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Modification of the Canadian Ice Regime System to Include Ship Operations

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

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.

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MODIFICATION OF THE CANADIAN ICE REGIME SYSTEM TO INCLUDE SHIP OPERATIONS

INSROP Project I.2.5

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Abstract

Data on ice navigation experience in the Russian Arctic was obtained for Russian Registry ULA, UL and L1 vessels. The data comprise transit times and distances for voyage segments and a description of ice conditions according to WMO terminology for each voyage segment. This is a useful data set for analysis of navigation experience and testing of methodologies for predicting safety and effectiveness of navigation in ice covered waters.

The Canadian Arctic Ice Regime Shipping System (AIRSS) uses ice conditions and vessel class to provide guidance on safe navigation in ice. The severity of ice conditions is quantified by a WMO-based ice regime in relation to multipliers based on ship type to calculate an Ice Numeral. In the AIRSS this Ice Numeral is used to define conditions for safe vessel operation in ice. If the Ice Numeral is positive or zero navigation is safe, but if it is negative navigation is unsafe. No allowance is made for operational factors such as speed or visibility. Ice Numerals have been determined for a number of vessels operating in the Russian Arctic and in turn related to average vessel speed and damage. The actual number and degree of damage is small, however, a negative Ice Numeral is an indicator of a higher risk of damage.

The AIRSS has been modified to take into account ice decay, ridging, floes size and icebreaker escort to calculate a Transit Numeral. The Transit Numeral is an indicator of ice severity; zero represents very severe conditions for a vessel while 50 represents conditions equivalent to open water. Transit Numeral has been related to average transit speed in ice. In the case of ULA and L1 vessels there is a general trend of increasing average transit speed with increasing Transit Numeral. For Transit Numerals greater than about 35 average transit speed is independent of ice conditions. The ice navigation data have been analysed to predict mean speed, standard deviation of speed and an upper limit average transit speed. These transit speeds provide and experience-based indication of expected long-term ship performance in actual practice along the Northern Sea Route.

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1. Introduction

Effective use of the Northern Sea Route requires both safe and economical navigation through ice affected waters. Traditionally such navigation has been based on the skill of the Captain and crew, and a vessel adequate for the ice conditions. The development of the required skill levels is a long and uneven process. With the envisioned expansion of international marine traffic through the Northern Sea Route it is not expected that the same level of operational skill will be available on all transiting vessels. Training will be one important factor in providing the skills required; however, other aids to safe and economic navigation are also desirable.

There are already systems in place in several countries to assist navigation in ice. In Canada the Arctic Ice Regime Shipping System (AIRSS) has been implemented as part of a revised Arctic Shipping Pollution Prevention Regulations (AIRSS, 1996). ASPPR is oriented to safety of shipping operations, setting requirements for hull strength, machinery strength and the limiting ice conditions in which various categories of vessels are permitted to operate. The AIRSS provides advice on whether a particular class of vessel can advance into an area having a specific set of ice conditions. In Russia, the Russian Registry maintains a classification of icebreakers and icebreaking vessels. There is additionally an Ice Passport that provides guidance to the captain on safe speed for navigation in various ice conditions, and a QAD system which provides a quantitative means for predicting transit speeds.

In the present work, the Canadian AIRSS is modified to make it more suitable for planning and managing vessel transit. The AIRSS does not take into account ship operations (vessel speed, visibility, etc.) in a direct fashion. It does, however, take advantage of current ice condition information generated by most national ice services, supplemented by detailed ice observations available on-board the vessel to guide safe transit. The same ice information, in a recast form, can provide a useful guide for the maximum speed with which a vessel may proceed through ice. Information on Russian navigation experience in the Arctic will be used to develop an experience-based model. This model can be used to predict transit times for particular classes of vessels in relation to quantifiable ice conditions (average and extreme) for particular regions and seasons. It can also be used to select a preferred routing. The Russian navigation data presented here is in sufficient detail and format that it can also be used to test other models of ice transit. This report will describe the AIRSS and how it has been modified to make it suitable for providing guidance on route selection based on actual ice conditions as determined from normal ice charts.

2. Description of Canadian Arctic Ice Regime Shipping System

The AIRSS was developed to provide guidance on safety of navigation in the Canadian Arctic. It relates the level of hull strength of a vessel to the actual ice conditions through which the vessel will transit. Based on this assessment of ice conditions in relation to ship type or class, the vessel is either allowed to proceed to not. AIRSS is strictly safety oriented; there is no provision for special operations, i.e. lower speed, extra caution, etc., which would allow a vessel to proceed into an otherwise forbidden ice condition. Similarly, it provides no operational guidance as to where a vessel is allowed to proceed, other than due caution of mariners. Before proposing modifications to AIRSS it is necessary to have a good understanding of the system as it now stands.

The central core of AIRSS is the quantitative description of ice conditions. The starting point is an ice regime, that is, a geographic area composed of a relatively even distribution of any mix of ice types, including open water. Thus an ice regime can have dimensions of several 10s of m to several 10s of km. The World Meteorological Organization (WMO) nomenclature is used to describe the ice types. A shorthand for this is the WMO Ice Code or "egg" code. The Canadian Ice Service (CIS) application of the WMO classification is illustrated in Figure 1. Ice services in other countries may have slightly different symbols (Lensu et al, 1996), but they are all basically similar. The code provides information on partial ice concentration, C_i, stage of development (thickness), S_i, and predominant floe size for each partial concentration, F_i. Usually only the three oldest (thickest) ice types are included, but this can be extended as necessary. Note in Figure 1 that for the stage of development, S_i, names, ice thickness ranges and codes are given. An example of an ice chart produced by the CIS in shown in Figure 2. This chart is derived from a RADARSAT image and the ice regimes vary greatly in size, having dimensions as large as 60 nautical miles and as small as 2 nautical miles. A Captain may use any ice information available to him, for example airborne SAR images, visual observations from a helicopter, the view from the bridge, etc.

In the Canadian regulations, the ship's structure must be designed to safely withstand impacts with a maximum thickness of ice (ASPPR 1989). This is the thickest ice type in which a properly navigated ship may operate without risk of structural damage. The regulations define 9 categories of vessels such that each ship category is related to an ice type. Table 1 presents the nine ship categories along with the corresponding ice type and thickness for each ship category. The ice is referred to as **category ice**, that is, ice of this thickness or less does not present a risk of hull damage to a properly navigated ship of that category.

Table 1 Ice Type for each Ship Category

WMO Ice Type	WMO Ice Code	Thickness (m)	Ship Category
Multiyear Ice (MY)	9.	> 3	CAC 1
Second Year Ice (SY)	8.	> 2	CAC 2
Thick First Year ice (TFY)	4. or 6	>1.2	CAC 3
Medium First Year Ice (MFY)	1.	0.7 – 1.2	CAC 4
Thin First Year Ice– 2nd Stage (THFY 2)	7 or 9	0.5 – 0.7	Type A
Thin First Year Ice– 1st Stage (THFY 1)	8	0.3 – 0.5	Type B
Grey-White Ice (GW)	3 or 5	0.15 – 0.3	Type C
Grey Ice (G)	4	0.1 – 0.15	Type D
New or Brash Ice, Open Water (OW)	1 or 2	< 0.1	Type E

An ice regime has two components: 1) ice that is above (or more severe than) the **category ice** for the vessel; and 2) ice at and below the "category ice" for the vessel. These two components always total $10/10^{ths}$. In any given ice conditions, the ratio of the two components will differ between ship categories, since each ship category has a different **category ice**. The risk of damage, therefore, will depend on the proportions of hazardous ice (i.e. above the **category ice**) and non-hazardous ice (i.e. at or below the **category ice**) in the regime.

To quantify the ice regime, a scheme has been developed which takes into account the relative amount of each type of ice, and relates it to the ship category. This is reflected through an **Ice Multiplier (IM)**. The value of the Ice Multiplier reflects the level of danger that the particular ice type poses to the particular category of ship, with the larger negative numbers representing larger hazards. Table 2 lists the Ice Multiplier values for each ship category. **Category ice** is shown in bold. Note that ice thinner than **category ice** always has a positive multiplier of 2, except initially 1 in the case of Type B ships. Ice one step thicker than **category ice** still has a positive multiplier of 1, however ice one further step thicker has a negative multiplier and is considered hazardous. This step is actually 2, going from 1 to –1, and emphasizes the shift to negative multipliers. The purpose of these multipliers in the AIRSS is to define an Ice Numeral, which if negative, precludes entry of a ship into that ice regime.

Table 2 Ice Multipliers for each Ship Category

Ice Type and Thickness, m		SHIP CATEGORY						
		TYPE ships					CAC	
		E	D	C	B	A	4	3
MY	>3	-4	-4	-4	-4	-4	-3	-1
SY	>2	-4	-4	-4	-4	-3	-2	1
TFY	>1.2	-3	-3	-3	-2	-1	1	**2**
MFY	0.7 -- 1.2	-2	-2	-2	-1	1	**2**	2
THFY2	0.5 – 0.7	-1	-1	-1	1	**2**	2	2
THFY1	0.3 – 0.5	-1	-1	1	**1**	2	2	2
GW	0.15 – 0.3	-1	1	**1**	1	2	2	2
G	0 – 0.15	1	**2**	2	2	2	2	2
OW	--	**2**	2	2	2	2	2	2

For any ice regime, an **Ice Numeral (IN)** is calculated by taking the sum of the products of the concentrations of the ice types present (in 10^{ths}), and their ice multiplier. The Ice Numeral is defined as:

$$IN = (C_a \times IM_a) + (C_b \times IM_b) + \ldots \qquad (1)$$

where IN is the Ice Numeral, C_n is the concentration (in tenths) of ice type "n", and IM_n is the Ice Multiplier from Table 2. The right side of the equation is expanded to include all the types of ice that are present, including open water. Note that the total of the partial concentrations (ice and open water) must add up to 10 tenths. The **Ice Multipliers (IM)** may be either positive or negative, depending on the ice type and ship category, so when combined into an **Ice Numeral (IN)** they represent a quantitative measure (a weighted average) of the ice regime in relation to a ship's structure. The Ice Numeral is therefore unique to the particular ice regime and category of ship operating within its boundaries. The system takes into account ice decay and ice ridging. For *decayed* ice, the multipliers are increased by 1 for multiyear and second-year ice, and thick and medium first-year ice. *Ridging* is taken into account for ice floes more than $3/10^{ths}$ ridged and in overall ice concentration greater than $6/10^{ths}$ by reducing the multiplier by 1 for that ice type. The affect of ridging is only considered for ice thicker than 0.15 m (WMO code 5 or greater). This reflects the higher level of risk presented by the thicker ice in a ridge.

It can be seen from Table 2 that the maximum **Ice Multiplier** is 2 and the minimum one is –4. Application of Equation (1) will normally result in an **Ice Numeral** between 20 and – 40. The effect of ice decay could result in an **IN** as great as 30 for CAC ships, while the effect of ridging could result in an **IN** as low as -50 for Type ships. For any given ship category, entry or non-entry into an ice regime is determined by the sign of the **Ice Numeral**. If the **IN** is *negative*, entry is not allowed. However, if the **IN** is *zero* or *positive*, then entry by the ship into that ice regime is allowed. The system does not allow for consideration regarding how negative or positive the **Ice Numeral** is.

Because of the heterogeneous nature of ice regimes, the more detailed the information on ice conditions is, the more likely that ice regimes can be

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defined with non-negative Ice Numerals. This is an incentive to have high quality ice information.

The Ice Multipliers in Table 2 are empirically based. They were initially established from judgement and experience of many Canadian Arctic mariners. Subsequently a number of validation voyages were conducted to adjust the multipliers and establish the effects of ice decay and ridging.

An extensive project is underway to compile and set up a database of experience with the AIRSS (Timco and Morin, 1998). The database considers incidents of damage and successful navigation. To date, the project has found over 1000 events of damage or successful navigation through various ice regimes. The database contains information on ship characteristics and the interaction event (ice regime, degree of damage, ship speed, visibility, etc.). The database has been examined to enable an appreciation of damage severity, ship speed and ice numeral. An example is shown in Figure 3. It can be seen that almost all examples of serious damage occurred for negative Ice Numerals. Also most of the damage occurred at speeds of 3 knots or greater. The numerous cases of high-speed navigation at negative Ice Numerals with no damage points to the need to consider other factors in defining conditions for safe navigation.

3. Description of Russian Ice Passport and QAD System

The Ice Passport and the QAD system are two aids that have been develop in Russia to assist the safety and efficiency of navigation in ice. The Ice Passport provides guidance on safe speed for navigation in various ice conditions. The QAD system provides predictions of expected operational speed for a given set of ice conditions. The QAD system has already been described in some detail in Brovin et al (1995) and reviewed in Lensu et al (1996) so it will not be treated in any detail here.

3.1 Ice Passport

The concept of an Ice Passport was developed at the Arctic and Antarctic Research Institute and implemented in the early 1970s. It is based on two factors: (1) the speed at which a ship can travel through given ice conditions in relation to the capability of its propulsion system, assuming the hull structure has infinite strength; and (2) the maximum speed at which a ship can travel through given ice conditions without experiencing hull damage (permanent deformation), ie. Taking hull strength into account. The lower of these speeds defines the safe operating environment. There are now several papers in the literature describing the Ice Passport, for example Likhomanov et al 1993 and Likhomanov et al 1998. Ice passports have been prepared for 17 ships, the most recent being for the Canadian Coast Guard icebreaker "Pierre Radisson" in 1997.

The concepts of the Ice Passport can be best described with the assistance of an illustration (Figure 4). Knowing the hull form, power, and propulsion

system characteristics, the maximum attainable speed of the ship can be determined as a function of ice thickness or ice conditions. Standard equations are available for doing this calculation. The results of such a calculation are shown as the solid curve marked "attainable speed". Assuming this curve is for level fast ice with no snow cover, curves at higher speeds could be drawn for smaller floes and lower ice concentrations, and lower curves for snow-covered and ridged ice. The dashed curve marked "dangerous speed" defines the speed above which there is danger of damage to the hull structures. The dangerous speed curve is a function of hull structure and geometry and ice conditions. This curve is derived from calculation based on the "hydrodynamic" model. With the definition of these two curves, Figure 4 can be divided into several zones. Zone A defines a condition of safe operation, zone B defines a condition where the hull structure could be damaged if the full power of the ship was used to exceed the "dangerous speed". Zone C also defines a condition for damage; however propulsion limitations of the ship preclude reaching this condition. A thorough description of the determination of an ice passport is given in Likhomanov et al (1997a, 1997b).

The actual Ice Passport is a document prepared for a particular ship or family of ships. It provides a series of plots of allowable ship speed as a function of ice thickness for a particular ice condition (floe size, concentration, degree of ridging). A copy of the Ice Passport is available on the bridge of the vessel and provides guidance to the Captain on the safe speed with respect to ice conditions. It is not clear how the Ice Passport is applied in the case of an "ice regime", which is a mix of ice thickness, concentration and floes sizes.

3.2 QAD System

QAD is the short form for **Q**uantitative **A**ssessment of navigation **D**ifficulty in ice. It too was developed by researchers at the Arctic and Antarctic Research Institute with the objective of supporting the organization, planning and operational management of shipping along the Northern Sea Route. The system was developed from an empirical-statistical basis, and has been refined based on year-round operational experience in the western part of the Russian Arctic.

The starting point of the approach is a quantitative description of the ice conditions that affect ship progress (thickness, concentration, floe size, snow depth, decay, ridging, leads, pressure, adhesion). The second step is to determine the ship's progress in relation to these factors. This is done through application of a number of algorithms for calculating ship speed through various ice types. In fact the equations used are those employed in calculating "attainable speed" and "dangerous speed" in the Ice Passport. Spatial averaging, taking into account the distance traveled in each type of ice, is used to obtain what is called the "ice technical velocity" (V_{it}). This velocity is then adjusted downwards for delays due to ice and other hydrometeorological reasons to an "ice operating net velocity" (V_{ion}). The adjustment is empirically based and depends on ship type, presence of escort, etc. The system seems to have been most often applied to transit of

icebreakers, or ships escorted by icebreakers. Brovin et al (1995) state that the system has an error of no more than 10 % for icebreaker transit, and 20 % for icebreaker escort.

The QAD system, like the Canadian Arctic Ice Regime Shipping System, depends upon detailed information on ice conditions. It employs satellite imagery, airborne reconnaissance and shipboard reports to describe ice conditions. In addition to operational planning on a voyage basis for existing ships, the QAD system can also be used to evaluate proposed new shipping routes, and vessel requirements, in relation to average and extreme ice conditions derived from historical ice data.

4. Russian Ice Navigation Data

Analysed data of Russian ice navigation experience for a number of vessels were procured from the Arctic and Antarctic Research Institute (Timofeev et al, 1997) as part of a study being conducted for Transport Canada on validating the Canadian Arctic Ice Regime Shipping System. The vessels studied were part of the fleet of the Murmansk Shipping Company. The experience, from the first half of the 1980s, covered both successful navigation in ice and a very small number of damage events.

The data were divided into two groups: the first examined the experience of the "Ivan Susanin", a Russian Registry type UL vessel for four ice navigation seasons from 1981 to 1985; and the second examined 3 types of ships, ULA, UL and LI for a single season (1983-84). Information on the ship particulars is summarized in Table 3 below. More details on the ships can be found in Timofeev et al (1997).

Table 3 Description of Ships

Ice Class of Ships	ULA	UL	L1
Name of Ship Series	"Norilsk"	"Dmitry Donskoy"	"Pioner"
Length overall (m)	174.0	162.1	105.7
Breadth (m)	24.5	22.86	15.6
Summer Draft (m)	10.5	9.88	6.8
Deadweight (t)	20,000/14,700	19,885	4648
Service Speed (kn)	17.0	15.2	13.8
Power (kW)	13,850	8240	2390

For the Ivan Susanin there were 136 voyage segments and for the 1983-84 season there were 555 voyage segments involving 24 different ships. Date, time, name of geographic location and coordinates of start and end points of each segment were given, so average speeds could be determined. Average ice conditions, according to WMO nomenclature, were give for each voyage segment. This allows vessel progress to be related to ice conditions. For completeness, WMO terminology used for ice age and floe size of the Russian data are repeated here in Tables 4 and 5. Note that an * is used to

designate thicker ice in the Russian presentation of ice conditions, rather than the dot used in WMO.

Table 4 WMO terminology for ice age and thickness

Term	Ice thickness (m)	WMO Code
New ice	< 0.1	1
Grey ice	0.1 - 0.15	4
Grey-white ice	0.15 – 0.3	5
Thin first-year ice	0.3 – 0.7	7
Medium first-year ice	0.7 – 1.2	1*
Thick first-year ice	> 1.2	4*
Old ice		7*
Second-year ice		8*
Multi-year ice		9*

The WMO terminology does not quote thickness for old, second-year or multi-year ice; however, as an estimate second-year ice is taken to be greater than 2 m and multi-year and old ice greater than 3 m.

Table 5 WMO terminology for floe size

Term	Floe size (m)	WMO Code
Small ice cake, brash	< 2	1
Ice cake	2 – 20	2
Small floe	20 – 100	3
Medium floe	100 – 500	4
Vast floe	500 – 2000	5
Fast ice		8

The area covered by this navigation experience was the Russian Arctic, primarily from Murmansk as far east as Dikson, but there were a few voyages across the entire Northern Sea Route. Navigation from Murmansk to Dudinka is conducted on a year round basis with transits through the Pechora Sea, Kara Sea and Yenisey River. A map of the Russian Arctic with the way points marked on it is presented in Figure 5. The geographic coordinates of the waypoints are presented in Appendix A.

4.1   Navigation Experience of Ivan Susanin, 1981-1985

Four seasons of voyage data are available for the Ivan Susanin, from August 1981 to September 1985. The vessel traded primarily between Murmansk and Dudinka on the Yenisey River. The results of the voyage data are presented in Appendix B. The date, time and place of departure are given together with the arrival point, voyage distance, elapsed voyage time and percentage of open water on the voyage. These data were used to calculate average speed for voyages in 100% open water. This provided an initial check of the data. Unreasonably high or negative speeds pointed to possible

errors in the data. These were traced back to the original source and corrected as appropriate.

The first stage of the analysis of these data was to determine the overall average and maximum of the open water speeds. The average speed was 11.2 knots and the maximum speed 14.1 knots. These speeds are lower than the service speed of 15.2 knots quoted for the vessel. Some of the open water speeds are quite low and may include waiting time for an escort icebreaker to arrive. Such an example is Voyage Segment # 38 of Appendix B which has an average speed of 2.4 knots in 100 % open water. The next voyage segment, # 39, is with escort by the Icebreaker Arctica from Kara Gate to Beliy, so it is very likely that the Susanin waited at Kara Gate for the icebreaker before proceeding.

The next stage of the analysis was to calculate average speed for voyages completely in ice (0% open water). This is straightforward to calculate, and simply the distance traveled divided by the elapsed time. For a number of voyages, however, transit was through a mixture of open water and ice, with a percentage for the open water portion given. In order to determine the average speed through the ice portion, the distance traveled through the ice portion and the time taken are needed. The distance traveled through ice in a Voyage Segment can be easily determined from the information given (percentage of voyage segment in open water). The time taken to traverse the in-ice portion is not given but it can be determined knowing the elapsed time for the Voyage Segment and time to traverse the open water portion. To calculate the time in the open water portion an average speed for the open water portion has to be determined. As discussed above, the average of all open water Voyage Segments was 11.2 knots, but this value is distorted by some unreasonably low speeds. Consequently, an average open water speed for each voyage from Murmansk was calculated and used in determining the transit time in the open water portion of a Voyage Segment. Note that these speeds would be termed "operating gross ice velocity" using the terminology of Brovin et al (1995).

