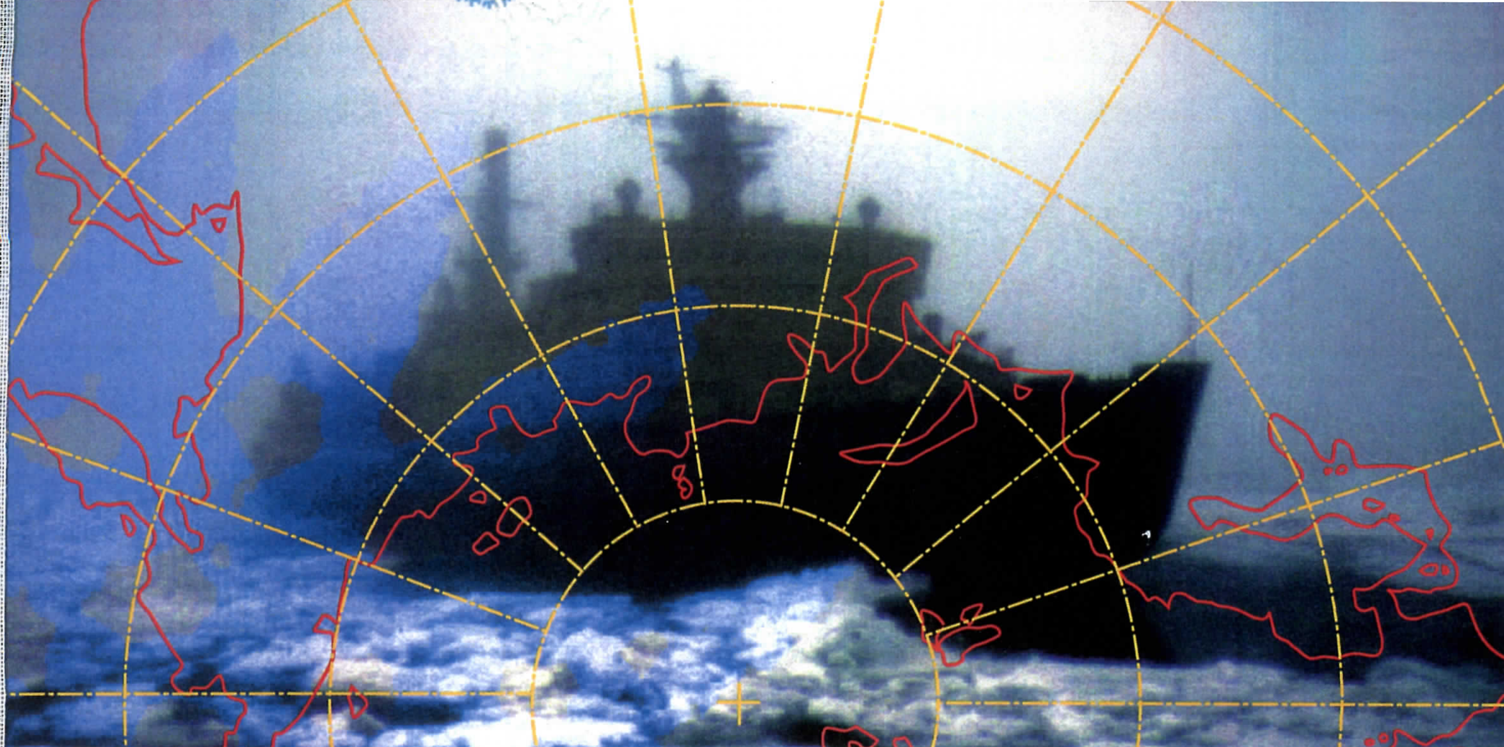

INSROP WORKING PAPER
NO. 68 - 1996, I.4.1

Content of Database.

By V.Vasilyev, L.Tsoy, Y.Glebko, L.Timofeeva, S.Brestkin, A.Buzuyev, Y.Gorbunov, S.Nikolayev, V.Porubayev, K.Teitelbaum, S.Frolov et.al.

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship & Ocean Foundation, Japan

INSROP WORKING PAPER NO. 68-1996

Sub-programme I: Natural Conditions and Ice Navigation

Project I.4.1: Content of Database

Supervisors: Alexander Baskin, Loly Tsoy and Sergey Brestkin

Title: **Content of Database**

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Date: 6 November 1996

Reviewed by: Dr. Robert Frederking, National Research Council of Canada, Ottawa, Canada.

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

FOREWORD - INSROP WORKING PAPER

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

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

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

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

SPONSORS FOR INSROP

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

PROFESSIONAL ORGANISATIONS PERMANENTLY ATTACHED TO INSROP

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

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PART I

Database on technical and operational characteristics and ice performance of prospective icebreakers and icebreaking cargo ships for the Arctic

I.4.1.1 Database on technical and operational characteristics and ice performance of promising icebreakers and icebreaking cargo ships for the Arctic

KEY PERSONNEL

Dr. Loly G.Tsoy, head of laboratory, CNIIMF
Dipl.eng. Yuri V.Glebko, scientist, CNIIMF
Dipl.eng. Ludmila A.Timofeeva, scientist, CNIIMF

SUMMARY

Structure of the information database on technical and operational characteristics and ice performance of perspective icebreakers and icebreaking cargo ships for the Arctic was developed. This structure is convenient for use in personal computers as a part of mathematical models to solve practical problems of the operation of ships navigating along the NSR.

Basic data were prepared on the characteristics of icebreakers and future large tankers, gas-carriers, container-carriers and dry cargo vessels of arctic navigation for subsequent loading into the database to be developed within GIS (ARCInfo). Transport vessels are presented as versions of ships of the active ice navigation and ships designed for the navigation under the escort of icebreakers. Number of ships included in the database:

- icebreakers - 3
- multipurpose ships - 4
- tanker ships - 7
- gas-carriers - 4
- container-carriers - 3
- heavy cargo ships - 2.

The information presented is similar to that developed earlier in 1993 - 1995 for existing Russian icebreakers and cargo vessels of arctic navigation. Data bases are arranged in files of the DBASE III PLUS structure.

Minimum required hardware and software to run the database:

- IBM PC type personal computer with a base memory size of at least 640 KB,
- MS-DOS operating system, version 3.3 and over,
- availability of 4 MB free space on a hard disk.

Information about ships is collected in the following information blocks:

- SP01.dbf - general data on ship (principal dimensions, displacement, power of the propulsion plant etc.),
- SP02.dbf - structural data on hull,
- SP021.dbf - information on ice properties,
- SP03.dbf - technical characteristics of the propulsion plant,
- SP04.dbf - technical and operational data.

Data base parameters

IDEN - TIFIER	FORMAT N - num., C - sys., D - date	PARAMETER NAME	FILE NAMES
mns	N 6	1.1. Identification number of vessel	SP01
ost	N 5	Basic type	SP01
slk	C 3	Ice category	SP01
snp	C 1	Subdivision marks	SP01
sav	C3	Automation marks	SP01
rgw	C 6	1.20. Gross tonnage, r.t	SP01
rgn	C 6	1.21. Net tonnage, r.t	SP01
dpz	C 6	1.24.Deadweight, t	SP01
lmx	C 6	2.1. Overall length, m	SP02
bmx	C 5	2.3. Extreme breadth, m	SP02
hbo	C 5	2.4. Depth, m	SP02
olm	C 5	2.6. Summer draft, m	SP02
gfu	C 6	2.14. Displacement at summer draft, t	SP02
gpo	C 6	2.15. Light displacement, t	SP02
lkwl	C 6	21.1 Length on DLW, m	SP02L
bkwl	C 5	21.2 Breadth on DLW, m	SP02L
oar	C 5	21.3 Draft, arctic water, m	SP02L
gar	C 6	21.4 Displacement at arctic draft, t	SP02L
pwo	C 5	21.7 Shaft power, total, kW	SP02L
rpw	C 7	Power distribution on shafts	SP02L
tgws	C 4	21.8 Propeller thrust, center	SP02L
tgwb	C 4	21.8 Propeller thrust, side	SP02L
tgwo	C 4	21.8 Propeller thrust, total	SP02L
dgwo	C 4	21.9 Propeller diameter, m	SP02L
unf	C 3	21.10 Bow rake, deg	SP02L
uns	C 3	21.11 Entrance angle of DLW, deg	SP02L
nbm	C 3	21.13 Side slope at midships, deg.	SP02L
kop	C 3	21.14 Block coefficient	SP02L
urnp	C 3	21.15 Section flare angle at F.P, deg	SP02L
ur2t	C 3	Section flare angle at sec. No.2	SP02L
urms	C 3	Section flare angle at midships	SP02L
tsu	N 1	3.1. Type of propulsion plant	SP03
pdk	C 5	Power of M.E.1, kW	SP03
mgd1	C 5	Power of propulsion motors 2, kW	SP03
tdg	C 36	3.15. Propeller type	SP03
kgw	C 1	3.16. Number of propeller	SP03
net	C 6	4.1. Net capacity, t	SP04
ogs	C 5	4.3. Load draft, m	SP04
oss	C 5	4.4. Specification draft, m	SP04
gsp	C 6	4.5. Net capacity specification, t	SP04
kbt	N2	4.6. Number of ballast tanks	SP04
gbt	C6	Capacity of all ballast tanks,cu.m	SP04
kom	C 3	4.8. Crew size	SP04
vgr	C 4	4.10. Speed loaded	SP04
vbl	C 4	Speed in ballast	SP04
avp	N3	4.13. Stores-based endurancy	SP04
dals	C 5	4.25. Operating range, n.mil, specification	SP04
lu1	C5	4.26.Ice passability	SP04
nss	C 2	7.8. Set service life	SP07

