maximum size for sailing through the canals the alternative is to sail south of the southern extremities of Africa and South America. Distance differences compared to the NSR/Polar-alternative will consequently be considerable. At the present time there are severe obstacles for such big ships navigating in the Arctic, but due to rapid

technological progress this can be an interesting concept in future trans-ocean shipping. For ship sizes exceeding the canal standards (Panmax, Suezmax) a distance comparison between actual markets and oil fields can be made. Some distances are listed in table 5.2.

Route	Cape of good Hope	High Polar Route
Persian Gulf - Rotterdam	11,200	
Valdez (Alaska) - Rotterdam	15,600	5,250 +
North Sea - Yokohama	14,740	6,450 +

Table 5.2 Distance comparison between some oil fields and major markets. The high polar route is considered to follow the Great Circle, close to the North Pole. Depending on ice-routing techniqes the Polar alternative will normally be increased slightly, indicated with "+" in the table.

The High Polar Route mentioned above is based on a Great Circle between the Strait of Bering and the Northern Atlantic, across the North Pole.

5.2 Distance table for the Northern Sea Route and adjacent waters.

It is very difficult to make a distance table with correct distances for all ships during different times of the year. In table 5.3 the distances are based on the most used routes in favorable ice conditions. Draft limitations on the routes are approximately 8 meters. For deeper vessels the routes will normally be longer (if sailing is possible), see chapter 5.4. Transit routes are considered to go through the Kara Gate. The route to the north of Novaya Zemlya is shorter than the Kara Gate route but the ice conditions are normally less favorable.

5.3 Suez and Panama limitations.

As mentioned above there will be some limitations connected to the canals just as there are limitations on the Northern Sea Route. When analyzing the trade potential on the NSR these limitations can be of some interest. Maximum figures are:

Suez:	Draught	Beam
	16.1 m	42.7 m
	11.6 m	56.1 m
	10.1 m	64.0 m

Tromsø	:	Tromsø														
Murmansk	:	407	Murmansk													
Archangel	:	772	435	Archangel												
Yugorskiy St.	:	848	578	659	Yougorskiy Strait											
Kara Gate	:	799	523	607	65	Kara Gate										
Matochkin St.	:	678	466	617	320	260	Matochkin Strait									
Ca. Zhelaniya	:	905	745	920	650	590	330	Cape Zhelaniya (Northern Novaya Zemlya)								
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					
Vilkitski St.	:	1686	1410	1491	874	887	858	521	496	826	922	Vilkitski St.				
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 St.	:	2285	2009	2090	1473	1486	1457	1120	1095	1425	1521	599	770	325	Sannikova St.	
Laptev St.	:	2288	2012	2093	1476	1489	1460	1123	1098	1428	1524	602	773	210	93	Laptev St.
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
Provideniya	:	3460	3184	3265	2648	2661	2632	2295	2270	2600	2696	1774	1948	1500	1175	1220	668
Duch Harbor	:	4150	3874	3955	3338	3351	3322	2985	2960	3290	3386	2464	2638	2190	1865	1910	1258
Valdez	:	4955	4679	4760	4143	4156	4127	3790	3765	4095	4191	3269	3443	2995	2670	2715	2063
Vancouver	:	5682	5406	5487	4870	4883	4854	4517	4492	4822	4918	3996	4170	4080	3755	3800	3248
Vladivostok	:	5885	5609	5690	5073	5086	5057	4720	4695	5026	5121	4199	4373	3925	3600	3645	3093
Yokohama	:	6043	5767	5848	5231	5244	5215	4878	4853	5183	5279	4357	4531	4441	4116	4161	3609

Abbreviations:
Ca. = Cape or Mys
St. = Strait or Proliv

		Bering Strait						
Provideniya	:	110	Provideniya					
Duch Harbor	:	690	615	Dutch Harbor				
Valdez	:	1495	1420	805	Valdez			
Vancouver	:	2332	2241	1626	1210	Vancouver		
Vladivostok	:	2535	2425	1880	2680	4378	Vladivostok	
Yokohama	:	2693	2583	2580	3380	4258	931	

Note that distances are based on most favorable ice conditions and recommended routes for medium draft vessels. In difficult ice other and longer routes can be most effective.