Information on the ice conditions encountered by the Ivan Susanin is presented in Appendix C. The Voyage Segment Numbers correspond between Appendices B and C. Ice conditions were determined from ice charts and on-board observations from the ship. Ice regimes, as described using WMO terminology, are presented in Appendix C. Ice age (thickness), partial concentration, floe size, degree of ridging and degree of fracture are provided for each voyage segment. In some voyages, where two or more ice regimes were encountered, the relative percentage length of each is presented. To explain the information in Appendix C an example is helpful. Consider Voyage Segment # 15 below:

Total concentration	%	fast ice	age	Partial concentration	floe size
	50		5/1	8/1-2	5
10	30		4/1	9/1	4
	20		1	9	

The total ice concentration is 10 tenths. 50% of the voyage length was through grey-white ice (WMO code 5) and new ice (1), partial concentration of 8 tenths grey-white and 1-2 tenths new ice, of vast floes (5). 30% was through grey ice (4) and new ice (1), partial concentration 9 tenths grey and 1 tenth new, of medium floes (4). 20% was new ice (1), partial concentration 9 tenths, with no floe size given. Information is also given in Appendix C on degree of ridging and fracture, expressed in fifths. For example part of Voyage Segment # 46 was through 3 fifths ridged medium and thick first-year ice. The name of the icebreaker used for escort and nature of escort are also given. For nature of escort, 1 denotes following in track broken by icebreaker, 2 is close towing by the icebreaker and 3 is icebreaking around the ship.

4.2   Navigation experience for Murmansk Shipping Company ships during 1983/84 season

Voyage data for three classes of ships operated by the Murmansk Shipping Company were available for the 1983/84 shipping season. Generally the data are from summer 1983 to spring 1984. Ships of three Russian Registry classes are in this compilation, ULA, UL and L1, in descending order of ice class. Thus there are three classes of vessels for performance evaluation, and because of the higher class of ship (ULA) the regions of operations extends across the entire Northern Sea Route. The names of the ships and their class are given in Table 6 below.

Table 6 Ships for which 1983/84 data are available

ULA	UL	L1
Arkhangelsk	Admiral Ushakov	Galya Komleva
Igarka	Alexandr Nevsky	Valay Kotik
Kandalaksha	Alexandr Suvorov	Vasya Korobko
Kola	Dmitry Pozsharsky	Yuta Bondarovskaya
Montshegorsk	Emalayn Pugachev	
Nikel	Kuzma Minin	
Norilsk	Mikhail Kutusov	
Tiksi	Stepan Rasin	
	Yuri Dolgoruky	
	Kapitan Chukhchin	
	Kapitan Tsirul	

The results of the voyage data are presented in Appendix D. In a similar manner to that explained for the Ivan Susanin (Section 4.1), average speed in open water and through ice were calculated for each voyage segment. It will be noted that for some voyage segments through 100 % open water average speeds have not been calculated since accurate estimates of the distance between the way points were not available. As was done in the previous section, checks on average speed were made to verify the basic data. In almost all cases of unrealistic speeds it was possible to have the source data

checked and problems resolved. There are, however, a few cases where the discrepancies could not be resolved.

Information on the ice conditions encountered by the MSC ships is presented in Appendix E. The data presentation format is identical to that of Appendix C. The only difference is that second year and multi-year ice are encountered by some of the ULA class ships.

4.3   Damage Events

In the almost 700 voyage segments reported here, there were less than 20 segments to which damage was attributed. These are summarized in Appendix F. More details of the damage are given in Timofeev et al (1997). In the majority of these cases damage could be described as minor, not affecting the safety of the ship. In two instances there was significant denting of the bow. Essentially this record of Russian navigation experience can be characterized as without damage. This has implications on how these data will be subsequently used in the next section of the report.

5. Method for Application of AIRSS to Operations

As was pointed out in Chapter 2, the Canadian Arctic Ice Regime Shipping System relates ice conditions to ship capability and provides an indication in terms of entry into an ice regime. This is done through a quantification of the ice regime using the WMO egg code and a system of Ice Multipliers to calculate an Ice Numeral that determines whether the ship should advance into that ice regime. In adapting the ice regime system to operations it has been decided to start from the same basis of the WMO ice code to quantify the ice conditions, but to use different ice multipliers and terminology. As was pointed out in Section 4.3, there were virtually no significant damage events in the Russian navigation data. Therefore, as a starting point for setting ice multipliers, the following assumptions will be made
- ice multipliers will always be taken to be positive
- ice multiplier for open water will be the same for all classes or types of ships
- the minimum ice multiplier for the most severe ice for each class or type of ship will be zero
- the most severe ice for each class or type of ship will increase in thickness as the ice capability of the vessel increases
- the ice multiplier will vary with ice thickness
- regardless of the ship class, the same magnitude of ice numeral should reflect a similar level of risk and difficulty for that speed

In addition to the ice multipliers discussed above, adjustment for ice decay, ridging and floe size will be applied. Decay is accounted for by adding 1 to each of the ice multipliers for medium and thick first year sea ice, and second year and multi-year ice. In this study it is assumed that during the months of June through September ice is decayed. Ridging is accounted for by subtracting 1 from the multiplier of each ice type for which the proportion of

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ridging is 2 fifths or more, and provided the total ice concentration is greater than 6 tenths. The influence of floe size is taken into account by adding 1 to each ice type for which the floe size is 20 m or less, that is WMO floe size codes 1 or 2. The effect of an icebreaker breaking a channel is accounted for by considering the floe size in the broken channel to be less than 20 m. The result of this operation is the determination of a **Transit Numeral, TN**, which is defined by the following equation

$$TN = (C_a \times (TM_a + D - R + F)) + (C_b \times (TM_b + D - R + F)) + \ldots \quad (2)$$

where , C_n is the concentration (in tenths) of ice type "n", TM_n is the Transit Multiplier for that ice type and ship category, D is the adjustment for decay, R is the adjustment for ridging, and F is the adjustment for floe size. A higher Transit Numeral would be expected to be associated with a higher speed, and a lower Transit Numeral with a lower speed. A set of Ice Multipliers has been established for the three classes of Russian Registry ships for which ice transit data are available. The multipliers are given in Table 7 below.

Table 7 Transit Multipliers for determination of Transit Numeral for Russian Registry ships

Ice Type and Thickness, m			L1	UL	ULA
MY	7*, 9*	>3	--	--	0
SY	8*	>2	--	--	2.0
TFY	4*	>1.2	--	0	3.6
MFY	1*	0.7 – 1.2	0	2.3	4.2
THFY	7	0.3 – 0.7	3.2	4.0	4.7
GW	5	0.15 – 0.3	4.4	4.7	4.9
G	4	0.1 – 0.15	5	5	5
New	1	0 – 0.1	5	5	5
OW		--	5	5	5

The multipliers range from 5 for open water to 0 for ice in which it is expected a ship of that type would just be able to move continuously under full power. The decrease in ice multiplier with increasing ice thickness is taken to be proportional to ice resistance. Ice resistance is assumed proportional to ice thickness raised to the 1.5 power. All the ice information to calculate a Transit Numeral can be obtained from an ice chart on which ice regimes are designated with a WMO egg code.

The application of these multipliers for a particular ice regime will result in a Transit Numeral for a particular type of ship. For a given Transit Numeral, it is proposed that there is an average transit speed which, if exceeded, would result in an elevated risk of damage. Additionally there is a range of speeds that represent what ships actually realize in practice. These concepts are notionally illustrated in Figure 6. The Ice Passport and QAD system, already discussed, represent approaches to calculating these speeds from first principles. In this work speeds are suggested by empirical data. In the following two sections, the empirical approach using Transit Multipliers to

determine Transit Numerals will be tested against navigation data from the Russian Arctic.

6. Application of AIRSS to Ivan Susanin data for several seasons

The four seasons of ice navigation experience with the Ivan Susanin provide a number of opportunities for analysis of the results. The Ivan Susanin is classified as UL under the Russian Registry of ships. While the ASPPR does not have equivalencies, the Susanin is probably closest to a Type A. The navigation experience of the Susanin will be examined both in terms of safety of navigation for given ice conditions and expected transit speed using the modified AIRSS described in Section 5.

The first stage of the analysis is to treat the Susanin as a Type A ship. Allowance was made for decayed ice in the months of June, July, August and September and ridging as called for in AIRSS (see Section 2 for details on application). The results of this analysis are plotted in Figure 7. Voyage segment numbers are printed next to the data points and one may refer to Appendices B and C for voyage information and ice conditions for each voyage segment. Segments for which there was icebreaker escort are designated with an "IB", following the voyage segment number. In cases where there was any "damage", actually mild denting, for the Susanin (see Appendix E). two asterisks "* *" bracket the segment number. All together there were 70 voyage segments in which ice was encountered. It can be seen that three of the "damage" events were for positive Ice Numerals, and two of those were while under icebreaker escort. There was a total of 59 voyage segments with a positive Ice Numeral. Of the 11 voyage segments with negative Ice Numerals, "damage" occurred in 4. The numbers are small, but about 1 in 3 voyage segments involved damage when the Ice Numeral was negative, compared to 1 out of 20 segments when the numeral was positive. A negative Ice Numeral is a significant indicator of an increased risk of damage.

Using the methodology described in Section 5, Transit Numerals were calculated for the Susanin navigation experience. The results are presented in Figure 8. Average transit speeds for "damage", icebreaker escort and no escort voyage segments are indicated as for Figure 7. The Transit Numerals include the effects of decay, ridging and floe size. The influence of icebreaker escort is taken into account by assuming that the icebreaker reduces the floe size to the range 2 to 20 m, WMO floe size category 2. Referring to Figure 8, it can be seen that there is no clear trend of speed as a function of Transit Numeral. A simple analysis of all the data indicates a mean transit speed of 6 kn with a standard deviation of 2.5 kn. Transit speed of voyage segments with icebreaker escort seems to be particularly independent of Transit Numeral. In Figure 9 the data are plotted again with the icebreaker escorted segments removed. Now there is a much clearer trend of decreasing transit speed with decreasing Transit Numeral.

Another approach to the analysis is to examine transit speed as a function of month of the year in which that voyage segment commenced, see Figure 10. There is considerable scatter in the data, but it can be seen that there is a general trend of decreasing speed from January through to May, and then roughly constant from June through November. Filtering out the escorted voyages, Figure 11, makes the trends a bit clearer. Trend lines of average speed are indicted on Figure 11.

7. Application to different vessels in one season

For the 1983/84 shipping season, data from over 700 voyage segments for three Russian Registry classes are available for analysis. These voyage segments cover a large part of the Russian Arctic, with some voyages traversing the entire Northern Sea Route. As discussed before, there are no direct equivalencies between the Russian Registry classes and ASPPR, however as a starting point ULA will be treated as CAC4, UL as Type A and L1 as Type B. The ice navigation experience or these three classes will each be examined in turn.

7.1   ULA Vessels

All the ULA vessels have been grouped and treated as CAC4 class vessels under the ASPPR classification system. The Ice Numerals for these vessels were determined for each ice regime and are plotted in Figure 12. Analysed as CAC4, no negative Ice Numerals are determined for ULA vessels for the ice they transited during the 1983/84 season. Note that there was one reported incident of damage on a ULA vessel. The "Montshegorsk", on Voyage Segment No. 364 from Sop. Karga to Dudinka on February 26 suffered a 150-mm deep dent on the bow. The vessel was travelling through medium first year (MFY) fast ice (Ice Numeral 20) and at an average speed of just under 8 kn. Such ice would not normally be expected to cause significant denting. Reviewing the ice conditions data in Appendix E indicates that some of the voyage segments on the Northern Sea Route did encounter old and multi-year ice; however, the Ice Numerals calculated were always positive and no damage was reported from voyages in these ice conditions.

The next stage of the analysis was to calculate the Transit Numerals for the ULA vessels using the Transit Multipliers from Table 7. The results of transit speed versus Transit Numeral are plotted in Figure 13. It is possible to estimate an upper envelope curve of maximum anticipated average transit speed as a function of Transit Numeral. Transit speed is taken to increase uniformly with Transit Numeral up to 13 kn at a TN of 40 and then remain constant. For Transit Numerals between 35 and 55 the mean transit speed is 8 kn with a standard deviation of 2 kn. Thus the upper envelope speed is equivalent to the mean plus 2 ½ standard deviations. Note that these data include voyages to Dudinka as well as 4 voyages across the Northern Sea Route. For comparison the voyages across the Northern Sea Route have been separated out and plotted in Figure 14. For the Northern Sea Route section the mean transit speed is 7.5 kn, a slight decrease from the overall

mean. Transit speed can also be examined in terms of seasonal variation. The results of such an analysis are presented in Figure 15, however no clear trend emerges. As separate examination of just the Northern Sea route data did not produce any clearly defined trends.

7.2 UL Vessels

The UL vessels have been grouped and treated as Type A vessels under the ASPPR classification system. The Ice Numerals for these vessels were calculated and are plotted versus speed in Figure 16. This group of vessels traveled over the same routes as the "Ivan Susanin", that is to Dudinka. The time interval of the voyages was from mid-August 1983 to mid-July 1984. Analysed as Type A, only one negative Ice Numeral was determined for UL vessels for the ice transited during the 1983/84 season. This was Voyage Segment 417 of the "Kuzma Minin" from Kara Gate to Beliy on November 7 and 8. There was one reported incident of damage on a UL vessel. A damage event of a 200 mm deep dent on the bow of the "Kapitan Chukhchin", on Voyage Segment 541 from Sop. Karga to Dudinka on November 30 was reported. The vessel was traveling with icebreaker escort, but no information on ice conditions was given in Appendix E.

Transit Numerals for the UL vessels were calculated using the Transit Multipliers from Table 7. The results of transit speed versus Transit Numeral are plotted in Figure 17. These results are similar to Figure 8 for the Susanin, which is also a UL vessel. No clear trend of decreasing transit velocity with decreasing Transit Numeral is apparent. For Transit Numerals from 35 to 55 mean transit speed is 9 kn with a standard deviation of 2.5 kn. This speed is higher than the value of 6 kn for the "Ivan Susanin" over the period 1981 to 1985. For a closer comparison, Susanin data for 1983/84 was examined; however the mean transit speed for this period was 6.5 kn. Transit speeds were examined in terms of seasonal variation. The results of such an analysis are presented in Figure 18; however no clear trend emerged.

7.3 L1 Vessels

The L1 vessels have been grouped and treated as Type B vessels under the ASPPR classification system. The Ice Numerals for these vessels were calculated and are plotted versus speed in Figure 19. This group of vessels, while operating out of Murmansk, traveled as far east as 150° E longitude. The period in which they encountered ice was July to October 1983. Analysed as Type B, only two negative Ice Numerals were determined for L1 vessels for the ice transited during the summer and fall of 1983. This was Voyage Segments 123 and 125 of the "Galya Komleva" from Murmansk to Kara Gate and to Beliy to Dikson July 16 to 21. There was no damage on L1 vessels, but 8 instances of minor denting. These are indicated with double asterisks "* *" in Figure 19, where it can be seen that the all denting was at an Ice Numeral of 20. In a few instances denting has been attributed to voyages in open water, so all these data are questionable.

Transit Numerals for the L1 vessels were calculated using the Transit Multipliers from Table 7. The results of transit speed versus Transit Numeral are plotted in Figure 20. In this case a trend of increasing transit velocity with increasing Transit Numeral is apparent. For Transit Numerals from 35 to 50 mean transit speed is 7.2 kn with a standard deviation of 3.4 kn. The trend line indicated in this figure increases linearly to 10.6 kn (mean speed plus one standard deviation) at a Transit Numeral of 40, and then remains constant. This trend line represents an upper limit of likely average transit speed for an L1 vessel in the ice conditions described by the Transit Numerals. Transit speed as a function of season is presented in Figure 21. There is too much scatter in the data to define any sort of a trend in transit speed with season for L1 vessels.

8. Discussion

Information on ice conditions, ship capability and operational skill are the three factors which combine to provide for safe and economical navigation in ice. The analysis and prediction of ship capability in the sense of structural strength and powering is perhaps the most technically advanced of the three factors. It is now possible to deliver processed satellite images in near real time to ships. Experienced Masters are able to put this information to good use. However, the quantification of ice conditions and their relation to ship safety and performance is still an area of active research. Ice conditions vary both spatially and temporally, and, while quantifiable in one respect (thickness, strength, floe size, ridging, etc.) are difficult to quantify in a manner which relates them to ice navigation in an integrated manner. Currently there is a comprehensive research project underway on defining "ice state" (Tuhkuri et al, 1997). The future will undoubtedly bring improved characterizations of ice conditions. Finally, operational skill is the least quantified factor and yet the most important.

At a more pragmatic and empirical level, the AIRSS addresses safety of ice navigation by integrating ice conditions and ship capability into an Ice Numeral using the WMO egg code quantification of ice conditions. The Russian ice navigation data has been used to test the AIRSS in relation to damage. An assumed equivalence of ULA to CAC4, UL to Type A and L1 to Type B was used. For the "Ivan Susanin", while "damage" was restricted to minor denting, a negative Ice Numeral was a significant indicator of a higher risk of damage. Examination of the three Russian Registry vessel classes showed only one damage event (150 mm dent in bow) for the ULA vessels, but all of the almost 200 voyage segments had positive Ice Numerals. For this group of UL vessels there was one damage event (200-mm dent in bow); however this damage may be due to the presence of an icebreaker rather than ice. There were 90 voyage segments in ice, but only one with a negative Ice Numeral. For the L1 vessels there were eight denting events and two negative Ice Numerals in 21 voyage segments in ice; however there was no correlation between damage and negative Ice Numerals.

The modification of the AIRSS to generate Transit Numerals as an indicator of average transit speed produced mean and upper limit average transit speeds that could be realized in actual practice in the Russian Arctic. It had been anticipated that there would be a more definitive relation between average transit speed and Transit Numeral. While not presented in the report, numerous variations of Transit Multipliers and corrections for decay, ridging and floe size were tried, however none produced clearer results. It appears that uncertainty in defining the ice conditions and actual transit speeds in ice preclude trying to refine the analysis any further at this time. In certain cases it is known that vessels stopped, perhaps to wait for icebreaker escort or for other reasons, resulting in low average transit speeds. There is no way at this time to filter out questionable average speeds. The average transit speed results should be treated as "operating gross ice velocity" as defined by Brovin et al (1995). As such they are a true indication of transit speed which are likely to be realized in actual operations. In the case of ULA and L1 vessels a speed dependency on Transit Numeral could be set. What can be drawn from the transit speed analysis is a value of mean and standard deviation of transit speed for various vessels. This is presented in Table 8 below.

Table 8 Mean and standard deviation of transit speed

Vessel	Season/Area	Mean Speed	Standard Deviation	Number of Samples
		kn	kn	
Ivan Susanin	All seasons	5.9	2.4	70
"	1981-82	5.9	3.2	20
"	1982-83	4.8	2.6	12
"	1983-84	6.5	1.7	17
'	1984-85	6.7	1.7	11
ULA	83-84/overall	8.0	2.1	197
"	83-81/NSR	7.6	2.6	39
UL	83-84	9.3	2.5	93
L1	83-84	7.2	3.4	17

These values can generally be used to predict expected average transit speed provided ice conditions are characterized by a Transit Numeral greater than about 35 as calculated with the Transit Multipliers given in Table 7.

Both Ice Numerals and Transit Numerals are calculated from ice conditions quantified by the WMO egg code. With some variations, ice information is available in this format for the Northern Sea Route area. Earlier work by Jones et al, 1995 used Russian ice information in this format to evaluate the class of vessels that would be required to safely transit various sections of the Northern Sea Route in different years.
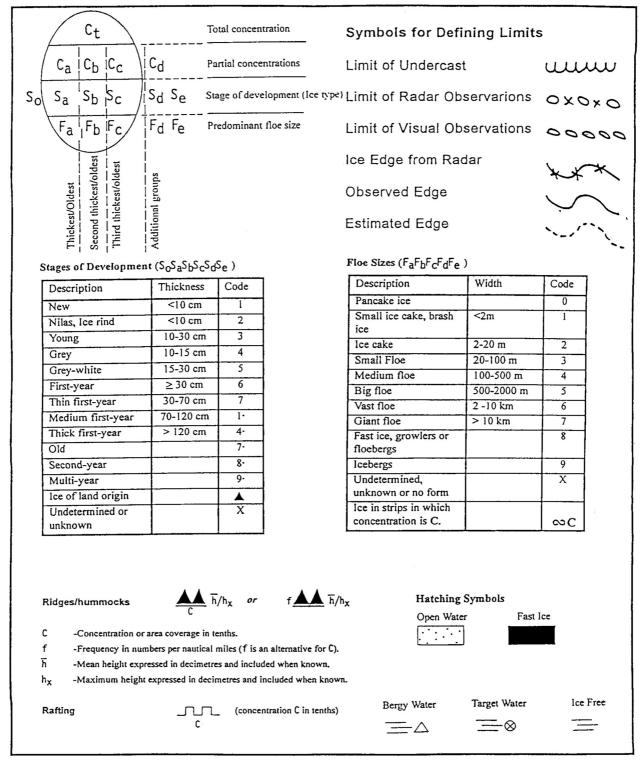
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9. Conclusions

- AIRSS Ice Numerals are a useful indicator of risk of damage for ships using the Northern Sea Route.
- Modification of the AIRSS to generate Transit Numerals provides a means for predicting average transit speeds which particular classes of vessels will realize under actual operating conditions along the Northern Sea Route provided the Transit Numeral is greater than 35
- Data quality do not permit any further refinement of a proportional dependence of transit speed on magnitude of the Transit Numeral.
- WMO egg code definition of ice conditions, in the absence of any other accepted means, is the best method for classifying ice regimes from the perspective of safety and efficacy of ice navigation.