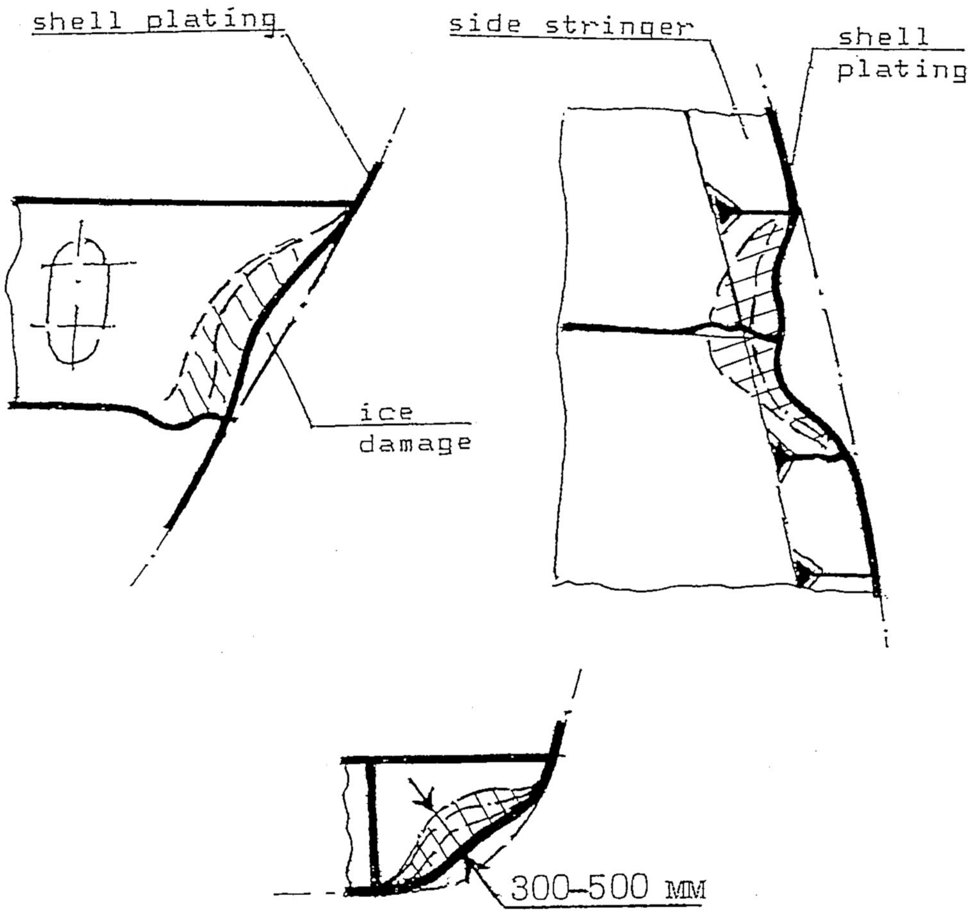

Fig. 7-2. Ice damage to the plate hull construction

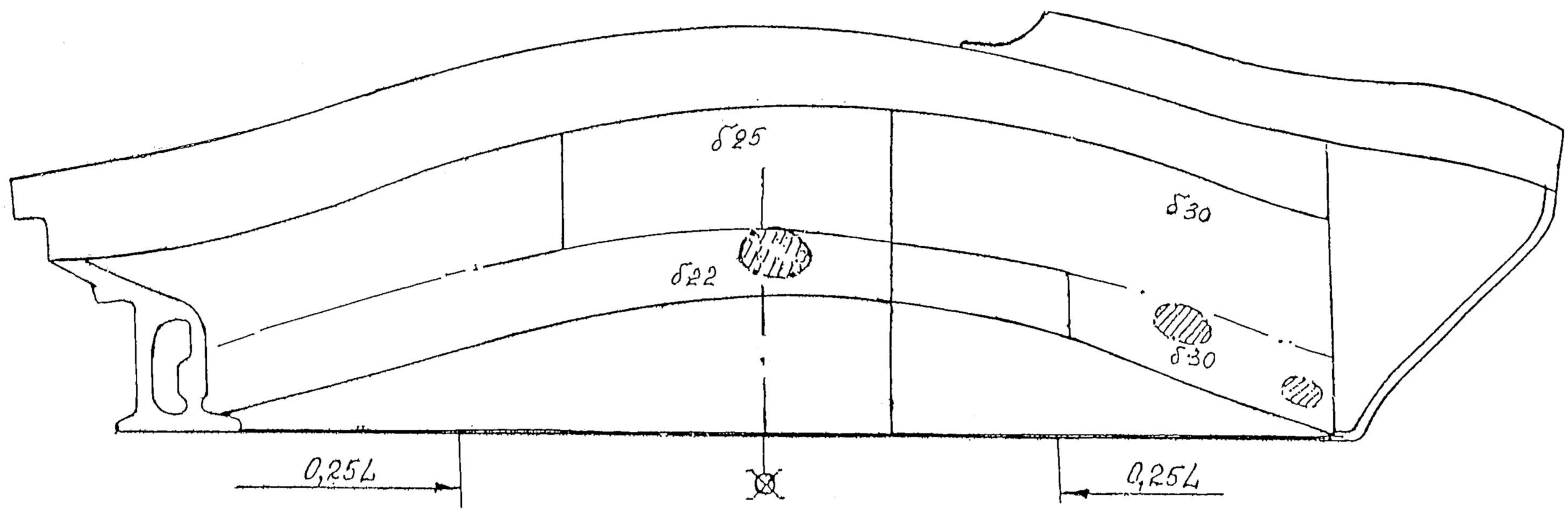

Fig. 7-3. Location of hull ice damage to m/s "Vitus Bering"

PART II

1.4.1.2 "Development of the base of cartography data in the form of electronic catalogue of charts"

Key personnel:

Vladimir Vasilyev, Sergey Samonenko, Vladimir Isakov

Summary:

The data on charts, issued by Head Department of Navigation and Oceanography of the Ministry of Defense and opened for international usage is presented as an electronic catalogue of charts.

Keywords: database, catalogue, chart.

THE ELECTRONIC CATALOGUE OF CHARTS

INTRODUCTION

Since the commencement of the work on cartographical maintenance of Russia's merchant marine fleet under INSROP significant progress has been made, and the details have been recorded in the respective annual reports.

The current maintenance system is described below. A general series of sea charts issued in Russia has five parts i.e. parts 1-4 on the various oceans, and part 5 which includes special charts and editions. The items of information on charts are entered in the respective catalogues.

As of January 1 1996 the catalogues contain data on 6465 charts including:

- Arctic ocean (No. 7107) - 666 items
- Atlantic ocean (No. 7207) - 3059 items
- Indian ocean (No. 7307) - 593 items
- Pacific ocean (No. 7407) - 2147 items

Special attention was given to cartographical maintenance of the Arctic region, thus-Catalogue 7107 was the first to be issued.

THE CATALOGUE 7107

Official notification of the Catalogue of charts and books on the Arctic ocean (No.7107) was announced 18.02.1995 in the Notices to mariners, issue 8.

The information in the Catalogue is for **March 12 1994.**

There are significant changes in the Catalogue, chiefly concerning the NSR, in the maintenance of region navigating editions.

The data on Catalogue updatings are published in each fourth issue by HDNO (Head Department of Navigation and Oceanography of Russia's Ministry of Defense).

You can evaluate updatings volume by the following data:

- Total updatings for 1995 - 337, including:
  - Charts - 300
  - Books - 37

Notices to mariners (weekly)No.	Updatings	
	Charts	Books
8	97	7
12	40	8
16	23	-
20	35	-
24	31	-
28	5	2
32	29	1
36	8	-
40	5	-
44	4	16
48	15	3
52	8	-
Total in 1995	300	37

Basic kinds of catalogue updatings:

1. New charts / books - 99/6

2. New editions of the charts / books - 71/44

Basic reasons for reedition:
- occurrence of new cartographical materials;
- too much corrections ;
- edition of bilingual charts (in Russian and English languages).

3. Withdrawal of the charts / books - 43/4
Basic reasons for withdrawal:
- replacement with the new editions;
- termination of the edition .

THE ELECTRONIC CATALOGUE of NAVIGATING Charts for NSR

The plan of the program INSROP stipulated creation of the catalogue of sea navigating charts on NSR on the basis of the personal computer. Such catalogue should contain the necessary information, contained in the official publications.

The development of Catalogue was as follows:

1993 Year - ideology was developed and software of the catalogue created;

1994 Year - the catalogue was filled by data on open charts, according to Catalogue 7007.1 and Addition 7007.1D;

1995 Year - the database of the catalogue was updated in conformity with the announced Catalogue 7107, and extended by incorporating of regions close to the NSR (Frantz-Joseph Land, Novaya Zemlya, etc.).

Updating of the Catalogue was made according to the Notices to mariners. Up to 28 week the Catalogue was complemented by data on 51 charts, and to the end of 1995 - data on a further 48 charts.

Now catalogue contains data on 265 charts, including:
- General (scale 1:2000 000 - 1:500 000) - 39;
- Sailing and plans (scale 1:250 000 - 1:2000) - 226;
- Bilingual (Russian-English) - 44.

By the years of charts issue the charts can be subdivided as follows:
- The oldest chart was issued in 1984;
- Charts, issued till 1992 - 33;
- Charts, issued in 1992 - 8;
- Charts, issued in 1993 - 42;
- Charts, issued in 1994 - 60;
- Charts, issued in 1995 - 122.

In the nearest future it is planned to include in the Electronic catalogue data on charts, ensuring navigation on all seas along the coast of Russia - from Bering Strait up to ports Murmansk and Archangelsk.

The table with data on charts is listed below.

Chart No.	Latitude 1	Longitude 1	Latitude 2	Longitude 2	Scale	Date issue
695	69°20.00N	54°20.00E	71°13.00N	62°30.00E	1:250000	8/04/1990
697	72°50.00N	56°00.00E	77°30.00N	81°00.00E	1:700000	8/11/1990
698	71°41.00N	78°31.00E	73°35.00N	83°40.00E	1:200000	9/09/1989
945A1	71°22.00N	82°03.00E	72°07.00N	83°50.00E	1:100000	1/01/1991
945A4	69°25.00N	82°50.00E	70°02.00N	85°15.00E	1:100000	1/01/1985
945A5	69°00.00N	84°40.00E	69°51.00N	86°25.00E	1:100000	1/01/1984
945A6	68°12.00N	85°49.00E	69°05.00N	87°02.00E	1:100000	1/01/1990
947	66°15.00N	10°00.00E	77°00.00N	59°00.00E	1:2000000	1/01/1990
948	73°30.00N	80°00.00E	78°52.00N	96°40.00E	1:700000	4/06/1991
949	75°52.00N	95°40.00E	79°26.00N	118°20.00E	1:700000	4/06/1991
951	70°40.00N	113°44.00E	76°50.00N	130°50.00E	1:700000	3/09/1991
952	70°40.00N	129°50.00E	75°30.00N	152°30.00E	1:700000	3/09/1991
953	72°16.00N	138°50.00E	75°00.00N	152°05.00E	1:500000	5/04/1991
954	69°20.00N	150°50.00E	74°29.00N	173°30.00E	1:700000	3/09/1991
955	66°50.00N	180°00.00W	72°30.00N	165°20.00W	1:700000	3/09/1991
13410	73°05.00N	106°03.00E	73°45.00N	109°18.00E	1:100000	1/01/1995
13420	72°50.00N	127°46.00E	73°31.00N	130°58.00E	1:100000	1/01/1995
13421	72°00.00N	128°38.00E	72°58.00N	131°00.00E	1:100000	1/01/1995
14403	71°21.00N	150°16.00E	71°44.00N	152°35.00E	1:100000	1/01/1995
15383	71°43.50N	82°28.00E	71°59.50N	83°37.50E	1:50000	1/01/1995
15386	70°41.50N	82°54.50E	71°03.90N	83°45.40E	1:50000	1/01/1995
15395A	67°48.25N	86°16.50E	68°14.40N	86°40.10E	1:50000	1/01/1995
16442	69°44.70N	172°43.30E	70°03.00N	173°56.50E	1:50000	1/01/1995
11114	68°00.00N	32°00.00E	73°16.00N	43°46.00E	1:500000	5/29/1993
11115	68°00.00N	43°00.00E	73°16.00N	54°56.00E	1:500000	11/20/1993
11116	72°50.00N	40°00.00E	75°56.00N	56°00.00E	1:500000	1/08/1994
11117	72°50.00N	25°00.00E	76°00.00N	41°00.00E	1:500000	1/01/1995
11118	75°30.00N	32°00.00E	79°00.00N	44°00.00E	1:500000	1/01/1995
11119	75°30.00N	43°10.00E	79°00.00N	55°00.00E	1:500000	12/01/1994
11123	76°52.00N	46°00.00E	80°15.00N	70°00.00E	1:500000	1/01/1994
11124	75°20.00N	68°10.00E	78°02.00N	84°15.00E	1:500000	1/01/1995
11126	71°40.00N	55°00.00E	75°00.00N	71°00.00E	1:500000	1/01/1995

11126	71°40.00N	55°00.00E	75°00.00N	71°00.00E	1:500000	1/01/1995
11127	72°50.00N	68°00.00E	75°28.00N	81°00.00E	1:500000	8/21/1993
11132	73°30.00N	78°45.00E	76°03.00N	91°45.00E	1:500000	1/01/1995
11134	78°00.00N	78°40.00E	82°00.00N	96°20.00E	1:500000	1/15/1994
11135	78°10.00N	95°00.00E	81°45.00N	119°50.00E	1:500000	1/15/1994
11136	76°25.00N	96°25.00E	79°43.00N	108°10.00E	1:500000	9/03/1994
11137	75°44.00N	104°10.00E	78°22.00N	120°16.00E	1:500000	10/01/1994
11138	73°00.00N	110°20.00E	76°25.00N	120°00.00E	1:500000	9/03/1994
11140	70°30.00N	128°10.00E	73°30.00N	141°15.00E	1:500000	1/01/1995
11141	72°50.00N	128°20.00E	75°27.00N	141°30.00E	1:500000	6/11/1994
11142	72°30.00N	117°50.00E	75°10.00N	131°00.00E	1:500000	3/05/1994
11143	74°38.00N	128°34.00E	77°00.00N	141°44.00E	1:500000	1/01/1995
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11149	68°46.00N	167°10.00E	71°40.00N	178°50.00E	1:500000	1/01/1995
11150	67°45.00N	180°00.00W	71°46.00N	175°15.00W	1:500000	12/25/1993
11151	65°25.00N	175°56.00W	69°52.00N	167°30.00W	1:500000	3/05/1994
11152	68°38.00N	176°13.00W	71°33.00N	164°35.00W	1:500000	3/05/1994
11154	71°03.00N	167°40.00E	73°38.00N	179°20.00E	1:100000	1/01/1994
11155	72°40.00N	158°55.00E	76°10.00N	168°30.00E	1:500000	11/13/1993
11156	73°32.00N	167°00.00E	76°04.00N	180°00.00E	1:500000	1/01/1995
11158	71°12.00N	171°00.00W	74°58.00N	161°20.00W	1:500000	1/01/1995
11163	70°50.00N	40°30.00E	77°00.00N	57°00.00E	1:700000	11/20/1993
11164	69°30.00N	53°30.00E	73°30.00N	71°00.00E	1:750000	11/20/1993
12003	67°39.00N	39°43.00E	68°54.00N	44°20.00E	1:200000	1/01/1995
12016	68°31.00N	56°24.00E	69°44.00N	61°03.00E	1:200000	3/26/1994
12212	79°36.00N	59°50.00E	81°12.00N	66°55.00E	1:200000	1/01/1994
12216	80°05.00N	51°10.00E	81°13.00N	60°50.00E	1:200000	1/01/1994
12305	70°18.00N	56°20.00E	71°25.00N	61°00.00E	1:200000	1/01/1995
12307	69°30.00N	60°50.00E	71°05.00N	64°17.00E	1:200000	1/01/1995
12308	68°23.00N	64°27.00E	69°37.00N	69°07.50E	1:200000	2/04/1993
12309	69°26.00N	64°05.00E	71°00.00N	67°30.00E	1:200000	9/25/1993
12310	70°54.00N	64°00.00E	72°00.00N	68°40.00E	1:200000	4/02/1994
12311	71°50.00N	65°30.00E	73°44.00N	70°10.00E	1:200000	11/20/1994

