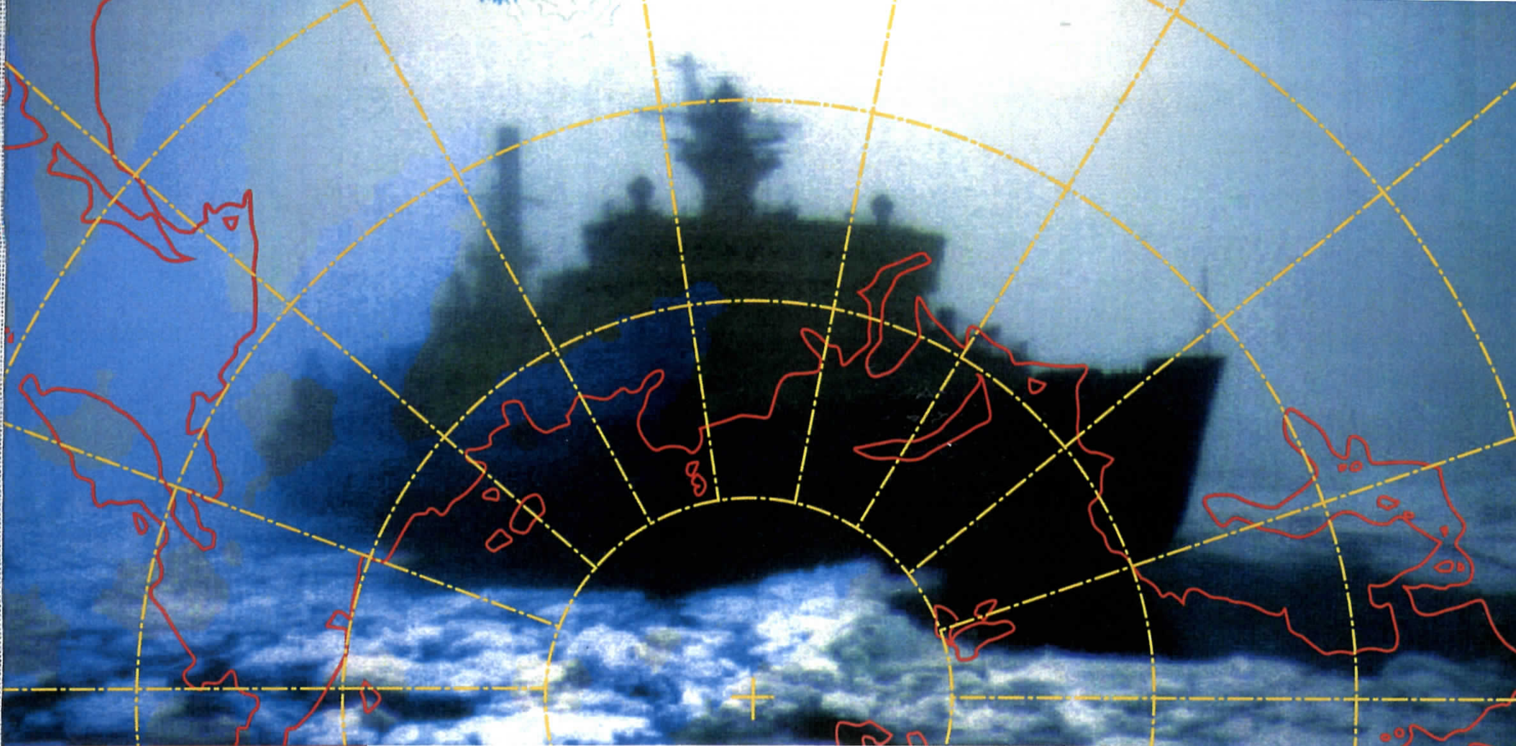

INSROP WORKING PAPER
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Operational Aspects
Volume 3 - 1995 Project Work

By Alexander Baskin, Arkady Buzuev,
Evgeny Yakshevich 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)

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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.

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General

This report consists of two parts.

The first part has been carried out by CNIIMF, and the research was conducted within the period 1991-1995. The work reflects changes in the operational aspects which have taken place during the last years, and basic long-term trends of development and improvement of organizational and technical aspects of navigation on the Northern Sea Route.

The second part has been prepared by AARI and deals with ice and hydrometeorological problems in the context of operational aspects.

PART I
PREPARED BY CNIIMF

CONTENTS

I.1.2.1 REGULATIONS LEGAL SUPPORT

KEY PERSONNEL

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SUMMARY

The work done in 1993-1995 was carried out in three stages. The general situation in the Russian marine legislation was described in 1993. The main tendencies of legislation development with regard to implementation of the International Safety Management Code were described in 1994. The draft of a Statute of the Safety Management System of the Russian Federation worked out by the authors and presented to the Ministry of Transport of Russia in 1995 is now submitted for consideration.

KEY WORDS

Guidelines, IMO Resolution, Document of Compliance, Regulations.

DRAFT

STATUTE OF THE SAFETY MANAGEMENT SYSTEM OF THE RUSSIAN FEDERATION

1. General

1.1. Basis

1.1.1 The RUSSIAN FEDERATION has acceded to the main international conventions for the safety of navigation and marine environment protection including:

.1 International Convention for the Prevention of Pollution from Ships (MARPOL);

.2 International Convention for the Safety of Life at Sea (SOLAS);

.3 International Convention on Load Lines (LL);

.4 Convention on the International Regulations for Preventing Collisions at Sea (COLREG);

.5 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).

1.1.2. As a Contracting Government (Party) to the International Conventions, the RUSSIAN FEDERATION Government has undertaken to give effect to the provisions of the Conventions including control of the compliance of all ships (irrespective of their State flags) entering Russian ports with the provisions of relevant international agreements.

1.1.3. According to the provisions of the International Convention for the Safety of Life at Sea, 1974 (SOLAS-74), adopted by the Conference of Contracting Governments, containing the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) as adopted by IMO Resolution A.741(18) on 04 November 1993, the merchant shipping activity of any shipping company and its approach to ship management should be based on a Safety Management System (SMS) approved by the Administration.

The SMS of a company and the SMS of a vessel are thought to be supplementary to the legal and normative base of the flag State and to be a part of the national Safety Management System.

1.2. Definitions

1.2.1. In the present Statute, unless expressly provided otherwise, the definitions of terms completely correspond to the International Convention SOLAS-74.

1.2.2. The Safety Management System of RUSSIA (further - the RUSSIAN SMS) means a national part of the global system of safety management, which is a system of international and national organizational structures and documents, as well as vessels, their masters and crews, incorporated in uniform policy in the field of safe operation of vessels and pollution prevention.

1.2.3. “Administration” means the RUSSIAN FEDERATION Government exercising jurisdiction over RUSSIAN organizations and ships, and represented by the Ministry of Transport.

1.2.4. “Company” means the Owner of the ship or any other organization or person such as the Manager or the Bareboat Charterer, who has assumed the responsibility for operation of the ship from the Shipowner and who on assuming such responsibility has agreed to take over all the duties and responsibility imposed by the ISM Code.

1.3. Objectives

The objectives of the RUSSIAN SMS are to ensure safety at sea, prevention of accidents, loss of life and avoidance of damage to the environment and to property.

1.4 Approaches to achieve the objectives

To achieve the objectives in view, the RUSSIAN SMS provides:

.1 national legal and normative base maintenance - the prompt implementation of new standards and withdrawal of out of date ones;

.2 introduction of national standards which should be not below the international standards;

.3 a state supervisory system to control the standards related matters.

1.5. Application

The requirements of the RUSSIAN SMS are applied to all companies acting in the field of merchant shipping in the RUSSIAN FEDERATION, to all ships flying the RUSSIAN flag as well as to foreign ships calling in ports of RUSSIA.

2. RUSSIAN SMS structure and components

2.1 The RUSSIAN SMS structure includes the following persons and bodies:

competent state body;

research, design and other organizations and experts, acting on behalf of the Administration;

shipping companies or other organizations engaged in merchant shipping;
Masters and crews of seagoing vessels.

2.2 The RUSSIAN SMS components are as follows:

a legal base;

a system of information support;

a SMS of shipping companies;

a SMS of marine vessels;

a data base.

2.3 Foreign organizations (supervisory state body, classification societies etc.) may be included on a contract basis in the structure of the Russian SMS.

3. Authorities

The Administration while executing State functions in the SMS of RUSSIA:

.1 forms and pursues the uniform policy of the safe operation of ships and pollution prevention;

.2 works out the drafts of legal and normative documents necessary for the RUSSIAN SMS functioning and submits them to relevant bodies for authorization.

.3 develops and accepts the necessary normative documents within its purview;

.4 provides the deposit of legal base documents of the RUSSIAN SMS, its maintenance on up-to-date level, its updating with new international and national documents, and removing of obsolete documents;

.5 licenses the activity of participants of marine transport activities;

.6 certificates the persons occupying posts of executive chiefs of companies involved in safe navigation maintenance, and masters of marine vessels;

.7 keeps register books of companies and marine vessels;

.8 organizes information support of participants of marine transport activities;

.9 regulates activities of state port supervisory bodies, collects and process the marine accident statistics in RUSSIA; develops measures to prevent marine accidents;

.10 executes the functions of customers when contracting for research and design work;

.11 authorizes organizations and experts in the surveys and certification of shore divisions and seagoing vessels on conformity to the requirements of the RUSSIAN SMS and issues Documents of Compliance;

.12 supervises the compliance of recognized organizations, companies and vessels with the requirements of the RUSSIAN SMS;

.13 organizes the marine transport activity so as to meet the requirements of international conventions;

.14 represents the RUSSIAN FEDERATION in any organizations when the problems of safe navigation management and prevention of the marine environment pollution from ships are under consideration;

.15 authorizes foreign organizations acting on behalf of the RUSSIAN Administration;

.16 presents to IMO any national legal acts, which regulate functioning of the RUSSIAN SMS, and data about an accident rate and the preventive measures taken.

3.2 Board of Directors and Harbour Masters:

.1 develop projects of local normative acts, standards, instructions and norms, necessary for functioning of RUSSIAN SMS at regional level, coordinate them with local authorities and present them to appropriate governing body for approval;

.2 develop and adopt necessary standard documents within their competence;

.3 deposit and support the RUSSIAN SMS legal base; and keep it up in up-to-date form;

.4 establish the information support of participants of marine transport activities within the area under their responsibility;

.5 direct activities of the inspection of port control body, supervise vessel traffic service and pilot organizations of the port;

.6 supervise the work of rescue coordinating centers;

.7 investigate accidents;

.8 collect and process the statistics of marine accident rates within the area under their responsibility; develop measures to prevent marine accidents;

.9 execute the functions of customers when contracting for research and design works, as well as for works on safe of navigation maintenance and pollution prevention;

.10 on behalf of the Administration, supervise the compliance of activity of recognized organization and shipping companies with the requirements of international, national and local regulations;

.11 on behalf of the Administration, represent its interests to local authorities while resolving problems of safety management and marine environment protection.

4. Research and design organizations

4.1. Research organizations carry out the scientific support of activity of safe operation management of ships and prevention of marine pollution in accordance with the agreements with the Administration and SMS participants.

4.2. Changes in the RUSSIAN SMS or in its elements should not, as a rule, be introduced without preliminary scientific research.

4.3. Design organizations execute according to agreements with the Administration and SMS participants or on its own initiative the design work and design development aimed at modernization of ships, ship's equipment, gears and systems, technical means for safety management system both ashore and aboard.

4.4. On behalf of the Administration the research and design organizations execute, within the limits of their power confirmed by the Document of Compliance of recognized organization, the survey of marine ships and shipping companies on compliance with the requirements of the RUSSIAN SMS.

5. Organizations and experts acting on behalf of the Administration

5.1. The Administration authorizes other organizations and experts to act in the surveys and certifications of companies and vessels on conformity to the requirements of the RUSSIAN SMS and signs a formal written agreement with an organization/expert to promote uniformity of inspections and maintain established standards. The agreement, based on the provisions of Resolution IMO A.739(18) "Guidelines for the Authorization of Organizations acting on behalf of the Administrations" of November 04, 1993, which specifies the responsibilities of parties and comprises instructions detailing actions to be followed in the event that a ship is found unseaworthy.

5.2 The power of an organization/expert to certificate and survey seagoing ships and shipping companies on conformity with the RUSSIAN SMS is certified by a Document of Compliance which is issued by the Administration and valid for the period of 5 years.

5.3. The organizations/experts, who seek to act in the survey and certification of marine vessels and shipping companies on conformity with the requirements of the RUSSIAN SMS, should submit an application to the Administration and complete information that they:

.1 have adequate resources in terms of technical, managerial and research capabilities in accordance with the Minimum standards for the Recognized organizations set out in IMO Resolution A.739(18);

.2 have the international and national legal base, regulating maintenance safe navigation and prevention of marine pollution from ships.