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Tuhkuri, J., Lensu, M., Riska, K. Sandven, S., Thorkildsen, F. Haapala, J., Leppäranta, M., Doble, M., Aksenov, Y., Wadhams, P. and Erlingsson, B., 1998, Local Ice Cover Deformation and Mesoscale Ice Dynamics "Ice State", Proceedings of Third European Marine Science and Technology Conference, Vol. I, The European Commission, DG XII, pp. 315-328.

Sea Ice Symbols - The 'Egg' Code

Total concentration — C_t

Partial concentrations — C_a C_b C_c C_d

Stage of development (Ice type) — S_o S_a S_b S_c S_d S_e

Predominant floe size — F_a F_b F_c F_d F_e

Thickest/Oldest | Second thickest/oldest | Third thickest/oldest | Additional groups

Symbols for Defining Limits

Limit of Undercast

Limit of Radar Observarions

Limit of Visual Observations

Ice Edge from Radar

Observed Edge

Estimated Edge

Stages of Development ($S_o S_a S_b S_c S_d S_e$)

Description	Thickness	Code
New	<10 cm	1
Nilas, Ice rind	<10 cm	2
Young	10-30 cm	3
Grey	10-15 cm	4
Grey-white	15-30 cm	5
First-year	≥ 30 cm	6
Thin first-year	30-70 cm	7
Medium first-year	70-120 cm	1·
Thick first-year	> 120 cm	4·
Old		7·
Second-year		8·
Multi-year		9·
Ice of land origin		▲
Undetermined or unknown		X

Floe Sizes ($F_a F_b F_c F_d F_e$)

Description	Width	Code
Pancake ice		0
Small ice cake, brash ice	<2m	1
Ice cake	2-20 m	2
Small Floe	20-100 m	3
Medium floe	100-500 m	4
Big floe	500-2000 m	5
Vast floe	2 -10 km	6
Giant floe	> 10 km	7
Fast ice, growlers or floebergs		8
Icebergs		9
Undetermined, unknown or no form		X
Ice in strips in which concentration is C.		∞C

Ridges/hummocks — ▲▲ $\bar{h}/h_x$ (C) or f ▲▲ $\bar{h}/h_x$

C -Concentration or area coverage in tenths.

f -Frequency in numbers per nautical miles (f is an alternative for C).

$\bar{h}$ -Mean height expressed in decimetres and included when known.

h_x -Maximum height expressed in decimetres and included when known.

Rafting — ⊓⊔⊓ (C) (concentration C in tenths)

Hatching Symbols

Open Water   Fast Ice

Bergy Water — △   Target Water — ⊗   Ice Free

Note: For more information, the Canadian Ice Service publication MANICE should be consulted.

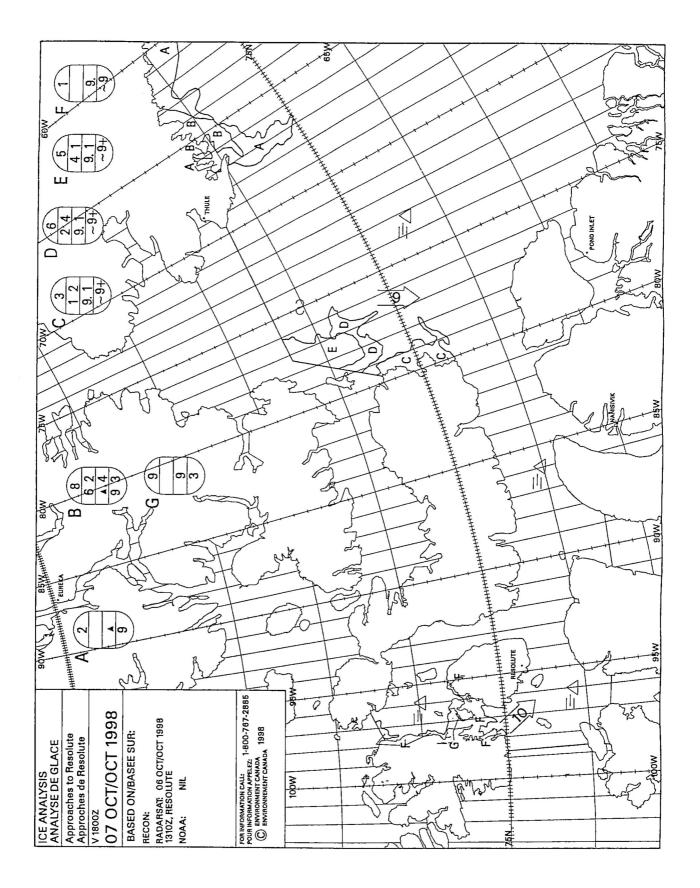Figure 1   Explanation of WMO ice classification terminology

Figure 2   Example of an ice chart prepared by the Canadian Ice Service
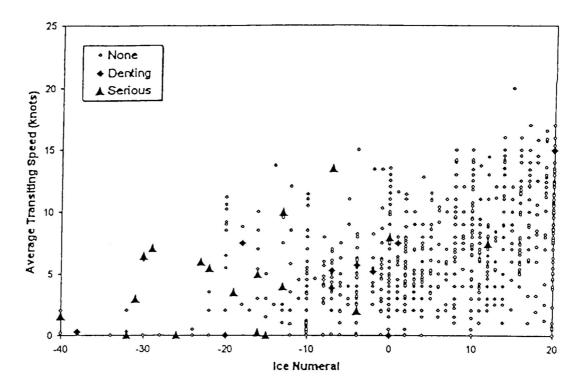
Figure 3 Severity of damage as a function of the average speed of vessel compared to Ice Numeral for that ice regime (after Timco and Morin, 1998)
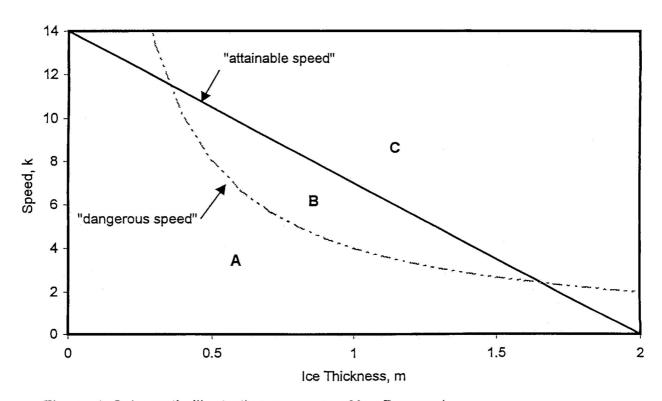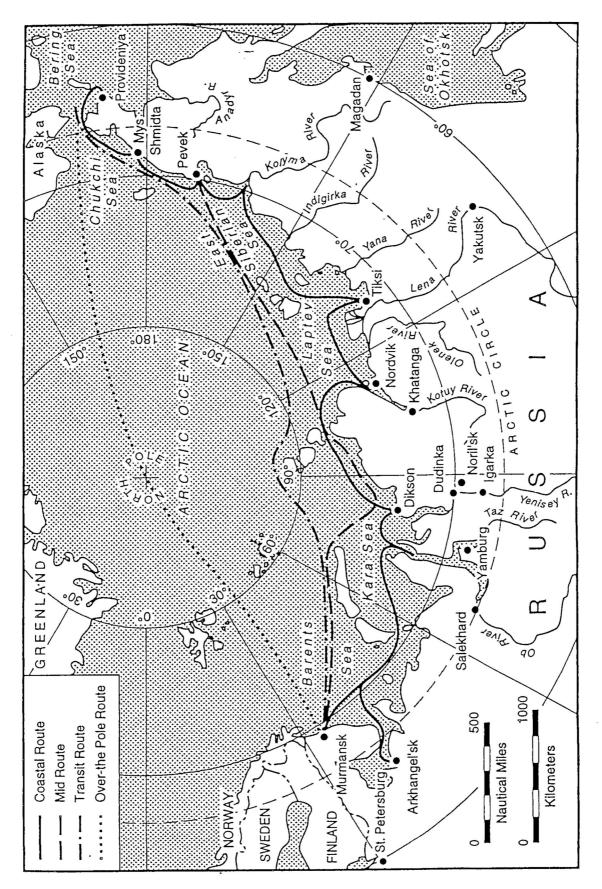

Figure 4 Schematic illustrating concepts of Ice Passport

Figure 5   Northern Sea Route showing major ports of call (after Mulherin et al., 1994)
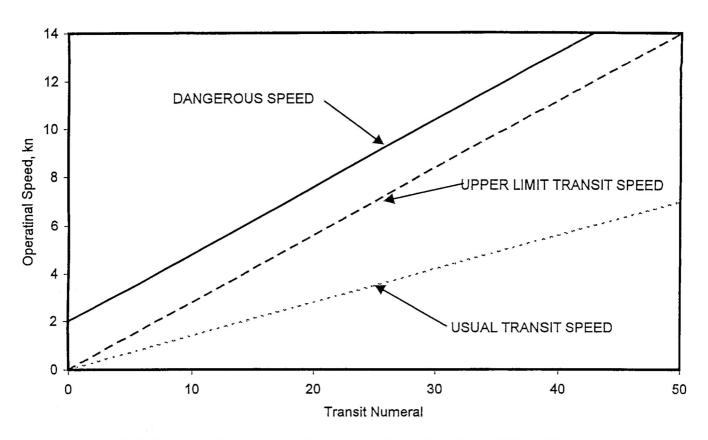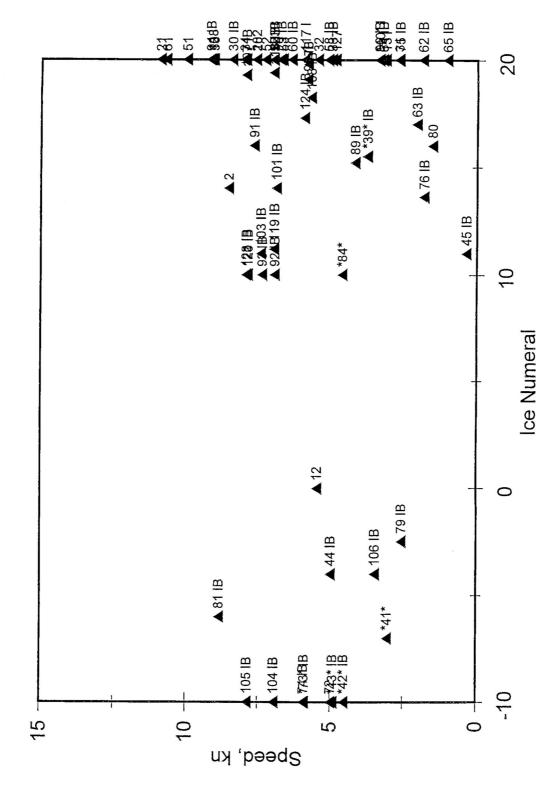
Figure 6 Notional guide of operational speed as a function of Transit
Numeral

Figure 7   Average vessel speed of the Ivan Susanin for the years 1981-1985 as a function of AIRSS Ice Numeral
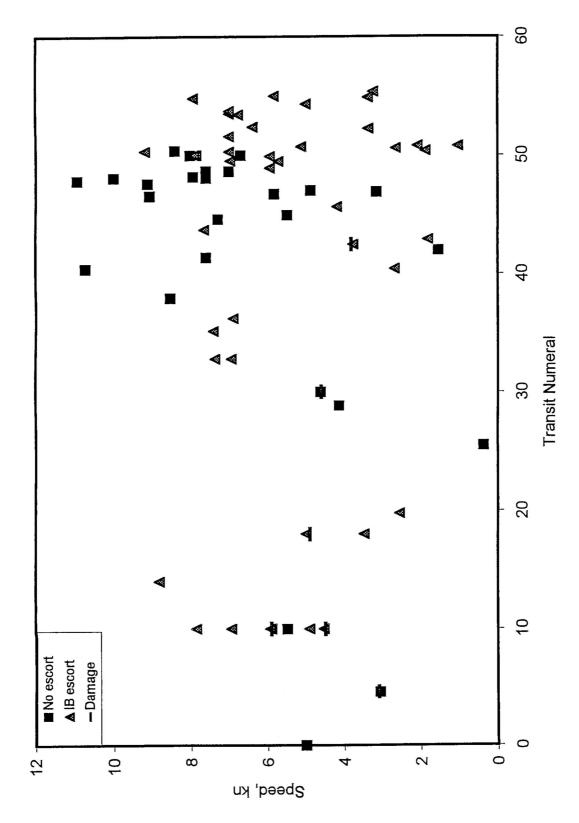
Figure 8 Transit speed of the Ivan Susanin as a function of Transit Numeral for years 1981-85
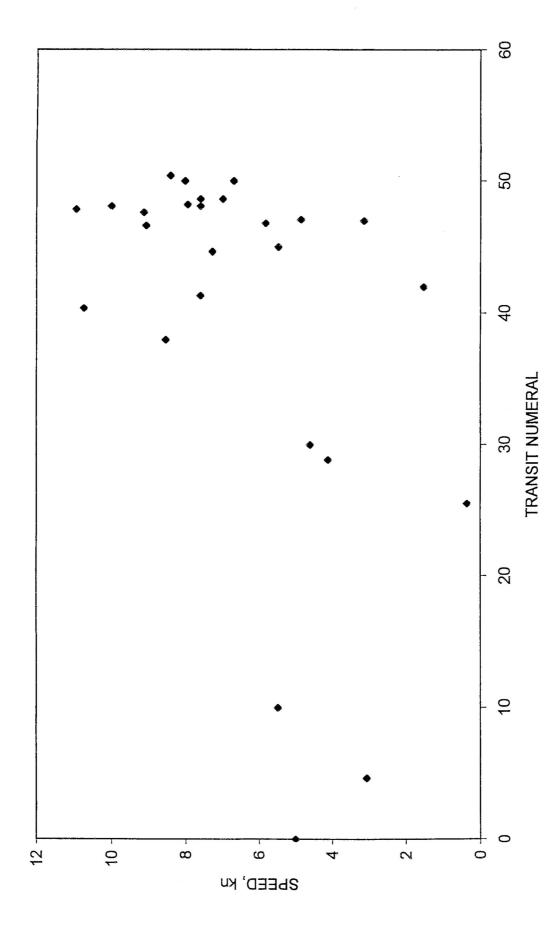
Figure 9 Transit speed of the Ivan Susanin for the years 1981/85 as a function of the Transit Numeral, escorted voyage segments removed
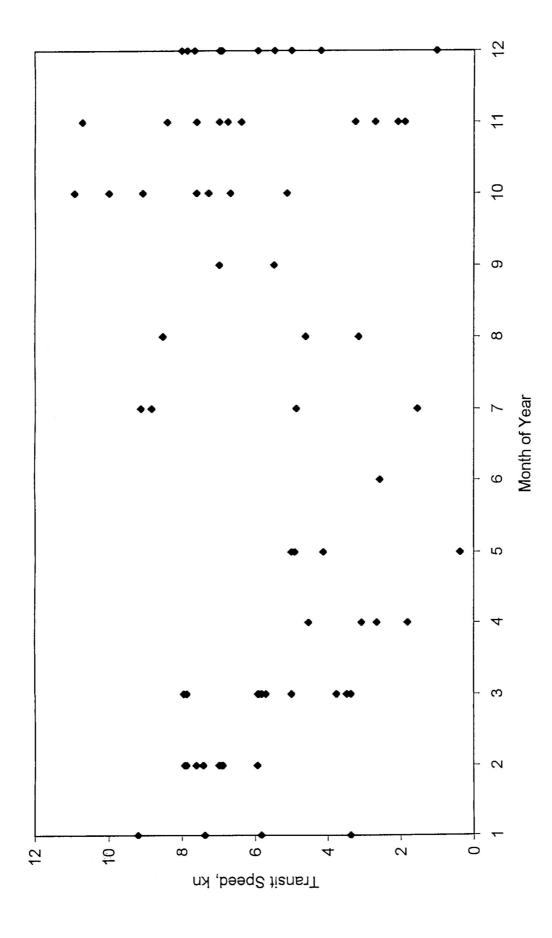
Figure 10 Seasonal variation of Transit Speed for Ivan Susanin
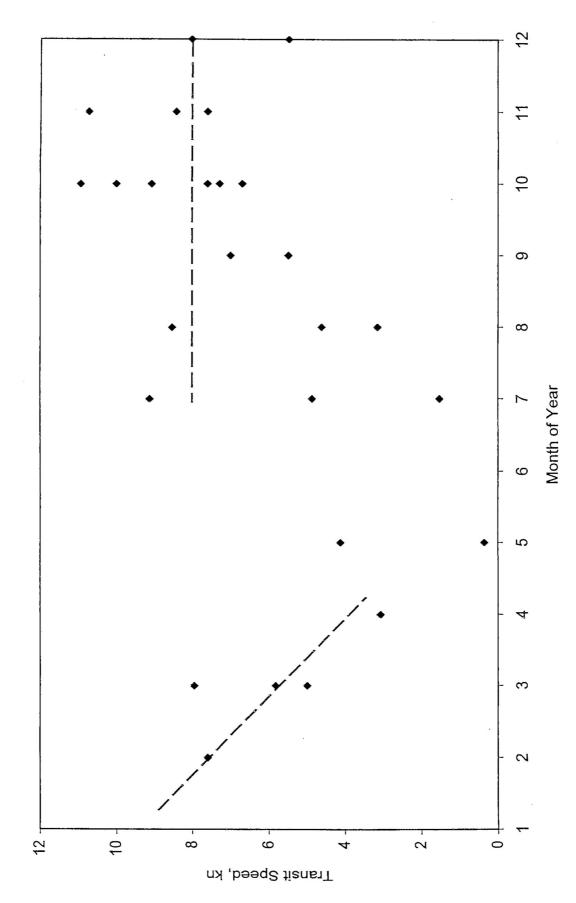
Figure 11   Seasonal variation of Transit Speed for Ivan Susanin, escorted voyage segments removed
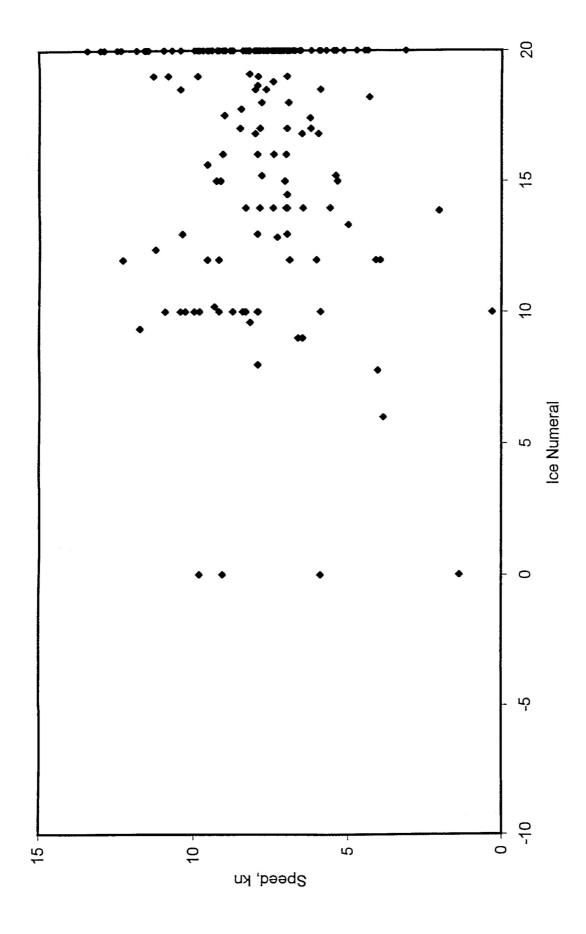
Figure 12   Ice numerals for ULA vessels evaluated as CAC4

Figure 13   Transit Numerals as a function of transit speed for ULA vessels

Figure 14 Transit Numerals as a function of transit speed for ULA vessels on Northern Sea Route