12312	72°39.00N	68°38.00E	74°00.00N	75°02.00E	1:200000	8/14/1993
12320	70°50.00N	75°00.00E	72°50.00N	79°45.00E	1:200000	1/01/1995
12321	72°15.00N	74°37.00E	73°38.00N	81°03.00E	1:200000	1/01/1995
12327	73°18.00N	79°02.00E	75°03.00N	83°45.00E	1:200000	5/29/1993
12328	73°35.00N	83°06.00E	75°18.00N	87°52.00E	1:200000	4/10/1993
12329	74°49.00N	84°44.00E	76°00.00N	91°10.00E	1:200000	10/23/1993
12330	75°35.00N	86°42.00E	76°42.00N	93°06.00E	1:200000	2/20/1993
12331	75°46.00N	92°30.00E	76°53.00N	98°56.00E	1:200000	12/25/1993
12332	76°02.00N	97°34.00E	77°30.00N	102°18.00E	1:200000	4/24/1993
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12345	76°51.00N	80°12.00E	77°53.00N	86°38.00E	1:200000	9/03/1994
12347	77°30.00N	81°40.00E	78°28.00N	88°08.00E	1:200000	10/23/1994
12348	78°23.00N	82°00.00E	80°10.00N	89°00.00E	1:200000	1/01/1995
12349	77°30.00N	76°40.00E	79°26.00N	83°47.00E	1:200000	4/23/1994
12400	76°27.00N	104°05.00E	77°52.00N	108°50.00E	1:200000	1/01/1995
12401	76°21.00N	108°06.00E	77°47.00N	112°50.00E	1:200000	4/30/1994
12402	75°53.00N	111°50.00E	77°22.00N	116°30.00E	1:200000	4/23/1994
12405	73°25.00N	112°45.00E	74°42.00N	119°10.00E	1:200000	4/30/1994
12407	73°08.00N	124°24.00E	74°54.00N	129°08.00E	1:200000	1/01/1995
12408	74°10.00N	128°50.00E	75°50.00N	133°30.00E	1:200000	10/08/1994
12409	72°25.00N	128°50.00E	74°15.00N	133°31.00E	1:200000	1/01/1995
12410	70°45.90N	128°28.00E	72°40.90N	133°11.00E	1:200000	7/09/1994
12411	71°18.00N	132°37.00E	73°15.00N	137°20.00E	1:200000	3/12/1994

12412	71°06.00N	136°43.00E	73°04.00N	141°25.00E	1:200000	3/05/1994
12413	72°41.00N	133°00.00E	74°15.00N	140°45.00E	1:200000	8/02/1995
12414	74°10.00N	132°54.00E	75°25.00N	139°20.00E	1:200000	1/01/1995
12415	75°20.00N	132°47.00E	76°30.00N	139°12.00E	1:200000	1/01/1995
12416	75°45.90N	138°25.30E	76°53.90N	144°50.50E	1:200000	1/01/1995
12419	74°31.00N	145°00.00E	75°44.00N	151°25.00E	1:200000	1/01/1995
12420	73°43.00N	138°35.00E	75°00.00N	145°08.00E	1:200000	1/01/1995
12423	70°48.00N	149°00.00E	72°49.00N	153°44.00E	1:200000	8/02/1995
12424	70°47.50N	153°11.00E	72°48.50N	157°54.00E	1:200000	7/03/1993
12425	70°32.00N	156°20.00E	72°03.00N	162°44.00E	1:200000	1/01/1995
12426	69°20.00N	159°35.00E	71°29.00N	164°22.00E	1:200000	8/02/1995
12427	69°20.00N	163°47.00E	71°29.00N	168°34.00E	1:200000	9/25/1993
12428	68°41.00N	167°58.00E	70°55.00N	172°46.00E	1:200000	1/01/1995
12429	69°17.00N	172°19.00E	70°54.00N	178°49.00E	1:200000	1/01/1995
12430	70°18.00N	180°00.00W	71°50.00N	176°15.00W	1:200000	1/01/1995
12431	68°12.00N	180°00.00W	70°27.00N	177°16.00W	1:200000	1/05/1995
12432	66°25.00N	177°40.00W	68°52.00N	173°00.00W	1:200000	1/01/1995
12433	65°50.00N	173°45.00W	68°20.00N	169°00.00W	1:200000	7/03/1993
12434	68°15.00N	178°27.00W	69°58.00N	171°53.00W	1:200000	1/05/1995
12435	68°11.00N	172°40.00W	69°53.00N	166°10.00W	1:200000	1/05/1995
12436	69°37.00N	172°20.00W	71°11.00N	165°55.00W	1:200000	1/05/1995
12437	69°52.00N	178°00.00W	71°24.00N	171°30.00W	1:200000	1/01/1995
12438	71°21.00N	178°00.00W	72°38.00N	171°30.00W	1:200000	1/01/1995
13314	70°11.80N	56°45.00E	70°46.00N	59°05.00E	1:100000	1/15/1994
13317	69°38.00N	61°04.00E	70°13.00N	63°25.00E	1:100000	4/10/1993
13329	72°06.50N	72°02.00E	72°49.00N	75°15.00E	1:100000	5/29/1993
13330	71°25.00N	71°48.00E	72°10.50N	75°03.00E	1:100000	11/20/1993
13331	70°56.00N	71°40.00E	71°31.00N	74°05.00E	1:100000	11/06/1993
13332	70°25.00N	72°13.00E	71°01.00N	74°40.00E	1:100000	9/30/1993
13333	69°51.20N	72°00.00E	70°27.70N	74°27.00E	1:100000	10/30/1993
13334	69°02.40N	72°20.00E	69°54.00N	74°08.00E	1:100000	11/06/1993
13335	68°29.00N	72°22.00E	69°08.20N	74°48.00E	1:100000	1/01/1995
13336	67°53.50N	72°34.00E	68°33.50N	75°00.00E	1:100000	1/01/1995

13337	68°36.40N	74°10.00E	69°15.20N	76°36.00E	1:100000	1/01/1995
13341	73°00.00N	74°08.00E	73°40.00N	77°20.00E	1:100000	1/15/1994
13344	70°53.00N	75°12.00E	71°39.00N	78°28.00E	1:100000	10/16/1993
13346	72°16.50N	76°48.00E	72°58.50N	80°00.00E	1:100000	1/01/1995
13347	72°16.00N	79°06.00E	73°13.50N	81°26.00E	1:100000	1/01/1995
13352	70°40.00N	82°00.00E	71°27.00N	83°45.00E	1:100000	1/01/1994
13353	69°57.00N	82°15.00E	70°46.00N	84°00.00E	1:100000	1/01/1995
13402	76°27.30N	106°32.00E	77°00.00N	108°03.00E	1:100000	8/02/1995
13427	71°20.00N	136°25.00E	72°20.00N	138°46.00E	1:100000	1/01/1995
13428	71°23.00N	138°10.00E	72°21.80N	140°29.80E	1:100000	1/01/1995
13432	74°13.00N	137°56.00E	74°50.00N	141°08.00E	1:100000	5/29/1993
14240	80°17.40N	44°54.00E	80°52.00N	49°43.00E	1:100000	1/01/1994
14248	80°30.00N	61°04.00E	81°15.40N	64°34.00E	1:100000	8/02/1995
14307	76°02.00N	93°40.00E	76°35.00N	96°52.00E	1:100000	1/01/1995
14309	76°49.00N	94°47.00N	77°20.50N	98°00.00E	1:100000	1/01/1995
14314	77°22.00N	101°13.00E	77°52.00N	104°26.00E	1:100000	4/23/1994
14316	77°45.50N	100°01.00E	78°15.00N	103°14.00E	1:100000	4/09/1994
14327	77°15.00N	80°10.00E	77°45.50N	83°23.50E	1:100000	1/01/1995
14328	76°56.00N	88°03.00E	77°27.00N	91°16.00E	1:100000	1/01/1995
14344	77°50.50N	105°48.00E	78°30.00N	108°10.00E	1:100000	1/01/1995
14400	72°10.00N	146°02.00E	73°07.00N	148°23.00E	1:100000	1/01/1995
14402	71°28.00N	148°56.00E	72°00.00N	151°15.00E	1:100000	1/01/1995
14427	68°52.00N	178°47.00E	69°41.00N	180°00.00E	1:100000	10/09/1993
14427	68°52.00N	180°00.00W	69°41.00N	179°29.00W	1:100000	10/09/1993
14433	66°49.00N	173°57.00W	67°28.00N	171°38.00W	1:100000	7/03/1993
14434	66°20.00N	172°00.00W	67°15.00N	170°20.00W	1:100000	10/09/1993
14453	71°23.00N	180°00.00W	72°07.00N	177°21.00W	1:100000	1/08/1994
15030	69°32.00N	59°56.00E	69°56.00N	60°47.50E	1:50000	9/25/1993
15031	69°21.50N	59°20.00E	69°40.00N	60°37.00E	1:50000	5/29/1993
15093	68°53.00N	58°50.00E	69°11.25N	60°00.00E	1:50000	1/01/1995
15095	68°43.50N	60°17.00E	69°08.70N	61°08.00E	1:50000	1/01/1995
15318	70°47.00N	66°04.00E	71°12.00N	67°04.00E	1:50000	11/20/1993
15320	72°55.50N	69°05.50E	73°20.50N	70°09.00E	1:50000	1/08/1994