Table 5.3 *Distances between ports and positions on the Northern Sea Route and adjacent waters. (All distances in Nautical miles).*

In terms of ship size this is equivalent to a laden ship of approximately 150,000 dwt., and a 370,000 dwt ship in ballast. The traffic is organized in north or south bound convoys with maximum 40 vessels. Suezmax is the normal terminology for the maximum size of ships sailing the Suez Canal.

Panama: Draft = 11.3 m Beam = 32.3 m
Length= 274.3 m
Length= 289.5 m (passenger / container vessel)

In terms of deadweight this means approximately a 70,000 tonn vessel. There is no convoy system and a passage takes approximately 9 hours. Panamax is the normal term for maximum size of ships intended for Panama Canal traffic.

5.4 Draft and ice dependency for navigation on the NSR

The shallow waters off the coast will normally force deep draft vessels several miles offshore. This draft limitation will also be very unfavorable in terms of ice-routing since it will not be possible to make use of the often open water close to the shore. How far away from the coast the ships have to go will also depend on the decided underkeel clearance and to what is considered as safe speed. This clearance must be over 5 meters in open water areas. In the rivers and the estuaries the clearance will often be marginal when the ships are loaded in a river port like Dudinka and Igarka. On table 5.4 it can be seen how the ice situation can influence ships with different draft sailing on the NSR (from Novaya Zemlya). The numbers in the table indicate how many nautical miles the ship has to sail in ice at different times of the year. The routes from whitch the distances are calculated can be seen on the maps (figure 5.1, 5.2 and 5.3). Three different routes are considered, 1 with a draft of 16 meters (70,000 tonn tanker), 1 with a draft of 11 meters (30,000 tonn bulk carrier) and 1 with a draft of 8 meters (icebreaker / supply vessel).

The 70,000 tonn Tanker will meet serious draft limitations in the Kara-, Laptev- and East Siberian Seas. Due to the 16 meter draft the ship will have to enter the NSR through the Kara Gate or to the north of Novaya Zemlya. The ship will be able to navigate the straits of the Nordenskiøld Archipelago and close to the west coast of Taymyr Peninsula. Off the Yamal Peninsula and off the Lena Delta the limited depths force the ship respectively 65 n.m. and 80 n.m. offshore. The straits between the New Siberian Islands and the mainland are also too shallow for a ship of this size, and the ship is forced to go 30 n.m. to the north of the islands. Off the Kolyma Delta the clearance to the coast has to be in the range of 60 n.m. before it can continue approximately 12 n.m. off the Chucotka

Peninsula. The ship will be unable to call at any port along the NSR and will even in the most favorable season meet difficult ice conditions in the Vilkitski Strait and in the East Siberian Sea. The important element of route flexibility in ice-infested waters will consequently not be maintained for a ship of this size.