Figure 15   Seasonal variation of speeds of ULA vessels

Figure 16   Ice Numerals for UL vessels evaluated as Type A

Figure 17 Transit Numerals as a functin of speed for UL vessels
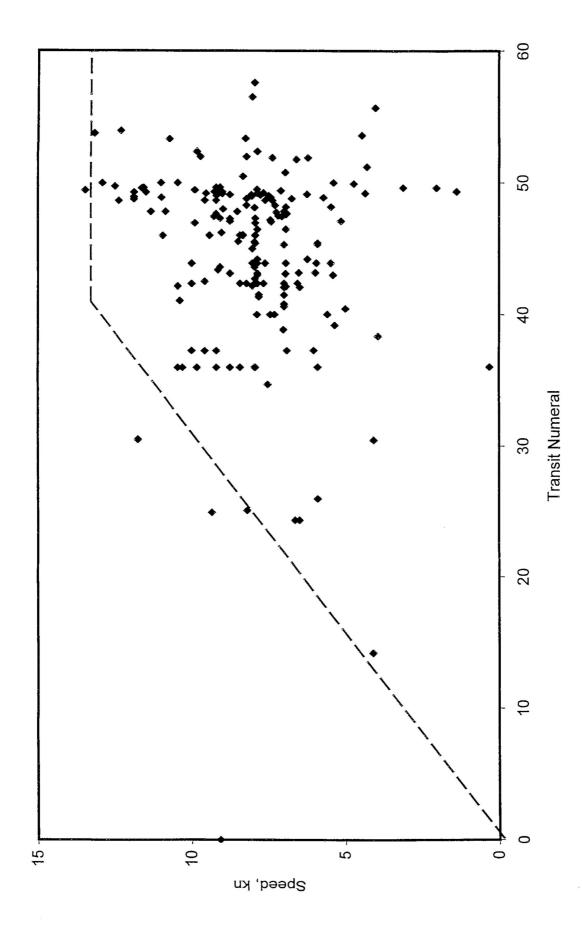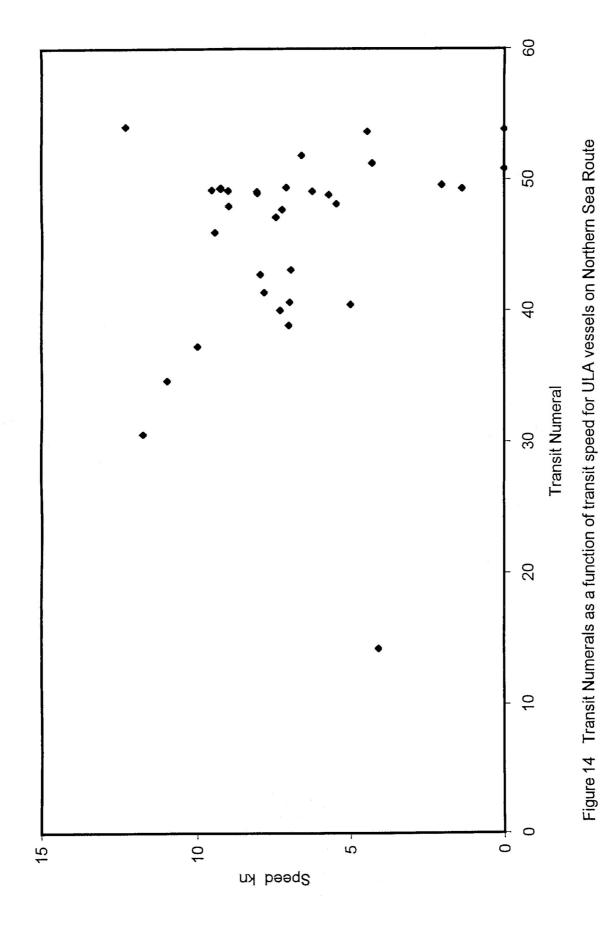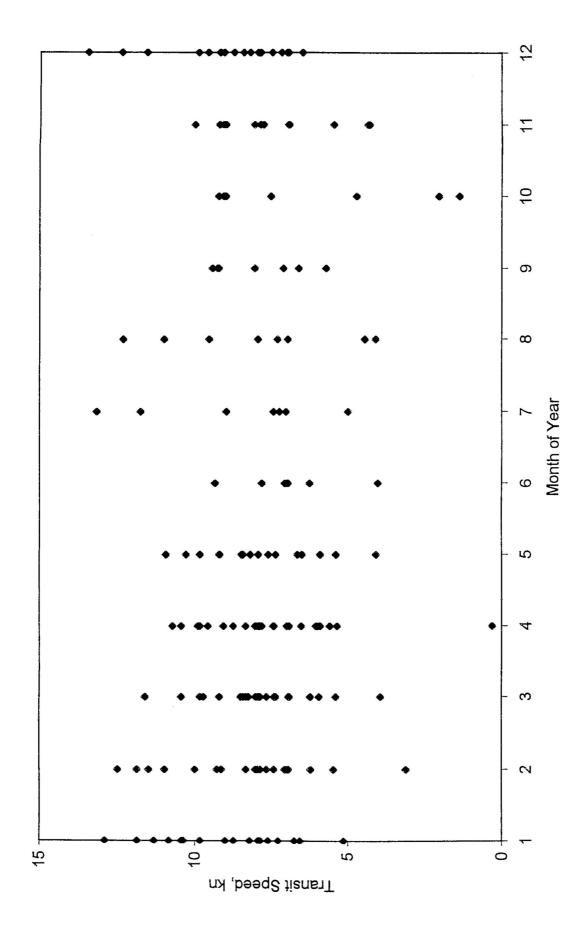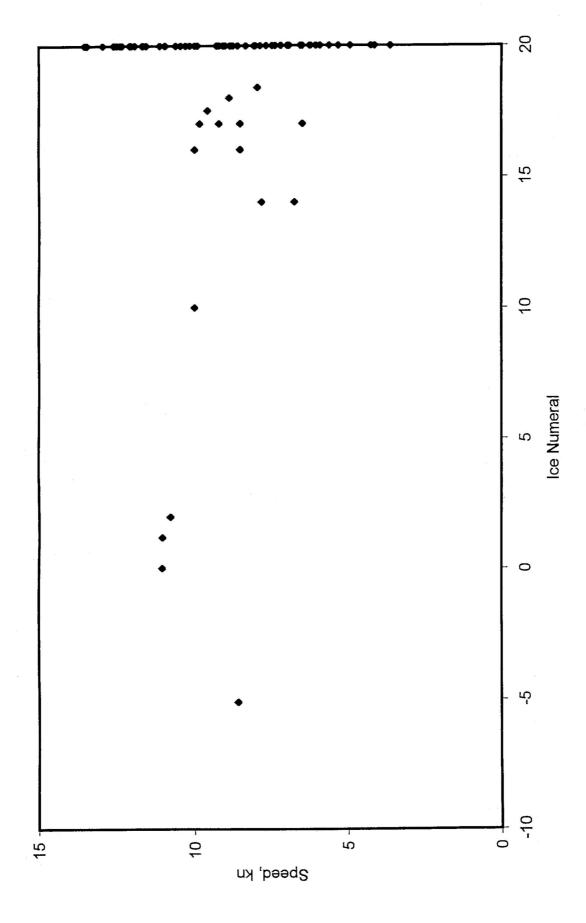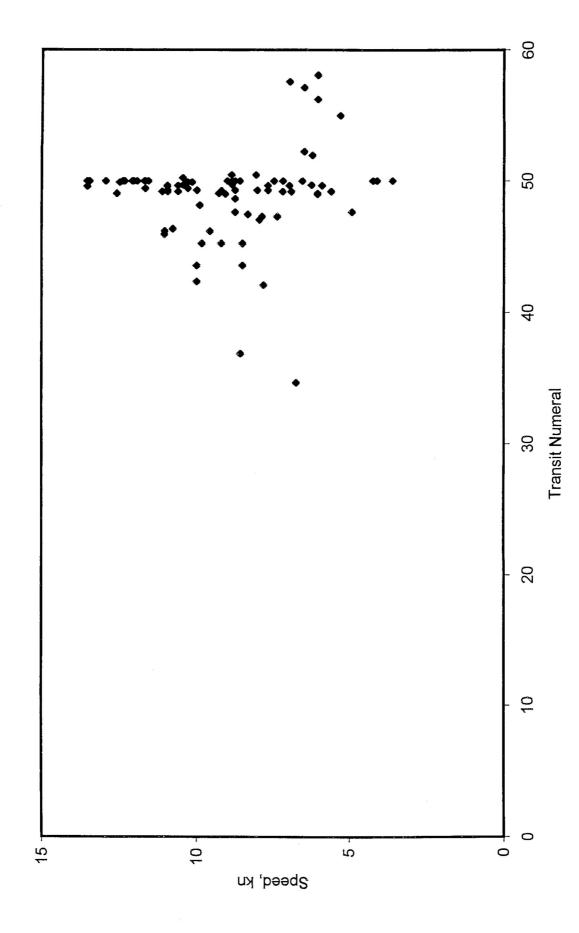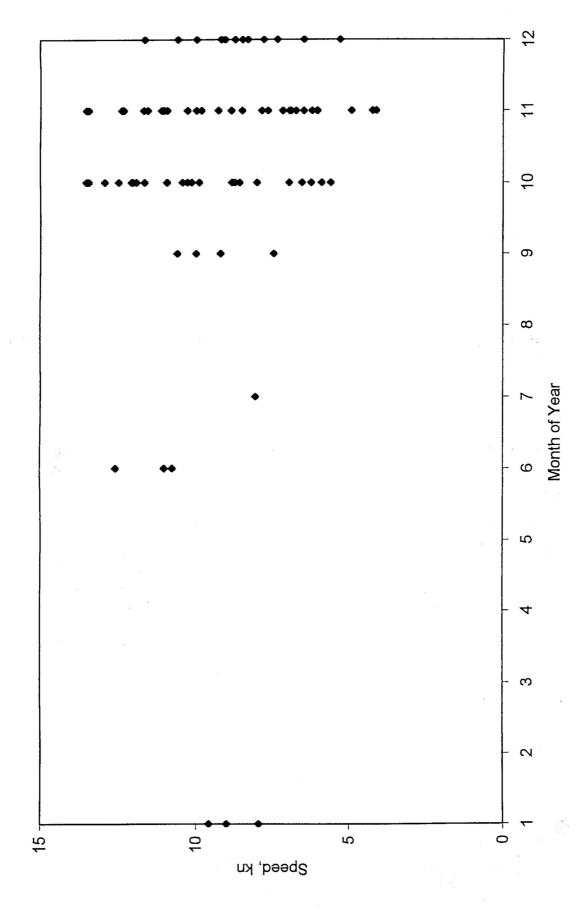
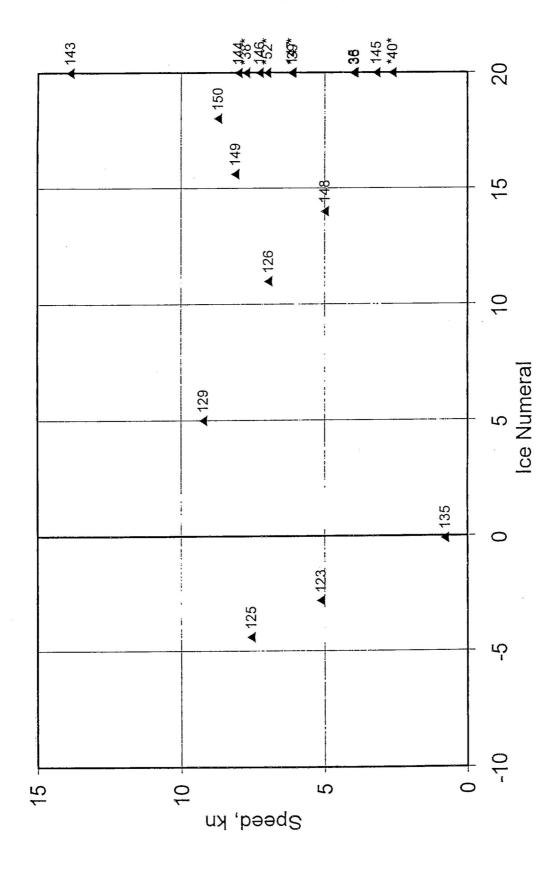Figure 18 Seasonal variation of speed for UL vessels

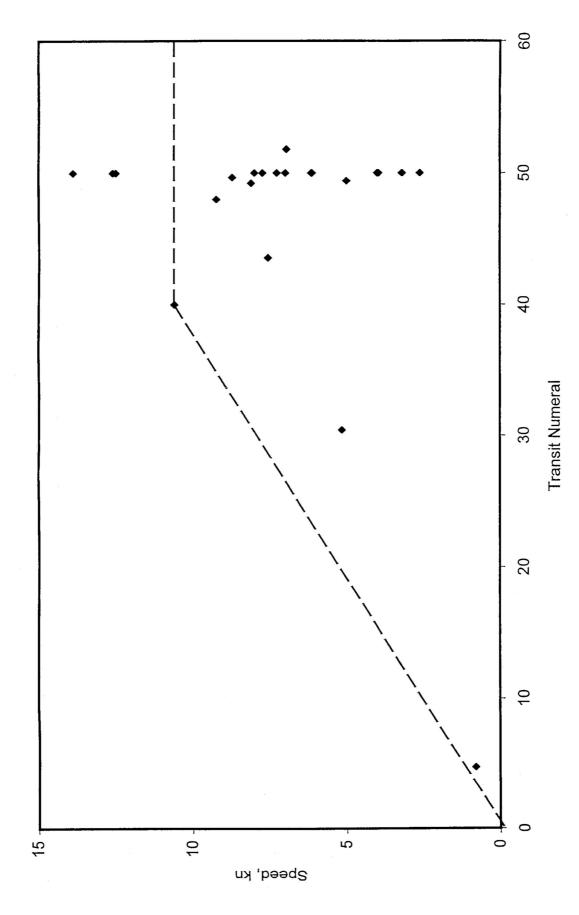Figure 19   Ice Numerals for L1 vessels evaluated as Type B

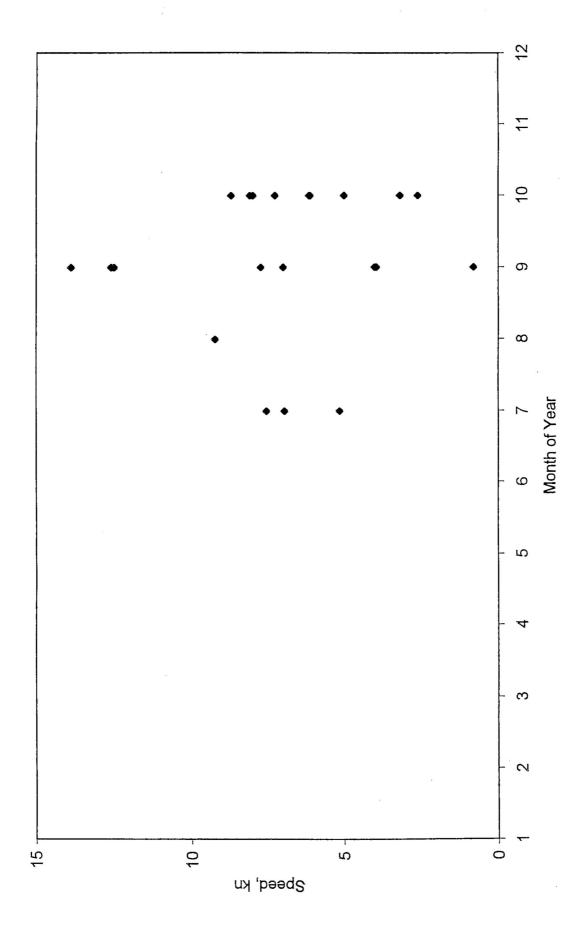Figure 20 Transit Numerals as a functin of speed for L1 vessels

Figure 21 Seasonal variation of speed for L1 vessels

Appendix A Ports of call of Ivan Susanin and other Murmansk Shipping Company vessels

Port	Latitud deg N	Longitud deg E	Port	Latitude deg N	Longitude deg E
a) Ivan Susanin			b) Murmansk Shipping Co. ships		
Arkhangelsk	40.50	64.50	175 w.l.	missing	175 wl
Beliy	74.00	71.00	Agvikanot	66.20	179.15 wl
Dikson	74.50	80.50	Amderma	69.50	61.45
Dudinka	69.50	87.00	Arkhangelsk	64.40	40.35
Kandalaksha	67.50	32.00	b.Provideniy	64.40	176.30 wl
Kara Gate	70.25	58.00	Balv.Nos	70.20	59.00
m. of Beliy S	66.50	42.50	Beliy	73.00	70.00
Murmansk	69.60	32.50	Bering strait	66.00	169.30 wl
Noviy Port	67.75	73.00	Dikson	73.15	80.30
Sop. Karga	82.50	70.50	Drovyanaya	72.00	72.50
Tambey	71.25	71.50	Gremiha	68.00	39.30
			Inkentiev's st	69.25	84.00
			isl. Zohova	76.00	153.00
			Kandalaksha	67.25	32.20
			Kara Gate	70.25	57.30
			Kharasavei	70.52	66.35
			Khatanga	72.00	102.25
			Kolguev	69.00	49.00
			Kosistyi	73.35	109.50
			Laptev strait	72.45	142.00
			Longa strait	70.30	180.00
			m. of Beliy S	66.40	41.40
			Medvezy isl.	70.55	160.40
			Morrasale	69.52	66.40
			Murmansk	69.00	33.10
			Novosibirsk i	75.00	140.00
			Novy Port	67.50	72.50
			Oleny	74.40	85.30
			p.s. Kisilyak	73.10	140.00
			p.s. Knengur	missing	missing
			p.s. Kotelny	76.00	137.40
			p.s. Stolbovo	64	136
			p/p4040	71.30	72.00
			Peter Kamc	missing	missing
			Pevek	69.40	170.15
			prom. Shmid	68.55	179.00 wl
			Sannikov str	74.30	141.00
			Sop. Karga	70.30	83.00
			Tambei	71.45	71.6
			Tiksi	71.40	128.30
			Tukhard	missing	missing
			Ugorsky Sha	69.45	60.30
			Umba	66.40	34.15
			Vilkitski Isl.	75.40	152.50
			Vilkitski strai	78.00	103.30
			Zemlya Boo	76.10	142.00

Appendix B Voyage Data of Ivan Susanin for period 1981 to 1985

Voyage Segment No.	Departure				Departure Point	Arrival Point	egme Distnc n-mi	lapse Time hr	% OW	Speed		
	Year	Month	Day	Time hr						OW kn	avg. kn	in ice kn
1	81	7	31	23	Murmans	Kara Gat	567	43	100	13.2		
2		8	2	18	Kara Gat	Beliy	297	30	40		9.9	8.5
3		8	4	24	Beliy	Noviy Po	420	30	100	14.0		
4		8	7	12	Noviy Po	Dudinka	837	60	100	14.0		
5		8	14	6	Dudinka	Beliy	525	40	100	13.1		
6		8	15	22	Beliy	Murman	864	65	100	13.3		
7		8	21	10	Murmans	Dudinka	1389	100	100	13.9		
8		8	25	20	Dudinka	Murman	1389	147	100	9.4		
9		9	4	9	Murmans	Dudinka	1389	118	100	11.8		
10		9	13	22	Dudinka	Murman	1389	108	100	12.9		
11		9	21	6	Murmans	Beliy	864	65	100	13.3		
12		9	24	0	Beliy	Dikson	175	19	70		9.2	5.5
13		9	24	19	Dikson	Dudinka	350	30		11.7		
14		9	28	10	Dudinka	Dikson	350	25		14.0		
15		9	29	11	Dikson	Beliy	175	25	0		7.0	7.0
16		9	30	12	Beliy	Murman	864	88	100	9.8		
17		10	5	6	Murmans	Beliy	864	66	100	13.1		
18		10	8	1	Beliy	Dikson	175	23	0		7.6	7.6
19		10	8	24	Dikson	Dudinka	350	26		13.5		
20		10	14	6	Dudinka	Dikson	350	26		13.5		
21		10	15	8	Dikson	Beliy	175	16	0		10.9	10.9
22		10	16	0	Beliy	Kara Gat	297	31		9.6		
23		10	17	7	Kara Gat	Murman	567	41	100	13.8		
24		10	21	12	Murmans	Kandala	540	42	100	12.9		
25		10	27	10	Kandalak	m. of Bel	430	57		7.5		
26		10	29	19	m. of Bel	Kara Gat	380	27	100	14.1		
27		10	30	22	Kara Gat	Beliy	297	27		11.0		
28		11	1	1	Beliy	Dikson	175	23	0		7.6	7.6
29		11	2	0	Dikson	Sop. Kar	230	34	0		6.8	6.8
30		11	3	10	Sop. Kar	Dudinka	118	14	0		8.4	8.4
31		11	30	10	Dudinka	Sop. Kar	118	44	0		2.7	2.7
32		12	1	6	Sop. Kar	Dikson	230	42	0		5.5	5.5
33		12	3	0	Dikson	Beliy	175	35	0		5.0	5.0
34		12	4	11	Beliy	Kara Gat	297	37	0		8.0	8.0
35		12	5	24	Kara Gat	Murman	567	46	100	12.3		
36	82	2	8	13	Murmans	Kandala	540	45		12.0		
37		2	23	6	Kandalak	m. of Bel	430	52		8.3		
38		2	26	10	m. of Bel	Kara Gat	380	158	100	2.4		
39		3	2	23	Kara Gat	Beliy	297	79	0		3.8	3.8
40		3	6	6	Beliy	Dikson	175	52	0		3.4	3.4
41		4	1	1	Dikson	Sop. Kar	230	75	0		3.1	3.1
42		4	5	23	Sop. Kar	Dudinka	118	26	0		4.5	4.5
43		5	5	10	Dudinka	Sop. Kar	118	24	0		4.9	4.9
44		5	6	10	Sop. Kar	Dikson	230	46	0		5.0	5.0
45		5	9	6	Dikson	Beliy	175	60	90		2.9	0.4
46		5	12	0	Beliy	Kara Gat	297	72	0		4.1	
47		5	14	24	Kara Gat	Murman	567	73	100	7.8		