15321	72°49.50N	69°27.00E	73°08.00N	70°52.00E	1:50000	1/01/1995
15322	72°48.00N	70°48.00E	73°13.00N	71°51.00E	1:50000	2/12/1994
15323	71°10.00N	66°10.00E	71°28.20N	67°28.00E	1:50000	1/01/1995
15324	71°19.40N	66°56.40E	71°37.80N	68°15.00E	1:50000	1/01/1995
15335	68°19.00N	73°20.70E	68°37.40N	74°29.00E	1:50000	2/12/1994
15351	70°14.40N	82°40.00E	70°27.00N	83°07.50E	1:25000	1/01/1995
15352	70°06.00N	82°20.00E	70°15.20N	82°57.00E	1:25000	5/29/1993
15353	69°54.30N	82°48.00E	70°07.00N	83°14.36E	1:25000	8/02/1995
15365	72°48.50N	74°37.00E	73°14.00N	75°41.00E	1:5000	1/01/1995
15366	72°28.00N	75°12.00E	72°53.00N	76°14.00E	1:50000	1/01/1995
15367	72°08.00N	75°22.00E	72°33.00N	76°23.00E	1:50000	1/01/1995
15368	71°51.50N	75°08.50E	72°10.00N	76°30.00E	1:50000	1/01/1995
15369	71°35.00N	75°08.00E	71°53.50N	76°28.00E	1:50000	1/01/1995
15370	71°10.00N	75°12.00E	71°37.00N	76°17.00E	1:50000	8/02/1995
15371	71°10.00N	76°09.00E	71°35.30N	77°06.00E	1:50000	1/01/1995
15373	70°52.50N	77°51.50E	71°11.00N	78°28.50E	1:50000	1/01/1995
15378	73°17.00N	79°40.50E	73°42.20N	80°45.50E	1:50000	1/01/1995
15385	71°01.90N	82°37.50E	71°24.40N	83°28.50E	1:50000	1/01/1995
15387	70°17.70N	82°58.50E	70°42.50N	83°49.50E	1:50000	1/01/1995
15389	69°41.00N	83°14.50E	70°05.00N	84°05.00E	1:50000	5/29/1993
15391	69°34.70N	84°41.00E	69°52.50N	85°50.50E	1:50000	1/01/1995
15392	69°16.70N	85°20.90E	69°41.20N	86°12.00E	1:50000	1/01/1995
15393	68°57.30N	85°32.50E	69°22.10N	86°23.50E	1:50000	1/01/1995
15394	68°12.50N	85°47.50E	69°01.00N	86°41.00E	1:50000	1/01/1995
15430	74°28.50N	111°45.00E	74°47.00N	113°20.00E	1:50000	4/09/1994
15448	73°12.40N	113°05.00E	73°40.20N	114°15.00E	1:50000	1/01/1995
15467	71°23.00N	128°45.00E	71°45.50N	130°21.00E	1:50000	1/01/1995
15476	71°30.50N	136°11.00E	71°48.90N	137°30.00E	1:50000	3/05/1994
15477	71°34.90N	137°25.60E	71°59.80N	138°24.00E	1:50000	1/01/1995
16244	80°26.75N	56°26.00E	80°45.25N	59°00.00E	1:50000	8/02/1995
16313	75°14.10N	87°49.50E	75°38.10N	89°00.00E	1:50000	1/01/1995
16326	76°03.00N	95°40.00E	76°21.00N	97°24.00E	1:50000	4/03/1994
16338	77°29.00N	100°33.00E	77°47.00N	102°31.00E	1:50000	1/01/1995

16348	79°32.00N	92°14.00E	79°50.18N	94°34.00E	1:50000	1/01/1995
16350	79°38.24N	90°03.00E	79°56'36N	92°24.00E	1:50000	8/02/1995
16408	69°00.00N	160°57.00E	69°12.50N	161°22.60E	1:25000	8/02/1995
16410	69°23.60N	160°55.00E	69°32.50N	161°30.60E	1:25000	1/05/1995
16412	69°28.00N	161°18.00E	69°46.00N	162°28.00E	1:50000	3/05/1994
16414	68°28.00N	160°48.00E	68°53.00N	161°38.00E	1:50000	1/01/1995
16420	71°23.00N	150°40.00E	71°47.20N	151°38.50E	1:50000	4/30/1994
16421	71°11.00N	151°20.00E	71°29.50N	152°38.00E	1:50000	3/05/1994
16422	70°48.00N	151°49.00E	71°13.00N	152°46.00E	1:50000	1/01/1995
18313	69°33.90N	59°58.20E	69°43.20N	60°34.20E	1:25000	1/01/1994
18314	70°24.62N	58°49.00E	70°30.40N	59°16.00E	1:25000	4/13/1992
18315	70°11.67N	58°13.50E	70°20.83N	58°50.50E	1:25000	5/29/1993
18316	69°38.50N	60°22.10E	69°51.00N	60°48.20E	1:25000	2/05/1991
18317	69°48.50N	61°12.08E	69°50.32N	61°15.42E	1:5000	4/26/1989
18318	69°44.30N	61°06.10E	69°53.50N	61°46.00E	1:25000	5/29/1993
18322	69°36.83N	66°34.00E	69°46.00N	66°50.60E	1:25000	1/23/1990
18324	71°03.50N	66°31.00E	71°07.20N	66°46.50E	1:10000	1/08/1994
18325	71°04.90N	66°41.80E	71°06.70N	66°49.50E	1:5000	1/08/1994
18327	73°14.60N	69°45.70E	73°23.73N	70°06.00E	1:25000	1/01/1995
18337	72°47.53N	74°36.00E	73°00.00N	75°07.00E	1:25000	3/12/1992
18373	70°53.30N	78°20.00E	70°58.33N	78°31.30E	1:10000	1/22/1992
18376	73°29.42N	80°25.00E	73°31.27N	80°33.83E	1:5000	5/29/1993
18377	73°28.00N	80°21.25E	73°33.00N	80°34.30E	1:10000	2/19/1994
18378	73°22.00N	80°09.30E	73°34.50N	80°41.80E	1:25000	2/12/1994
18381	72°14.32N	80°42.30E	72°27.06N	81°12.30E	1:25000	1/01/1993
18383	71°47.50N	82°26.50E	72°00.00N	82°56.00E	1:25000	2/12/1994
18387	70°32.10N	83°14.70E	70°42.10N	83°36.70E	1:20000	10/29/1990
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18392	69°18.40N	85°47.00E	69°30.90N	86°12.00E	1:25000	1/22/1991
18393	69°09.50N	85°41.20E	69°22.00N	86°07.00E	1:25000	12/09/1991
18395	67°24.25N	86°28.58E	67°27.90N	86°41.82E	1:10000	8/15/1990
18400	77°39.00N	103°46.00E	77°48.00N	104°45.00E	1:25000	1/01/1995
18402	76°41.00N	110°13.80E	76°50.25N	111°08.00E	1:25000	1/01/1995

18410	74°34.70N	112°45.00E	74°43.80N	113°06.75E	1:25000	1/01/1995
18417	73°07.00N	106°34.00E	73°19.50N	107°09.00E	1:25000	9/15/1989
18418	73°05.00N	106°02.00E	73°19.50N	106°40.00E	1:25000	4/28/1990
18419	72°55.40N	105°51.00E	73°07.90N	106°22.00E	1:25000	6/18/1990
18420	72°51.20N	106°00.00E	73°00.30N	106°42.10E	1:25000	4/27/1984
18421	72°45.00N	105°34.00E	72°57.50N	106°05.00E	1:25000	8/15/1990
18422	72°42.30N	104°56.10E	72°51.40N	105°38.60E	1:25000	4/27/1984
18423	72°34.60N	104°29.00E	72°47.20N	105°00.00E	1:25000	10/15/1990
18424	72°28.70N	104°05.70E	72°38.10N	104°48.00E	1:25000	1/22/1991
18425	72°23.80N	103°37.20E	72°33.20N	104°19.50E	1:25000	6/10/1992
18426	72°20.20N	103°02.00E	72°29.60N	103°44.20E	1:25000	6/16/1992
18427	72°09.50N	102°45.50E	72°22.20N	103°16.00E	1:25000	8/13/1992
18428	71°58.50N	102°25.50E	72°11.20N	102°55.50E	1:25000	12/14/1992
18429	71°47.30N	102°03.50E	72°00.00N	102°33.50E	1:25000	12/18/1993
18430	71°35.70N	102°09.60E	71°48.40N	102°39.50E	1:25000	1/08/1994
18431	71°58.50N	102°21.50E	72°02.20N	102°38.00E	1:10000	1/22/1991
18460	72°47.87N	113°10.00E	72°52.80N	113°22.50E	1:10000	5/29/1991
18461	72°51.00N	113°09.00E	73°03.50N	113°40.50E	1:25000	1/22/1992
18462	73°02.00N	113°18.00E	73°14.50N	113°49.50E	1:25000	10/08/1991
18470	71°38.10N	128°51.65E	71°39.10N	128°54.00E	1:2000	1/01/1995
19244	80°35.65N	57°39.00E	80°41.50N	58°36.00E	1:25000	8/02/1995
19305	75°35.50N	90°54.00E	75°44.67N	91°44.20E	1:25000	12/01/1994
19316	78°03.83N	102°17.00E	78°17.00N	103°18.00E	1:25000	4/09/1994
19326	75°51.75N	82°27.50E	75°57.50N	83°05.00E	1:25000	1/01/1995
19327	77°30.00N	82°05.30E	77°33.70N	82°16.00E	1:10000	1/01/1995
19329	79°30.50N	90°29.50E	79°34.10N	90°57.10E	1:10000	1/01/1995
19411	68°44.03N	161°17.58E	68°45.20N	161°22.67E	1:5000	1/01/1995
19412	68°47.20N	161°20.10E	68°47.90N	161°22.80E	1:2000	1/05/1995
19415	68°56.20N	161°29.50E	69°01.20N	161°34.50E	1:10000	1/01/1995
19425	69°16.70N	161°21.15E	69°29.25N	161°47.00E	1:25000	1/01/1995
19426	68°55.65N	161°21.00E	69°19.40N	161°37.50E	1:25000	1/01/1995
19445	68°45.00N	169°18.50E	68°57.60N	169°44.00E	1:25000	3/05/1994
19454	69°39.00N	170°01.50E	69°48.20N	170°37.70E	1:25000	4/23/1994

19456A	69°43.30N	170°25.51E	69°43.95N	170°27.95E	1:2000	1/01/1995
19466	69°26.40N	178°25.50E	69°28.75N	178°36.00E	1:10000	8/02/1995
19471	67°48.00N	176°02.00W	67°53.80N	175°37.80W	1:25000	1/01/1995

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

The Fridjof Nansen Institute, Norway

Ship & Ocean Foundation Japan

INSROP WORKING PAPER

I.4.1, Part III

Content of Database

Volume 3 - 1995 project work

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SUMMARY

The aim of INSROP Project 1.4.1, Part III is comprehensive use of the databases on ice, meteorological and hydrological conditions created at the AARI, for substantiating the possibility, safety and efficiency of international shipping along the NSR in various seasons of the year.

Examination of data available at the AARI, assessment of their volume and quality have shown that the AARI has sufficient information for addressing the goals of the Program. However, only a small portion of the work necessary for arranging this information, can be fulfilled within the framework of the Project.

Under these conditions it was considered advisable to focus on supplementing and adapting the databases available at the AARI and to develop a technology for their use which will allow the probability of favourable and unfavourable conditions of navigation along the Northern Sea Route to be estimated in the first approximation.

It is shown in the Report that an assessment of the probability of various types of navigation conditions can be made based on the available databases within the WMO framework. The obtained probability estimates should be corrected taking into account information on discontinuities in the ice cover and atmospheric pressure, which is contained in the databases of observations from ships of opportunity.

The following work was performed:

1. An approach to employing climatic (review) databases in estimating the probability of encountering ice of different thickness along the ship motion route was developed. It is shown that this objective can be achieved on the basis of the regression analysis and classification of ice thickness distribution depending on navigation difficulty.
2. Technology for taking into account the generalized characteristics of discontinuities in the ice cover when selecting the routes for an escort of ships by icebreakers was evolved. The regions of the probable use of discontinuities along the route for navigation on anomalous early dates were identified. Modal orientation, the specific length, distribution of orientation and distribution of the length of discontinuities were calculated in grid points. It is shown in what way these data can be used for addressing the goals of INSROP. The results of calculating the generalized characteristics of discontinuities in April-June for the Laptev Sea were transferred to the INSROP Secretariat in the form of ASCII files.
3. Technology for the probabilistic assessment of the degree of ice pressures along the NSR based on multiyear data on atmospheric pressure was developed. A computer-based Handbook was prepared and transferred to the INSROP Secretariat. It allows estimates of the probability of varying ice pressures in the NSR region with a temporal resolution of one 10-day period and a spatial resolution of 200 km. The Handbook presents a set of the files with a total volume of 6 Mbytes.

TABLE OF CONTENTS

1. Introduction

As mentioned in 1993 and 1994 Reports, the main aim of the work fulfilled within the framework of INSROP Project 1.4.1, Part III is comprehensive use of the databases on ice, meteorological and hydrological conditions which are created at the AARI for:

- justification of the possibility and perspectives of international shipping along the NSR;
- analysis of efficiency and safety of shipping in different seasons;
- modeling motion of ships through ice.

At the initial stage, the composition of the databases which can be used in the interest of the Program was preliminarily determined, the data available at the AARI were examined and their volume and level of arrangement were evaluated. This allowed a conclusion to be drawn that the AARI has sufficient hydrometeorological information for achieving the Program goals. However, to create all necessary databases requires considerable effort. Only part of this work can be implemented within the framework of the present Project.