5.4. The Administration or any other organization(s), authorized to act on its behalf, carries out periodic surveys of recognized organizations/experts on their compliance with relevant requirements.

On behalf of the Administration the assessment of the quality system of recognized organization/expert should be executed by an independent body of auditors recognized by the Administration.

6. Legal base

6.1. The RUSSIAN SMS legal base includes the documents regulating safety management and protection of marine environment in RUSSIA, on international sea ways, in waters of other states, in ports of call of RUSSIAN vessels:

international rules and regulations (Conventions, Codes etc.);
regional agreements;
contracts of RUSSIA with other states;
interstate contracts of other states;
national documents of other states;
legislative and normative acts of RUSSIA;
rules of classification society entitled to class the company's ships;
manuals on Safety Management of RUSSIAN Companies;
nautical hydrographic publications.

6.2. The legal base of participants of the RUSSIAN SMS (recognized organization, shipping companies, vessels etc.) besides the documents mentioned in 6.1, includes legal documents issued to confirm the rights of participants.

6.3 By their legal status, the documents are distributed into:

rules i.e. international and national rules of law, subject to compulsory execution;

procedures (orders of actions) i.e. rules of law, containing compulsory volumes and orders of actions;

instructions, directions i.e. detailed additions to rules, including compulsory procedures;

recommendations i.e. summarized experience of implementation of rules, procedures and instructions under conditions of stochastic order and outcome of actions, admitting different decisions under particular conditions and circumstances of the case;

letters, circulars i.e. information materials directing attention of addressees to certain problems.

6.4. Efficiency of the use of legal base at any SMS level depends on efficiency of available documents control system that involves:

annual inventory of valid documents with withdrawals of out-of-date rules of law;

annual announcement of Lists of valid documents for different directions of activity;

availability of compulsory documents to RUSSIAN SMS participants;

organization of study of new documents;

appointment of persons, responsible for legal base maintenance;

systematic control and management of legal base.

7. SMS of shipping companies

7.1. The objectives of company in terms of safety management should completely correspond to the objectives of the RUSSIAN SMS, set out in 1.3.

7.2. The SMS of company provides the achievement of purposes in view by:

.1 compliance with compulsory norms and rules;

.2 creation of such conditions, that the applicable codes, guidelines and standards, recommended by IMO, Administration, classification companies and marine transport organizations; will be taken into consideration;

.3 systematic checks of adherence to compulsory norms and rules on the part of personnel ashore and aboard.

7.3. Each company should develop, put into force and maintain an SMS, which includes the following functional features:

.1 a safety and environmental protection policy;

.2 a document control system to make available all documents whether on shore or on board and to provide conditions to study them;

.3 instructions and procedures to ensure safe operations of ships and protection of the environment in compliance with relevant international right and legislation of the RUSSIAN FEDERATION;

.4 defined levels of authority and lines of communication between and amongst shore and shipboard personnel;

.5 procedures for reporting accidents and non-conformities with the provisions of SMS of company;

.6 procedures to prepare for and respond to emergency situations;

.7 procedures for internal audits and management reviews.

7.4. Responsibility, authorities and mutual relations of personnel involved in SMS of company should be documented.

7.5. Company should designate a person or persons ashore whose responsibility and authority involve safety standard control and prevention of pollution from each ship in operation as well as provision of sufficient resources and rendering of appropriate aid ashore.

7.6. Company should ensure that each vessel is manned with qualified, certificated and medically fit seafarers, in accordance with the relevant international and national requirements.

7.7. SMS of company should include procedures ensuring that non-conformities, accidents and dangerous situations are reported to the relevant authorities, investigated and analyzed as appropriate.

7.8. SMS of company should establish procedures of maintenance and repair of a vessel in conformity with the provisions of the existing norms and rules, execution of regular inspections, reporting to the Administration on any cases of non-conformities with indication of causes and implementation of an appropriate remedial action.

7.9. A Company is surveyed by the Administration, organization recognized by the Administration, or by the Government of the country acting on behalf of the Administration in which the Company has chosen to conduct its business.

A Document of Compliance relevant to a certain type of ships is issued for every Company which has met the requirements of the RUSSIAN SMS relating to these types of ships. The Document of Conformity is issued for a period of 5 years and should be confirmed on the basis of periodic survey, an appropriate entry in the Document of Conformity being made.

A copy of such a Document of Conformity should be placed on board each vessel of the Company.

8. SMS of marine vessels

8.1 The shipmaster should ensure the compliance with the requirements of the RUSSIAN SMS by way of organization and maintenance of functioning of ship's SMS on due level of quality.

The shipmaster is responsible for implementation of the rules of the RUSSIAN SMS on board the ship.

The orders of the master are obligatory to all members of the crew and to all persons on board.

8.2. Ship's SMS should provide, that the hull of a vessel, all vessel systems and equipment are maintained in serviceable and safe condition during all operation of the vessel.

To fulfill this requirement the master should ensure:

.1 availability and validity of all ship certificates, including the certificates of withdrawal, required by international agreements or RUSSIAN legislation;

.2 availability of valid special ship certificates, required by vessel's type (chemical tankers, gas carriers etc.) or region of navigation (a single voyage out of the region of usual operation), or regional agreement, or legislation of the country of a port of call;

.3 availability of ship documents, required at carriages/securing of some freights (grains, wood on deck, oil etc.), approved by the Administration (various Codes, Information, Manuals, Guidelines, Rules, etc.);

.4 availability of insurance certificate or other financial support to civil liability for damages from pollution;

.5 availability and maintenance of ship's logs in accordance with established rules;

.6 availability of documents on stability and unsinkability under intact and damaged conditions of vessel;

.7 working conditions and good appearance of all ship devices, systems and equipment;

.8 availability of plant - manufacturer tables (plates) and/or passports (certificates) for all engines, devices and equipment;

.9 availability of certificates and/or proper marks on fiber and steel ropes, tackles, chains, lanyards, hooks, blocks, hoses etc., used in cargo and craft devices and for freight securing;

.10 availability in the vicinity of all engines, devices and equipment of descriptions and manuals on their checks, repair and maintenance, and filling by responsible crew members their appropriate data cards;

.11 that all important devices and appliances (ladders, tackles, rails etc.), made on vessel for the purposes of safety or for execution even of temporary work and/or plant made devices and engines repaired in ship conditions, are repaired/made by the most qualified persons of ship's crew, appeared reliable and tested with drawing-up of a ship certificate signed by the master;

.12 availability of standard connections of pipelines for connection with coast (fire mains, mains of delivery of various polluted waters etc.), devices to check an atmosphere structure in holds/tanks required at carriage of certain freights (gas analyzer and/or oxygen concentration meter)

8.3. Ship's SMS should provide that:

.1 members of crew required to hold appropriate certificates (diplomas), should have valid certificates, or valid preferential allowances. In cases defined by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, any certificate should have appropriate confirmations;

.2 the members of ship's crew with diplomas of expert in survival crafts are present on board the ship;

.3 the number of crew members meets the national requirements of the flag state and the certificate of the minimum allowable number of crew is available;

.4 members of crew have the qualification, sufficient to operate appropriate equipment, devices etc., ensuring safety and prevention of environmental pollution;

.5 appropriate members of crew hold the certificate of improved/additional qualification (taking different sort of courses of professional development, passing specialized preparation on simulators and in educational centers etc.), including medical training;

.6 responsible persons of the watch know the general requirements of international and national documents concerning safety and environmental protection;

.7 the requirements in relation to the medical surveys of crew are satisfied;

.8 watch staff includes a person knowing English to a degree sufficient for negotiations with port authorities;

.9 the rigorous registration of those persons on board the ship who are not members of crew, is conducted;

.10 appearances and behavior of members of the watch do not give rise to any doubt in their abilities to execute their duties;

.11 training, drills and alarms with registration of necessary data in ship's logs are executed.

8.4. Ship's SMS is surveyed by the Administration, organization recognized by the Administration or by the Government of the State of port of call on behalf of the Administration. The ship complying with the requirements of the RUSSIAN SMS obtains a Safety Management Certificate.

A Safety Management Certificate is valid for a period of 5 years and should be confirmed by periodical surveys; a corresponding entry is made in the Certificate.

A Copy of the Ship's Certificate of Safety Management should be placed at the main office of the Company.

9. Data base

9.1. Data base of the RUSSIAN SMS includes:

a legal base of the RUSSIAN SMS and participants' bases;

registers of companies, recognized organizations and experts;

international data base with information on vessels (ISID);

data on accidents, cases of pollution of environment, any failures of equipment and hardware, connected with the vessels of the company;

data on ship and shore staff;

information on disciplinary faults of staff resulting in accidents or cases of environment pollution;

remarks of port States inspectors on vessel's survey;

contracts for research and design work;

programs of preparation of marine specialists in educational institutions of RUSSIA;

programs of training on simulators;

mathematical models of types of RUSSIAN vessels and computer software capable of simulating maneuvers of vessels;

catalogues of charts and books, navigation charts and directions for the World Ocean;

collection of electronic charts and hardware-software system to display them;

weather forecasts for the Seven Seas and data on actual weather.

9.2. The data base of participants of SMS contains a corresponding part of a general data base of RUSSIAN SMS and own data (on vessels, personnel, certificates etc.).

9.3. Data base information should be stored on computer data media and in writing form i.e. books, charts, schemes etc.

9.4 Data base should be in the form enabling experts to choose statistical samples and make estimations.

10. Information support system

10.1. The information support system, as a part of the RUSSIAN SMS, is intended for maintenance of its legal base on the up-to-date level.

10.2. The information support system includes structural divisions, ensuring systematic supply with international documents and translation of the documents into RUSSIAN language.

10.3 Functioning of then information support system is stipulated by duties established by the Administration.

The duties:

of the Legal Department of the Ministry of Transport are to submit for publication the texts of international conventions on navigation;

of directors and harbour masters are to provide the Administration with the texts of local regulations and with information on accidents within the region of activity;

of recognized organizations are to analyze and summarize the information of surveys of companies and vessels and submit the results to the Administration;

of shipping companies are to submit information on accident investigation and accident statistics to the Administration as well as information on preventive measures.

11. Applicants

11.1. "Applicant" is a company, ship, organization, juridical or natural person that put in an application for a Document of Compliance/Safety Management Certificate.

11.2. An applicant should:

.1 submit an application with all required documents in compliance with established rules and procedures;

.2 provide for free functioning on the part of authorized persons of state supervision body, recognized organization and experts;

.3 submit prescribed data to the state supervision body;

.4 pay for work at established tariff;

.5 provide the conformity of his (its) activity in the field of safe navigation management and prevention of pollution from vessels with the provisions of the RUSSIAN SMS;

.6 suspend or stop his (its) activity when it does not meet the requirements of legal acts, on conformity with which a Document of Compliance/Safety Management Certificate was issued, or when the term of validity of the Document of Compliance/Safety Management Certificate has expired.

.7 notify the body issued the Document of Compliance/Safety Management Certificate about changes in the SMS.

REFERENCES

SOLAS - 74 INTERNATIONAL CONVENTION

IMO RESOLUTION A.739(18) adopted on 4 November 1993. GUIDELINES FOR THE AUTHORIZATION OF ORGANIZATIONS ACTING ON BEHALF OF THE ADMINISTRATION

IMO RESOLUTION A.741(18) adopted on 4 November 1993. INTERNATIONAL MANAGEMENT CODE FOR THE SAFE OPERATION OF SHIPS AND FOR POLLUTION PREVENTION (INTERNATIONAL SAFETY MANAGEMENT (ISM) CODE)

I.1.2.2 ROUTE PLANNING
CARTOGRAPHICAL SUPPORT OF ROUTE PLANNING

KEY PERSONNEL

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SUMMARY

The present report contains data on a modern state of cartographical support to the Arctic navigation in Russia by conventional paper charts and electronic navigational charts as well.

KEY WORDS

Nautical charts, Catalogue of charts, Electronic nautical chart.

Introduction

As the optimization of routes of navigation mainly depends on quantity and quality of available information, the previous report on Sub-Program 1 "Routing" gives the analysis of information support to international navigation along the NSR in terms of hydrometeorological, icebreaking, pilotage, hydrographic and cartographical disciplines. The cartographical support is determined as one of priority problems when planning and making any passage.

A detailed description of cartographical support system of merchant shipping in Russia was given in the 1994 report. The description includes historical information, quantity and characteristic of navigational charts for NSR up to the date of preparation of the report, changes in chart supplying system for consumers planned by Russian hydrographers (HDNO), specific feature of handling Russian charts.