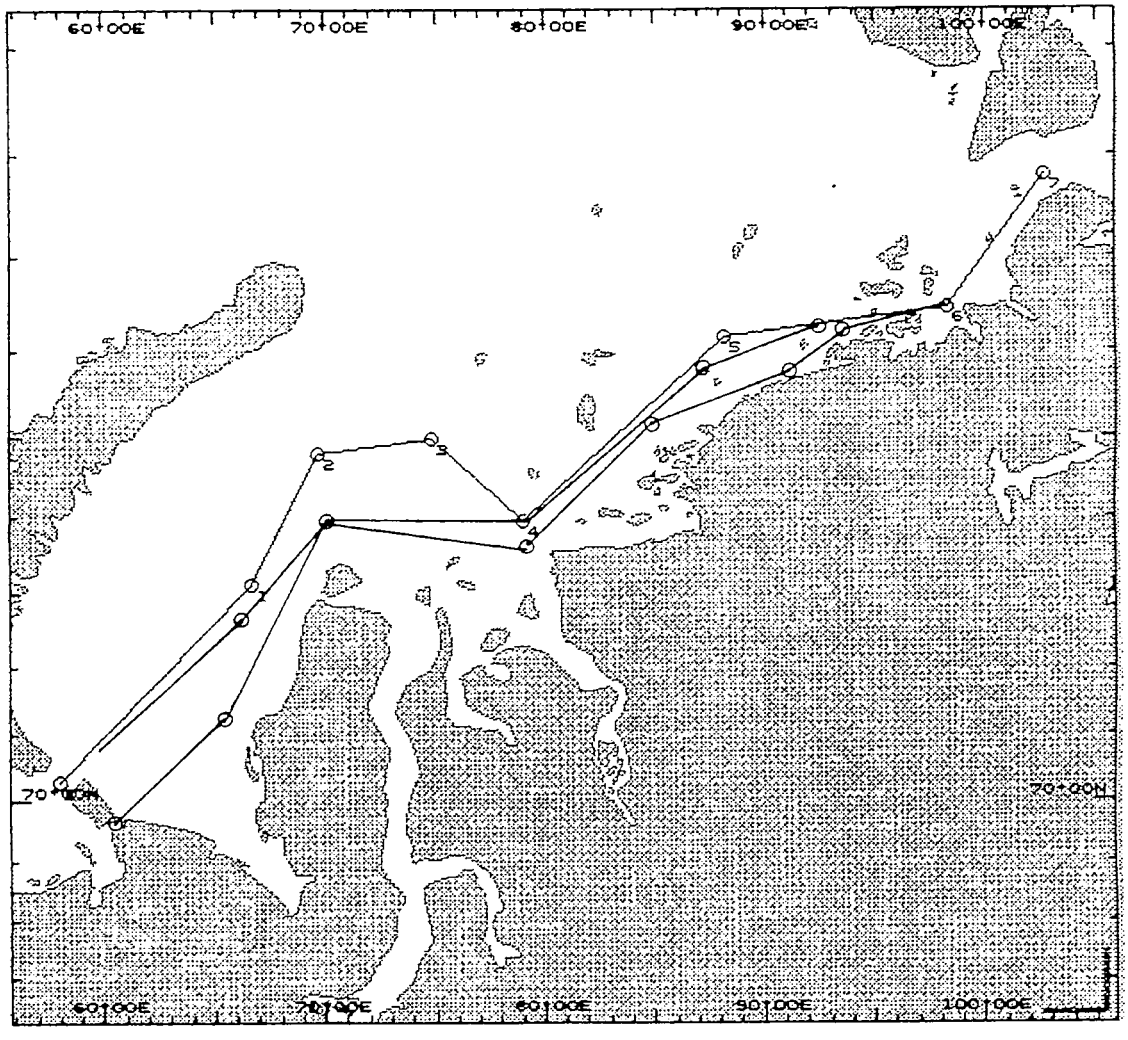


Figure 5.1 *Draft dependent routes in the Kara Sea. Depending on the draft different ships have to choose different routes. The northernmost route is considered to be navigable for a ship with 16 meter draft, the middle - 11 meter draft, and the southernmost is considered to be navigable with a draft of 8 meters.*

The 30,000 tonn Bulker will naturally encounter fewer draft limitations. It will be able to enter the NSR through the Yugor Strait. Off the Yamal Peninsula the ship must sail 8

n.m. of the West Coast and 20 n.m. of the North Coast. On the NE-Coast of the Taymyr Peninsula an inshore route can be followed before the ship heads over the Laptev Sea with a safety distance to the Lena Delta of 30 n.m. With special caution it is possible to sail the Sannikova Strait south of the New Siberian Islands. Safety distance to the coast will in the East Siberian Sea have to be approx. 45 n.m. The ship is able to call at the roadsteads in Pevek and Dikson.