The efforts of investigators were largely focused on supplementing and adapting the databases available at the AARI and on developing technologies for their use which allows a rough evaluation of favourable and unfavourable conditions of navigation along the NSR. The following directions of work were selected.

1. Development of technologies for using climatic (review) databases included into the Global Sea-Ice Data Bank in the interest of INSROP. These databases are generally available (for international exchange). They are most complete and contain series of the most important characteristics along the entire NSR for a multiyear period. By using these data, the probability of some conditions or other in the given region and during the given period of the annual cycle, in particular, the probability of the presence of open water, open and close ice and ice of different age categories can be estimated. However, it should be taken into account that when sailing, the easiest route is selected. The ice conditions on the motion route of ships can differ significantly from the conditions averaged by 25x25 km squares which were used for creating the review databases. In addition to the effect of selectivity, the typical differences in the thickness of ice of the same age category in different regions and in different seasons should also be taken into account. Only data of measurements on an opportunity basis (shipborne) can give a true picture. Unfortunately, these data are non-uniform and fragmentary. Sampling based on these data, would be insufficiently representative for probabilistic estimates. However, the use of shipborne observation data allows us to obtain the corresponding functions for transition from the averaged conditions to the conditions on the navigation route.
2. Development of the database on discontinuities in the ice cover. This work aims to take into account data on discontinuities for selecting the optimal motion routes of ships and to evaluate the possibility for extending the navigation period by using discontinuities along the route when navigating on early (in spring) or late (in autumn) dates.
3. Development of the calculated database on the degree of pressures in close ice. The assessment of navigation conditions would be incomplete without taking into account the degree of ice pressures. Data on the actually observed pressures, available at the AARI, are insufficient for probabilistic calculations. However, there are empirical dependencies obtained on the basis of analyzing these

data which could be used for an indirect assessment of the probability of some degree of pressure or other based on multiyear data on atmospheric pressure.

The choice of the work directions under the Project was governed by the following general considerations.

For a rough evaluation of the probability of different types of conditions of transit navigation, the databases available within the framework of WMO can be used. The obtained probabilistic estimates should be corrected taking into account information which is contained in the databases:

- observations from ships of opportunities (taking into account the selectivity of ship motion, differences in the thickness of ice of the same age category);
- on discontinuities in the ice cover (taking into account the possibility for using discontinuities along the route);
- on atmospheric pressure (taking into account the probability of varying pressures in ice).

2. Use of climatic (review) databases for estimating the probability of encountering ice of varying thickness along the motion route of ships

For addressing the INSROP goals, it is necessary to evaluate climatic distribution of the ice thickness on the ship motion route. However, the number of shipborne observations are insufficient for such an evaluation. Hence we have to estimate climatic distribution of ice thickness ranges along the motion route of ships indirectly. The Global Sea-Ice Data Bank contains necessary initial information. The objective is to determine the possibility for transfer from climatic distribution of the occurrence frequency of different ice thickness ranges based on data of the Global Bank, to climatic distribution of different ice thickness ranges on the motion route. It is obvious that the character of the relation between two climatic distributions should not significantly differ from that between ice thickness distributions for specific years. Hence it is sufficient to establish the existence of the relation between ice thickness distributions for specific years.

Let us, for brevity, designate the values of the occurrence frequency of ice thickness ranges obtained from data of the Global Data Bank as data of type I and the values of the occurrence frequency of ice thickness ranges obtained from shipborne data, as data of type II. Data of both types refer to a specific year, month and a 10-day period.

For comparing ice thickness distributions, data of types I and II for May-June 1986 were used. Data of type II are represented by measurements onboard the icebreaker «Arktika» along the route Zhelaniya Cape - Pevek port. The whole route was divided into 82 segments about 25 miles long . For each segment based on data of types I and II, the occurrence frequencies of 6 ice thickness ranges were calculated: 0-10, 10-30, 30-70, 70-120, 120-200 and >200 cm. Two sequences were constructed. The first sequence was based on data of type I: occurrence frequencies within 1 to 6 thickness range for the first segment, within 1 to 6 thickness range for the second segment and so on. The second sequence was constructed in the same way on the basis of data of type II.

The mutual correlation coefficients of these two sequences were calculated using different shifts (lags). At a zero lag, the correlation coefficient characterizes the relation between the values of the occurrence frequency of the same thickness ranges for the same segments, at a lag equal to 1 - the relation between the values of the occurrence frequency of i-ranges based on data of type II and i+1 ranges based on data of type I and at a lag equal to 6 - the relation between the values of the occurrence frequency of the same thickness ranges of the adjacent segments.

Table 1 presents the mutual correlation coefficients for different lags. The significance level of 5% has a corresponding correlation coefficient of 0.15.

Table 1. Mutual correlation coefficients of the sequences of the occurrence frequency of ice thickness ranges.

Lag	Correlation coefficient	Lag	Correlation coefficient
0	**0.24**	10	-0.08
1	**0.35**	11	-0.08
2	-0.24	12	**0.19**
3	-0.14	13	**0.27**
4	-0.10	14	-0.14
5	-0.08	15	-0.14
6	**0.25**	16	-0.06
7	**0.32**	17	-0.08
8	-0.21	18	0.13
9	-0.17	19	**0.22**

The significant correlation coefficients are observed at lags 0 and 1, 6 and 7, 12 and 13, 19. Such a character of change in the correlation coefficients can be explained by the fact that evaluation based on data of type I overestimates the amount of thicker ice, as compared to that based on data of type II This is related to the fact that a ship selects the route in thinner ice.

Table 2 presents the correlation coefficients between the occurrence frequency of separate (specific) thickness ranges.

Table 2. Mutual correlation coefficients of occurrence frequency of separate ice thickness ranges

Ice thickness range		Correlation coefficients, corresponding to a 5% significance level	Correlation coefficient			
type II	type I		lag =0	lag =1	lag = 2	lag = 3
10 - 30	10 - 30	0.25	-0.05	0.15	-0.09	-0.05
10 - 30	30 - 70	0.24	0.05	0.08	0.04	0.02
10 - 30	70 - 120	0.32	-0.10	-0.11	-0.14	-0.08
10 -30	120 -200	0.29	0.21	0.06	0.07	0.02
30 - 70	10 - 30	0.26	0.06	0.08	0.06	**0.27**
30 - 70	30 - 70	0.29	-0.04	0.20	**0.32**	**0.36**
30 - 70	70 - 120	0.37	**0.59**	**0.49**	**0.47**	**0.47**
30 -70	120 - 200	0.35	-0.27	-0.22	-0.10	-0.00
70 - 120	10 - 30	0.27	0.08	0.14	**0.35**	**0.35**
70 - 120	30 - 70	0.28	0.10	**0.28**	0.17	0.15
70 - 120	70 - 120	0.45	**0.66**	**0.62**	**0.51**	**0.44**
70 - 120	120 - 200	0.41	0.07	0.10	0.13	0.15
120 - 200	10 - 30	0.28	-0.18	-0.07	-0.02	-0.16
120 - 200	30 - 70	0.27	-0.05	-0.09	-0.18	-0.17
120 - 200	70 - 120	0.47	-0.35	-0.28	-0.25	-0.23
120 - 200	120 - 200	0.42	0.20	0.18	0.09	0.07

In this case, the lag value characterises the remoteness of the segments under comparison from each other. As is apparent from the table, the relation between the occurrence frequencies of different ice thickness ranges is quite complicated. However, the large values of some correlation coefficients indicate the possibility for deriving the multiple regression equations.

When proceeding to the adjacent segments, the values of the correlation coefficients decrease insignificantly. Hence it follows that it is desirable to increase the scale of data averaging. Table 3 presents the mutual correlation coefficients at a zero lag for the segments 75 miles long.

Table 3 Mutual correlation coefficients of the sequences of data of types I and II for the segments 75 miles long.

Thickness ranges (data of type I)	Thickness ranges (data of type II)				
	10 - 30	30 - 70	70 - 120	120 - 200	>200
10 - 30	0.16	041	0.39	-0.40	-0.33
30 - 70	0.07	0.38	0.29	-0.29	-0.19
70 - 120	-0.21	**0.86**	**0.75**	-0.50	-0.31
120 - 200	0.24	-0.56	-0.27	0.34	0.08
>200	-0.40	-0.47	-0.55	0.51	0.49

The large correlation coefficients (0.86 and 0.75 at a significance level of 0.56) are observed only in two cases. This is not enough for deriving the necessary transfer equations. The best results are achieved when the ranges 10-30 and 30-70, as well as 120-130 and >200 are combined (Table 4).

Table 4 Mutual correlation coefficients between data of types I and II for the segments 75 miles long for three ice thickness ranges

Thickness ranges (data of type I)	Thickness ranges (data of type II)					
	0 - 70		70 - 120		> 120	
	correlation coefficient	a 5% significance level	correlation coefficient	a 5% significance level	correlation coefficient	a 5% significance level
0 - 70	**0.56**	0.43	0.28	0.50	**-0.66**	0.46
70 - 120	0.06	0.48	**0.75**	0.56	**-0.58**	0.54
> 120	-0.40	0.46	**-0.64**	0.58	**0.79**	0.64

Thus at a 75 mile scale of averaging, the equations of transfer for each of the three ice thickness ranges can be obtained. However, for this purpose a large amount of additional work has to be performed, including a significant supplement of the database of shipborne observations.

Let us consider a simplified variant of transfer from data of type I to data of type II. The obtained ice thickness distributions are subdivided into three classes. Let us include distributions where the occurrence frequency of ice less or equal to 70 cm is 50% and more to the first class, distributions where the occurrence frequency of ice thicker than 120 cm is 50% and more to the third class and all other distributions to the second class.

Such a classification characterizes, on average, the influence of the ice thickness on navigation conditions. The ice thickness distributions of the first class can be assumed as easy conditions of navigation, the ice thickness distributions of the second class as average conditions of navigation and the ice thickness distributions of the third class as heavy conditions of navigation.

Table 5 presents the results of comparing ice thickness distributions obtained from data of types I and II for the same segments.

Table 5. The probability of coincidence of ice conditions based on data of type I with ice conditions based on data of type II.

Ice conditions based on data of type I	Ice conditions based on data of type II		
	easy, %	average, %	heavy, %
easy, %	72	14	14
average, %	33	67	0
heavy, %	18	5	77

The Table illustrates the possibility for approximate estimation of some navigation conditions or other. Thus if the Global Bank contains evidence on the conditions belonging to average (Table 5), then the probability for average conditions on the navigation route is 67%, the probability of easy conditions is 33% and the probability of heavy conditions is 0%.

3. Taking into account generalized characteristics of discontinuities in the ice cover for selecting the routes of ship escort by icebreakers.

As shown in the 1994 Report, the period of transit navigation along the NSR can be extended due to spring and late autumn. In spring, navigation can be effected by means of a combined use of the zones of young ice or open water which periodically occur along fast ice boundary, and discontinuities whose direction is close to that of the route of ships. In late autumn the discontinuities can also be used for escort of ships in the zones of remaining close ice.

An assessment of the possibility for using the discontinuities along the route can be based on the databases created at the AARI within the framework of the national program. The 1994 Report contains a brief description of this database (initial information, main generalized characteristics of discontinuities). Let us remind that data which are taken from the charts of discontinuities, are entered to the database, each of the charts being based on processing and generalizing of low resolution satellite images for periods 1 to 5 days. Data from one chart are arbitrarily considered as data of one observation.

Evidence on the number of observations over the spring and autumn seasons, entered to the database, are presented in Table 6.

Table 6. Number of observations of discontinuities in the ice cover in the spring and autumn seasons

Sea	1979	1980		1981		1982		1983	For all years	
	IV-VI	IV-VI	X-XII	IV-VI	X-XII	V-VI	X-XII	IV-VI	IV-VI	X-XII
Laptev	10	11	10	14	6	10	23	10	55	39
East-Siberian	10	12	12	14	4	14	15	12	62	31
Chukchi	5	3	8	11	2	2	12	4	25	22

Kara Sea

1979	1980	1981	1983	1986	1987	1991	1992	1993		For all years	
IV-V	IV-V	IV-V	IV-V	XII	V	IV-V	IV	IV-V	XII	IV-V	XII
11	10	9	11	8	12	5	7	11	4	76	12

The available software allows calculations of generalized characteristics of ice discontinuities by the prescribed periods and grid squares. For the Chukchi, East-Siberian and Laptev Seas the 100x100 km calculation grid constructed at reference meridian 130° E was used. The beginning of the grid coordinates is in 700 km from the North Pole along the X-axis and in 600 km along the Y-axis. The southern direction of reference meridian is assumed to be a positive direction of the X-axis. For the Kara Sea a 50x50 km grid is used which is also constructed at reference meridian 130°. The beginning of the grid coordinates is in 350 km from the North Pole along the X-axis and in 2300 km along the Y-axis.