All four parts of the "Catalogue of charts and books," declared by HDNO as intended for a wide range of consumers, have been issued. All catalogue parts have been continuously supplemented with new charts, and so a large number of updating corrections are to be made.

Simultaneously with publications of conventional paper charts, the formation of a database of electronic navigational charts is now in progress in Russia.

The present report contains data on a modern state of cartographical support to the Arctic navigation in Russia by conventional paper charts and electronic navigational charts as well.

Integrated approach to the problem of cartographical support to navigation

The provision of navigational charts, navigational manuals and sailing directions for merchant vessels is considered to be a specific part of legal support to navigation and a component of navigation technology. Such approach follows not only from the provisions of the SOLAS-74 International Convention, not only from usual practice of checking ships' collection of charts and books by Paris memorandum inspectors and others, but also because charts and books only together with means of navigation are capable to give necessary information on a current and forthcoming position of a vessel relative to the point of destination and to any artificial or natural obstacles to navigation.

It is obvious that at each stage of development of a system designed to supply vessels with aids of navigation, navigational charts, manuals and sailing directions, it is necessary to review the contents and form of the editions so that the changes made were adequate to the changing needs of navigation.

The technology of navigation known to be invariable for centuries has qualitatively changed today. Modern means of navigation allow us to determine a vessel position practically in any region at appropriate intervals and with needed accuracy. Therefore it is possible to give up superfluous manual measurements of navigational parameters, complex graphic and computational processing of observations, scrupulous determination of navigational instrument corrections, detailed dead reckoning and careful plotting of routes carried out by navigators. As a result, charts of smaller scale may be of use now.

When the satnav systems of the second generation, ensuring practically continuous high-precision positioning and implementation of sea electronic cartographical systems using SNS capabilities, came into being, conventional paper charts began to lose their practical importance. At the same time so long as ECDIS is considered as a legal auxiliary equipment, the legality of its use is provided by special bridge service arrangements.

The above peculiarities of electronic navigational technology should be taken into account while supporting navigation by conventional paper charts and electronic charts.

Modern condition of cartographical support to the Arctic navigationin Russia by paper charts

The declared reorganization of the Catalogues system by HDNO has been accomplished. The navigational charts collection on the World ocean edited by HDNO for civil consumers included by the end of 1995 6465 charts announced in four parts of the Catalogue.

The named collection of conventional paper charts is now intensively being supplemented mainly with Arctic Seas charts, causing intensive updating of the Catalogues. Suffice it to say, that up to the end of the year, the first editions of 99 charts and 6 books were issued; 71 charts and 44 books were reedited.

The convincing reasons for a new edition are the following: appearance of new cartographical materials; many corrections to be made; publication of charts in two languages - Russian and English (44 charts).

The coverage of the NSR regions by general charts and charts of scale 1:250 000 and larger is shown hereafter (division into regions has been carried out according to indexes of the Catalogue):

General	- 36	(fig. 2-1);
The East part of the Barentz Sea and the West part of the Kara Sea	- 27	(fig. 2-2);
Zemlya Franza Iosyfa	- 6	(fig.2- 3);
The Ob-Yenisey region of the Kara Sea	- 63	(fig.2- 4);
The East part of the Kara Sea and the Laptevs' Sea	- 81	(fig.2- 5);
The East-Siberian and Chukchi Seas	- 52	(fig.2- 6).

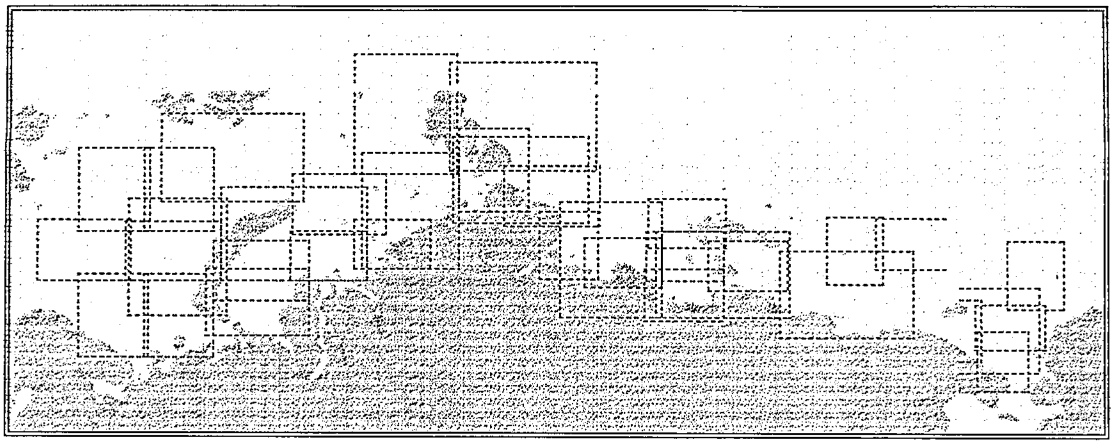

Fig. 2-1 Index 2 of Catalogue 7107. General charts

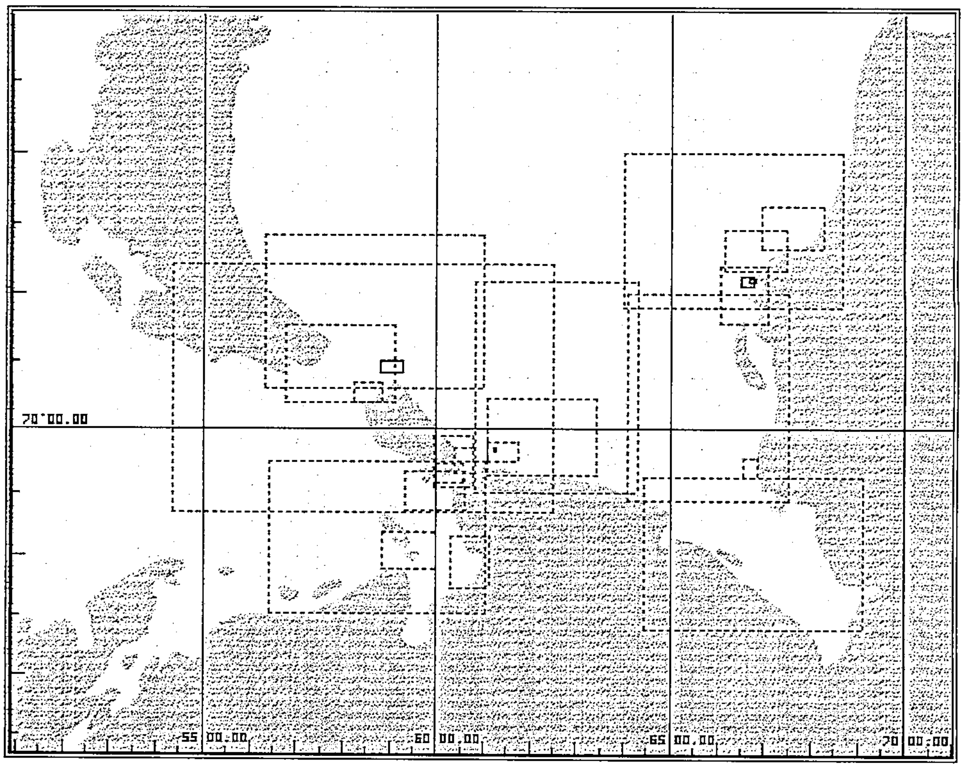

Fig. 2-2 Index 8 of Catalogue 7107. The East part of the Barentz Sea and the West part of the Kara Sea

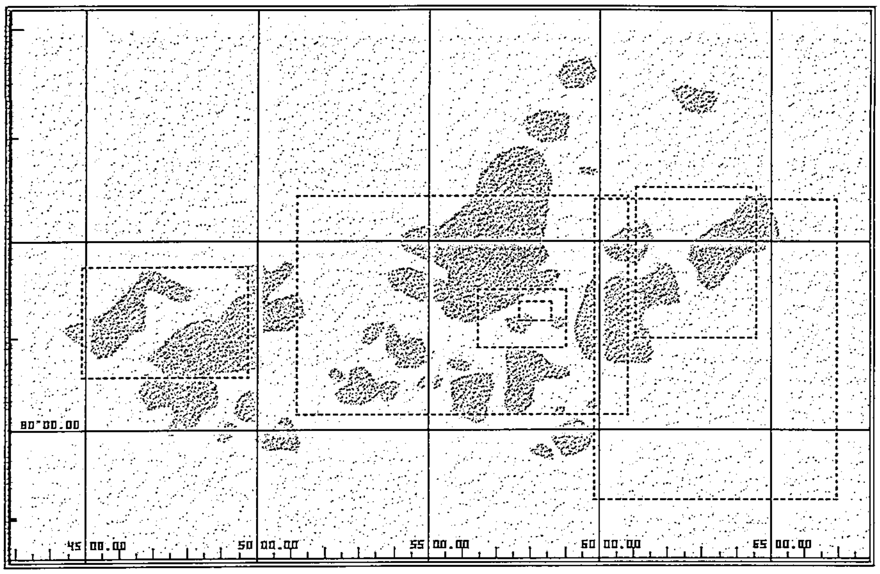

Fig.2- 3 Index 9-B of Catalogue 7107. Zemlya Franza Iosyfa

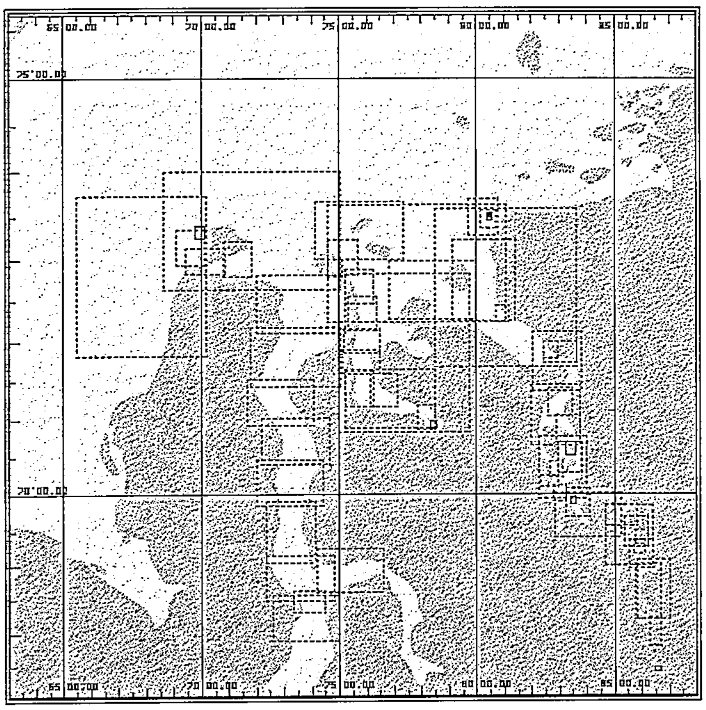

Fig. 2-4 Index 10 of Catalogue 7107. The Ob-Yenisey region of the Kara Sea

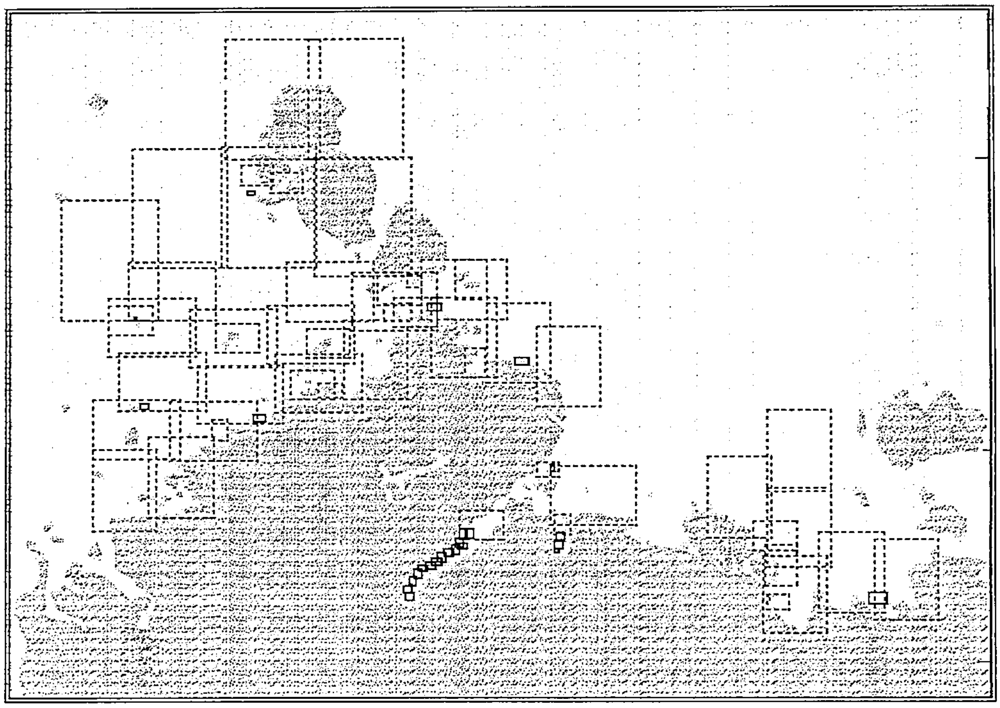

Fig. 2-5 Index 11 of Catalogue 7107. The East part of the Kara Sea and the Laptev Sea