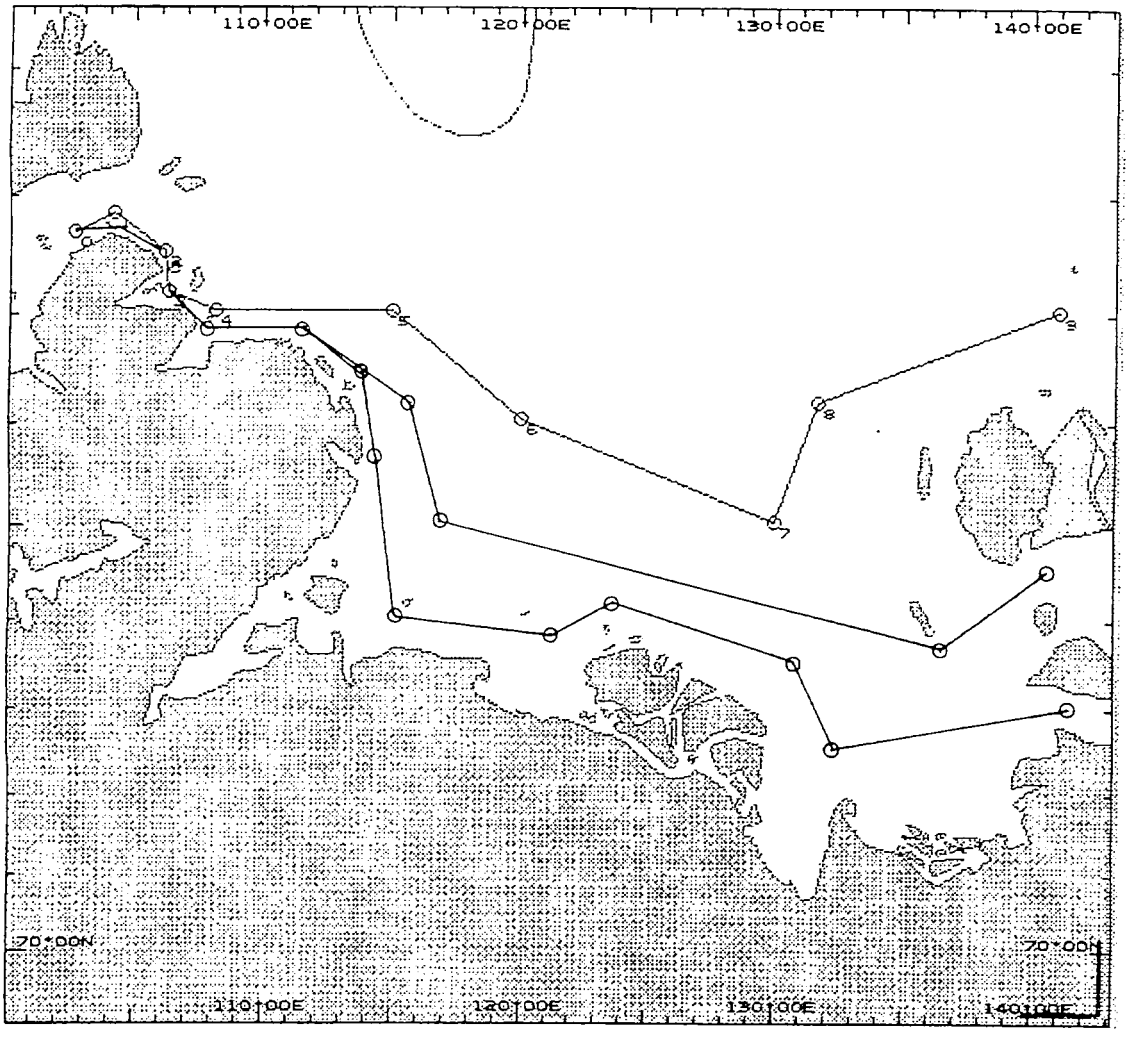


Figure 5.2 *Draft dependant routes in the Laptev Sea, Depending on the draft different ships have to choose different routes. The northernmost route is considered to be navigable for a ship with 16 meter draft, the middle - 11 meter draft, and the southernmost is considered to be navigable with a draft of 8 meters. The underkeel clearance will in some straits be less than 5 meters (ref. chapter 5.5)*

The Icebreaker/Supply vessel will with its 8 meter draft be able to enter the NSR through the Matochkin Strait (considering permission is obtained). The limited draft to the north of the Yamal Peninsula forces the ship 20 n.m. offshore in this area, but it is possible to sail up the Ob Gulf to the roadstead of Novyy Port. It is also possible to navigate the Yenisey up to the ports of Dudinka and Igarka. In the Laptev Sea a safe distance of 25 n.m. off the Lena Delta is necessary, but the ship can call at the port of Tiksi and with caution sail the Dimitry Laptyev Strait. Through parts of the East Siberian Sea an offshore clearance of 30 n.m. must be used. The ship is able to berth in Pevek and sail pretty close to the coast in the Long Strait.