Information which is contained in the database, was used for calculating the following generalized characteristics.

1. Modal orientation of discontinuities (α_m) is the direction to which the maximum probability density corresponds. For determining α_m, the total length of the segments of discontinuities which are within the range of directions $\alpha_i \pm \Delta\alpha$ («moving range») is calculated. The direction α_i changes successively by 1° from 0° to 180°. At an insignificant number of the segments of discontinuities in the square, it is desirable to assume . $\Delta\alpha$ equal to 15-20°. The direction α_i at which the total length of discontinuities in the «moving range» turns out to be the largest is assumed to be modal. Along with the first mode, the next by value second mode is determined.
2. The specific length of discontinuities (q) characterizes the mean length of discontinuities per unit area.

$$q=L / n\cdot S,$$

where L is the total length of all segments of discontinuities in the square; S is the area of the square; n is the number of observations. This characteristic is the measure of density of discontinuities in the squares and is expressed in m/km^2.
3. Distribution of orientation of discontinuities is governed by their occurrence frequency by the ranges of the direction. The occurrence frequency (p_i) of each range is calculated as a ratio of the total length of the segments of discontinuities L_i whose orientation is within this range, to the total length of all segments in the square.

$$p_i=L_i / L$$

Calculation is performed at the value of 20° ranges from 0° to 180°. The orientation of discontinuities is read out from the positive direction of the X-axis counter-clockwise.

On the basis of the calculated characteristics it is possible to analyze the possibility for using the discontinuities at transit navigation.

Let us delineate in each of the seas the region where it is advisable to use discontinuities for escort of ships in spring. The position of the squares in the Kara Sea is shown in Fig. 1 and in the Laptev, East-Siberian and Chukchi Seas - in Fig. 2.

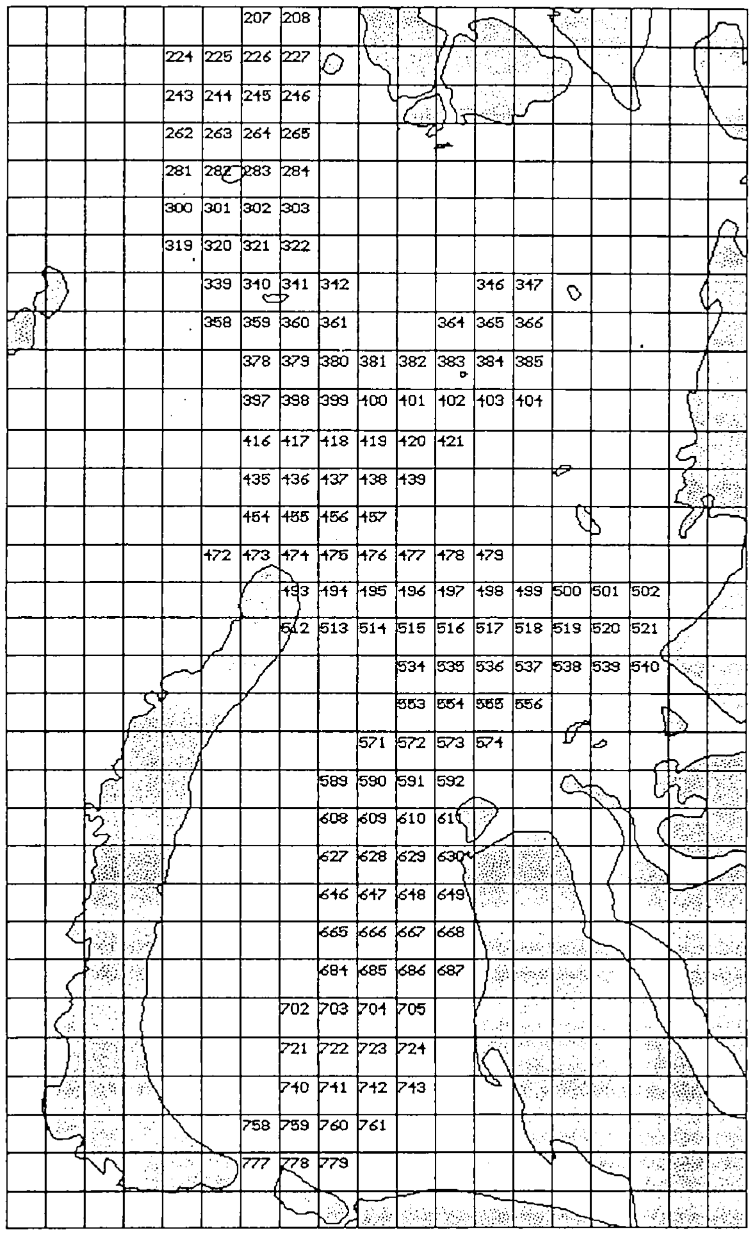

Fig. 1. Numbering of squares of possible navigation of ships in the spring season in the Kara Sea using discontinuities along the route.

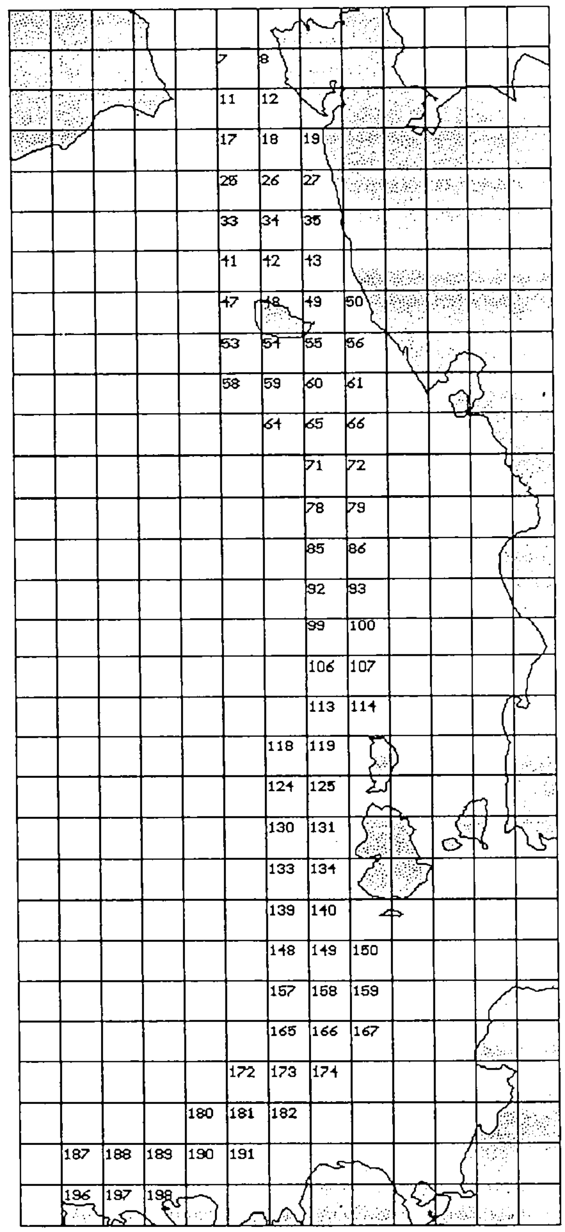

Fig. 2. Numbering of squares in the regions of the routes of possible navigation of ships from Severnaya Zemlya to Bering strait in the spring season using discontinuities along the route.

In the Kara Sea the squares were selected taking into account the following possible variants of navigation:

- from the Zhelaniya Cape using discontinuities, to the north-east to the region of Viese Island, Ushakov Island and further to the Arktichesky Cape exiting to the Laptev Sea (in the absence of flaw zones of young ice and polynyas in the Kara Sea);
- from the Zhelaniya Cape eastward to the region of Kirov Islands, subsequently breaking a channel in fast ice, to Vil'kitsky strait or using a flaw zone of young ice from Kirov Islands to Shmidt Island (in the presence of such a zone);
- from the Zhelaniya Cape to Dikson and further to Vil'kitsky strait, breaking a channel in fast ice;
- Kara Gate - Dikson using discontinuities (in case the Amderminskaya and Yamalskaya flaw zones of young ice are absent) and further to the strait breaking a channel in fast ice.

There is considerable experience of sailing using discontinuities along the routes Zhelaniya Cape-Dikson, Kara Gate-Dikson in springtime.

In the Laptev Sea the squares for two variants of icebreaker's escort of ships along discontinuities are delineated:

- from the Arktichesky Cape toward a relatively stable flaw zone of young ice north of New-Siberian Islands;
- from the region adjoining Vil'kitsky strait from the east toward the same zone.

There is experience of sailing along these routes in the spring season.

In the East-Siberian Sea the squares were selected in the region of a possible icebreaker's escort of ships using a high-latitudinal variant. This route is an alternative of the variant of navigating along the fast ice boundary which is not always possible since a flaw polynya is rarely formed here.

Experience of navigating along a high-latitudinal variant using discontinuities in the East-Siberian Sea is absent. Nevertheless, its possibility for transit navigation of foreign ships along the NSR should not be excluded. Up to a comparatively recent time, there was no experience of the voyages of icebreakers to the North Pole, however, such cruises are successively made to-date.

Basing on our experience, the exit to the Chukchi Sea from the west depending on ice conditions can be by two variants. In the first case, provided there is the Chukchi flaw polynya from the Billings cape to Uellen, navigation is effected along the fast ice boundary. At the western approaches to Long strait its is possible to use discontinuities along the route for exiting to the polynya. In the second case, considering the prevailing direction of the system of discontinuities, the route can pass north of Vrangel Island. Then the route continues to Bering strait using a system of discontinuities.

For determining the regions of the possible escort of ships by icebreakers in the spring season, a modal orientation of discontinuities α_m and the total length of L_m discontinuities whose orientation is within the range $\alpha_m \pm 20°$ were taken into account. Also, stability of the modal orientation of discontinuities over the observation period was taken into account.

The results of calculations of the generalized characteristics of discontinuities in April-June for the Laptev Sea are presented in the form of six ASCII-files (**tbl_1.txt, tbl_2.txt,.., tbl_6.txt**) and are transferred to the INSROP Secretariat along with the Report.

The record of the files **tbl_1.txt** includes the following fields: *No. of the square; latitude of the center of the square (degrees); longitude of the center of the square (degrees).*
The record of the files **tbl_2.txt**, ... **tbl_6.txt** includes the following fields: *No. of the square; year; month; number of observations; specific length (m/km^2); first mode of the orientation of discontinuities (degrees); second mode of the orientation of discontinuities (degrees); the occurrence frequency of the orientation range 0°-20° (%); the occurrence frequency of the orientation range 20°-40°; the occurrence frequency of the orientation range 40°-60°; the occurrence frequency of the orientation range 60°-80°; the occurrence frequency of the orientation range 80°-100°; the occurrence frequency of the orientation range 100°-120°: the occurrence frequency of the orientation range 120°-140°; the occurrence frequency of the orientation range 140°-160°; the occurrence frequency of the orientation range 160°-180°.*

In case the second mode is absent, the corresponding field remains empty.

Let us illustrate the possibility for using results of calculation by the example of data for April 1980 for the Laptev Sea. The values of the characteristics of discontinuities by grid squares are given in Figs.4 and 5. The number of observations a month (Fig. 3) was 4-6 in the main. In the region of navigation the unidirectional orderly systems of discontinuities prevailed. Bi-modal orientation distributions occurred only in some squares in the middle of the region. The length of the segments characterizing modal orientation (Fig. 4), is proportional to the occurrence frequency of discontinuities whose direction is within the range $\alpha_m \pm 20°$.