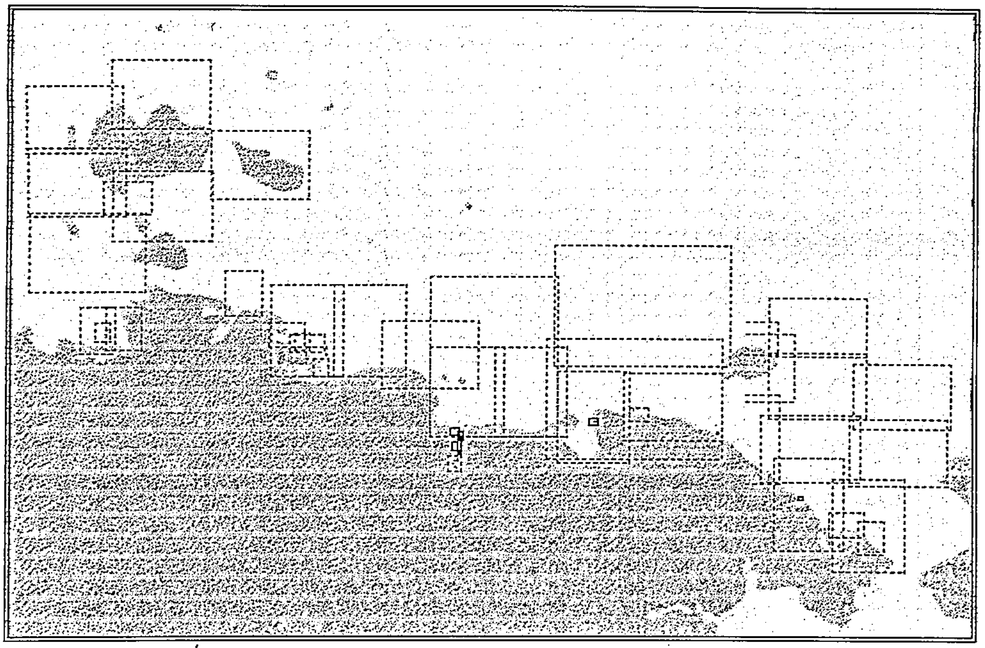

Fig. 2-6 Index 12 of Catalogue 7107. The East-Siberian and Chukchi Seas

These data show that even nowadays the cartographical support to the NSR navigation is adequate enough for both conventional (coastal) routes and high latitude routes.

Modern condition of cartographical support with electronic navigational chartsto the Arctic navigation in Russia

In Russia the main makers of electronic nautical charts (ENC) on the Arctic Seas bordering Russia are the Head Department of Navigation and Oceanography of the Ministry of Defense (HDNO), State Hydrographic Office of the Ministry of Transport of Russia (SHO) and "TRANSAS MARINE" software house.

In spite of essentially different approach to the creation of ENC, various "know-how" and check of final production, these organizations have much in common.

Electronic charts of each maker are reproduced by electronic cartographical systems of maker's own design. The point is that there are no finally authorized international requirements to ECDIS and ENC. It takes the same time for makers to check and to create an ENC, which is conditioned by special features of chart creation.

Since 1994 HDNO carries out work on creation of both a Russian national databank of digital sea navigational charts according to the standard of the International Hydrographic Organization on exchange of digital cartographical data in format DX-90/S-57 and systems of ENC display (Electronic

Chart Display Information System - ECDIS).

HDNO works in cooperation with the Russian company MORINTECH. This company was organized in St.-Petersburg and since 1989 is engaged in the activity on the basis of the Central cartographical HDNO factory and in scanning and digitizing technology. The outputs of the Company are 10-15 admiralty numbers of charts a month.

The experts of MORINTECH have developed and put into operation several hard/software structures designed for issue of digital data sets of sea navigational charts according to the international exchange standard incorporated in the DKART Technology. This technology has been adopted by national hydrographic services of Russia, Estonia and Latvia not only for paper originals of charts to be digitized, but also for new paper charts to be issued on their basis with operative using of the up-to date hydrographic measurements.

Simultaneously the Company develops ECDIS systems which, after sea tests, have been issued a relevant certificate of the Department of Marine Transport of Russia. These systems are now in use on seagoing vessels.

The DKART Technology received an international recognition during fulfillment of the international project EVABALT, organized on the initiative of the Estonia Marine Administration, which resulted in establishing the Baltic regional coordination center uniting efforts of hydrographic services of the Baltic States in the field of digital cartography.

Attaching paramount importance to the provision of digital sea navigational charts for international navigation along the NSR, HDNO according to the plan of publication of digital charts has prepared the charts with admiralty numbers 697, 948, 949, 951, 952, 954, 955, 11114, 11115, 11151, 11164, 12000 (Catalogue # 7007) in an international format for regions from Murmansk to the Bering Strait.

The SHO has carried out navigational hydrographic support to the safety of navigation along the NSR since its establishment, in other words more than 60 years by now. Among the tasks to be done by SHO, one of the most important is to survey bottom configurations of the Arctic seas for the purpose of publication of nautical charts, manuals and sailing directions with the use of modern electronic aids. The SHO has wide experience in this field.

The work on ECDIS development and creation of an ENC databank has been conducted since 1992 under the resolution of the Russian Government, directed at improvement of the NSR management. To this effect, a group of digital cartography with a stuff of 27 persons has been formed.

ECDIS "TRIS-100" has been developed. The system performs the basic ECDIS functions and operates with the ENC database meeting Standard S-57/DX-90 of the International Hydrographic Organization. System TRIS-100 is the navigational equipment satisfying the Russian "Technical and operational requirements to electronic cartographical systems." The certificate of approval of TRIS-100 had been in force when the ship equipment was received in August 1996.

Two complete sets of TRIS-100 were established on hydrographic vessels. Two other complete sets passed the trials during winter navigation on board the nuclear ice breakers *Vajgatch* and *Soviet Union;* the experimental operation of system on the ice breaker *Soviet Union* is still in progress. In May 1996 system TRIS-100 was presented to the second International seminar on ECDIS use in ice conditions and received positive reviews done by the participants.

The "know-how" of ENC creation has steadily been improved. At the moment the high precision scanning technology of ENC database creation - *CARIS,* developed by the Canadian company Universal Systems Ltd. has been introduced in SHO. The technology in use provides the following:

- connection of a network of 15 remote terminals to the station, which allows simultaneous work of 15 operators;
- conversion of ENC databanks, made according to the earlier working versions of the S-57 standard, to the modern version of the Standard with simultaneous creation of a databank;
- generating of ENC with direct application of the results of hydrographic surveys, i.e. without any time wasted for compiling paper charts, which provides operativeness of ENC creation.

Now the first stage of creation of the ENC databank for the NSR region has been completed. A total of about 200 ENC (S-57 cells) on a basis of more than 60 paper nautical charts has been made. On fig.2-7 the charts of scale range B (scales 1:700 000 - 1:500 000) are shown by white color, the charts of scale ranges C (scale 1:100 000), D (scale 1:50 000), I (scale 1:25 000) and N (scale 1:10 000) are shaded.

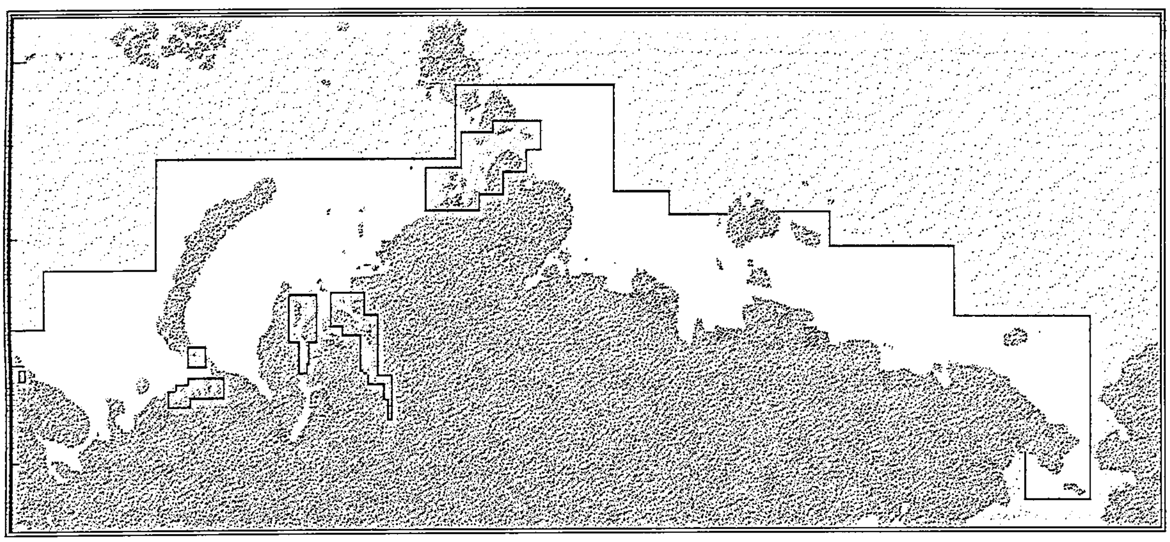

Fig. 2-7. NSR coverage by SHO electronic charts

SHO is technically capable to carry out updating of the NSR ENC database. The distribution of updating files can be made through the INMARSAT channels. Such transmission of ENC updating files together with ice information files was carried out from the ice breaker *Soviet Union*. Moreover the updating information can be distributed via electronic mail or through the network of hydrographic bases.

SHO plans within the next few years the expansion of the ENC database and its modernization. In the near future, ENC of scale 1:700 000 will be replaced by ENC made on the basis of paper charts of scale 1:500 000 of the editions of recent years. All difficult navigational regions of the NSR routes will be covered by ENC of scale range C (scales 1:100 000 - 1:200 000). The conversion of the existing ENC database to the third version of the S-57 Standard is planned; adequate software should be supplied by Universal Systems Ltd. in the autumn of 1996.

The Russian enterprise TRANSAS MARINE (TRANsport SAfety System) was founded in Leningrad by a group that included professional seamen (both shipmasters and navigators) and programmers, who started their joint work since 1986. Now 22 operators and 15 hydrographers are involved in ENC creation. The process of generation, checking and distribution of charts is continually supported by 5 software and 2 hardware engineers. The separate group of updating chart support contains 3 experts. All chart makers, the developers and distributors of final production are connected to a uniform computer net. The company is one of the largest manufacturers of specialized sea software in the following fields:

- marine electronic cartographical systems;
- vector substandard electronic navigational charts for own ECDIS;
- navigational computer simulators;
- computer GMDSS radiocommunication simulators;
- vessel stability, unsinkability and durability estimation programs;
- vessel traffic control systems;
- coastal controlling information systems for shipping companies.

Although TRANSAS MARINE works exclusively in Russia, its production is well known abroad. TRANSAS MARINE has developed the whole family of sea navigational cartographical systems NAVI MASTER, taking into account peculiarity of wide circles of consumers from warships to yachts. Seven versions of the system, meeting the Russian "Technical operational requirements to electronic cartographical systems" are in service now. The company's product has certificates issued by the Russian Register of Shipping, German Lloyd and other classification societies. TRANSAS MARINE ENC has passed checking by a commission, set up by HDNO specially for this purpose; the commission has recognized TRANSAS MARINE ENC standard suitable for electronic charts creation. The company has a license of the Federal Service of Geodesy and Cartography of Russia for the cartographical activity in Russia i.e. creation and updating of digital and electronic nautical charts and plans.

All systems of the TRANSAS MARINE company are made in series and installed by a TRANSAS MARINE service on vessels of customers. Today more than 1 000 systems are in operation on vessels of many countries. About 300 systems are used on Russian vessels, including vessels operating in the Arctic. The largest Russian customer is the Northern Shipping Company (45 systems), which has developed a special technology to use ECDIS for navigation in ice.

Between TRANSAS MARINE branches and service centers, which ensure guarantee and post guarantee service as well as personnel training, there are some centers located in the ports of Murmansk and Nakhodka.