#					From	To	Dist	Num	Pct			
48		9	21	14	Murmans	Noviy Po	1284	104	100	12.3		
49		10	5	8	Noviy Po	Dudinka	837	66	100	12.7		
50		10	10	12	Dudinka	Sop. Kar	118	13	0		9.1	9.1
51		10	11	1	Sop. Kar	Dikson	230	23	0		10.0	10.0
52		10	12	0	Dikson	Beliy	175	24	0		7.3	7.3
53		10	13	0	Beliy	Kara Gat	297	25	90		11.9	6.7
54		10	14	1	Kara Gat	Murman	567	47	100	12.1		
55		10	20	6	Murmans	Kandala	540	41	100	13.2		
56		10	27	23	Kandalak	m. of Bel	430	34	100	12.6		
57		10	29	9	m. of Bel	Kara Gat	380	53	100	7.2		
58		10	31	14	Kara Gat	Beliy	297	58	0		5.1	5.1
59		11	3	0	Beliy	Dikson	175	25	0		7.0	7.0
60		11	4	1	Dikson	Sop. Kar	230	36	0		6.4	6.4
61		11	5	13	Sop. Kar	Dudinka	118	11	0		10.7	10.7
62		11	11	10	Dudinka	Sop. Kar	118	63	0		1.9	1.9
63		11	15	15	Sop. Kar	Dikson	230	111	0		2.1	2.1
64		11	28	12	Dikson	Beliy	175	54	0		3.2	3.2
65		12	1	20	Beliy	Kara Gat	297	291	0		1.0	1.0
66		12	14	23	Kara Gat	Murman	567	59	100	9.6		
67	83	2	20	11	Murmans	Kandala	540	80		6.8		
68		2	26	6	Kandalak	m. of Bel	430	42		10.2		
69		2	27	24	m. of Bel	Kara Gat	380	98	100	3.9		
70		3	1	2	Kara Gat	Beliy	297	51	0		5.8	5.8
71		3	6	6	Beliy	Dikson	175	22	0		8.0	8.0
72		3	7	4	Dikson	Sop. Kar	230	46	0		5.0	5.0
73		3	10	14	Sop. Kar	Dudinka	118	20	0		5.9	5.9
74		3	29	4	Dudinka	Dikson	350	59	0		5.9	5.9
75		4	2	17	Dikson	Beliy	175	66	0		2.7	2.7
76		4	8	22	Beliy	Kara Gat	297	164	0		1.8	1.8
77		4	16	10	Kara Gat	Murman	567	47	100	12.1		
78		6	25	9	Murmans	Kara Gat	567	44	100	12.9		
79		6	27	5	Kara Gat	Beliy	297	116	0		2.6	2.6
80		7	1	1	Beliy	Tambey	224	43	80		5.2	1.5
81		7	2	24	Tambey	Noviy Po	230	26	0		8.8	8.8
82		7	25	14	Noviy Po	Dudinka	837	76	100	11.0		
83		7	30	6	Dudinka	Beliy	525	42	100	12.5		
84		8	1	4	Beliy	Kara Gat	297	27	90		11.0	4.6
85		8	2	7	Kara Gat	Murman	567	52	100	10.9		
86		12	8	16	Murmans	Arkhang	437	80		5.5		
87		12	16	5	Arkhang	m. of Bel	270	34		7.9		
88		12	17	15	m. of Bel	Kara Gat	380	34	100	11.2		
89		12	19	1	Kara Gat	Beliy	297	71	0		4.2	4.2
90		12	22	0	Beliy	Dikson	175	25	0		7.0	7.0
91		12	23	1	Dikson	Sop. Kar	230	30	0		7.7	7.7
92		12	24	7	Sop. Kar	Dudinka	118	17	0		6.9	6.9
93	84	1	11	8	Dudinka	Sop. Kar	118	16	0		7.4	7.4
94		1	11	24	Sop. Kar	Dikson	230	25	0		9.2	9.2
95		1	13	1	Dikson	Beliy	175	30	0		5.8	5.8
96		1	14	7	Beliy	Kara Gat	297	88	0		3.4	3.4
97		1	17	23	Kara Gat	Murman	567	47	100	12.1		

98		1	22	14	Murmans	Kandala	540	73		7.4		
99		2	9	17	Kandalak	Murman	540	69		7.8		
100		2	12	12	Murmans	Kara Gat	567	47	100	12.1		
101		2	14	11	Kara Gat	Beliy	297	37	30		8.0	6.9
102		2	18	1	Beliy	Dikson	175	23	0		7.6	7.6
103		2	19	0	Dikson	Sop. Kar	230	31	0		7.4	7.4
104		2	20	7	Sop. Kar	Dudinka	118	17	0		6.9	6.9
105		3	12	20	Dudinka	Sop. Kar	118	15	0		7.9	7.9
106		3	13	11	Sop. Kar	Dikson	230	66	0		3.5	3.5
107		3	16	5	Dikson	Beliy	175	22	0		8.0	8.0
108		3	17	3	Beliy	Kara Gat	297	52	0		5.7	5.7
109		3	19	7	Kara Gat	m. of Bel	380	29	100	13.1		
110		3	20	12	m. of Bel	Arkhang	270	34		7.9		
111		3	28	10	Arkhang	Murman	437	52		8.4		
112		8	24	6	Murmans	Kandala	540	42	100	12.9		
113		8	31	12	Kandalak	Dudinka	1632	131	100	12.5		
114		9	24	23	Dudinka	Murman	1389	125	100	11.1		
115		12	15	23	Kandalak	Murman	540	61				
116		12	21	0	Murmans	Kara Gat	567	44	100	12.9		
117		12	22	20	Kara Gat	Beliy	297	50	0		5.9	5.9
118		12	24	22	Beliy	Dikson	175	25	0		7.0	7.0
119		12	25	23	Dikson	Sop. Kar	230	33	0		7.0	7.0
120		12	27	8	Sop. Kar	Dudinka	118	15	0		7.9	7.9
121	85	2	1	11	Dudinka	Sop. Kar	118	15	0		7.9	7.9
122		2	2	2	Sop. Kar	Dikson	230	29	0		7.9	7.9
123		2	3	7	Dikson	Beliy	175	25	0		7.0	7.0
124		2	8	8	Beliy	Kara Gat	297	50	0		5.9	5.9
125		2	10	10	Kara Gat	Murman	567	63	100	9.0		
126		7	4	12	Murmans	Kara Gat	567	44	100	12.9		
127		7	6	8	Kara Gat	Beliy	297	61	0		4.9	4.9
128		7	9	0	Beliy	Noviy Po	420	46	0		9.1	9.1
129		7	27	10	Noviy Po	Dudinka	837	69	100	12.1		
130		7	31	23	Dudinka	Beliy	525	38	100	13.8		
131		8	2	13	Beliy	Kara Gat	297	30	90		9.9	3.1
132		8	3	19	Kara Gat	Murman	567	47	100	12.1		
133		9	1	10	Murmans	Dudinka	1389	107	100	13.0		
134		9	10	9	Dudinka	Murman	1389	134	100	10.4		
135		9	16	12	Murmans	Dudinka	1389	109	100	12.7		
136		9	23	9	Dudinka	Murman	1389	111	100	12.5		

# voyage	% of open water	Ice condition description								Icebreaker name	Nature of escort
		total concen tration	% ice cover	fast ic	age	concentr ation	floe size	ridging degree	fracture degree		
1	100										
2	40	3	60		4*	3	3				
3	100										
4	100										
5	100										
6	100										
7	100										
8	100										
9	100										
10	100										
11	100										
12	70	9-10	30		4*	9-10					
13											
14											
15		10	50		5/1	8/1-2	5				
			30		4/1	9/1	4				
			20		1	9					
16	100										
17	100										
18		9	50		5/1	8/1-2	5				
			30		4/1	9/1	4				
			20		1	9					
19											
20											
21		10	70		5/1	9/1	5				
			30		4/1	8/2	5				
22											
23	100										
24	100										
25											
26	100										
27											
28		10	30		4/1	8/2	5				
			70		5/4	8/2	5				
29		10	50		5	10	4			Kapitan Dranitsin	1
			25		4	10	4				
			25		7	10	4				
30				thin							
31				thin						Kapitan Sorokin	1
32		10	40		4	10	5				
			60		7/5	8/2	4/3				
33		10	70		5/4	9/1	4/3			Leningrad	2
			30		7/4	8/2	5/3				
34		9	50		1	9	4				
			50		1	4					
35	100										
36											

37											
38	100										
39		10	50		7/4	9/1	5/4			Arctica	1
			50		1*/7	9/1	5/3				
40		10	70		7/4	9/1	5/3			Sibir	2
			30		5	10	4				
41		10	10		5	10	4				
			90	thick							
42				thick						Kapitan Sorokin	1
43				thick						Kapitan Sorokin	1
44		10	20		1	10				Kapitan Sorokin	1
			80	thick						Sibir	1
45	90	9-10	10		1*	9	5				
46		10	40		1*	2-3	3				
			20		4*/1*	7/3	5/4				
			20		1*	3	4				
			20		1*/4*	7/2-3	5/3	3			
47	100										
48	100										
49	100										
50				grey-white							
51		10	70		5/4	8/2	5/4				
			30		1	10					
52			100		5/4	4/5	5/4	0-1			
53	90	2	10		1	2					
54	100										
55	100										
56	100										
57	100										
58		10	20		7/5	7/3	4/3			Kiev	1
			60		4/1	8/2	5				
			20		5/4	2/8	4/5				
59		10	90		4/1	8/2	5			Kiev	1
			10		7/5	6/4	4/3				
60		10	50		5/4	7/3	4/3			Kapitan Dranitsin	1, 2
			35		4/1	7/3	4/3				
			15	thin							
61				thin							
62				thin						Kapitan Nikolaev	1, 2
63		10	70		5/4	8/2	5/4			Kapitan Nikolaev	1, 2
			30	thin				1-2			
64		10	100		5/4	8/2	5/4			Arctica	1
65		10	80		4/1	8/2	5			Arctica	1
			20		5/4	6/4	4/4				
66	100										
67											
68											
69	100										
70		10	20		1*/7/5	1/7/2	3/5/4				
			40		5/1	9/1	4				
			40		1	10	4				
71		10	80		4	10	4				
			20		7/5	9/1	5/3				
72				thick							
73				thick						Norilsk	3
74				thick						Kapitan Sorokin	1

75		10	40		4	10	4			Sibir	1
			60		7/5	9/1	5/3			Sibir	1
76		10	40		7	10	5				
			30		1*/7	8/2	5/4	3			
			30		7/5	6/4	4/3				
77	100										
78	100										
79		9	50		4*	9	5,4	2-3	1-2	Sibir	1
			50		1*	9-10	5,4	2	1-2		
80	80	2	20		4*	1-2	3				
81		10	70		4*	10	5	1	3	Kapitan Dranitsin	1
			30	thick				1-2	2-3		
82	100										
83	100										
84	90	5	10		4*	5	4,3				
85	100										
86											
87											
88	100										
89		10	60		7/5	8/2	5/4	1-2		Lenin	1
			20		7/5/4	3/5/2	4/5/3	1			
			20		4	10	4				
90		10	50		7/5	9/1	5/3			Lenin	1
			50		5/1	9/1	3				
91		10	60		7/5	9/1	5/3			Kapitan Sorokin	1
			40	edium							
92			medium							Kapitan Sorokin	2
93			medium							Kapitan Dranitsin	1
94		8	20		1	8				Kapitan Dranitsin	1
			80	thin							
95		10	10		7/5	2/8	4/5			Lenin	1
			10		7/5	9/1	5/3	1-2			
			80		5	10	5				
96		10	20		7/4	9/1	4/3			Lenin	1
			80		5/4	9/1	5/3				
97	100										
98											
99											
100	100										
101	30	10	25		7/4	9/1	5/3			Sibir	1
			25		5/4	7/3	5/3				
			20		1	8	3				
102			100		7/4	9/1	5/3			Arctica	1
103		10	10		5	10	5			Kapitan Dranitsin	1
			90	edium							
104			medium							Kapintan Nikolaev	1
105			thick							Kapitan Dranitsin	2
106		10	20		4	10	4			Kapitan Dranitsin	1
			80	thick							
107		10	90		5	10	4			Sibir	1
			10		1*/7/4	7/2/1	5/4/3				
108		10	50		1	10				Sibir	1
			25		7/4	7/3	5/3	1-2			
			25		5/4	7/3	5/4				
109	100										

110											
111											
112	100										
113	100										
114	100										
115											
116	100										
117		10	40		5/4	8/2	5/3	1-2		Arctica	1
			60		7/5	8/2	5/3				
118		10	70		5	10	4			Arctica	1
			30		1*/7	2/8	3/5				
119		10	15		1*/7	2/8	3/5			Kapitan Nikolaev	1
			85	edium							
120			medium							Kapitan Nikolaev	1
121			medium							Kapitan Dranitsin	1
122			medium							Kapitan Nikolaev	1
123		10	10		5	10	4			Arctica	1
			90		7/5	9/1	5/3				
			35		5/4	7/3	5/3			Arctica	1
124		10	30		7/5	9/1	5/3	1-2			
			35		4/1	7/3	5				
125	100										
126	100										
127		9	20		5	9	5,4	3	3-4		
			80		5	2	3				
128		7	100		5	7	4,3		4		
129	100										
130	100										
131	90	9	10		5	9	4,3				
132	100										
133	100										
134	100										
135	100										
136	100										

Voyage #	Yea 19	ont	day	Tim hr	Departure point	ont	day	Time	Arrival. point	n-mi	elapsed time hr
Mikhail Kutusov UL											
1	83	9	25	9	Kandalaksha	9	30	6	Dudinka	1632	117
2		10	15	9	Dudinka	10	15	19	Sop. Karga	118	10
3		10	15	19	Sop. Karga	10	16	20	Dikson	230	25
4		10	16	20	Dikson	10	17	11	Beliy	175	15
5		10	17	11	Beliy	10	18	10	Kara Gate	297	23
6		10	18	10	Kara Gate	10	20	21	Murmansk	567	59
7		10	30	8	Kandalaksha	11	1	12	Kara Gate	810	52
8		11	1	12	Kara Gate	11	2	12	Beliy	297	24
9		11	2	12	Beliy	11	3	4	Dikson	175	16
10		11	3	4	Dikson	11	4	10	Sop. Karga	230	30
11		11	4	10	Sop. Karga	11	6	8	Dudinka	118	46
12		12	6	7	Dudinka	12	7	0	Sop. Karga	118	17
13		12	7	0	Sop. Karga	12	8	13	Dikson	230	37
14		12	8	13	Dikson	12	9	16	Beliy	175	27
15		12	9	16	Beliy	12	11	24	Kara Gate	297	56
16		12	11	24	Kara Gate	12	13	14	Murmansk	567	38
Dmitry Pozsharsky UL											
17	83	11	7	8	Murmansk	11	8	22	Kara Gate	567	38
18		11	8	22	Kara Gate	11	10	14	Beliy	297	40
19		11	11	4	Beliy	11	12	9	Dikson	175	29
20		11	12	9	Dikson	11	14	21	Dudinka	418	60
21		11	19	7	Dudinka	11	19	22	Sop. Karga	118	15
22		11	19	22	Sop. Karga	11	21	6	Dikson	230	32
23		11	21	7	Dikson	11	22	10	Beliy	175	27
24		11	24	15	Beliy	11	26	14	Kara Gate	297	47
25		11	26	14	Kara Gate	11	28	12	Murmansk	567	46
Vasya Korobko L1											
26	83	7	19	22	p/p4040	7	23	0	Amderma		74
27		7	23	15	Amderma	7	25	21	Sop. Karga		54
28		8	3	23	Murmansk	8	11	6	Morrasale		175
29		8	13	23	Morrasale	8	15	10	Kharasavei		35
30		8	26	18	Kharasavei	8	28	4	Beliy		34
31		8	31	8	Beliy	9	2	2	Vilkitski isl.		42
32		9	12	0	Vilkitski isl.	9	13	20	Tambei		44
33		9	14	1	Tambei	9	14	23	Oleny		22
34		9	15	18	Oleny	9	19	1	Dikson		79
35		9	19	14	Dikson	9	22	3	Vilkitski strait		61
36		9	24	20	Vilkitski strait	9	26	7	Kosistyi		35
37		9	26	18	Kosistyi	9	27	19	Khatanga		25
38		9	30	8	Khatanga	10	2	2	Kosistyi		66
39		10	2	2	Kosistyi	10	3	9	Vilkitski strait		31
40		10	3	9	Vilkitski strait	10	5	19	Dikson		58
41		10	6	14	Dikson	10	10	8	Murmansk	1039	90
42		12	17	11	Murmansk	12	19	20	Umba		57
43		12	22	18	Umba	12	23	5	Kandalaksha		11
44		12	24	6	Kandalaksha	12	25	10	Gremiha		28
45		12	27	6	Gremiha	12	27	24	Murmansk		18
46	84	7	16	23	Kandalaksha	7	21	2	Dikson	1232	99
47		7	23	9	Dikson	7	27	5	Murmansk	1039	92

Valya Kotik L1

48	83	8	29	23	Dikson	9	2	5	Arkhangelsk	1122	78
49		9	12	10	Ugorsky Shar	9	13	0	Balv.Nos		14
50		9	13	10	Balv.Nos	9	13	22	Morrasale		12
51		9	14	20	Morrasale	9	15	6	Kharasavei		10
52		9	16	0	Kharasavei	9	16	20	Beliy		20
53		10	18	6	Dikson	10	18	21	Beliy	175	15
54		10	18	21	Beliy	10	21	1	Kolguev		52

Uta Bondarovskaya L1

55	83	9	30	21	Dikson	10	4	2	Sop. Karga	230	101

Mikhail Strekalovsky UL

56	83	9	9	6	Murmansk	9	13	22	Novy Port	1284	112
57		9	29	14	Novy Port	10	2	12	Dudinka	837	94
58		10	3	15	Dudinka	10	8	223	Murmansk	1389	328
59		10	13	10	Murmansk	10	15	12	Kandalaksha	540	50
60		10	19	12	Kandalaksha	10	24	1	Beliy	1107	109
61		10	24	1	Beliy	10	25	5	Dikson	175	28
62		10	25	5	Dikson	10	26	6	Sop. Karga	230	25
63		10	26	6	Sop. Karga	10	26	21	Dudinka	118	15
64		11	28	0	Dudjnka	11	31	5	Beliy	525	77
65		11	31	5	Beliy	12	2	10	Kara Gate	297	53
66		12	2	10	Kara Gate	12	4	17	m. of Beliy Sea	380	55
67		12	4	17	m. of Beliy Sea	12	6	23	Kandalaksha	430	54
68		12	13	0	Kandalaksha	12	15	20	Murmansk	540	68

Alexander Nevsky UL

69	83	9	6	22	Murmansk	9	12	4	Dudinka	1389	126
70		9	30	18	Dudinka	10	5	11	Murmansk	1389	137
71		10	13	9	Murmansk	10	15	7	Kara Gate	567	46
72		10	15	7	Kara Gate	10	16	6	Beliy	297	23
73		10	16	6	Beliy	10	16	20	Dikson	175	14
74		10	17	12	Dikson	10	18	14	Sop. Karga	230	26
75		10	18	14	Sop. Karga	10	19	10	Dudinka	118	20
76		10	30	9	Dudinka	10	30	24	Sop. Karga	118	15
77		10	30	24	Sop. Karga	11	1	2	Dikson	230	26
78		11	1	2	Dikson	11	1	22	Beliy	175	20
79		11	3	9	Beliy	11	4	22	Kara Gate	297	37
80		11	4	22	Kara Gate	11	6	20	Murmansk	567	46
81		11	8	12	Murmansk	11	9	23	Kara Gate	567	35
82		11	9	23	Kara Gate	11	10	22	Beliy	297	23
83		11	10	22	Beliy	11	11	20	Dikson	175	22
84		11	14	3	Dikson	11	15	17	Sop. Karga	230	38
85		11	15	17	Sop. Karga	11	16	17	Dudinka	118	24
86		11	22	0	Dudinka	11	22	10	Sop. Karga	118	10
87		11	22	10	Sop. Karga	11	23	19	Dikson	230	33
88		11	23	19	Dikson	11	25	0	Beliy	175	29
89		11	1	18	Beliy	11	3	11	Kara Gate	295	41
90		11	3	11	Kara Gate	11	5	14	Murmansk	567	51
91	84	6	21	14	Murmansk	6	23	3	Kara Gate	567	37
92		6	23	3	Kara Gate	6	24	2	Beliy	295	23
93		6	26	10	Beliy	6	27	19	Drovyanaya		33
94		6	28	15	Drovyanaya	6	30	13	Novy Port		46
95		7	11	20	Novy Port	7	14	13	Dudinka	837	65
96		1	16	14	Dudinka	1	16	24	Sop. Karga	118	10
97		1	16	24	Sop. Karga	1	17	23	Dikson	230	23
98		1	22	20	Dikson	1	23	18	Beliy	175	22
99		1	23	18	Beliy	1	25	3	Kara Gate	295	33
100		1	25	6	Kara Gate	1	27	15	Murmansk	567	57

Tiksi ULA

101	83	8	26	18	Murmansk	8	31	14	Dudinka	1389	116
102		9	30	19	Dudinka	10	4	13	Murmansk	1389	114
103		11	28	10	Murmansk	11	30	19	Kara Gate	567	57
104		11	30	19	Kara Gate	12	1	5	Beliy	297	34
105		12	1	5	Beliy	12	2	1	Dikson	175	20
106		12	2	1	Dikson	12	3	5	Sop. Karga	230	28
107		12	3	5	Sop. Karga	12	3	20	Dudinka	118	15
108		12	24	4	Dudinka	12	24	21	Sop. Karga	118	17
109		12	24	21	Sop. Karga	12	26	5	Dikson	230	32
110		12	26	5	Dikson	12	27	8	Beliy	175	27
111		12	27	9	Beliy	12	28	15	Kara Gate	297	30
112		12	28	15	Kara Gate	12	30	23	Murmansk	567	56
113	84	1	11	0	Murmansk	1	13	12	Kara Gate	567	60
114		1	13	12	Kara Gate	1	14	11	Beliy	297	23
115		1	14	11	Beliy	1	15	21	Dikson	175	34
116		1	15	21	Dikson	1	17	2	Sop. Karga	230	29
117		1	17	2	Sop. Karga	1	17	20	Dudinka	118	18
118		2	1	5	Dudinka	2	1	22	Sop. Karga	118	17
119		2	1	22	Sop. Karga	2	2	18	Dikson	230	20
120		2	2	18	Dikson	2	3	16	Beliy	175	22
121		2	3	16	Beliy	2	4	15	Kara Gate	297	23
122		2	4	15	Kara Gate	2	6	22	Murmansk	567	55