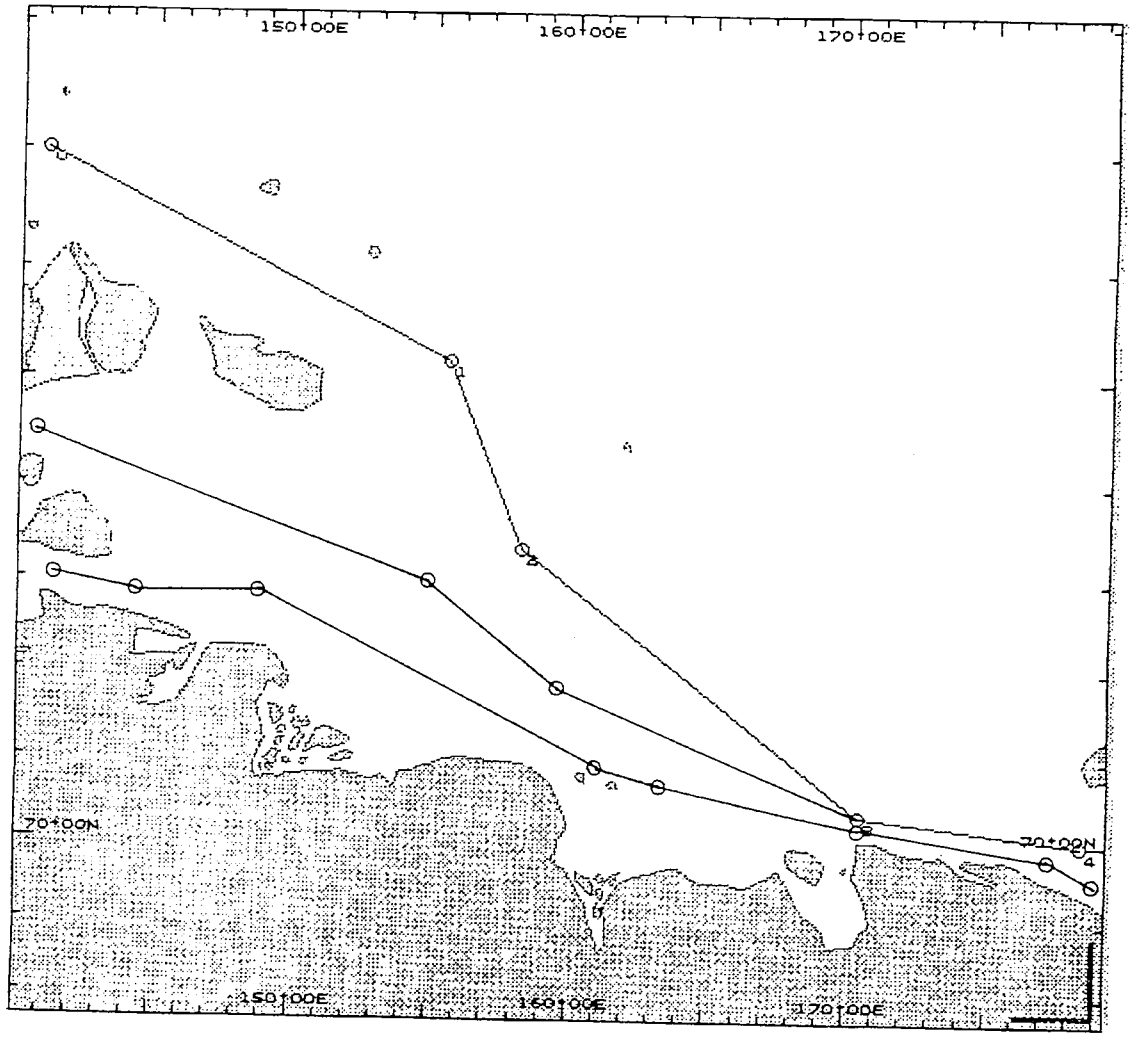


Figure 5.3 *Draft dependent routes in the East Siberian Sea. Choise of route depends upon draft depth. The northernmost route is considered to be navigable for a ship with 16 a meter draft, the middle - 11 meter draft, and the southernmost is considered navigable with a draft of 8 m.*

5.5 Important straits

When navigating the Northern Sea Route the route will go through different straits. Some of these straits have shallow depths and in some cases there will be special restrictions for navigation. The most important straits are indicated on figure 5.4.