The systems of NAVI MASTER family used to apply not only vector electronic navigational charts in formats TM (TRANSAS MARINE), FINGIS (Finland), IFF (South Africa Republic), VPF (USA), ALL (Canada), but also the data officially issued by the Hydrographic services of Great Britain and the USA.

The ENC "know-how" is being improved and powerful mathematical methods are available now, which allow us to exclude superfluous actions of operator, to recalculate various projections, to compensate deformations and defects of paper charts as well as the technique of mathematical check of charts.

The ENC database of TRANSAS MARINE includes more than 2 500 charts covering all regions of the World ocean. The collection includes about 1 200 charts of the British Admiralty, 700 charts of HDNO, 250 charts of the USA, and also charts of Sweden, Finland, Germany, Southern Korea etc. The choice of a paper chart for ENC generation is based on a careful analysis. ENC on the seas of the Russian Arctic are made on the basis of charts of HDNO. The chart collection of TRANSAS MARINE includes 68 ENC for the Arctic region ensuring navigation in the White, Barents and Kara Seas.

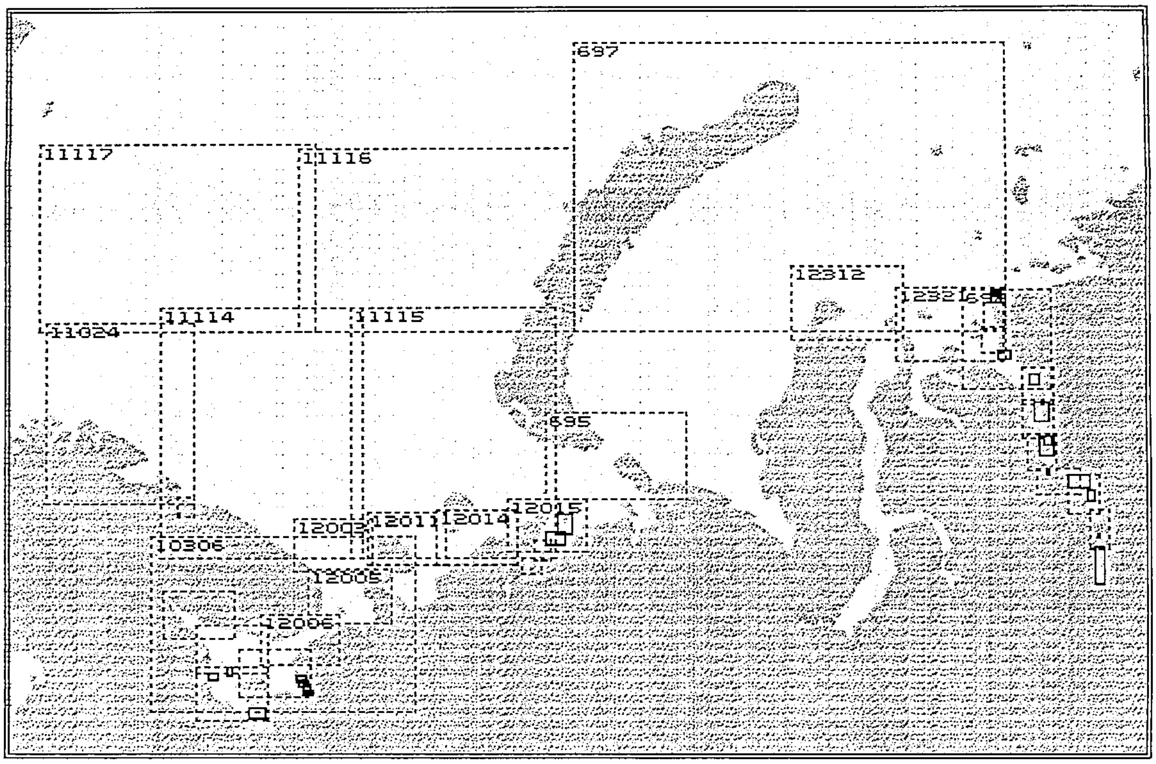

Fig 2-8 TRANSAS MARINE electronic charts

The ENC production technology of TRANSAS MARINE allows us to issue about 70 charts per month and provides an opportunity to prepare rather quickly any new electronic chart at customer's request.

We used TRANSAS MARINE software while preparing this Report.

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I.1.2.3 NAVIGATION AND POSITIONING
RESULTS OF DGPS EQUIPMENT TESTS IN THE KARA SEA

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SUMMARY

This section describes the results of DGPS equipment tests in the Kara Sea in 1994-1995.

Based upon investigations under INSROP project in 1993-1995, generalized characteristics of navigation and positioning in the Russian Arctic are given.

KEY WORDS

DIFFERENTIAL GPS, TESTS, PILOT OPERATION, REFERENCE STATIONS, RADIO BEACONS

INTRODUCTION

As it was stated in previous stage reports under I.1.2.3, the most promising means of providing positioning along the NSR is employment of differential GPS (DGPS). Russian specialists (CNIIMF, State Hydrographic Department, Morsviazsputnik) have developed a project for establishing a network of DGPS reference and control stations in the Russian Arctic. The first step in realization of this project was the tests of DGPS equipment in the Kara Sea in the 1994-1995 navigation. Basic results of these tests are described below.

DGPS RESEARCHES AND PILOT OPERATION IN THE ARCTIC

Experience of DGPS operation in 1994 and positive results of the works in the vicinity of Dikson Island formed the basis for further improvement of navigational support of sailing, as well as for better efficiency of special activities in the Arctic in 1995.

The DGPS tests and pilot operation were conducted by specialists from the State Hydrographic Department of the Ministry of Transport in the 1995 summer navigation.

The main objectives of the DGPS tests were:

- Determination of position measurement errors at various points within the operating area formed by DGPS reference stations.
- Assessment of compatibility of imported equipment of reference stations with the Russian-produced modified radio beacon (RB) *Almaz.*
- Evaluation of efficiency of employing high precision DGPS techniques for carrying out special works.

Used in the tests was the equipment manufactured by U.S. Trimble Navigation Company. Brief technical characteristics of the equipment are given in Table 3-1

TABLE 3-1 Technical Characteristics of the Equipment

Equipment	**Characteristics**			
	Number of receiver channels	**Signal type**	**Accuracy, m (P=0.95)**	**Rate of availability, s**
Reference station 4000 DGPS /MSK L1 Dual	12	C/A, L1	< 0.6	0.5
Integrity monitor 4000 IM	12	C/A, L1	-	-
Receiver NT 2000 D	6	C/A, L1	4 - 10	1.0
Hydrographic receiver 4000 DS	12	C/A, L1	< 0.2	0.5
Receiver NavTrack XL	6	C/A, L1	4 - 10	1.0
Receiver Ensign XL	3	C/A, L1	< 20	1.5 - 5

Basic technical characteristic of ***Almaz*** RB:

Transmitter output power:	**80 W**
Number of transmitter channels:	**1**
Correction signal field strength at 600 km: *under the following conditions:* • *signal propagation above the sea surface* • *operating having an efficient height of 18 m, capacity of 30-1000 pF, resistance of 6 Ω*	**5 μV/m**
Operating frequency stability:	**$50*10^{-6}$**
Power supply: *AC* *DC*	**220 V, 50 Hz** **24-36 V**

- With the NavTrack XL and Ensign XL receivers being used NAV beacon XL was employed for receiving correction signals transmitted by reference stations in the maritime RB frequency band. This receiver operates in the frequency band 283.5 - 325 kHz and provides reception of corrections transmitted at a rate of 25 - 200 baud with a minimal input signal level of 5 μV/m.

A block diagram of DGPS in the test period is shown of Figure 3-1

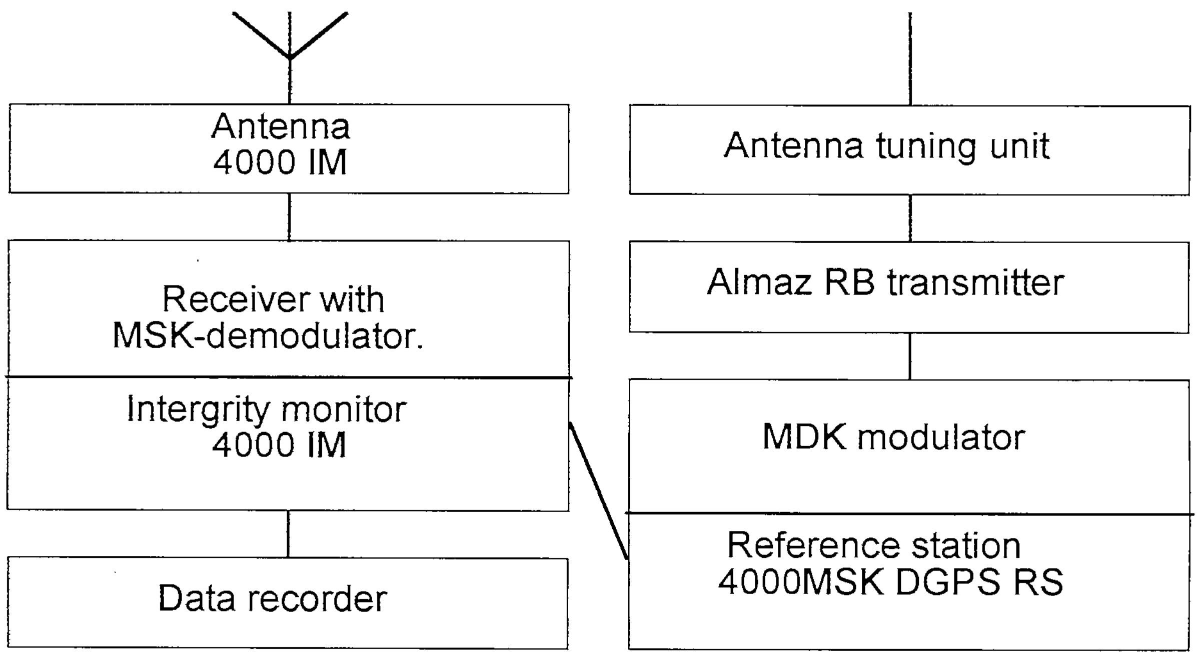

Figure 3 - 1

DGPS stations were deployed at the following sites:

- Oleniy Island, Yenisei Bay, Kara Sea
- Sterlegov Cape, Taimyr Peninsula, Kara Sea

Characteristics of the DGPS stations are given in Table 3-2

TABLE 3-2 Characteristics of the DGPS Stations

Installation site, No.	Latitude	Longitude	Frequency	RB used
Oleniy Island (1000)	72°35.9 N	77°39.9 E	318.5	*Almaz*
Sterlegov Cape	72°23.6 N	88°45.0 E	318.5	*Almaz*

Shown in Figure 3-2 are the operating areas of DGPS stations based upon calculations of the areas of reliable reception with the following initial parameters being accounted for:

- shipborne receiver minimum sensitivity in the correction reception mode: dB/μV/m;
- average noise level in the Arctic: 15 dB/μV/m;
- effective power of radiated signal: 1 W for the *Almaz* RB;
- desired signal minimum level for the reliable reception area: 25 dB/μV/m;
- nature of underlying surface.

Prior to starting the DGPS pilot operation, the reference station equipment was checked and the evaluation of measurement error was made at the port of Dikson - point 1 in Figure 3-2

There were three series of measurements obtained with the 4000 IM receiver. Corrections were received from the Oleniy RB reference station, located some 133 km away from the receiving station.

Correction age in the course of the measurements was 7 - 12 s.