Galya Komleva L1

123	83	7	16	4	Murmansk	7	20	2	Kara Gate	567	94
124		7	20	2	Kara Gate	7	21	1	Beliy	297	23
125		7	21	1	Beliy	7	21	23	Dikson	175	22
126		7	22	10	Dikson	7	24	11	Vilkitski strait		49
127		7	26	15	Vilkitski strait	7	30	12	Tiksi		93
128		8	5	10	Tiksi	8	9	7	p.s. Kisilyakh		93
129		8	11	18	p.s. Kisilyakh	8	12	2	p.s. Stolbovoy		8
130		8	18	10	p.s. Stolbovoy	8	18	21	Sannikov strait		11
131		8	25	23	Sannikov strait	8	27	1	p.s. Knengurusa		26
132		8	31	1	p.s. Kotelny	8	31	24	p.s. Knengurusa		23
133		9	2	18	p.s. Knengurusa	9	3	17	p.s. Kotelny		23
134.		9	4	15	p.s. Kotelny	9	5	14	p.s. Knengurusa		23
135		9	5	23	p.s. Knengurusa	9	7	1	Zemlya Boonge		26
136		9	9	20	Zemlya Boonge	9	11	8	isl. Zohova		36
137		9	16	19	isl. Zohova	9	18	16	Tiksi		45
138		9	24	23	Tiksi	9	26	3	p.s. Kisilyakh		28
139		9	26	4	p.s. Kisilyakh	9	26	12	Sannikov strait		8
140		9	26	13	Sannikov strait	9	27	23	isl. Zohova		34
141		9	27	24	isl. Zohova	9	28	12	Zemlya Boonge		12
142		9	28	18	Zemlya Boonge	9	29	2	Sannikov strait		8
143		9	29	20	Sannikov strait	9	30	5	Laptev strait		9
144		10	3	13	Laptev strait	10	4	14	p.s. Knengurusa		25
145		10	5	0	p.s. Knengurusa	10	6	23	p.s. Kisilyakh		47
146		10	6	24	p.s. Kisilyakh	10	7	11	p.s. Stolbovoy		11
147		10	7	13	p.s. Stolbovoy	10	8	2	p.s. Kisilyakh		13
148		10	8	3	p.s. Kisilyakh	10	9	23	Tiksi		44
149		10	15	0	Tiksi	10	18	2	Vilkitski strait		74
150		10	18	2	Vilkitski strait	10	20	1	Dikson		47
151		10	23	1	Dikson	10	24	11	Beliy	175	34
152		10	24	11	Beliy	10	24	23	Arkhangelsk	947	12
153		10	29	23	Arkhangelsk	11	1	10	Murmansk	437	59

Kola ULA

154	83	9	17		Murmansk	9	20		Tukhard		72
155		9	20		Tukhard	9	24		Dudinka		96
156		10	16	22	Dudinka	10	17	11	Sop. Karga	118	13
157		10	17	11	Sop. Karga	10	18	12	Dikson	118	25
158		10	20	1	Dikson	10	20	14	Beliy	175	13
159		10	20	14	Beliy	10	22	23	Murmansk	864	57
160		11	6	0	Murmansk	11	7	9	Kara Gate	567	33
161		11	7	9	Kara Gate	11	8	18	Beliy	297	33
162		11	8	18	Beliy	11	9	13	Dikson	175	19
163		11	9	7	Dikson	11	10	6	Sop. Karga	230	23
164		11	10	6	Sop. Karga	11	10	18	Dudinka	118	12
165		11	30	22	Dudinka	12	1	5	Inkentiev's stvory		31
166		12	1	7	Inkentiev's stvory	12	1	15	Sop. Karga		8
167		12	1	15	Sop. Karga	12	2	17	Dikson	350	26
168		12	2	17	Dikson	12	3	18	Beliy	175	25
169		12	3	18	Beliy	12	4	17	Kara Gate	297	23
170		12	4	17	Kara Gate	12	6	18	Murmansk	567	49
171		12	11	1	Murmansk	12	13	2	Kara Gate	567	49
172		12	13	2	Kara Gate	12	14	2	Beliy	297	24
173		12	14	2	Beliy	12	14	24	Dikson	175	22
174		12	15	0	Dikson	12	16	5	Sop. Karga	230	29
175		12	16	5	Sop. Karga	12	16	20	Dudinka	118	15
176		12	18	23	Dudinka	12	19	16	Sop. Karga	118	17
177		12	19	16	Sop. Karga	12	21	0	Dikson	230	32
178		12	21	0	Dikson	12	22	1	Beliy	175	25
179		12	22	1	Beliy	12	22	24	Kara Gate	297	23
180		12	23	0	Kara Gate	12	25	20	Murmansk	567	68
181	84	1	3	1	Murmansk	1	5	3	Kara Gate	567	50
182		1	5	3	Kara Gate	1	6	23	Beliy	297	44
183		1	6	23	Beliy	1	7	19	Dikson	175	20
184		1	7	19	Dikson	1	8	23	Sop. Karga	230	28
185		1	8	23	Sop. Karga	1	9	14	Dudinka	118	15
186		1	21	4	Dudinka	1	21	19	Sop. Karga	118	15
187		1	21	19	Sop. Karga	1	22	23	Dikson	230	28
188		1	22	23	Dikson	1	23	23	Beliy	175	24
189		1	23	23	Beliy	1	24	22	Kara Gate	297	23
190		1	24	22	Kara Gate	1	26	14	Murmansk	567	40
191		2	5	2	Murmansk	2	7	16	Kara Gate	567	62
192		2	7	16	Kara Gate	2	9	5	Beliy	297	37
193		2	9	5	Beliy	2	10	3	Dikson	175	22
194		2	10	3	Dikson	2	11	2	Sop. Karga	230	23
195		2	11	2	Sop. Karga	2	11	17	Dudinka	118	15
196		2	29	3	Dudinka	2	29	18	Sop. Karga	118	15
197		2	29	18	Sop. Karga	3	1	20	Dikson	230	74
198		3	1	20	Dikson	3	2	9	Beliy	175	13
199		3	2	9	Beliy	3	3	7	Kara Gate	297	22
200		3	5	7	Kara Gate	3	8	7	Murmansk	567	72
201		3	17	10	Murmansk	3	20	20	Kara Gate	567	82
202		3	20	20	Kara Gate	3	22	9	Beliy	297	37
203		3	22	9	Beliy	3	23	6	Dikson.	175	21
204		3	23	6	Dikson	3	24	11	Sop. Karga	230	29
205		3	24	11	Sop. Karga	3	25	4	Dudinka	118	17
206		4	9	6	Dudinka	4	9	17	Sop. Karga	118	11
207		4	9	17	Sop. Karga	4	10	24	Dikson	230	31
208		4	11	0	Dikson	4	11	13	Beliy	175	13
209		4	11	19	Beliy	4	12	12	Kara Gate	297	17
210		4	12	12	Kara Gate	4	16	3	Murmansk	567	87
211		4	26	5	Murmansk	4	29	5	Kara Gate	567	72
212		4	29	5	Kara Gate	4	30	24	Beliy	297	43

213		4	31	0	Beliy	5	1	6	Dikson	175	30
214		5	1	6	Dikson	5	2	15	Sop. Karga	230	33
215		5	2	15	Sop. Karga	5	3	7	Dudinka	118	16
216		5	16	3	Dudinka	5	18	18	Dikson	350	63
217		5	18	13	Dikson	5	19	3	Beliy	175	14
218		5	19	3	Beliy	5	20	4	Kara Gate	297	25
219		5	20	4	Kara Gate	5	23	2	Murmansk	567	70
220		7	14	4	Murmansk	7	17	1	Beliy	864	69
221		7	17	1	Beliy	7	17	23	Dikson	175	22
222		7	17	22	Dikson	7	20	10	Vilkitski strait		60
223		7	20	10	Vilkitski strait	7	23	22	Tiksi		84
224		8	7	4	Tiksi	8	7	21	Sannikov strait		17
225		8	7	21	Sannikov strait	8	8	18	Medvezy isl.		21
226		8	8	18	Medvezy isl.	8	9	18	Longa strait		24
227		8	11	22	Longa strait	8	13	7	b.Provideniya		33
228		9	8	20	b.Provideniya	9	10	21	Pevek		49
229		9	13	4	Pevek	9	13	17	Medvezy isl.		13
230		9	13	17	Medvezy isl.	9	15	2	Sannikov strait		33
231		9	15	2	Sannikov strait	9	16	13	Vilkitski strait		35
232		9	16	13	Vilkitski strait	9	17	20	Dikson		31
233		9	18	19	Dikson	9	21	21	Murmansk	1039	74
Arkhangelsk											
234	83	8	10	4	Murmansk	8	13	23	Novy Port	1287	91
235		8	25	5	Novy Port	8	27	22	Dudinka	837	65
236		8	30	2	Dudinka	9	3	18	Murmansk	1387	112
237		9	17	10	Kandalaksha	9	20	18	Dikson	1282	80
238		9	20	8	Dikson	9	22	20	Vilkitski strait		60
239		9	22	20	Vilkitski strait	9	23	19	Sannikov strait		23
240		9	23	19	Sannikov strait	9	25	9	Medvezy isl.		38
241		9	25	9	Medvezy isl.	9	25	22	Pevek		13
242		10	6	7	Pevek	10	6	20	Medvezy isl.		13
243		10	6	20	Medvezy isl.	10	8	2	Sannikov strait		30
244		10	8	2	Sannikov strait	10	8	15	Vilkitski strait		13
245		10	8	15	Vilkitski strait	10	11	17	Beliy		74
246		10	20	23	Beliy	10	25	14	Arkhangelsk	947	111
247		11	9	10	Murmansk	11	12	11	Kara Gate	567	73
248		11	12	11	Kara Gate	11	14	6	Beliy	297	43
249		11	14	6	Beliy	11	15	2	Dikson	175	20
250		11	15	2	Dikson	11	15	24	Sop. Karga	230	22
251		11	16	0	Sop. Karga	11	16	17	Dudinka	118	17
252		11	30	2	Dudinka	11	30	17	Sop. Karga	118	15
253		11	30	17	Sop. Karga	12	1	22	Dikson	230	53
254		12	1	22	Dikson	12	2	12	Beliy	175	14
255		12	2	12	Beliy	12	3	11	Kara Gate	297	23
256		12	3	11	Kara Gate	12	5	20	Murmansk	567	57
257		12	17	23	Murmansk	12	20	6	Kolguev		55
258	84	1	19	5	Kolguev	1	20	20	Murmansk		39
259		1	23	10	Murmansk	1	24	22	Arkhangelsk	437	36
260		1	29	6	Arkhangelsk	1	30	8	m. of Beliy Sea	270	26
261		1	30	8	m. of Beliy Sea	1	31	16	Kara Gate	380	32
262		1	31	10	Kara Gate	2	2	1	Beliy	297	39
263		2	2	1	Beliy	2	3	2	Dikson	175	25
264		2	3	2	Dikson	2	4	8	Sop. Karga	230	30
265		2	4	8	Sop. Karga	2	4	23	Dudinka	118	15
266		2	14	6	Dudinka	2	14	23	Sop. Karga	118	17
267		2	14	23	Sop. Karga	2	16	2	Dikson	230	27
268		2	16	2	Dikson	2	16	17	Beliy	175	15
269		2	16	17	Beliy	2	17	23	Kara Gate	297	30
270		2	17	23	Kara Gate	2	19	13	m. of Beliy Sea	380	38
271		2	19	13	m. of Beliy Sea	2	22	2	Arkhangelsk	270	61

272		2	28	18	Arkhangelsk	2	29	12	Kandalaksha		18
273		3	5	10	Kandalaksha	3	6	23	m. of Beliy Sea	430	37
274		3	6	23	m. of Beliy Sea	3	9	12	Kara Gate	380	61
275		3	9	12	Kara Gate	3	11	14	Beliy	297	50
276		3	11	14	Beliy	3	12	12	Dikson	175	22
277		3	13	10	Dikson	3	14	15	Sop. Karga	230	29
278		3	14		Sop. Karga	3	15	6	Dudinka	118	30
279		4	1	1	Dudinka	4	1	21	Sop. Karga	118	20
280		4	1	21	Sop. Karga	4	3	2	Dikson	230	29
281		4	3	2	Dikson	4	3	16	Beliy	175	14
282		4	4	16	Beliy	4	5	22	Kara Gate	297	30
283		4	5	22	Kara Gate	4	7	23	Murmansk	567	49
284		4	14	10	Murmansk	4	16	4	Kandalaksha	540	42
285		4	17	2	Kandalaksha	4	20	2	m. of Beliy Sea	430	72
286		4	20	2	m. of Beliy Sea	4	22	22	Kara Gate	380	68
287		4	22	22	Kara Gate	4	24	5	Beliy	297	31
288		4	24	5	Beliy	4	25	1	Dikson	175	20
289		5	2	19	Dikson	5	3	20	Sop. Karga	230	25
290		5	3	20	Sop. Karga	5	4	10	Dudinka	118	14
291		5	21	2	Dudinka	5	21	22	Sop. Karga	118	20
292		5	21	22	Sop. Karga	5	23	3	Dikson	230	29
293		5	23	18	Dikson	5	24	8	Beliy	175	14
294		5	24	8	Beliy	5	25	7	Kara Gate	297	23
295		5	25	7	Kara Gate	5	26	12	m. of Beliy Sea	380	29
296		5	26	12	m. of Beliy Sea	5	27	18	Arkhangelsk	270	30

Norilsk ULA

297	83	12	2	2	Murmansk	12	4	1	Kara Gate	567	47
298		12	4	1	Kara Gate	12	5	7	Beliy	297	30
299		12	5	7	Beliy	12	6	8	Dikson	175	25
300		12	7	10	Dikson	12	8	11	Sop. Karga	230	25
301		12	8	11	Sop. Karga	12	9	1	Dudinka	118	14
302		12	30	4	Dudinka	12	30	19	Sop. Karga	118	15
303		12	30	19	Sop. Karga	12	31	23	Dikson	230	28
304		12	31	23	Dikson	1	1	24	Beliy	175	-8903
305		1	1	24	Beliy	1	2	21	Kara Gate	297	21
306		1	2	21	Kara Gate	1	4	14	Murmansk	567	41
307	84	3	30	10	Murmansk	4	3	19	Kara Gate	567	105
308		4	3	19	Kara Gate	4	5	9	Beliy	297	38
309		4	5	9	Beliy	4	6	14	Dikson	175	29
310		4	6	14	Dikson	5	8	3	Sop. Karga	230	781
311		5	8	3	Sop. Karga	5	8	23	Dudinka	118	20
312		5	20	1	Dudinka	5	20	21	Sop. Karga	118	20
313		5	20	21	Sop. Karga	5	22	2	Dikson	230	29
314		5	22	2	Dikson	5	22	20	Beliy	175	18
315		5	22	20	Beliy	5	23	18	Kara Gate	297	22
316		5	23	18	Kara Gate	5	27	2	Murmansk	567	80

Igarka ULA

317	83	7	23	10	Murmansk	7	25	20	Kara Gate	567	58
318		7	25	20	Kara Gate	7	26	17	Beliy	297	21
319		7	26	17	Beliy	7	28	4	Dikson	175	35
320		8	8	8	Dikson	8	10	9	Vilkitski strait		49
321		8	10	9	Vilkitski strait	8	11	11	Sannikov strait		26
322		8	11	11	Sannikov strait	8	12	21	Medvezy isl.		34
323		8	12	21	Medvezy isl.	8	13	10	Pevek		13

324	83	9	7	9	Kandalaksha	9	10	6	Dikson	1282	69
325		9	10	6	Dikson	9	11	14	Vilkitski strait		32
326		9	11	14	Vilkitski strait	9	13	12	Tiksi		46
327		9	25	7	Tiksi	9	28	17	Medvezy isl.		82
328		9	28	17	Medvezy isl.	9	29	14	Pevek		21
329		9	29	17	Pevek	10	1	4	prom. Shmidta		59
330		10	1	4	prom. Shmidta	10	1	12	175 w.l.		8
331		10	1	12	175 w.l.	10	2	23	Agvikanot		35
332		10	16	12	Agvikanot	10	17	5	b.Provideniya		17
333		10	24	16	b.Provideniya	10	30	10	Bering strait		138
334		10	30	10	Bering strait	11	12	4	Pevek		306
335		11	17	9	Pevek	11	18	13	Medvezy isl.		28
336		11	18	14	Medvezy isl.	11	21	2	Novosibirsk isl.		60
337		11	21	2	Novosibirsk isl.	11	23	21	Vilkitski strait		67
338		11	23	21	Vilkitski strait	11	26	24	Dikson		75
339		11	27	22	Dikson	11	28	23	Sop. Karga	230	25
340		11	28	23	Sop. Karga	11	29	12	Dudinka	118	13
341		12	11	0	Dudinka	12	11	13	Sop. Karga	118	13
342		12	11	13	Sop. Karga	12	12	13	Dikson	230	24
343		12	12	13	Dikson	12	13	8	Beliy	175	19
344		12	13	8	Beliy	12	14	5	Kara Gate	297	21
345		12	14	5	Kara Gate	12	16	11	Murmansk	567	54
346		12	21	14	Murmansk	12	23	16	Kandalaksha	810	50
347	84	1	6	1	Kandalaksha	1	7	20	m. of Beliy Sea	430	43
348		1	7	20	m. of Beliy Sea	1	9	7	Kara Gate	380	35
349		1	9	1	Kara Gate	1	10	2	Beliy	297	25
350		1	10	2	Beliy	1	10	22	Dikson	175	20
351		1	10	22	Dikson	1	11	20	Sop. Karga	230	22
352		1	11	20	Sop. Karga	1	12	11	Dudinka	118	15
353		1	31	19	Dudinka	2	1	7	Sop. Karga	118	12
354		2	1	7	Sop. Karga	2	3	1	Dikson	230	42
355		2	3	10	Dikson	2	2	11	Beliy	175	-23
356		2	2	11	Beliy	2	4	5	Kara Gate	297	42
357		2	4	5	Kara Gate	2	6	8	Murmansk	567	51
358		2	11	23	Murmansk	2	14	6	Kandalaksha	810	55
359		2	21	4	Kandalaksha	2	22	10	m. of Beliy Sea	430	30
360		2	22	10	m. of Beliy Sea	2	23	13	Kara Gate	380	27
361		2	23	13	Kara Gate	2	24	14	Beliy	297	25
362		2	24	14	Beliy	2	25	4	Dikson	175	14
363		2	25	4	Dikson	2	26	3	Sop. Karga	230	23
364		2	26	3	Sop. Karga	2	26	18	Dudinka	118	15
365		3	20	2	Dudinka	3	20	14	Sop. Karga	118	12
366		3	20	14	Sop. Karga	3	21	12	Dikson	230	22
367		3	21	12	Dikson	3	22	7	Beliy	175	19
368		3	22	7	Beliy	3	23	23	Kara Gate	297	40
369		3	23	23	Kara Gate	3	26	4	Murmansk	567	53
370		4	4	18	Murmansk	4	6	14	Kara Gate	567	44
371		4	6	14	Kara Gate	4	7	20	Beliy	297	30
372		4	7	20	Beliy	4	8	18	Dikson	175	22
373		4	10	19	Dikson	4	12	14	Sop. Karga	230	43
374		4	12	14	Sop. Karga	4	13	3	Dudinka	118	13
375		4	27	23	Dudinka	4	29	22	Dikson	350	47
376		4	30	18	Dikson	5	1	19	Beliy	175	49
377		5	1	19	Beliy	5	2	22	Kara Gate	297	27
378		5	2	22	Kara Gate	5	7	1	Murmansk	567	99
379		6	3	11	Murmansk	6	5	20	Kara Gate	567	57
380		6	5	20	Kara Gate	6	7	10	Beliy	297	38
381		6	7	10	Beliy	6	8	11	Dikson	175	25
382		6	13	3	Dikson	6	15	14	Vilkitski strait		59

383		6	15	14	Vilkitski strait	6	18	2	Novosibirsk isl.		60
384		6	18	10	Novosibirsk isl.	6	22	10	Medvezy isl.		96
385		6	23	3	Medvezy isl.	6	24	7	Pevek		28
386		7	5	4	Pevek	7	6	7	175 w.l.		27
387		7	6	7	175 w.l.	7	11	23	Peter Kamch.		136
388		7	28	0	Peter Kamch.	8	1	0	Bering strait		96
389		8	1	0	Bering strait	8	3	17	Pevek		65
390		8	3	17	Pevek	8	4	20	Medvezy isl.		27
391		8	4	20	Medvezy isl.	8	5	14	Sannikov strait		18
392		8	5	14	Sannikov strait	8	9	2	Vilkitski strait		84
393		8	9	2	Vilkitski strait	8	10	7	Dikson		29
394		8	11	12	Dikson	8	12	23	Novy Port		35

Stepan Rasin UL

395	83	8	12	15	Murmansk	8	16	14	Dudinka	1389	95
396		8	25	6	Dudinka	8	30	5	Murmansk	1389	119
397		9	5	15	Murmansk	9	9	14	Dudinka	1389	95
398		9	22	23	Dudinka	9	27	22	Murmansk	1389	119
399		11	20	23	Murmansk	11	23	8	Kara Gate	567	57
400		11	23	8	Kara Gate	11	24	12	Beliy	297	28
401		11	24	13	Beliy	11	25	2	Dikson	175	13
402		11	28	5	Dikson	11	29	19	Sop. Karga	230	38
403		11	29	20	Sop. Karga	11	30	4	Dudinka	118	8
404		12	2	21	Dudinka	12	3	9	Sop. Karga	118	12
405		12	3	9	Sop. Karga	12	4	12	Dikson	230	27
406		12	9	7	Dikson	12	9	22	Beliy	175	15
407		12	10	19	Beliy	12	11	14	Kara Gate	297	19
408		12	11	15	Kara Gate	12	13	7	Murmansk	567	40
409	84	7	27	23	Kandalaksha	8	2	2	Dudinka	1632	123