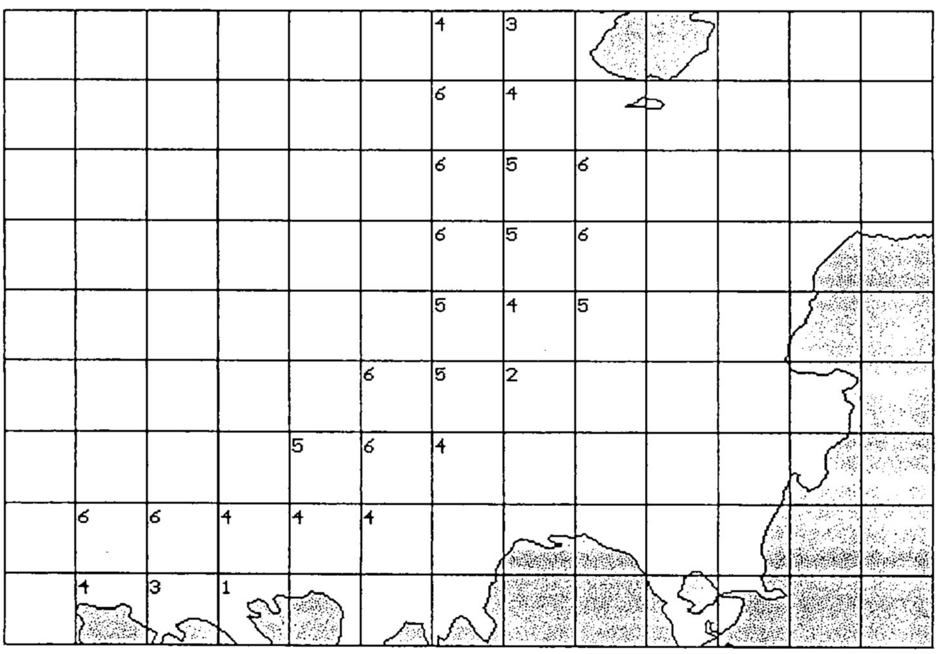

Fig. 3. The number of observations in the region of possible high-latitudinal navigation using discontinuities in the Laptev Sea in April 1980.

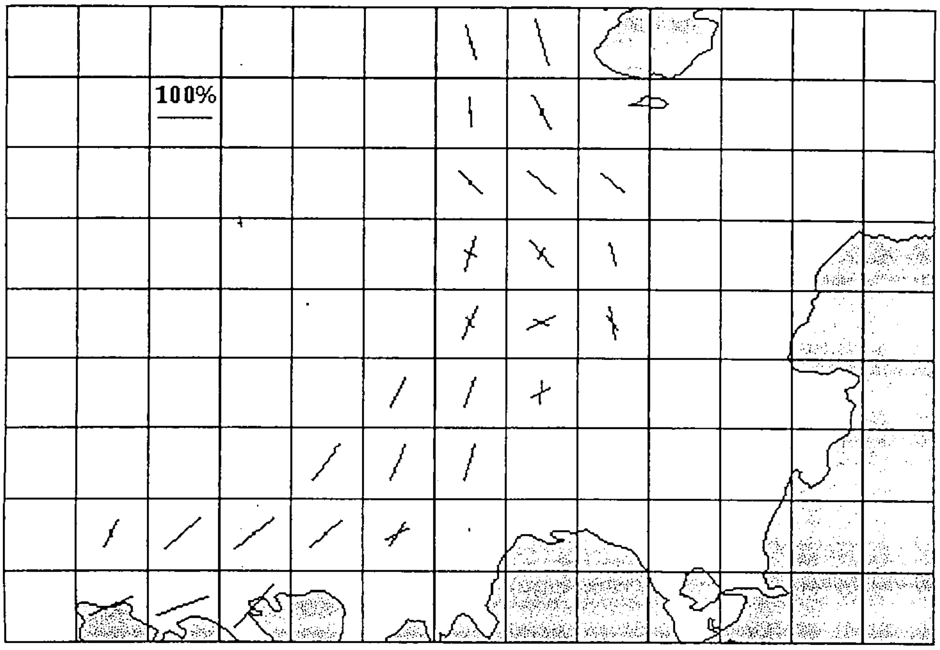

Fig. 4. Modal orientation of discontinuities in the region of possible high-latitudinal navigation in the Laptev Sea in April 1980.

The specific length of discontinuities (Fig. 5) changes within 4 to 34 m/km^2. This is consistent with changes in the total length of discontinuities in the square 100x100 km from 40 to 340 km.

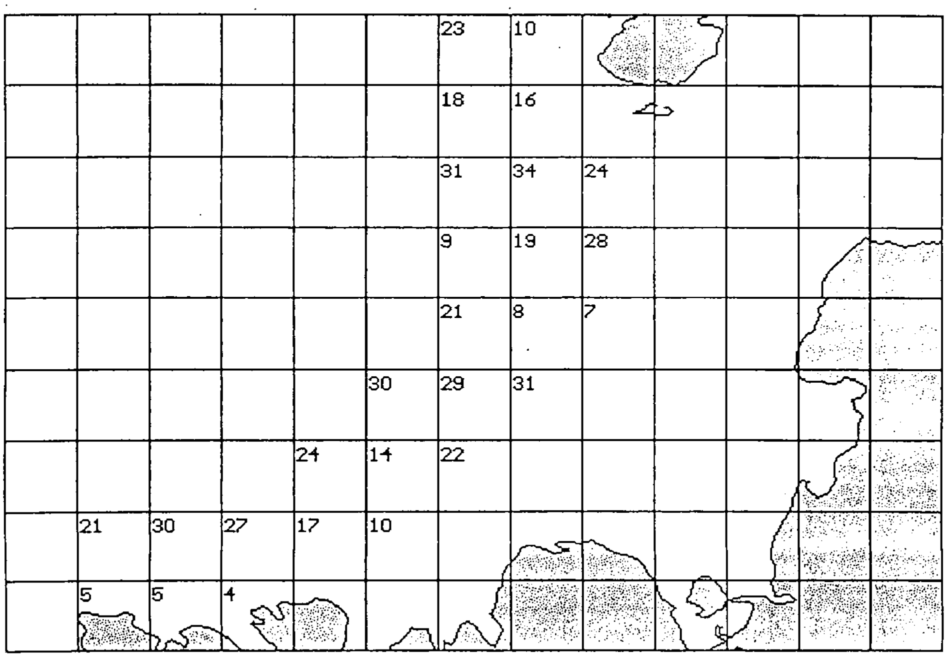

Fig. 5. A specific length of discontinuities in the region of possible high-latitudinal navigation in the Laptev Sea in April 1980.

It is obvious that for escort of ships by icebreakers the possibility for using discontinuities on a separate route segment will be the greater the smaller the difference between the direction of the route α_r and the prevailing direction of discontinuities α_m and also the larger the length of discontinuities L_m of the given direction.

Fig. 6 shows the modal direction of discontinuities α_m by oriented segments whose length is proportional to $L_m = q\ S\ p_m$ where p_m is taken in fractions of 1.

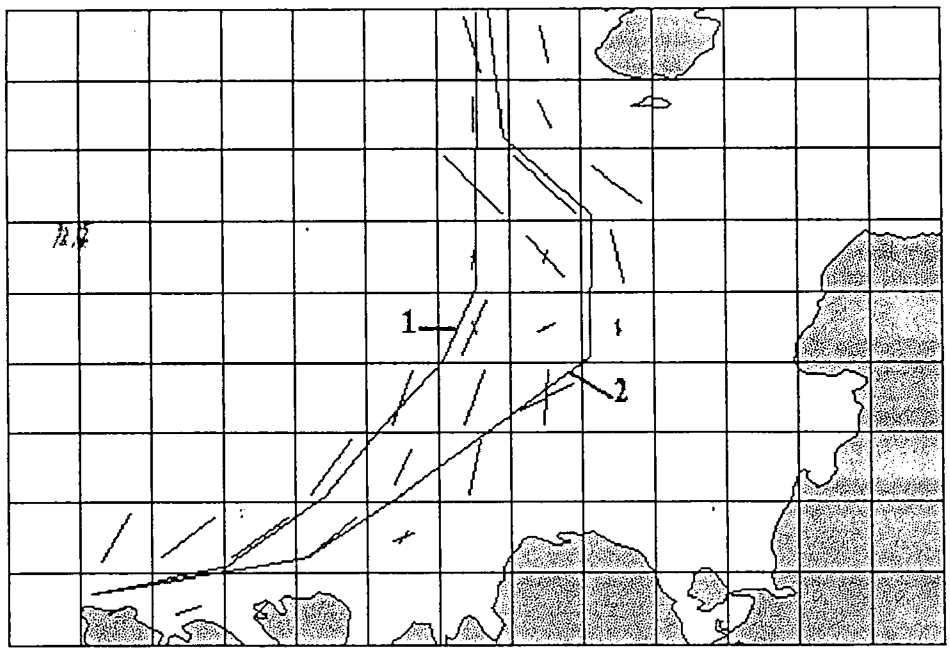

Fig. 6. The routes selected in the Laptev Sea taking into account the characteristics α_m and L_m from April 1980 data.

In the study region two routes are selected taking into account α_m and L_m Let us estimate at which of the variants the most significant effect can be expected.

Let us assume that the discontinuities which deviate from the route direction α_r not more than by some prescribed value $\Delta\alpha$, are «along the route». Their length $L_r = q\ S\ p_r$ where p_r is the occurrence frequency of discontinuities in the range $\alpha_r \pm \Delta\alpha$, is calculated by the distribution of orientation in those squares across which the route passes. The length of the route segment in each of the squares is taken into account.

The sum of the values L_r comprises the total length of discontinuities which deviate from the direction of linear route segments not more than by $\Delta\alpha$. It is obvious that the probability of using the discontinuities along the route is greater , the larger the value of this sum (Table 7).

Table 7 The total length of discontinuities along the routes

Route	Length of the route, km	Length of discontinuities along the route, km	
		$\Delta\alpha = \pm 10°$,	$\Delta\alpha = \pm 20°$
1	1129	597	815
2	1334	462	798

As is seen from table 7, the total length of discontinuities along Route 1 is larger than along Route 2 (at $\Delta\alpha = \pm 10°$ by 135 km and at $\Delta\alpha = \pm 20°$ by 17 km). The length of the first route is 205 km less, as compared to the second one. In the first variant the total length of discontinuities at $\Delta\alpha = \pm 10°$ is equal to 53% of its length and at $\Delta\alpha = \pm 20°$ it is 72%. For the second variant of navigation the total length of discontinuities is 35% and 60%, respectively, of the route length. In other words, from the viewpoint of using discontinuities along the route the conditions of navigation along Route 1 were more favourable as compared to Route 2.

Thus the considered algorithm allows us on the basis of historical data to estimate and compare the possibilities for using discontinuities at different navigation variants and to identify optimal regions and routes for escorting ships by icebreakers along the NSR.

Up to now, we have discussed the characteristics calculated by grid squares based on data of approximately linear segments into which the discontinuities are divided for taking information from the charts constructed on the basis of satellite images. These characteristics provide sufficiently full understanding of the features of spatial distribution of density and orientation of discontinuities in the given region. However, they do not contain information on the length of the actual discontinuities on the whole for the region, although such data are also of interest for evaluating the conditions of ice navigation. For example, based on the specific length values, one cannot predict the possible values of the mean and the maximum length of the route under icebreaker's escort in one discontinuity, as after passing it, it is necessary to use the next discontinuity.

Initial data allow calculating a series of characteristics which provide understanding about the length of discontinuities in the prescribed region.

Table 8 presents evidence on the number of discontinuities of a different length in the region of the high-latitudinal route in the Laptev Sea in April 1980. The length of each discontinuity was calculated by summing up the length of the segments into which it was divided when initial data were taken from the chart. Along with the actual length (f), the length of the segment of the straight line (f*) between the extreme points of the discontinuity, as well as orientation (α_{f*}) of this segment characterizing the resulting orientation of the discontinuity was calculated. Obviously, the ratio

$$k = \frac{\sum_{i=1}^{n} f_i}{\sum_{i=1}^{n} f_i'}$$

can be used as an indicator of winding of discontinuities in the region. Let us call it the winding coefficient.

Table 8 Distribution of the length of discontinuities in the region of possible high-latitudinal navigation in the Laptev Sea in April 1980.