Summary data on the measurement results are given in Table 3-3

TABLE 3-3 Results of Measurements at the Port of Dikson

Point of observation	Date, series number	Error, rms, m			Number of readings in the series
		Latitudinal	Longitudinal	Radial	
1.Geodetic mark	04/08, 1st	0.3	0.2	0.4	4236
	04/08, 2nd	0.3	0.2	0.3	426
	04/08, 3d	0.3	0.2	0.4	1223

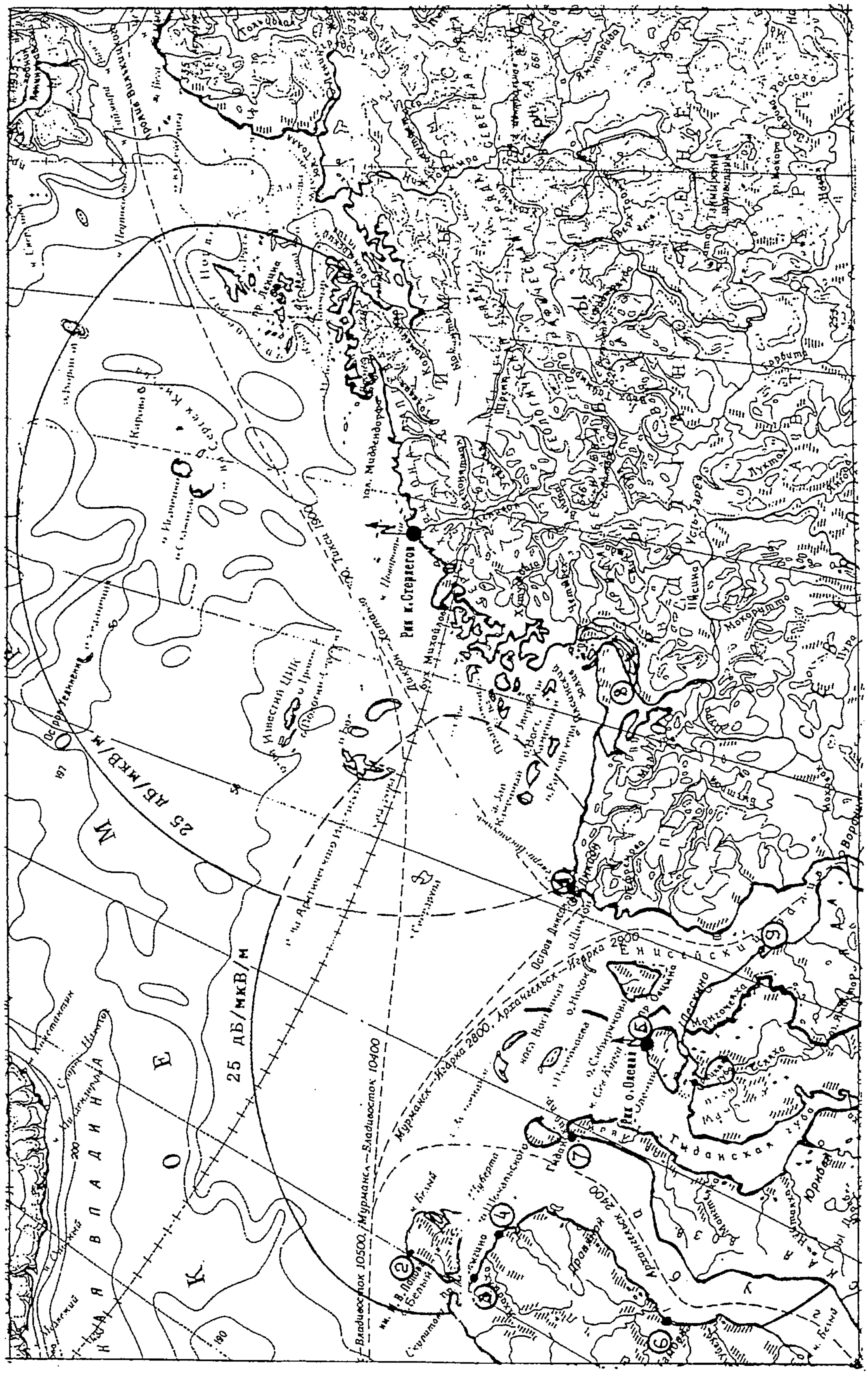

Figure 3 - 2

The difference in coordinates in various series of measurements was 0.8, that not exceeding the cumulative error due to the receiver systematic error, GPS system measurement method error, constellation of satellites used, satellite characteristics.

The random measurement errors, their latitudinal and longitudinal components did not exceed 1 m, with P = 0.95.

In July - October 1995 the DGPS stations on Oleniy Island and Sterlegov Cape were operating 24 hours a day. After launching the stations, the tests were made to measure the signal-to-noise ratio and the field strength of the correction signals transmitted from station No. 1001 (Sterlegov Cape) and received at station No. 1000 (Oleniy Island) (Point 5 in Figure 3-2).

The spacing between the two stations was 215 miles (400 km). The Trimble 4000 MSK GPS receiver was used as a control receiver.

The tests showed that the signal-to-noise ratio was 8 - 10 dB by day and 7 - 11 dB at night. The correction signal field strength varied within 21 - 23 dB/μV/m by day and within 20 - 22 dB/μV/m at night.

To conduct special works, which require high-precision fix, the use was made of the correction signals transmitted by reference station No. 1000 (Oleniy Island).

To determine accuracy, measurements were made at points 2, 3, 6 shown in Figure 3-2

The Ensign XL GPS receiver was used in conjunction with the Nav Beacon XL receiver of corrections at point 2 (RB on Bely Island) and point 3 (scaffold Nadoyakha). Used for measurements at point 6 (scaffold No.2341) was the NavTrack XL receiver. The duration of observations was 40 min, with the intervals between data records being 1 min. The summary results of data processing are given in Table 3-4.

TABLE 3-4 Results of Measurements on Geodetic Marks

Point of observation, Point number, Receiver type	**Date**	**rms Lat (m)**	**rms Lon (m)**	**rms Rad (m)**	**Number of readings**	**Distance to the point of observations, miles**
RB on Bely Island Point #2 Ensign+NavBeacon	09/08	3.1	1.7	3.5	50	143
Scaffold Nadoyakha Point #3 Ensign+NavBeacon	10/08	2.8	1.5	3.2	60	131
Scaffold No.2341 Point #6 NavTrack+NavBeacon	05/10	1.0	0.3	1.1	40	129

The stability of DGPS operation was checked also at anchorages near Khasal Cape (point

No.4) and Turisal Cape (point No.7). The results of measurements at points No.2-7 showed that the reliable reception of correction signals is provided both by day and at night at a distance up to 130 - 160 miles from the reference station. There was no changeover from the DGPS mode to the standard GPS mode.

An evaluation of range of correction reception was made when the hydrographic ship *Pavel Bashmakov* operated at Yugorski Shar some 380 miles away from the reference station on Oleniy Island. Analysis of the measurement results showed that a stable operation in the DGPS mode is not provided because of the low level of the received correction signals.

The accuracy evaluation was not made because of frequent transitions to the standard GPS mode. The obtained data made it possible to determine the DGPS availability at extreme ranges which was found to be 43.3% for Varneka Bay and 63.3% for Khabarovo Cape. This confirmed the conclusion made earlier as to the need to install a reference station on the Tonkiy Cape, that allowing to establish a single high-precision DGPS area extending from Kolgujev Island to the Vilkitsky Strait.

During the DGPS pilot operation special works were conducted which required highly accurate ties:

1. On 17-18 August 1995 at point No.8 the work was carried out on the pilot boat *Narzoy* to set buoyage on the mouth of the P'asina river. The NavTrack XL receiver was used to accomplish fix by signals from the Oleniy reference station, the spacing being 318 km. The correction age was 7 - 16 s. The course was planned in advance and the points of installation of obstruction beacons were entered. The use of DGPS made it possible to reduce the time of execution of the work, irrespective of weather conditions.

2. On 5-13 August 1995 at point No.9 the work was carried out on the hydrographic ship *Nicolay Kolomeitsev* to set buoys in the Yenisey Bay. The NavTrack XL receiver was used to effect ties by signals from the Oleniy reference station, 155 km away from the receiver. The use of DGPS allowed the reduction of time of operations for deployment and removal at the end of the navigation of the buoys and marks.

3. On 25-28 September 1995 the NavTrack XL receiver operating by signals from the Sterlegova reference station was used for salvaging after a helicopter had fallen to sea. The operative and highly accurate measurements obtained with DGPS allowed pinpointing the location of the accident and the distance to the coastline.

4. On 11 October 1995 the NavTrack XL receiver was installed on the nuclear-powered ice-breaker *Yamal*. The receiver operated by signals from the Oleniy reference station. The use of DGPS techniques provided the safety of navigation in narrow waters and channels.

On the basis of the results obtained in the course of the DGPS pilot operation it was concluded that it is advisable to employ DGPS on nuclear ice-breakers and for geodetic and SAR activities.

Requirements to the ship equipment DGPS are represented in the standards IEC1108-1, IEC1162-1. These requirements have universal character and are the same for the ships sailing in the Arctic Seas.

CONCLUSION

The following practical conclusions were made in the course of summing up the results of the research conducted in 1993-1995 under Section I.1.2.3 "Navigation and Positioning":

- Methods for sailing NSR differ to a considerable extent from traditional methods for sailing open seas and coastal areas.
- This accounts for the fact that as the ship is navigated under limiting ice conditions the necessity for making operational corrections to navigational route arises in the course of strategic and tactical planning.
- Navigational and hydrographical conditions of sailing the Arctic seas are aggravated by a great number of navigational hazards, both of traditional and specific character.
- Specialists will be in position to plot nautical charts and provide navigational aids in accordance with requirements only after research into hydrographical peculiarities of navigational areas, and especially of northern routes, will be accomplished. Such research should be done with utmost care.
- Peculiarities of specific distribution of ice formations result in the fact that sailing routes run frequently not far from coastline and navigational hazards.
- Sailing under such conditions can be performed successfully provided higher position accuracy, as compared with the accuracy stipulated by the IMO requirements, is obtained.
- According to the IMO standard of navigation (Resolution A529/13) up-to-date methods for positioning with the aid of global satellite navigation system meet the requirements to accuracy of navigation at a distance more than 1 mile from danger.
- Creation on NSR of a network of differential GPS subsystems (for GLONASS, as well) will ensure the most effective navigational positioning. Owing to such subsystems the required accuracy will be obtained during navigation under limiting conditions.
- Creation of DGPS network guarantee effectiveness of the use of electronic charts together with ECDIS equipment during navigation under limiting conditions (at harbour entrances not far from coastline, estuaries, etc.).
- As far as special-purpose services in the Arctic region are concerned, particularly hydrography, piloting, sweeping, search and mining of minerals, research works, etc., the use of DGPS subsystem will ensure solution of entire spectrum of problems concerning accurate positioning.
- Application of high accuracy navigational aids, DGPS and ECDIS require the use of common methods for assessment of distinctions between geodesic datum used in current chart-making materials of different countries.
- The project of creation of DGPS network on NSR was drawn up.
- Tests on the use of the first two reference DGPS stations were conducted. The results of these tests confirmed that the use of the subsystem in Russian Arctic is very effective.

During the research into aspects of navigation and positioning done in 1993-1995 assessment of current problems and perspectives of their solution was carried out. During further research Russian specialists consider it necessary to study the following problems:

- Accomplishment of creation of DGPS on NSR, conducting complex tests and experimental scientific research.
- Making practical recommendations for the use of DGPS on Russian and foreign vessels with regard to specific character of wave propagation and other peculiarities of the Arctic region.
- Doing research on specific features of the safe use in the Arctic region of independent technical shiphandling aids, namely of subsystems of setting the course (use of gyro-compass in high latitudes and during making changes in the course), velocity meters (efficiency of transmitters used under ice conditions), radar systems (influence of ice stretching surface).
- In future attention will be paid to research into joint use of communication and navigational aids with the object of providing safety of navigation.
- Taking into account development prospects of export of mining products from ports of Russian Arctic and import of supply products, it is necessary to ensure safety of navigation on estuaries and approaches to ports. Accordingly, scientific substantiation of creation of shiphandling systems to be used in ports of Arctic should be given.
- In order to adopt international resolutions concerning carriage of dangerous goods and discharge of oil in Arctic a system of tracking position and movement of ships carrying dangerous goods should be created. With the aid of such system search for, and rescue of ships and other objects (planes, expeditions) will be performed.

The above conclusions can be taken as a basis for further research under INSROP project to be conducted in 1977.

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I.1.2.4 COMMUNICATIONS

REALIZATION OF THE SCHEME OF COMMUNICATION SYSTEM DEVELOPMENT IN THE RUSSIAN ARCTIC

KEY PERSONNEL

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Transl. O.Andreyeva

SUMMARY

Based upon the findings of investigations in earlier phases of this Project a scheme of communication system functioning in the Russian Arctic is proposed.

Recommendations are made on the composition and purpose of communication equipment aboard ships and at coast radio centers on the NSR.

A list of radio stations to be fitted with radiotelex facilities is given.

The Arctic points and polar stations equipped with VHF radiotelephone stations are listed.

KEY WORDS

SCHEME OF COMMUNICATION SYSTEM FUNCTIONING , RECOMMENDED RADIO EQUIPMENT, FIBER OPTIC COMMUNICATION LINKS, SATCOM SYSTEMS, IMPLEMENTATION STAGES, LIST OF RADIO STATIONS

INTRODUCTION

In the previous Reports (I.1.2.4.93/94), it was shown that a single system based upon satcom and MF/VHF techniques is best suited to the needs of providing efficient communications through the NSR.

To maintain reliable operational communications on the NSR and to meet the GMDSS requirements, all ships and coast radio stations in the area concerned should be equipped by appropriate communication aids.