Emelyan Pugachev UL

410	83	10	8	22	Novy Port	10	11	7	Dudinka	837	57
411		10	12	8	Dudinka	10	12	19	Sop. Karga	118	11
412		10	12	19	Sop. Karga	10	13	12	Dikson	230	17
413		10	13	15	Dikson	10	13	24	Beliy	175	9
414		10	14	1	Beliy	10	14	20	Kara Gate	297	19
415		10	14	21	Kara Gate	10	16	4	Murmansk	567	31

Kuzma Minin UL

416	83	11	5	18	Kandalaksha	11	7	15	Kara Gate	810	45
417		11	7	15	Kara Gate	11	8	24	Beliy	297	33
418		11	9	1	Beliy	11	9	15	Dikson	175	14
419		11	10	6	Dikson	11	10	21	Sop. Karga	230	15
420		11	10	22	Sop. Karga	11	11	6	Dudinka	118	8
421		7	31	10	Dudinka	8	5	7	Murmansk	1389	117
422		8	7	9	Murmansk	8	11	6	Dudinka	1389	93
423		8	12	21	Dudinka	8	17	17	Murmansk	1389	116
424		9	13	22	Murmansk	9	17	3	Novy Port	1287	77
425		9	27	14	Novy Port	9	30	11	Dudinka	837	69
426		9	30	23	Dudinka	10	5	2	Murmansk	1389	123
427		10	7	16	Murmansk	10	8	23	Kara Gate	567	31
428		10	9	0	Kara Gate	10	9	19	Beliy	297	19
429		10	9	19	Beliy	10	10	6	Dikson	175	11
430		10	10	23	Dikson	10	12	8	Sop. Karga	230	33
431		10	12	9	Sop. Karga	10	12	17	Dudinka	118	8
432		10	16	11	Dudinka	10	16	19	Sop. Karga	118	8
433		10	16	20	Sop. Karga	10	17	17	Dikson	230	21
434		10	17	17	Dikson	10	18	6	Beliy	175	13
435		10	19	7	Beliy	10	20	3	Kara Gate	297	20
436		10	20	3	Kara Gate	10	21	8	Murmansk	567	29

Admiral Ushakov UL

437	83	9	22	23	Dudinka	9	28	1	Murmansk	1387	122
438		10	7	9	Murmansk	10	10	6	Dudinka	1387	69
439		10	18	23	Dudinka	10	19	11	Sop. Karga	118	12
440		10	19	11	Sop. Karga	10	20	8	Dikson	230	21
441		10	20	9	Dikson	10	20	22	Beliy	175	13
442		10	20	23	Beliy	10	21	19	Kara Gate	297	20
443		10	21	20	Kara Gate	10	23	3	Murmansk	567	31
444		10	26	13	Murmansk	10	28	15	Beliy	864	50
445		10	28	15	Beliy	10	29	5	Dikson	175	14
446		10	29	5	Dikson	10	30	3	Sop. Karga	230	22
447		10	30	3	Sop. Karga	10	30	12	Dudinka	118	9
448		11	2	15	Dudinka	11	2	22	Sop. Karga	118	7
449		11	2	23	Sop. Karga	11	3	20	Dikson	230	21
450		11	3	21	Dikson	11	4	13	Beliy	175	16
451		11	4	13	Beliy	11	5	9	Kara Gate	297	20
452		11	5	10	Kara Gate	11	7	1	Murmansk	567	39
453	84	7	5	20	Murmansk	7	7	23	Beliy	864	51
454		7	8	0	Beliy	7	8	7	Dikson	175	7
455		7	9	6	Dikson	7	9	23	Sop. Karga	230	17
456		7	10	0	Sop. Karga	7	10	9	Dudinka	118	9
457		7	24		Dudinka	7	29		Murmansk	1389	120

Yuri Dolgoruky UL

458	83	10	19	10	Dudinka	10	19	19	Sop. Karga	118	9
459		10	19	19	Sop. Karga	10	20	17	Dikson	230	22
460		10	21	22	Dikson	10	22	18	Beliy	175	20
461		10	22	19	Beliy	10	23	15	Kara Gate	297	20
462		10	23	16	Kara Gate	10	25	4	Murmansk	567	36

Alexander Suvorov UL

463	83	9	30	21	Kandalaksha	10	9	5	Dudinka	1632	224
464		10	30	16	Dudinka	10	30	23	Sop. Karga	118	7
465		11	1	0	Sop. Karga	11	1	23	Dikson	230	23
466		11	1	23	Dikson	11	2	15	Beliy	175	16
467		11	2	15	Beliy	11	3	10	Kara Gate	297	19
468		11	3	10	Kara Gate	11	4	12	m. of Beliy Sea	380	26
469		11	4	13	m. of Beliy Sea	11	5	9	Kandalaksha	430	20
470		11	20	19	Murmansk	11	22	2	Kara Gate	567	31
471		11	22	3	Kara Gate	11	23	23	Beliy	297	44
472		11	23	0	Beliy	11	23	16	Dikson	175	16
473		11	29	3	Dikson	11	29	20	Sop. Karga	230	17
474		11	29	20	Sop. Karga	11	30	6	Dudinka	118	10
475		12	17	21	Dudinka	12	18	12	Sop. Karga	118	15
476		12	18	13	Sop. Karga	12	19	12	Dikson	230	23
477		12	19	12	Dikson	12	20	9	Beliy	175	21
478		12	23	23	Beliy	12	25	13	Kara Gate	297	38
479		12	25	14	Kara Gate	12	27	4	Murmansk	567	38
480	84	6	21	17	Murmansk	6	23	5	Kara Gate	567	36
481		6	23	5	Kara Gate	6	24	3	Beliy	297	22
482		6	24	4	Beliy	6	25	15	Drovyanaya		35
483		6	29	13	Drovyanaya	6	30	18	Novy Port		29
484		7	8	6	Novy Port	7	9	20	Beliy	420	38
485		7	9	21	Beliy	7	10	8	Dikson	175	11
486		7	10	8	Dikson	7	11	10	Dudinka	350	26
487		7	11	18	Dudinka	7	12	21	Dikson	350	27
488		7	13	22	Dikson	7	14	14	Beliy	175	16
489		7	14	15	Beliy	7	17	3	Murmansk	864	60

Kandalaksha ULA

490	84	1	31	4	Murmansk	2	1	13	Kara Gate	567	33
491		2	1	13	Kara Gate	2	2	21	Beliy	297	32
492		2	2	21	Beliy	2	3	18	Dikson	175	21
493		2	4	7	Dikson	2	5	20	Sop. Karga	230	37
494		2	5	20	Sop. Karga	2	6	11	Dudinka	118	15
495		2	19	6	Dudinka	2	19	21	Sop. Karga	118	15
496		2	19	22	Sop. Karga	2	20	23	Beliy		25
497		2	21	0	Beliy	2	22	13	Kara Gate	297	37
498		2	22	14	Kara Gate	2	24	12	Murmansk	567	46
499		3	5	16	Murmansk	3	7	2	Kara Gate	567	34
500		3	7	2	Kara Gate	3	7	23	Beliy	297	21
501		3	8	0	Beliy	3	8	18	Dikson	175	18
502		3	8	19	Dikson	3	9	22	Sop. Karga	230	27
503		3	9	23	Sop. Karga	3	10	15	Dudinka	118	16
504		3	26	0	Dudinka	3	26	14	Sop. Karga	118	14
505·		3	26	14	Sop. Karga	3	27	20	Dikson	230	30
506		3	27	20	Dikson	3	28	18	Beliy	175	22
507		3	28	19	Beliy	3	30	7	Kara Gate	297	36
508		3	30	8	Kara Gate	4	1	1	Murmansk	567	41
509		4	11	20	Murmansk	4	13	11	Kara Gate	567	39
510		4	13	12	Kara Gate	4	14	19	Beliy	297	31
511		4	17	10	Beliy	4	18	6	Dikson	175	20
512		4	22	19	Dikson	4	23	17	Sop. Karga	230	22
513		4	23	18	Sop. Karga	4	24	6	Dudinka	118	12
514		5	10	6	Dudinka	5	11	16	Dikson	350	34
515		5	13	21	Dikson	5	14	16	Beliy	175	19
516		5	14	17	Beliy	5	16	4	Kara Gate	297	35
517		5	16	5	Kara Gate	5	18	2	Murmansk	567	45

Nikel ULA

518	84	4	22	20	Arkhangelsk	4	23	16	m. of Beliy Sea	270	20
519		4	23	16	m. of Beliy Sea	4	25	23	Kara Gate	380	55
520		4	26	0	Kara Gate	4	27	13	Beliy	297	37
521		4	27	14	Beliy	4	28	11	Dikson	175	21
522		5	1	17	Dikson	5	2	18	Sop. Karga	230	25
523		5	2	18	Sop. Karga	5	3	6	Dudinka	118	12
524		5	15	16	Dudinka	5	16	14	Dikson	350	22
525		5	19	13	Dikson	5	20	12	Beliy	175	23
526		5	20	13	Beliy	5	22	1	Kara Gate	297	36
527		5	22	2	Kara Gate	5	23	16	m. of Beliy Sea	380	38
528		5	23	16	m. of Beliy Sea	5	24	5	Arkhangelsk	270	13
529		6	2	22	Murmansk	6	4	0	Kolguev		26
530		7	6	15	Kolguev	7	7	10	Murmansk		19
531		7	27	4	Murmansk	7	31	20	Dudinka	1389	112

Kapitan Tsirul UL

532	83	10	13	4	Dudinka	10	13	16	Sop. Karga	118	12
533		10	13	16	Sop. Karga	10	14	22	Dikson	230	30
534		10	14	23	Dikson	10	15	19	Beliy	175	20
535		10	15	19	Beliy	10	16	20	Kara Gate	297	25
536		10	16	20	Kara Gate	10	18	10	Murmansk	567	38

Kapitan Chukhchin UL

537	83	10	23	18	Murmansk	10	25	10	Kara Gate	567	40
538		10	25	11	Kara Gate	10	26	9	Beliy	297	22
539		10	26	9	Beliy	10	27	2	Dikson	175	17
540		10	28	23	Dikson	10	30	1	Sop. Karga	230	26
541		10	30	1	Sop. Karga	10	31	0	Dudinka	118	23
542		11	14	22	Dudinka	11	16	7	Dikson	350	33
543		11	18	16	Dikson	11	19	12	Beliy	175	20
544		11	24	22	Beliy	11	26	6	Kara Gate	297	32
545		11	26	6	Kara Gate	11	28	3	Murmansk	567	45
546		11	30	17	Murmansk	12	2	10	Kara Gate	567	65
547		12	2	11	Kara Gate	12	3	9	Beliy	297	22
548		12	3	9	Beliy	12	4	2	Dikson	175	17
549		12	9	14	Dikson	12	10	15	Sop. Karga	230	25
550		12	10	16	Sop. Karga	12	11	5	Dudinka	118	13
551		12	14	22	Dudinka	12	15	14	Sop. Karga	118	16
552		12	15	15	Sop. Karga	12	16	18	Dikson	230	27
553		12	18	12	Dikson	12	19	8	Beliy	175	20
554		12	19	9	Beliy	12	20	13	Kara Gate	297	28
555		12	20	14	Kara Gate	12	22	7	Murmansk	567	41

# voyage	% of open water	Ice condition description								Icebreaker name	Nature of escort
		total concentration	% ice cover	fast ice	age	concentration	floe size	ridging degree	fracture degree		
1	100										
2											
3		10	70		5/4	10	3/3				
			30		5/1	2/8					
4		9	50		1	9	3				
			50		4/1	8/2	5/3				
5	80	10	20		4/1	8/2	5,3				
6	100										
7	100										
8	70	9	30		4/1	2/7	3/4				
9		10	100		5/4	7/3	5/3				
10		10	100		5/4	7/3	5/3				
11											
12										Kapitan Dranitsin	1
13		10	30		7/5	8/2	5/4			Murmansk	1
			70		5/4	4/6	4/4				
14		10	70		7/5	2/8	4/5			Lenin	1
			30		7/5	9/1	5/4	2			
15		10	70		5/4	8/2	5/3	1		Lenin	1
			30		4/1	7/3	5/3	1			
16	100										
17	100										
18	70	9	30		4/1	2/7	3/4			Murmansk	1
19		10	100		5/4	7/3	5/4			Murmansk	1
20		10	100		7/5	8/2	5/4			Kapitan Nikolaev	1
21											
22		10	100		4/1	9/1	4/1				
23		10	100		5/4	8/2	5/4			Murmansk	1
24	50	10	50		4/1	8/2	5/3			Murmansk	1
25	100										
26											
27	100										
28	100										
29	100										
30	100										
31	100										
32	100										
33	100										
34	100										
35	60	8	40		1	8	1				
36	40	10	60		1	9-10	1				
37	100										
38		10	100		4/1	8/2	4/1				
39		10	60		4/1	9/1	4/1				
			40		-/4	2/8	3/3				
40	80	10	20		-/4	2/8	4/3				
41	100										
42											
43											

44					1						
45											
46	100										
47	100										
48	100										
49	100										
50	100										
51	100										
52		9	50		1	9	1				
			50		4/1	8/2	5/3				
53	100									Murmansk	1
54	100										
55	100										
56	100										
57	100										
58	100										
59	100										
60		10	80		4/1	2/7-8	3/1				
			20		5/4	4/6	4/3				
61		10	100		5/4	3/7	4/5				
62											
63											
64		10	100		7/5	5/5	5/4				
65		10	100		5/4	8/2	5/4				
66		10	100		5/4	8/2	5/3				
67	100										
68											
69											
70	100										
71	100										
72	100										
73	80	10	20		4/1	8/2	5/3				
74		9	50		1	9	1				
			50		4/1	8/2	5/3				
75		10	70		5/4	4/6	3/3				
			30		5/1	2/8	3/3				
76										Murmansk	1
77										Murmansk	1
78		10	100		5/4	7/3	5/3				
79		10	100		5/4	7/3	5/4				
80	70	9	30		4/1	2/7	3/4				
81	100										
82	100										
83	30	10	30		4/1	7/3	5/-				
			40		5/4	8/2	5/3				
84		10	50		7/1	4/6	3/3				
			50		5/4	8/2	5/3				
85		10	100		7/5	8/2	5/4				
86											
87										Murmansk	1
88		10	100		7/5	5/5	5/4			Murmansk	1
89		10	100		5/4	8/2	5/4				
90		10	100		5/4	8/2	5/3	1			
91	100										
92				medium							
93		10	80	dium/thin		2/8					
			20		1	8	3				
94		9	100		1	9	3				
			50		5	10	5,4				

95	20	10	20		7/5	8/2	5/3	1-2			
			10		5/4	7/3	5/3				
96	100										
97	100									Kapitan Nikolaev	1
98	100									Kapitan Nikolaev	1
99	100										
100		8	30		5	8	3				
			70		5	10	5,4				
			10		5/4	7/3	5/3				
101	100										
102	100										
103	100										
104	40	10	60		4/1	8/2	5,4/3				
105		10	30		7/5	9/1	5/4				
			70		5/4	2/8	4/5				
106		10	30		7/5	8/2	5/4			Kapitan Nikolaev	1
			70		5/4	4/6	4/4				
107				medium						Kapitan Nikolaev	1
108		10	20	medium							
			80		7/5	9/1	5/3				
109		10	100		7/5	9/1	5/3				
110		10	60		7/5	8/2	5/4	1-2			
			30		7/5,4	3/7	4/5,3				
			10		5/5	2/8	3/4				
111	100										
112	100										
113	20	10	50		5	10	5,4				
			20		7/5	8/2	5/3	1-2			
			10		5/4	7/3	5/3				
114			100		1	9					
115		10	80	dium/thin		2/8					
			20		1	8					
116				medium							
117				medium							
118		10	80	medium							
			20		4	10					
119		10	100		5/4	7/3	4/3				
120		10	70		7/5	8/2	5/4	2		Leonid Bregnev	1
			30		5/4	8/2	7/3				
121	100									Leonid Bregnev	1
122	100										
123	30	9	40		4*	5	3				
			30		4*	9	5,4	1-2			
124	100										
125	20	10	30		4*	9-10	5,4		2-3		
			30		5/4*	1/9	5/5	2	2		
			20	thick							
126	40	3	60		4*	3	3,4			Lenin	1
127	100									Lenin	1
128	100										
129	90	5	10		4*	5	3				
130	100										
131	100										
132	100										
133	100										
134	100										
135	90	5	5		4*	4-5	3				
			5		4*/1	9/1	4/-				
136	100										
137	100										

138	100											
139	90	7	10			1	7	4				
140	85	7	15			1	7	4				
141	100											
142	100											
143		10	10			1	10	4				
			90			4/1	8/2	5/3				
144		10	100			4/1	8/2	5/3				
145			100			4/3	7/3	5/3				
146			100			4/1	7/3	5/3				
147		10	60			4/1	7/3	5/1			Semen Cheluskin	1
			40			1	9-10	3				
148		10	30			4/1	9/1	5/3				
			40			5/4	9/1	5/3				
			30			/5	2/8	3/3				
149		10	50			4/1	8/2	5/1				
			30			5/4	8/2	5/3				
			20			7	10	4				
150		10	20			5/4	4/6	4/3				
			80			4/1	2/7-8	3/1				
151	100											
152	100											
153	100											
154	100											
155												
156		10	70			5/4	4/6	3/3				
			30			5/1	2/8	3/3				
157		10	20			5/4	4/6	4/3				
			80			4/1	2/7-8	3/1				
158	100											
159	100											
160	70	9	30			4/1	2/7	3/4				
161		10	100			5/4	7/3	5/4				
162		10	100			5/4	7/3	5/3				
163												
164												
165												
166		10	30			7/5	8/2	5/4				
			70			5/4	4/6	4/4				
167		10	70			5/4	8/2	5/3	1			
			30			4/1	7/3		1			
168		10	70			7/5	2/8	4/5				
			30			7/5	9/1	5/4	2			
169	100											
170	100											
171		10	20			4/1	2/8	3/1				
			30			1	8	3				
			50			5/4	7/3	5/3				
172		10	100			7/5	2/8	3/5				
173		10	40			7	10	5,4				
			20			5	10	5				
			40	thin					2			
174				thin								
175				medium								
176		10	20	medium								
			80			7/5	9/1	5/3				
177			100			7/5	9/1	5/3				
178			60			7/5	8/2	5/4	1-2			
		10	30			7/5	3/7	4/5				

			10		5/4	2/8	3/4				
179	100										
180	100										
181		10	10		7/5	2/8	4/5				
			10		7/5	9/1	5/3	1-2			
			80		5	10	5				
182		10	20		7/4	9/1	4/3				
			80		5/4	9/1	5/3				
183		10	10		5/4	9/1	5/3				
			10		4	10	34				
			70	thin							
			10	medium							
184				medium							
185				medium							
186		10	80	medium							
			20		4/1	9/1	5/1				
187		10	90		4/5	2/7	3/5				
			10		7/5/1	7/2/1	5/4/1	1-2			
188		10	70		7/4	8/2	5,4/3				
			30		5/4/1	7/2/1	5/3/1				
189	100										
190	100										
191		10	50		5/4	8/2	5/3	1			
			50		7/5	8/2	5/4	2			
191		10	15		7	10	5				
			85		5/4	7/3	4/3				
192		10	20		4	10	3				
			80	medium							
193				medium							
194				medium							
195		10	10		4	10	3				
			90	medium							
196		10	40		4	10	3				
			30		1*/7	8/2	5/4	2-3			
			30		7	10	5				
197		10	10		7/5	9/1	5/4				
			20		5/4	7/3	5/3				
			70		1	9	4				
198	100										
199	100										
200		10	10		5/4	7/3	5/4				
			20		7/4	7/3	5/3				
			70		4	10	4				
201		10	100		7/5	8/2	4/3				
202		10	15		7/5	8/2	4/3				
			15	тол с							
			70	medium							
203				thick						Kapitan Sorokin	1
204				thick						Kapitan Sorokin	1
205		10	20		7/5	8/2	4/3				
			20	thick							
			60	medium							
206			100		1*/7	8/2	5/4			Kapitan Sorokin	1
207		10	40		4/1	8/2	5/1				
			40		1*/7	9/1	5/4	3		Kapitan Sorokin	1
			20		5/4	7/3	5/4				
208	100										
209	100										
			20		1*/7	2/7	4/5				

210		10	40		1*/1	8/2	5/1	3			
			20		7/4	9/1	5/3				
			20		4	10	3				
211		10	60		1*/7	8/2	5/4	2-3			
			40		1	9	1				
212			20	medium							
			80	thick							
213				thick							
214				thick						Kapitan Sorokin	1
			10		1*/4	8/2	5/3				
215		10	60		1	8	1			Kapitan Sorokin	1
			30		7	9	4				
216	40	10	30		1*/5	8/1-2	5/4			Kapitan Nikolaev	1
			30		7/4	8/2	5/3				
217	100										
218	100										
219	60	2	40		1	1-2	1				
220	20	10	70		4*	9-10	5,4	2	3		
			10		4*	3	3				
221	20	4	70		4*	3	3				
			10		4*	7	4,3				
222		10	70		4*	4	4,3				
			30		4*	9-10	5,4				
			50		4*	10	5,4		4		
223		10	20		4*	6	4				
			30		9*/4*	1-2/8	4/4,5				
224		4	100		9*	4	4,3				
225	100										
226	100										
227	100										
			20		8*/1	6/4	4/1				
228		10	40		4*/1	9/1	4,3/1				
			20		4*/1	2/3	3/1				
			20		4*	2	3				
229	80	5	15		4*/1	2/3	3/1			Sibir	1
			5		4*	2	3				
230	80	3	20		4*	3	3			Sibir	1
231	100										
232	100										
233	100										
234	100										
235	100										
236	60	9	40		-/1	1/8	4/1				
237	80	10	20		-/1	3/7	4/1				
238	100										
239		10	70		4*	3	3				
			30		-/5/4	2/3/5	3/5/3				
240		10	100		-/5	4/6	4/4				
241		10	50		-/5/4	2/6/2	3/5/3				
			50		5/4	8/2					
			70		5/4	8/2	5/4				
242		10	20		4/1	9/1	5/4			Sibir	1
			10		-/5	2/8	3/3				
			20		4/1	2/8	3/4				
243		10	30		4/1	8/2	3/1			Sibir	1
			25		5/4	8/2	4/3				
			25		7/5	9/1	4/3				
244	100										
245	100										