	8 meter draft			11 meter draft			16 meter draft		
Time	Kara	Lapt	East	Kara	Lapt	East	Kara	Lapt	East
Jan	918	827	1124	896	618	1121	956	658	1165
Feb	918	827	1124	896	618	1121	956	658	1165
Mar	918	827	1124	896	618	1121	956	658	1165
Apr	918	827	1124	896	618	1121	956	658	1165
May	918	827	1124	896	618	1121	956	658	1165
Jun	756	720	1124	756	528	1121	900	474	1165
Jul	350	638	417	523	420	593	686	444	643
Aug	200	0	0	211	108	110	237	253	393
Sept	0	0	0	0	0	0	0	90	328
Oct	450	827	746	523	618	763	537	658	807
Nov	810	827	1000	810	618	1000	850	658	1045
Dec	918	827	1124	896	618	1121	956	658	1165
Total:	** 2869 **			** 2635 **			** 2779 **		

Table 5.4 Figures indicate the nautical miles different ships have to sail through ice with concentration of 7/10 (or higher) in different areas on the NSR. The calculation is based on average values of ice extent and will vary considerably from year to year. Ships with 3 different drafts are considered, 16, 11 and 8 meters (ref. figure 5.1, 5.2 and 5.3). The total distance is between the Kara Gate and the Strait of Bering.

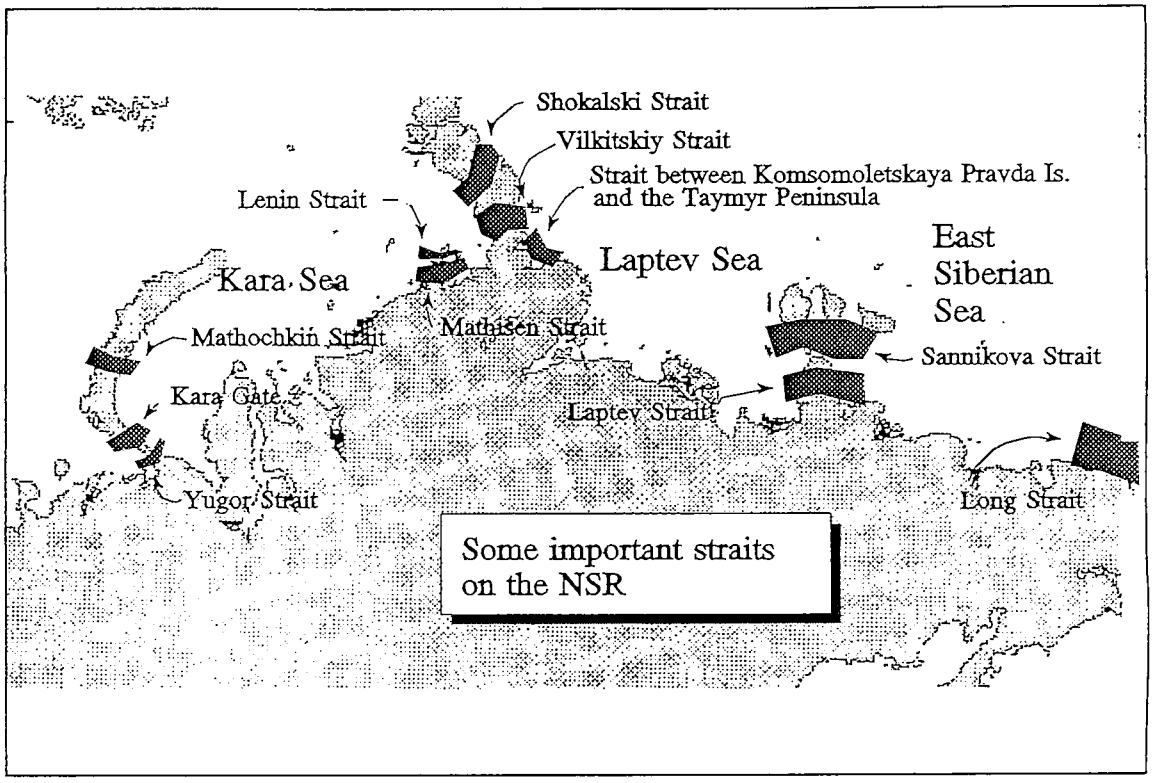


Figure 5.4 *The most important straits in the Kara Sea are indicated on the map.*

The Kara Gate (Proliv Karskiy Vorota)

Area: This strait is the main shipping lane between the Barents Sea and the Kara Sea. A Traffic Separation Scheme is established in the strait (still not IMO adopted) and separates Novaya Zemlya from Vaygach Island and the Mainland.