Integration of the communication system in the Russian
Arctic with the national and international communication networks will be effected stage by stage together with modernization of existing radio relay communication links, laying of fiber optic cables and development of national satcom systems such as MARAPHON, GONETS and YAMAL.

SCHEME OF FUNCTIONING OF COMMUNICATION SYSTEM

Organizational basis of the system is daily communication between ships, ship owners and Arctic radio centers.

The basic elements of functioning of the communication system are the following:

* Each ship should keep communications in radiotelex mode with a radio center in its sailing area. The radiotelex channels are used for transmission of routine information, such as navigation and service information.

* Each ship should keep continuous radio watch on the distress frequencies of digital selected call (DSC) channel.

* Interconvoy communications with coast radio stations deployed at the Arctic points and polar stations and communications between ice reconnaissance aircraft are effected in the VHF band.

* The ships get access to the national and international communication and data networks via satellite channels of the international INMARSAT and domestic OCEAN system.

* The information exchange between coast radio centers is provided through interport communication via radio relay links, cable and radio channels.

* The automatic interface of ship radio channels with land channels is accomplished by message switching centers.

* For distress and safety communications, the coast radio stations:

- Keep continuous watch on the VHF distress frequencies on DSC channel 70 and on channel 16 in sea area A1;
- Keep continuous IF radio watch on the distress frequencies in sea area A2;
- Keep watch on the telegraph safety frequencies 500 kHz and DSC LF distress frequencies.

In addition, NAVTEX service radio stations transmit meteorological, navigational and urgent information to ships on schedule.

All ships sailing the NSR should comply with the provisions of the "Instructions for communication along the NSR during the Arctic navigational season". These Instructions, issued annually, specify such items as frequencies, operating channels, schedule, radio calls and give other necessary information.

COMPOSITION AND PURPOSE OF COMMUNICATION EQUIPMENT

The radio equipment that ships and coast radio stations on the NSR are recommended to be fitted with was determined having regard to peculiarities of radio-communication in the Russian Arctic.

The composition and purpose of the shipborne radio equipment recommended to be carried on ships engaged on running voyages along the NSR or, when in convoy, on the leading ship or icebreaker, are outlined in Figure 4-1.

In addition to the conventional radio-communication equipment, the ships should be fitted with:

- ship earth satcom station;
- equipment for sound recording and reception of facsimile, including means for reception of weather maps;
- VHF radio station operating on 122.5 MHz for communication with airplanes, helicopters, and ships in convoy.

The composition and purpose of the radio equipment recommended for coast radio centers in the Russian Arctic are presented in Figure 4-2.

In accordance with the Program of development of communication equipment and aids to navigation in the Arctic over 1995-1999, several coast radio stations on the NSR will be fitted with equipment capable of ARQ radiotelex communications with ships in the MF and HF bands. The points where the equipment is expected to be installed are listed in APPENDIX I.

The operating frequencies and schedules of the radio stations concerned will be determined after the design stage and installation of NBDP facilities at the coast stations having completed.

In addition to the existing message switching centers at Murmansk, Arkhangelsk and Vladivostok, it is planned to install such centers at the area radio centers at Amderma, Dikson, Chelyuskin, Tiksi, Shmidta and Provideniya.

The points, where NAVTEX radio stations are expected to be installed, are Amderma, Dikson, Chelyuskin, Tiksi, Shmidta, Providence, Bely, Sterlingov, Begichev, Stolbovoy, Tabor, Kamenka.

Listed in APPENDIX II are the points and polar stations where VHF radiotelephone stations operating in the band of the maritime mobile service are available. Installation locations, call signs, schedule and operating channels of the VHF stations are given.

Equipment		Purpose
VHF radio station		Radiotelephony, communication with ships in convoy and with airplanes
DSC equipment		Transmission of DSC alerting signal
VHF watching receiver on channel 70		Reception of DSC alerting signal
MF, IF, HF radio station		Radiotelephony
		Transmission of radiotelephony alarm
DSC equepment		Transmission of DSC alerting signal
DSC MF, IF, HF watching receiver		Reception of DSC alerting signal
Radiotelex		
Watching receiver on 2182 kHz		Reception of radiotelephone alarm
NAVTEX receiver		Reception of maritime safety information
COSPAS/SARSAT or INMARSAT emergency beacons		Transmission of ship position information when in distress
INMARSAT A, OCEAN		Distress message telephone, telex, data, facsimile
EGC receiver	or	Reception of maritime safety information
INMARSAT-C/EGS		Distress messages, telex, facsimile, data

Figure 4 - 1

Equipment	Purpose
INMARSAT C/EGC	Distress messages, telex, facsimile, data
MF radio station	Transmission/reception of navigational and service information in radiotelex mode; continuous DSC watch on the frequency in the MF band which is assigned as the distress frequency in the Artic basin
IF, HF radio station	The coast radio centre maintains a continuos watch on the calling frequencies of the radio centre and on the GMDSS DSC distress frequencies
Message switching centre	Automatic switching and processing of incoming messages; interface between wive channels and radio channels
NAVTEX receiver	Reception of maritime safety information
VHF radio station with the DSC unit for channel 70	Continuous automatic watch on the GMDSS DSC calling and safety channel in sea area A1
VHF radio station on channel 16	Listening watch on the GMDSS calling and safety channel in sea area A1
IF receiver on 2187.5kHz	Continuous automatic watch on the GMDSS DSC calling and safety frequency in sea area A2
IF receiver on 2182 kHz	Continuous listening watch in sea area A2

Figure 4 - 2

INTEGRATION WITH THE NATIONAL AND INTERNATIONAL COMMUNICATIONS AND DATA NETWORKS

At present an access to the international communication network is provided through the satcom INMARSAT and OCEAN systems.

In later stages, in addition to satcom facilities, it is supposed to implement a complex of digital radio relay stations and fiber optic communication (FOC) links for integration of the existing communication system with the national and international communications and data networks.

In spite of economic problems in recent years, Russia is involved in the construction of FOC. Two underwater FOCs, Denmark - St.Petersburg and Japan - Korea - Nakhodka with extention of the land FOC to Khabarovsk are already constructed and entered into operation. Also, two digital radio relay links, St. Petersburg - Moscow and Moscow - Khabarovsk were put into operation. The construction of FOC from Moscow to the south in Italy through Turkey will be finished in the near future.

Nowadays, the transsiberian FOC (TFOC) Moscow - Khabarovsk is being constructed. This TFOC should combine the western, eastern and southern sites in a uniform complex, which will include digital radio relay links (7650 km in length, 11520 channels), a FOC (3400 km in length) and the switching centers in Novosibirsk, Ekaterinburg and Samara.

For reservation of TFOC and creation of a global digital communication circuit, three projects of transarctic FOC construction are being studied:

- FOC1, 4560 km in length, from Murmansk through the Arctic Ocean up to the North Pole and further to the Canadian western coast.
- FOC2, 4890 km in length, from Murmansk through the Arctic Ocean across the Bering Strait to the US Pacific coast.
- FOC3, 12060 km in length, along the Russian coast of the Arctic Ocean and further along the Russian eastern coast to Nakhodka (Figure 4-3.).

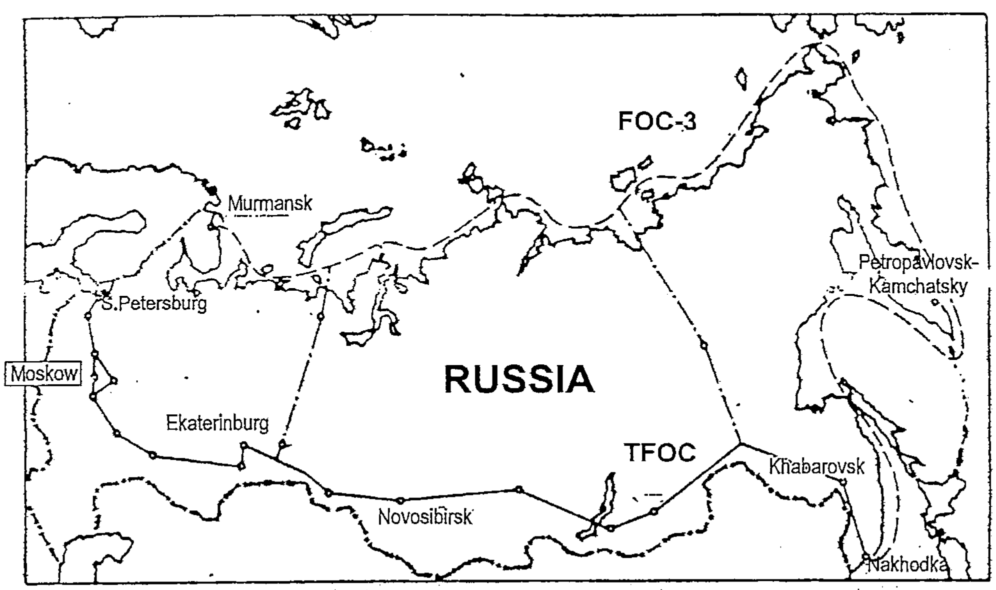

Figure 4 - 3

This line will be connected with TFOC by radio relay links. This configuration will meet the needs of digital communications practically for the whole northern territory of Russia.

The cost of FOC1 and FOC2 projects are estimated about in $200 million, FOC3 -$500 million.

Digital communication services and access to the national and international communications and data will be also provided by new Russian satcom systems.

In addition to the MARAPHON system, which was described in the previous project, it is worth mentioning the YAMAL and GONETS satcom systems.

The YAMAL system is being created by the GASCOM joint-stock company together with Rocket Space Corporation "Energia". The system is primarily intended to provide ommunication services to the Russian gas industry.

At present the GASCOM uses capacity of the Horizon satellite, and operate a network consisting of 20 earth stations, fitted at some points of the Russian Tyumen area such as Nadym, Ukhta, New Urengoy, Yugorsk, Kharasovey, Bovanenkovo etc.

Two YAMAL geostationary satellites placed at 19.5W and 75E will be launched in 1997.
The YAMAL system will provide automatic transmission of telex massages, high quality digital duplex channels, facsimile and data transmission.

Both a fixed multichannel terminal with 1.57 m antenna and a mobile station with 0.8 m antenna will be used as user stations.

It is expected that there will be about 12500 duplex channels, each having a capacity of 32 kbits/sec.

The GONETS low orbit system, which is being created by the Smolsat association, is intended for providing digital communications to mobile users, objects state control, ecological monitoring and personal calls.

This system will use the polar orbit satellites at an altitude of 1500 km. In this system, the data collection and transmission will be effected in the range of 0.3/0.4 GHz at a rate of 4.8-9.6 kbits/sec and 64 kbits/sec in the near-real time, inside a region of about 5000 km diameter.

Should subscribers be in different regions, the information will be transferred in the E-mail mode. The messages transferred to the satellite will be stored (the onboard memory capacity is 8 Mbytes) and transferred to the user when the latter is in the satellite radio visibility area. An average time of the information delivery is 3 hours.

The small- size satellite terminals (about 1.3 kg) will be used as the users stations. The system will serve up to 50 000 users. The cost of 1 Kbytes of information is estimated at $0.9.

IMPLEMENTATION STAGES

Improved communications on the NSR are expected to be implemented in two stages, depending upon availability of new communications facilities in the area concerned.
In the first stages, up to 2000, it is planned:

- to fit the equipment capable of radiotelex communication in the MF,IF and HF bands;
- to deploy NAVTEX stations;
- to install DSC equipment and message switching centers at coast radio centers.

In the second stages, starting from 2000, there will be two domestic satcom system, MARAPHON and GONETS, available for use in the Arctic basin under the Federal space program of Russia.

In 1997 it is planned to launch more powerful Inmarsat satellites of new 3rd generation. The possibilities of operation via these satellites at low elevation have not yet been determined in world practice.

Thus it is very important to study the questions connected with maintenance of reliable satellite communication on the NSR.

For this purpose the experimental research of SES Inmarsat-A and C reception in various modes at low elevation angles is scheduled in 1997-1998 in accordance with INSROP I.1.3.