246	30	10	30		4/1	7/3	5/1					
			40		5/4	8/2	5/3					
247		10	50		7/1	4/6	3/3					
			50		5/4	8/2	5/3					
248		10	100		7/5	8/2	5/4					
249												
250												
251		10	100		7/5	5/5	5/4					
252		10	100		5/4	8/2	5/4					
253		10	100		5/4	8/2	5/4	1				
254	100											
255	100											
256												
257												
258												
259	100											
260		10	70		7/5	8/2	5/5	2				
			30		5/4	8/2	5/3					
261		10	100		5/3	7/3	4/3					
262		10	80	medium								
			20		4	10	3					
263				medium								
264				medium								
265		10	90	medium								
			10		5	10	5					
266		10	100		7/4	9/1	5/3					
267			25		7/4	9/1	5/3					
	30	10	25		5/4	7/3	5/3					
			20		1	8	3					
268	100											
269												
270												
271												
272	100											
273		10	10		7/5	9/1	5/4					
			20		5/4	7/3	5/3					
			70		1	9	4					
274		10	40		4	10	3					
			30		1*/7	8/2	5/4	2-3				
			30		7	1-	5					
275		10	80	medium								
			20		4	10	3					
276				thick								
277				thick								
278		10	40	thick								
			40	thick								
			20		7/4	8/2	5/3					
279		10	50		7	10	4					
			35		7/4	8/2	5/3					
			15		1*/7	9/1	5/4	3-4				
280			60		7/5	8/2	5/3					
			10		1*/7	8/2	5/4	3-4				
			30		4/1	8/2	3/1					
281	100											
282												
283												
284	100											
285		10	20		1*/7/1	2/7/1	4/5/1					
			40		1*/1	8/2	5/1	3				
			20		7/4	9/1	5/3					

			20		4	10	3				
286			60		1*/7	8/2	5/4	2-3			
			40		1	9	1				
287			20	medium							
			80	thick							
288				thick							
289				thick							
290				thick				1			
291		10	60		1*/7/1	7/2/1	5/4/1				
			40		7	10	4				
292	40		30		1*/7	8/1-2	5/4	3			
			30		7/4	8/2	5/3				
293											
294	100										
295											
296	100										
297			70								
			30								
298		10	70		5/4	8/2	5/3	1			
			30		4/1	7/3	5/3	1			
299		10	30		7/5	2/8	4/5				
			70		7/5	9/1	5/4	2			
300		10	30		7/5	8/2	5/4				
			70		5/4	4/6	4/4				
301				medium							
302		10	20	medium							
			80		7/5	9/1	5/2				
303		10	20		7/4	9/1	4/3				
			80		5/4	9/1	5/3				
			10		7/5	2/8	4/5				
304		10	10		7/5	9/1	5/3	1-2			
			80		5	10	5				
305	100										
306	100										
			50		1*/7/4	2/6/1-2	3/5/3	1-2			
307		10	10		1*/4	8/2	5/4	2-3			
			40		1	9	1				
308		10	60		1*/4	8/2	5/4	2-3			
			40		1	9	1				
309			20	medium							
			80	thick							
310				thick							
311				thick							
312				thick				1-2			
313		10	60		1*/7/1	7/2/1	5/4/1				
			40		7	10	4				
314	40	10	30		1*/4	8/1-2	5/4	3			
			30		7/4	8/2	5/3				
315	100										
316	100										
317	20		80		4*	5	4,3	2-3			
318	100										
319		10	30		4*	2	4,3				
			70		4*	9-10	5,4	2-3	2-3		
320	70	9	15		4*	4	4,3				
			15		4*	9	4,3				
321		10	75		4*	9-10	5,4	2-3	3		
			25		8*,4*	5	4,3				
322		10	100		8*/4*	1-2/8	3/4	2	3-4		

323	100										
324	60	9	40		-/1	1/8	4/1				
325	100										
326	100										
327		10	25		-/5/1	2/3/5	3/5/3				
			75		4*	2	3				
328		10	70		-/1	2/8	3/1				
			30		4*	9-10	5				
329		10	100		4*	10	4				
330	100										
331	100										
332	100										
333		10	18		7*/7	2/8	4/4				
			10		5	10	5				
			70		9*,8*/	9/1	5,4/3	4-5			
			2	old							
334		10	15	old							
			20		7*/7	8/2	4/4				
			65		8*/7	1/9	3/4				
335		10	70		7/5	9/1	5/3				
			30		8*/7	3/7	4/4				
336		10	100		7	10	5,4	2			
337		10	100		5/4	9/1	4/3				
338		10	100		7/5	5/5	5/4				
339											
340				thin							
341		10	40		7	10	5,4				
			20		5	10	5				
			40	thin				2			
342			100		7/5	2/8	3/5				
343		10	20		4/1	2/8	3/1				
			30		1	8	1				
			50		5/4	7/3	5/3				
344	100										
345	100										
346											
347	100										
348		10	10		7/5	2/8	4/5				
			10		7/5	9/1	5/3	1-2			
			80		5	10	5				
349		10	20		7/5	9/1	4/3				
			80		5/4	9/1	5/3				
350		10	80	dium/thin		2/8					
351			20		1	8	1				
352				medium							
353				medium						Kapitan Dranitsin	1
354		10	80	medium							
			20		4	10	3				
355		10	15		7	10	5			Sibir	2
			85		5/4	7/3	4/3				
356		10	50		5/4	8/2	5/3	1		Sibir	2
			50		7/5	8/2	5/4	2			
357	100										
358											
359											
360	100										
361		10	15		1	4	1				
			60		5/4	7/2-3	5,4/4				
			25		7/5	9/1	5/4				

			70		1	8	3				
362		10	10		7/5	9/1	5/4				
			20		4	10	3				
363		10	80	medium							
			20		4	10	3				
364				medium							
365				thick				2		Kapitin Sorokin	1
366		10	15		7/5	8/2	4/3				
			15	thick							
			70	medium							
367		10	100		7/5	8/2	4/3				
368			50		5/4	9/1	5/3	0-1			
		10	25		7/5	6/4	5/4				
			25		5/4	7/3	5/3				
369	100										
370	100										
371			60		7/5	8/2	5/3				
		10	10		1*/7	8/2	5/4	3-4			
			30		4/1	8/2	3/1				
372			50		7	10	4				
		10	35		7	8/2	5/3				
			15		1*/1	9/1	5/1	3-4			
373			50	thick							
			50	medium							
374				thick							
				thick							
375		10	60		1*/7	8/2	5/4	2-3			
			40		1	9	1				
376			50		1*/7	2/6	3/5	1-2			
		10	10		1*/4*/	8/1/1	5/4/3	3			
			40		1	9	1				
377	100										
378	100										
379	40	10	20		7	9	5,4	2-3	0-1		
			40		1*/1	9/0-1	5/1	2-3	0-1		
380		10	100		1*/7	8/1-2	5/4	2-3			
381		10	45	thick							
			55		4*/7	8/2	5/3	3			
382		10	95		1*	9-10	5,4	2-3			
			5		7	1	3				
383	60	9	40		1*	9	5,4			Arctica	1
384			65		9*/4*	2/7-8	4/5				
		10	25		4*	2	3			Arctica	1
			10	thick							
385			80		9*/4*	7/2-3	5/4	4	3		
		9	10		9*/4*	5/3	4/3			Arctica	1
			10		4*	2	3				
386	100										
387	100										
388		5	60		9*	5	3				
			40		9*	2	3				
389			100		4*	2	3				
390		10	70		4*	9-10	5,4		4	Arctica	1
			30		4*	2-3	3,4				
391	20	9	60		4*	1-3	4,3			Arctica	1
			20		4*	9	4				
392		8	80		4*	3	3			Arctica	1
			20		4*	7-8	4,3				
393	100										
394	100										

395	100										
396	100										
397	100										
398	100										
399	50	10	50		4/1	8/2	5/3				
400		10	100		5/4	8/2	5/4				
401		10	100		4/1	9/1	4/1				
402											
403											
404		10	30		7/5	8/2	5/4				
			70		5/4	4/6	4/4				
405		10	70		7/5	2/8	4/5				
			30		7/5	9/1	5/4	2			
406		10	70		5/4	8/2	5/3				
			30		4/1	7/3	5/3	1			
407	100										
408	100										
409	100										
410	100										
411											
412		10	100		5/4	4/6	3/3				
413		10	50		1	9	1				
			50		4/1	8/2	5/3				
414	80	10	20		4/1	8/2	5/3				
415	100										
416	100										
417	10	10	60		4*	7-8	5,4				
			20		4*	9	5,4	2	2		
			10		1*	9-10	5,4				
418	65	2	35		1*	2	4			Lenin	1
419	100										
420	100										
421	100										
422	100										
423	100										
424	100										
425	100										
426	100										
427	100										
428	100										
429	100										
430		10	70		5/6	4/6	3/3				
			30		5/1	2/8	3/3				
431											
432											
433		10	100		5/4	4/6	3/3				
434		10	50		1	9	1				
			50		4/1	8/2	5/3				
435	80	10	20		4/1	8/2	5/3				
436	100										
437	100										
438	100										
439											
440		10	70		5/4	4/6	3/3				
			30		5/1	2/8	3/3				
441		10	50		1	9	3				
			50		4/1	8/2	5/3				
442	70	10	30		4/1	2/7-8	3/1				
443	100										

444	100										
445		10	80		4/1	2/7-8	3/1				
			20		5/4	4/6	4/3				
446		10	100		5/4	3/7	4/5				
447											
448											
449		10	100		5/4	7/3	5/3				
450		10	100		5/4	7/3	5/4				
451	70	9	30		4/1	2/7	3/4				
452	100										
453.	100										
454	85	8	15		4*	7-8	5,4				
455	90	10	10		4*	10	5		3-4		
456	100										
457	100										
458											
459		10	70		5/4	4/6	3/3				
			30		5/1	2/8	3/3				
460		10	50		1	9	3				
			50		4/1	8/2	5/3				
461	70	10	30		4/1	2/7-8	3/1				
462	100										
463	100										
464											
465		10	100		5/4	7/3	5/3				
466		10	100		5/4	7/3	5/4				
467	70	9	30		4/1	2/7	3/4				
468	100										
469											
470	100										
471	50	10	50		4/1	8/2	5/3				
472		10	100		5/4	8/2	5/4				
473		10	100		4/1	9/1	4/1				
474											
475				thin							
476		10	40		7	10	5,4				
			20		5	10	5				
			40	thin				2			
477			100		7/5	9/1	5/3				
478		10	60		7/5	8/2	5/4	1-2			
			30		7/5	3/7	4/5				
			10		5/4	2/8	3/4				
479	100										
480	100										
481	100										
482	100										
483		10	30		4*	8	3				
			70		4*	10	5,4		3-4		
484	10	9	90		4*	9	4,3				
485	100										
486	100										
487	100										
488	60	2	40		1*	1-2	4,3				
489	100										
490	100										
491		10	50		5/4	8/2	5/3	1		Arctica	1
			50		7/5	8/2	5,4	2			
492		10	15		7	10	5			Arctica	1
			85		5/4	7/3	4/3				

493		10	80	medium						Kapitan Dranitsin	1
			20		4	10	3				
494				medium						Kapitan Dranitsin	1
495				medium						Kapitan Nikolaev	1
496		10	90	medium						Arctica	1
			10		5	10	5				
497		10	100		7/4	9/1	5/3			Arctica	1
			25		7/4	9/1	5/3				
498	30	10	25		5/4	7/3	5/3				
			20		1	8	3				
499	100										
500	100										
501		10	10		7/5	9/1				Arctica	1
			20		5/4	7/3				Arctica	1
			70		1	9	4				
502		10	40		5	10	3			Kapitan Dranitsin	1
			30		1*/7	8/2	5/4	2-3			
			30		7	10	5				
503		10	80	medium						Kapitan Dranitsin	1
			20		4	10	3				
504				thick						Kapitan Nikolaev	1
505			70	medium						Kapitan Nikolaev	1
		10	15	thick							
			15		7/5	8/2	4/3				
506			100		7/5	8/2	4/3			Arctica	1
507		10	50		5/4	9/1	5/3	0-1		Arctica	1
			25		7/5/4	6/3/1	5/4/3				
			25		5/4	7/3	5/3				
508	100										
509	100										
510		10	40		4/1	8/2	5/1				
			40		1*/4*	9/1	5/4	3			
			20		5/4	7/3	5/4				
511		10	30		1*/4	9/1	5/3				
			70		7/4	9/1	4/3				
512				thick							
513				thick							
514				thick							
515		10	10		1*/4	8/2	5/3				
			60		1	8	1				
			30		7	9	4				
516		10	40		4	10	4				
			10		7/1	8/2	5/1				
			25		1*/7/1	8/1/1	5/4/1	3			
			25		4	3	3				
517	100										
518											
519	100										
520		10	20		1*/7/1	2/7/1	4/5/1			Arctica	1
			40		1*/1	8/2	5/1	3			
			20		7/4	9/1	5/3				
			20		4	10	3				
521		10	60		1*/7	8/2	5/4	2-3		Arctica	1
			40		1	9	1				
522			20	medium							
			80	thick							
523				thick							
524				thick							
525		10	10		1*/4	8/2	5/3				
			60		1	8	1				

			30		7	9	4				
526	40	10	30		1*/7	8/1-2	5/4	3			
			30		7/4	8/2	5/3				
527	100										
528											
529	100										
530	100										
531	100										
532											
533		10	70		5/4	4/6	3/3				
			30		5/1	2/8	3/3				
534		10	50		1	9	1				
			50		4/1	8/2	5/1				
535	80	10	20		4/1	8/2	5/3				
536	100										
537	100										
538	100										
539		10	80		4/1	2/7-8	3/1				
			20		5/4	4/6	4/3				
540		10	100		5/4	3/7	4/5				
541										Kapitan Nikolaev	1
542											
543		10	100		7/5	8/2	5/4				
544		10	50		7/1	4/6	3/3				
			50		5/4	8/2	5/3				
545	50	10	50		4/1	8/2	5/3				
546	100										
547	100										
548		10	70		5/4	8/2	5/3	1			
			30		4/1	7/3	5/3	1			
549		10	70		7/5	2/8	4/5				
			30		7/5	9/1	5/4	2			
550		10	30		7/5	8/2	5/4				
			70		5/4	4/6	4/4				
551				thin							
			40		7	10	5,4				
552		10	20		5	10	5				
			40	thin				2			
553			100		7/5	2/8	3/5				
			20		4/1	2/8	3/1				
554		10	30		1	8	1				
			50		5/4	7/3	5/3				
555	100										

Appendix F Damage incidents for Ivan Susanin (1981 to 1985) and Murmansk Shipping Company vessels (1983/84)

Voyage Segment no	Type of damage	Amount of Damage
Ivan Susanin UL		
38	bilge keel	
39	plastic deformation of outside plating	30 mm dent
40	plastic deformation of outside plating	26 mm dent
41	plastic deformation of outside plating	17 mm dent
42	plastic deformation of outside plating	18 mm dent
43	plastic deformation of outside plating	20 mm dent
73	collision with another ship	
82	plastic deformation of outside plating	45 mm dent
83	bilge keel	
84	plastic deformation of outside plating	30 mm bulge
Vasya Korobko L1		
38	plastic deformation of outside framing an	40 mm dent
39	plastic deformation of outside plating	35 mm dent
40	plastic deformation of outside plating	20 mm dent
41	plastic deformation of outside plating	48 mm dent
Valya Kotik L1		
52	plastic deformation of outside framing an	25 mm dent
53	plastic deformation of outside framing an	20 mm dent
54	plastic deformation of outside framing an	18 mm dent
Uta Bondarovskaya L1		
55	plastic deformation of outside plating	15 mm dent
Montshegorsk ULA		
364	plastic deformation of bow	150 mm
Kapitan Chukhchin UL		
541	plastic deformation of bow	200 mm

Anders Backman
Captain
Swedish Maritime Administration

28 February 1999

Review of the INSROP discussion paper "Modification of Canadian Ice Regime System to Include Ship Operations"

In this interesting and unique paper statistics from several voyages in the Russian Arctic has been analysed and processed together with classification of ice conditions and vessels in accordance with the Canadian Arctic Ice Regime Shipping System (AIRSS). In this system "Ice Numerals" defines conditions for safe navigation in ice.

"Transit Numeral" is an improved concept taking access to icebreaker service, ridging etc. into account.

Russian Ice Passport and QAD systems are two aids developed by the AARI. AARI can also offer ice advisers, ice charts and forecasts shipping. The Passport and QAD-systems are clearly described in the paper.

In Paragraph 8, Discussion, the author has mentioned the three factors, ice conditions, ship capability and operational skill being of importance for safe and economical navigation in ice. I agree on that, but will also point out that information about the actual ice situation and forecasted changes to weather and ice are important factors. It is today possible to achieve real time ice information from microwave satellites. The satellite images have to be processed by experienced people ashore and transmitted in edited form to the vessels. Those ice charts will probably replace or complete the traditional hand drawn charts with the eggs.

There are special regulations for the navigation in the Northern Sea Route. Vessels are not allowed to navigate by themselves. Foreign vessels, and Russian vessels without special permission, must have one or two "State Ice Pilots" onboard. Those pilots are certified by "The Northern Sea Route Administration" which also is responsible for the official "Permission of leading the vessel through the Northern Sea Route". It is important to be aware of the differences between the definitions of a vessel's Ice Class, issued either by the Maritime Administration of a State or by a Classification Society and an Ice Passport which is a non compulsory aid.

The vessel traffic in the Northern Sea Route is controlled and directed from two centres along the Route. Those centres provide the vessels with necessary ice information and information about where the vessel has to wait for ice-breaker assistance.

As almost all vessels need ice breaker assistance in some areas the transit times are depending on the allocation of and access to ice-breakers. Vessels are normally not allowed to find their own way through the ice. They have to follow the directions from the icebreakers or from the vessel control stations in order to be escorted in convoys together with other vessels.

This presentation of a method to calculate trafficability for a transport system through the Northern Sea Route by means of the combination of statistics and definitions from the AIRSS developed to a model for average speed etc, is excellent.

The calculations can be of benefit to evaluate the profitability of different transport systems during different times of the year.

In my opinion the Ice Numerals are not indicators of risk of damages on vessels as other factors are more important.

I agree that WMO egg code is the best system to define and describe the ice conditions but not in the perspective of safety and efficacy of ice navigation.

My congratulation to an interesting and important presentation which I am convinced that will meet many interested readers.
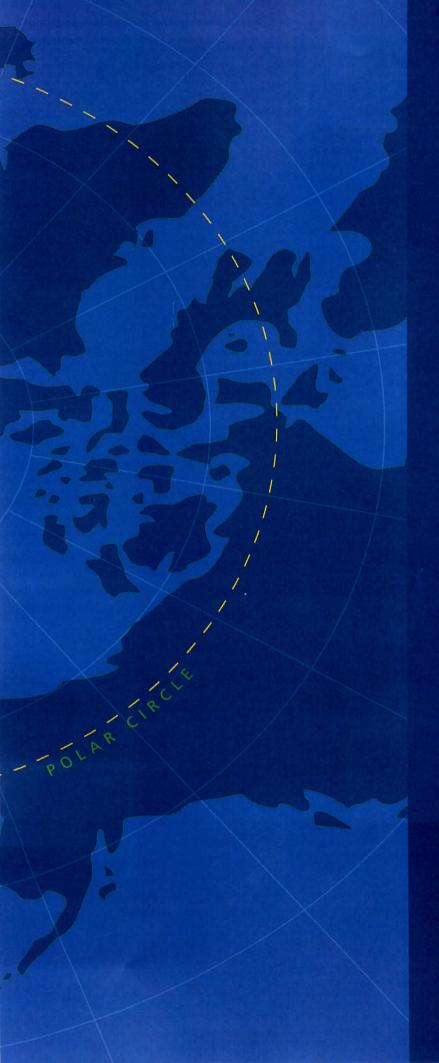
Reply to Captain Backman

I would like to thank Captain Backman for his review of this report and his supportive comments. He has raised a number of good points. Firstly, he emphasizes the importance of ice _information_ in Arctic navigation. High quality satellite imagery is now available, and together with other weather information it can be processed and interpreted on shore, and transmitted in near real time to ships at sea. With experienced Masters, this information greatly assists navigation in ice.

Captain Backman has also added very useful comments concerning regulations for navigation along the Northern Sea Route and how they impact on actual operations. The involvement of icebreaker escort has a significant influence on actual average transit speeds attained by cargo vessels. Escort allows vessels to make faster progress through what might otherwise be impossible ice conditions, but also results in time delays while waiting for arrival of escort icebreakers. He has explained the distinction between a vessel's Ice Class, which is conferred by a State Maritime Administration or Classification Society, and the non compulsory aid of an Ice Passport.

Again, thanks to Captain Backman for his clarifying comments.

Robert Frederking
12 March 1999

POLAR CIRCLE

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 Nippon 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.