Distance: Approx. 30 n.m.
Minimum depth : 21 meters

The Yugor Strait (Proliv Yugorskiy Shar)

Area : The southernmost entrance from the Barents Sea into the Kara Sea. Limited depths make pilotage normally required for large vessels. The Strait has been mined and anchor sites are limited.

Distance: Approx. 30 n.m.
Minimum depth : 12 meters

Mathochkin Strait (Proliv Mathochkin Shar)

Area : This narrow strait separates Novaya Zemlya approximately at the middle. The area has been used as a nuclear test site the last 4-5 decades and is at the present time closed to shipping.

Distance: 60 n.m.
Minimum
depth : 13 meters

Mathisen Strait (Proliv Mathisena)

Area : This strait is probably the most frequently used shipping lane in the eastern Kara Sea, and is located south in the Nordenskiold Archipelago.

Distance: 50 n.m.
Minimum
depth : 53 meters

Lenin Strait (Proliv Lenina)

Area : This strait is the northernmost in the Nordenskiold Archipelago. Advised routes are drawn through the strait but the ice conditions are normally better in the Mathisen Strait.

Distance: 45 n.m.
Minimum
depth : 25

Vilkitskiy Strait (Proliv Vilkitskitskogo)

Area : This strait separates Severnaya Zemlya from the northernmost extremity of the Eurasian continent, Cape Chelyuskin, and is the main shipping lane between the Kara Sea and the Laptev Sea. Radio reporting to Cape Chelyuskin is required and can take place on VHF ck. 16 Pilotage is compulsory for non-Russian vessels.

Distance: 100 n.m.
Minimum
depth : Deeper than 25 meters in recomanded routes.

Shokalski Strait (Proliv Shokalskogo)

Area : This strait is located in the eastern part of the Severnaya Zemlya. Ice conditions are normally more favorable in the Vilkitskiy Strait but in special circumstances the Shokalski Strait can be preferred.

Distance: 90 n.m.
Minimum depth : 102 meters

Route between Komsomoletskaya Pravda Islands and Taymyr Peninsula

Area : This route must be considered to run through inshore waters, and is very often used in the summer season when the offshore route has more severe ice conditions. Many shallow grounds have been found and navigation must be performed with care.

Distance: 40 n.m.
Minimum depth : Deeper than 20 meters in advised route.

Sannikova Strait (Proliv Sannikova)

Area : This is one of the two main straits linking the Laptev Sea to the East Siberian Sea. Most of the Sannikova Strait is very shallow with depths between 13 - 15 meters. These marginal depths will be the limiting factor with regard to maximum ship size on the NSR. The Sannikova Strait is often used even when ordinary underkeel clearance can not be obtained and consequently the speed has to be reduced in parts of the strait. A sloping coastline on the New Siberian Islands makes it difficult to discover land visually and on Radar.

Distance: 160 n.m.
Minimum depth : 13 meters

Laptev Strait (Proliv Dimitriy Lapteva)

Area : Together with the Sannikova Strait this strait links The Laptev Sea to the East Siberian Sea. Depths are limited and the strait will normally not be used by loaded ships.

Distance: 120 n.m.
Minimum depth : 9 meters

Long Strait (Proliv Longa)

Area : This wide strait separates the East Siberian Sea and the Chukchi Sea. This shipping lane leads between Wrangel Island and the Chuchotka Peninsula. At Cape Shmidt there is compulsory radio reporting. On the coast of Chucotka characteristic tall cliffs can be observed, often described as " stone forests".