Ranges of the length of discontinuities, km	Number of discontinuities	Total length of discontinuities in the range, km	Occurrence frequency, %
0 - 200	396	19245	38.0
100 - 200	111	15286	30.1
200 - 300	31	7399	14.6
300 - 400	10	3404	6.7
400 - 500	6	2674	5.3
500 - 600	1	520	1.0
600 - 700	2	1264	2.5
700 - 800	0	0	0
800 - 900	0	0	0
900 - 1000	1	929	1.8

As is seen from these data, with the increase in the length of discontinuities, their number rapidly decreases. The discontinuities up to 200 km long, comprise almost 70% of their total length. Hence, mean length of discontinuities is relatively not large.

With respect to navigation, the discontinuities of significant length are most interesting. In the event under consideration, 4 discontinuities more than 500 km long were observed, one of them being 929 km long. Two-three such successively located discontinuities along the route are sufficient for icebreaker's escort of ships in the given region.

Table 9 presents data on the length of discontinuities of different direction which were also obtained on the whole for the entire region. According to these data, the discontinuities are mainly centered in two ranges of directions. In the range 60°±20° the total length of discontinuities is 38% of their total length and in the range 120° ± 20° it is equal to 28%. The discontinuities in the western zone of the region largely belong to the first range and discontinuities in the eastern zone to the second range.

Table 9 Distribution of the length of discontinuities by their resulting directions in the region of possible high-latitudinal navigation in the Laptev Sea in April 1980

Ranges of the resulting direction of discontinuities, degrees	Number of discontinuities	Total length of discontinuities in the range, km	Mean length of discontinuities, km	Occurrence frequency, %
0 - 20	21	1315	63	2.6
20 - 40	43	4353	101	8.6
40 - 60	77	10041	130	19.8
60 - 80	94	9316	99	18.4
80 - 100	84	6116	73	12.0
100 - 120	88	7003	80	13.8
120 - 140	71	7312	103	14.4
140 - 160	59	4108	70	8.1
160 - 180	21	1157	55	2.3

Number of discontinuities recorded in the region	558
Mean length of discontinuity, km	91
Standard deviation, km	93
Winding coefficient	1.07
Resulting direction of all discontinuities, degrees	82

The characteristics under analysis can also be represented by a two-dimensional distribution which gives probabilistic estimates for a varying combination of the length and the direction of discontinuities. Based on this distribution, it was, in particular, found that in the case under consideration, of the four discontinuities more than 500 km long, the direction of the three discontinuities, including the longest one, was within the range 40°-60°. Their total length was 4.1% of the total length of all discontinuities in the region. Along with the enhanced number of discontinuities up to 100 km long in the range of directions from 40° to 140° there is a relatively increased number of discontinuities in the length range 300-400 km at the direction 40°-60° and 400-500 km at the direction 60°-80°.

Mean value of the k coefficient for the region is quite small. The actual length of discontinuities is only 7% greater than the length of the segment of the direct line between the points of the beginning and the end. Hence it follows that no significant increase in the length of the route of ship escort when moving using discontinuities along the route, will take place.

Calculations of statistical characteristics generalized over the regions for different months and years will allow estimates of stability of the systems of discontinuities in the regions of navigation.

Data on the occurrence frequency of the ranges of the orientation of discontinuities, their actual length and winding generalized over monthly periods for all regions of transit navigation can be prepared and transferred to the INSROP Secretariat in the event the work under the Project will be continued. Also, it is advisable to carry out additional studies of the possible extension of the navigation period due to the use of the systems of discontinuities in the zones of remaining ice in late autumn.

4. A probabilistic estimate of the degree of ice pressure along the NSR based on multiyear data on atmospheric pressure

Ice pressure is considered the most dangerous phenomenon for shipping. Wind is the main cause for ice pressures in the Arctic. There are empirical relationships between the degree of pressure and the character of the wind field which take into account the differences in the wind influence in the coastal regions and in open sea areas. Observations of ice pressure were of occasional character. However, using the databases on atmospheric pressure one can calculate the surface wind fields and to estimate from them with sufficient statistical reliability the probability of varying pressures in the given regions over the given time periods.

For achieving this objective the following work was performed.

Based on the data of the US National Center for Atmospheric Research, a data set of surface atmospheric pressure over the Arctic Basin for 1946-1989 containing observations at four standard synoptic times in 2.5°x2.5° grid points, was prepared. This data set was used for calculating the wind fields at a height of 10 m for each of the four times. The methods adopted in Russia, were applied. The calculation results are generalized by 10-day periods of each year and presented in the form of two-dimensional tables containing distribution of wind directions by 8 sectors and wind speeds by ranges 0-5, 6-10, ≥ 11 m/s. For each 10-day period and for each grid point (137 knots) there is a separate table. Such a selection of ranges is governed by the character of the empirical relations used.

The wind depending on the coastline orientation relative to its direction, was subdivided into «on-shore» (90 ± 22°), «off-shore» and «neutral». The coastline orientation was described with a spatial spacing of 50 km.

The two-dimensional tables for the period 1946-1989 are entered to the database which serves as a basis for the computer-based Handbook. The Handbook allows probabilities of varying ice pressures to be calculated for any group of squares and for any sequence of 10-day periods. The calculation method is based on the known understanding of the relation between ice pressure and wind /2, 3, 6/. It is assumed that concentration of the ice cover is 9/10-10/10.

For calculating the probability of ice pressures, the formula of total probability for the groups of incompatible events was used /4/:

$$P_{\rightarrow\leftarrow} = \sum_{k=1}^{n} P(B_k) \cdot \sum_{i=1}^{n} P(B_i) \cdot P\left(A_{ik} / B_{ik}\right)$$

where A and B refer to pressures and wind, respectively; i= 1, 2, 3 - ranges of the wind speed; k= 1, 2, 3 - types of the wind by the character of impact on the ice (on-shore, off-shore, neutral).

The conventional probability $P(A_{ik} / B_{ik})$ is based on shipborne observation data which are in good agreement with data of airborne ice reconnaissance and drifting stations «North Pole» /1, 3/.
The user's interface is based on using the «mouse» and is constructed according to the dialogue principle. The Handbook contains information on the extent of ice pressure in percentage.

Thus within the framework of this section of the Project the following work was performed:

- a set of surface pressure fields over the Arctic Basin at four standard synoptic times for the period 1946-1989 was formed;
- software for calculating the wind fields was evolved;
- the wind fields for the period indicated above, were calculated;
- the two-dimensional tables of wind speed distribution by directions were calculated. They form the basic set of the computer-based Handbook;
- software for subdividing wind into «on-shore», «off-shore» and «neutral» directions was developed;
- the algorithm and software which allow the probability of ice pressure to be calculated in any of the regions prescribed and for any time period (with a minimum time interval - 10 days) were created;
- the user's interface was created.

As a result of the work performed, a computer-based Handbook was prepared for transfer and for use within the next INSROP phase. It allows the probability of the varying degree of ice pressure in the NSR region to be estimated with a resolution in time of one 10-day period and a spatial resolution of 200 km.

The Handbook presents a set of the files with a total volume of 6 Mbytes which were transferred to the INSROP Secretariat:

- **redme** - the instruction for using the handbook;
- **wpepi.exe** - software which allows queries to the database regarding the wind, calculation of ice pressure, output of the obtained results to the monitor screen and other functions;
- **wpepi.par** - parameters required for software ;
- **wind.dat** - the database on wind (two-dimensional tables in a binary form).

It should be noted that the probabilistic characteristics of ice pressure for the winter season can differ from real ones due to not taking into account the orientation of the fast ice boundary which can be non-coincident with the coastline orientation. The entry of data on the fast ice boundaries would significantly increase the total volume of the Handbook and make software more complicated. However, this should be done in the future. It is also desirable for the Handbook to include calculation of the degree of pressure using a hydrodynamic model of the ice cover. The AARI has corresponding publications for this purpose /8, 9/.

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RE: Review of Project I.4.1 Content of Database, Report on 1995 Work

This report presents the third instalment or work on this project. Part 1, from CNIIMF, has added new data to the database on icebreakers and icebreaking cargo vessels. The data are in digital form on diskette (diskette was not supplied). It would be very helpful to the reader if the text of the report gave some indication of the number of vessels added to the database and a bit more explanation. The following section on an electronic catalogue of charts is quite complete and an example of how the section on the icebreaker database should be done.

Part 2 was prepared by AARI and presents the use of meteorological and hydrological databases to (i) estimate the probability of encountering ice of different thicknesses and establish a means for using global ice conditions for predicting ice conditions along a navigation route, (ii) use generalized characteristics of discontinuities (leads) in route selection, and (iii) probabilistic estimate of ice pressure. Quite useful forecasting ideas are presented in this part of the report.

A few editorial suggestions: Figures 3 to 6 are very black and would benefit from a lightening. Also the third line from the bottom of page 17 should refer to Table 7.

There are several references to computer programs on file with the INSROP Secretariat. The means by which such programs could be requested should be identified, either in the report, or a forward from the INSROP Secretariat.

Overall this report is a useful contribution to assessing navigation along the Northern Sea Route.

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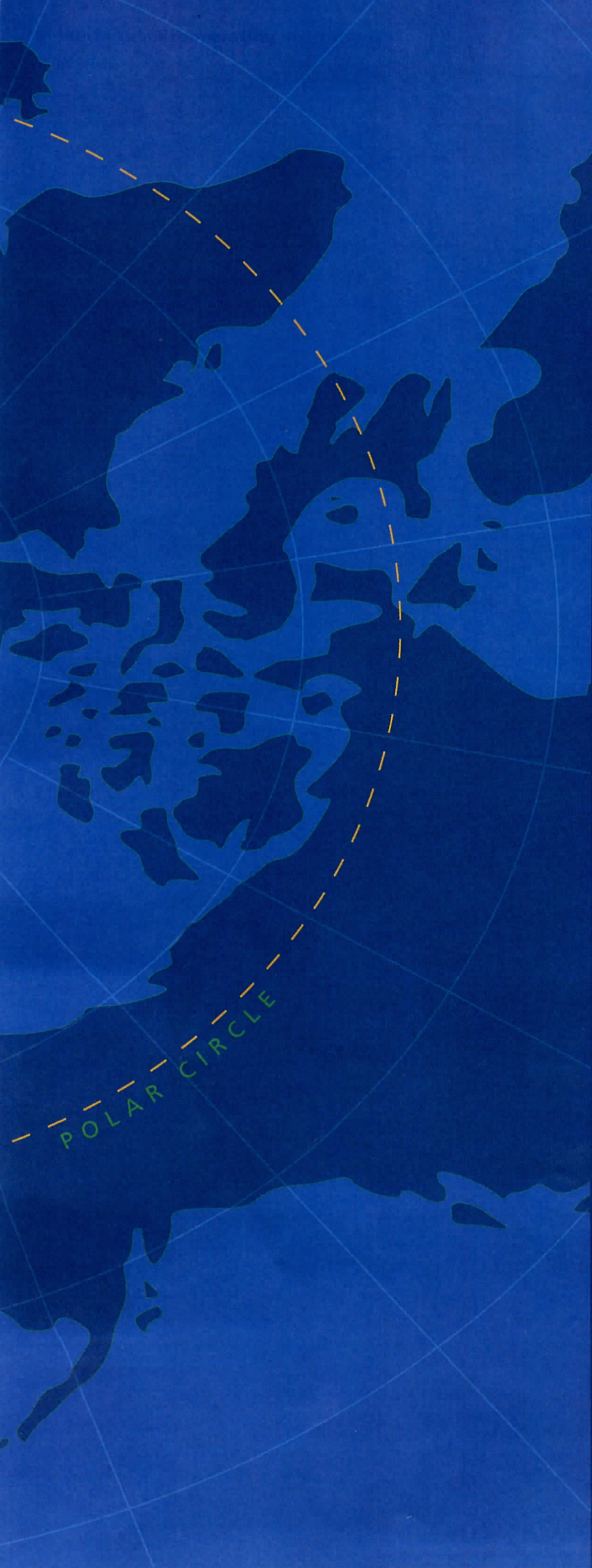

The three main cooperating institutions of INSROP

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

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.
CNIIMF was founded in 1929. The institute's research focus is applied and technological with four main goals: the improvment of merchant fleet efficiency; shipping safety; technical development of the merchant fleet; and design support for future fleet development. CNIIMF was a Russian state institution up to 1993, when it was converted into a stockholding 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.