Distance : 120 n.m. (southern alternative)
160 n.m. (northern alternative)
Minimum depth : 20 meters (southern) / 33 meters (northern)

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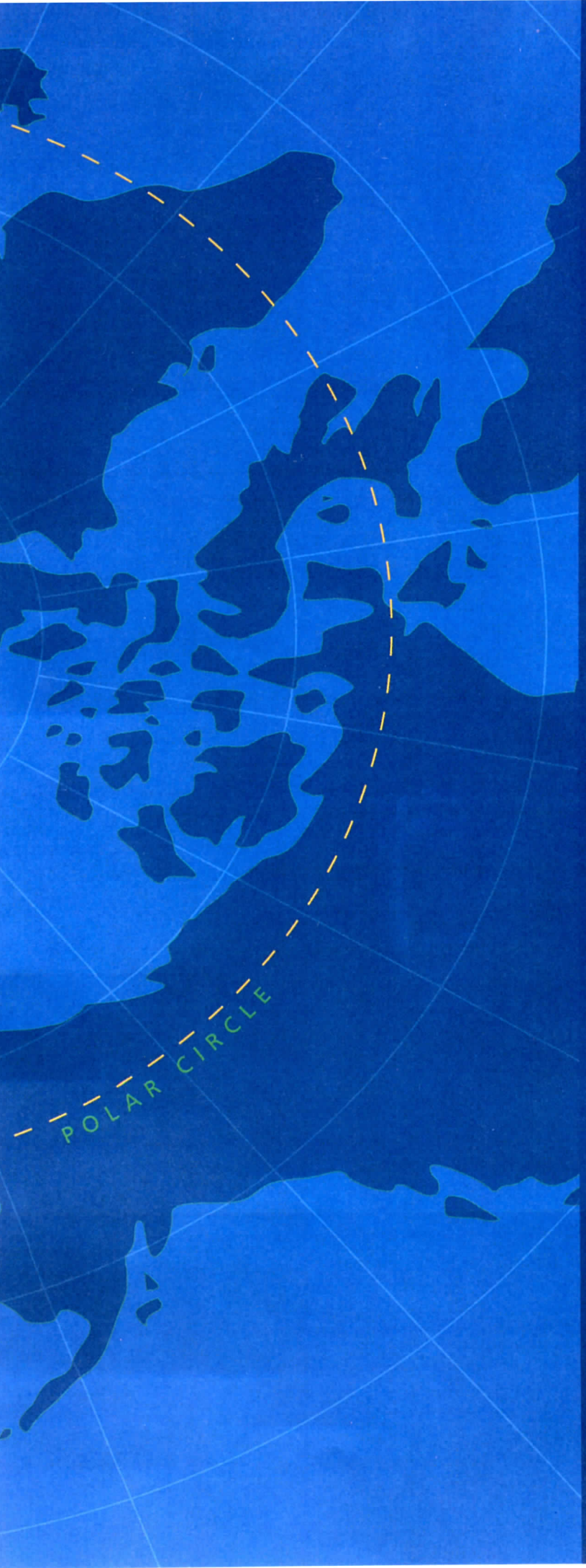

The three main cooperating institutions of INSROP

Ship & Ocean Foundation (SOF), Tokyo, Japan.

SOF was established in 1975 as a non-profit organization to advance modernization and rationalization of Japan's shipbuilding and related industries, and to give assistance to non-profit organizations associated with these industries. SOF is provided with operation funds by the Sasakawa Foundation, the world's largest foundation operated with revenue from motorboat racing. An integral part of SOF, the Tsukuba Institute, carries out experimental research into ocean environment protection and ocean development.

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.

CNIIMF was founded in 1929. The institute's research focus is applied and technological with four main goals: the improvment of merchant fleet efficiency; shipping safety; technical development of the merchant fleet; and design support for future fleet development. CNIIMF was a Russian state institution up to 1993, when it was converted into a stock-holding company.

The Fridtjof Nansen Institute (FNI), Lysaker, Norway.

FNI was founded in 1958 and is based at Polhøgda, the home of Fridtjof Nansen, famous Norwegian polar explorer, scientist, humanist and statesman. The institute spesializes in applied social science research, with special focus on international resource and environmental management. In addition to INSROP, the research is organized in six integrated programmes. Typical of FNI research is a multi-disciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.