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LIST OF POINTS WHERE RADIOTELEX EQUIPMENT IS EXPECTED TO BE INSTALLED

Point	Latitude	Longitude
Arkhangelsk	69.6 N	41 E
Murmansk	69.2 N	33 E
Amderma	69.5 N	62 E
Dikson	73.6 N	81 E
Chelyuskin	77.7 N	105 E
Tiksi	71.6 N	129 E
Pevek	69.7 N	170 E
Shmidta	68.7 N	179 W
Providence	64.4 N	173 W

LIST OF POINTS AND POLAR STATIONS WHERE VHF RADIOTELEPHONE STATION OPERATING

Geographic Name	*Radio Station Position*	*Radio Call*	*Watch and Radio Channels*
Amderma	Port	Amderma-port	24 h
Bely (island)	port station named Popov	Bely Island- 88	by agreement - channel 9
Vaigach(island)	port station named Fedorov	Vorobei	by agreement - channels 6, 13, 14
Igarka	port station named 60 years of VLKSM VLKSM	Igarka-radio	by agreement - channels 6, 9, 12
Novaya Zemlya (island)	port station Karmakuly	Phortuna	by agreement - channels 6, 9, 12
Dikson	Radiometeocenter Marine operation headquater Hydrobase Port Supervizory port body	Dikson-radio Dikson-radio2 Dikson-radio23 Dickson-radio1 Portnadzor	24 h - channel 16 24 h 09.00 - 18.00 local time and by agreement 24 h 24 h
Medvezhiy (island)	Control point radionavigation system (RNS)Bras	Medvezhiy-radio	on request via Dikson
Vise (island)	port station	Vise-radio 2	on request via Dikson
Dudinka	Pilot watchkeeping Port radio office Supervizory port body Port control office Sea agency	Lotsvakhta Dudinka-radio *Portnadzor* *Port* *Moragenstvo*	24 h - channel 9 09.00 - 13.00 except Saturday, Sunday - channel 13 24 h - channel 14 24 h - channel 10 24 h - channel 12
Zhelany	portstation	Zhelany-88	by agreement - channels 64
Igarka	Hydrobase control office Hydrobase radio office Port control office	Igarka-radio 23 Igarka-radio 4	04.00-13.00 (except 08.00-09.00) channel 9 04.00-13.00 (except 08.00-09.00) channel 13
Lipatnikovo	Water level control post	Lipatnikovo- radio 23	24 h - channel 9

Geographic Name	Radio Station Position	Radio Call	Watch and Radio Channels
Chelyuskin (cape)	Hydrometeooffice	Chelyuskin-88	on request via radiometeocentre, channels 12,16
Khatanga	Radiometeocentre Port control office Portfleet Port agency Captain of port Hydrobase	Khatanga-radio 1 Khatanga-radio 2 Khatanga-radio 6 Khatanga-radio 3 Khatanga-radio 4 Khatanga-radio 23	24 h during navigation 15 June - 01 Octobre channel 16 24 h during navigation 15 June - 01 Octobre channel 14 08.00 - 20.00 channel 14 08.00 - 20.00 channel 14 08.00 - 20.00 channel 14 Call by agreement via seaport
Sopochnaya Karga	port station	Sopochnaya-Karga 88	24 h channels 9, 16
Kheisa (island)	hydrometeooffice named Krenkel	Kheisa-88	by agreement - channel 64
Tadibe-Yakha	port station	Tadibe-Yakha 88	by agreement - channel 14
Novyi Port	port station	Novyi Port 88	by agreement - channel 9
Tiksi	Hydrobase	Tiksi-radio 23	24 h
Tiksi Arctic shipping company	Fleet exploitation agency Transfleet Captain of port Port	Tiksi-radio 1 Transflot Tiksi-radio 5 Tiksi-radio	03.00 - 12.00 channel 9 work from 1 July to 01 November 09.00 - 18.00 channel 30 09.00 - 18.00 channel 8 24 h - channel 9
Kotelnyi	port station	Kotelnyi 88	24 h - call via Tiksi channels 6, 9, 14
Sannikova	portstation	Sannikova 88	24 h - call via Tiksi channels 6, 9, 14
Kigilyakh	port station	Kigilyakh 88	24 h - call via Tiksi channels 6, 9, 14
Terpyai-Tumsa	port station	Terpyai-Tumsa 88	24 h - call via Tiksi channels 6, 9, 14
Shalaurovo	port station	Shalaurovo88	24 h - call via Tiksi channels 6, 9, 14
Pevek	Radiometeocenter Supervizory port body Marine operation headquater Port control office Seaport Hydrobase	Pevek 88 Pevek-radio 5 Pevek-radio 19 Pevek-radio 6 Pevek-radio 2 Pevek-radio 23	24 h - channel 9 24 h 24 h - channel 14 24 h - channel 9 24 h Call via radiometeocentre or seaport channels
Providence	Radio office	Ureliki-radio 4	24 h - channel 67
Sea trade port	Port control office Supervizory port body Port fleet Oil station Hydrobase	Providence-radio 2 Providence-radio 5 Providence-radio 6 Providence-radio 13	24 h - channel 14 24 h - channel 9 08.00 - 17.00 (local time) - channel 67 08.00 - 17.00 (local time) - channel 29

Geographic Name	*Radio Station Position*	*Radio Call*	*Watch and Radio Channels*
		Providence-radio 23	23.30-08.30 by agreement
Anadyr	Port control office Supervizory port body, captain of port	Anadyr radio 2 Anadyr radio 5	24 h - channel 9 from15 June - to 15 November 24 h - channel 14 from15 June - to 15 November
Beringovskiy	Radiometeocentre Port control office	Beringovskiy-radio 2 Beringovskiy-radio 5	24 h during navigaion channel 9 24 h - channel 9
Shmidt	Radiometeocentre Extracaptain	Shmidt 88 Neptun	24 h call via radiometeocentre when required

I.1.2.5 INFRASTRUCTURE

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SUMMARY

The actual data on the navigation of 1995 along the NSR with regard to the infrastructure of the Route and to its readiness to maintain international navigation in the seas of the Russian Arctic is under consideration in the present project.

KEY WORDS

Navigational and hydrographic support, aids to navigation, pilotage, hydro-base, port.

1 General

In 1995, in common with the past, the arrangements for the navigation in the Arctic seas of Russia were under control of the Marine Operations Headquarters of the West and East sectors of the Russian Arctic, operating under the direction of NSRA.

Navigational and hydrographic support to the safety of navigation in the West sector are carried out by the Arkhangelsk, Dikson, Igarka, Tiksi and Hatanga hydrographic bases of the State Hydrographic Office (SHO) of the Ministry of Transport of Russia, in the East sector - by the Tiksi, Kolyma and Providenya hydrographic bases and by the pilot and hydrographic group of Pevek. All zones of the responsibility of the SHO Arctic divisions are given in the report on INSROP project IV.1.1, 1994.

Since July 1, 1995, all vessels engaged in navigation along the NSR are under general supervision of a new SHO division - the Arctic Marine Oil Pollution Service.

2 Navigational and hydrographic support

Having been created by the SHO, the complex system of navigational and hydrographic support to the safety of navigation on the NSR is designed to provide safe conditions of navigation of merchant vessels for delivering cargoes in 12 Arctic ports and in more than 80 points of discharge on roadstead.

Navigational and hydrographic support to the safety of navigation along the NSR involve the following basic directions:

- study of bottom configurations of the Arctic seas and of internal water ways with a view to edit navigational charts, manuals and sailing directions;
- equipment of NSR with aids to navigation and its maintenance in compliance with the current rules;
- informing seafarers on changes in navigation conditions;
- pilotage along the Yenisey, Hatanga, Anabar and Kolyma rivers of about 680 miles in length.

A separate problem is the prevention of pollution of the Arctic seas.

The following works are thought to be promising:

- creation of a network of coastal GPS differential stations in the Arctic seas;
- creation of a databank of digital navigation charts for the NSR region in the format DX-90.

The work on maintenance of aids to navigation along the NSR and in low streams of the Siberian rivers in 1995, is divided into four basic categories according to four kinds of aids - lighted, radio, radar and visual.

Type of aids to navigation	Number
Lighted aids to navigation, including:	776
Lighted landmarks	573
Electric lighthouses	24
Light buoys	179
Radio aids to navigation, including:	35
Watched radio beacons	4
Unattended radio beacons	31
Radar aids to navigation, including:	773
Parasitic coastal radar reflectors	466
Parasitic floating radar reflectors	288
Radar responder beacons	20
Visual aids to navigation, including:	668
Day sea-marks	534
Hazard beacons	134
Aids to navigation in total	2253

In 1995 the structures and equipment of all aids to navigation on the NSR were repaired, restored or modernized by the SHO divisions.

Examining the prospects of development of the NSR infrastructure in the interests of international navigation, it is necessary to take into account the fact that SHO has 13 independent units, which make it possible to establish networks of both NAVTEX coastal stations and shore stations to communicate satnav GPS differential corrections (two units - on Oleny Island and on Sterlegov Cape were involved during the last shipping season).

All units provide accommodations for 10 persons; technical, warehouse and subsidiary premises with a total area of 150 m^2; aerials, radioequipment; power supply, heating equipment and means of transportation.

During the Arctic navigation hydrographers supervised the proper activation of aids to navigation, regularly informed the shipmasters about changes in ice and navigation conditions. The hydrographic divisions periodically informed the shipmasters of ice breakers and transport vessels about valid and canceled Coastal warnings. 53 warnings were issued for the West sector and 24 - for the East sector during the navigation of 1995. The proper control and updating of chart and sailing directions collections on ice breakers and transport vessels were carried out.

3 Hydrographic coverage

On the whole the West sector of the Kara Sea is well surveyed, an additional survey is required only for a few areas. The Western part of the Laptevs Sea, along east coast of the Taymyr Peninsula requires an additional survey. The chart correction and preparation of new chart editions covering the navigable part of the Yenisey River needs systematic surveys and soundings of shallow places restricting the navigation. Control soundings carried out annually by the hydrobase do not meet the requirements of chart editions with respect to details and accuracy.

The East sector of the NCR is surveyed satisfactorily. The materials of a hydrographic survey made it possible to issue a number of new navigation charts of various scales. The areas important for navigation (approaches to ports and places of discharge, bays, river fairways etc.) are covered by charts of scales 1:25 000 and 1:10 000. The data of soundings carried out in different years by SHO divisions were used.

4 Pilotage

During the Arctic navigation of 1995, pilotage of sea vessels was carried out on the rivers Yenisey, Hatanga, Anabar and Kolyma. Some features of the pilotage in these areas are given in the following table.

Region	Distance miles	Pilotage beginning	Pilotage ending	Pilotage period, days	Pilot actions strength	Number of pilotage	Number of vessels
Yenisey	360	16.06.	03.11.	142	20	258	258
Hatanga	185	01.09.	29.09.	29	4	10	10
Anabar	65	21.09.	25.09.	5	4	4	4
Kolyma	76	07.08.	07.10.	61	11	93	

In addition to the pilotage shown in the table, there were 107 acts of piloting carried out along the Yenisey River.

5 Supervising the prevention of oil pollution from vessels in the Arctic Seas

Early in the 1995 navigation the scheduled check of bunkering stations, located in the Arctic ports, was carried out with a view to determine their readiness to take and handle tankers and to make water protection arrangements.

In the 1995 navigation 204 checks of vessels of 22 shipowners were carried out. Of this number, 182 checks were carried out in 9 ports, 19 checks - at sea and 3 aircraft checks, while doing hydrographic work.

As a result of these checks, 325 cases of infringement of rules were revealed.

Preliminary analysis of the results of the work has shown the following. Average age of Russian vessels, engaged in the Arctic navigation, has decreased. The water protection equipment on vessels is under modernization. A considerable increase of infringements of rules as compared with the previous years is mainly connected with almost complete absence on vessels of the normative documents on pollution prevention issued in 1995.

No doubt, the systematic control of vessels on the NSR by aircraft is to be carried out.

6 Ports

The resolution of the Government of Russia concerning international navigation on a regular basis is known to open only a part of Russian ports in the North of the country. These ports are Murmansk, Arkhangelsk, Kandalaksha, Onega, Mezen, Narjan-Mar, Igarka and Providenya. A few more ports will be open for individual visits of foreign vessels during each Arctic navigation season.

INSROP program III.02.2-95 contains prospects of development of such ports as Murmansk, Amderma, Dikson, Anadyr, Narjan-Mar and Arkhangelsk, as well as suggestions on construction of new ports (Pechenga, Harasavey and a port in the Obskaya Guba region). The program also contains prognosis data on the freight turnover in the Russian Arctic and northern ports (Pevek, Tiksi, Hatanga and Providenya).

Some information on less known Arctic ports of Russia is given below. These data are taken from the Directory "Seaports of the Far East coast of the Russian Federation", DNIIMF, edited by V/O "Mortehinformreklama", Moscow, 1993.

Providenya (64°25'N, 173°14'E). The port of Providenya is on the Northern coast of Komsomolskaya bay which is a part of the Anadyr gulf of the Bering Sea. The bay is surrounded by mountains with a maximum height of 650 m; the mountains decline almost vertically to the sea.

The coasts are granitic. The full length of the bay is 36 km, and the width bay in entry part is 7 km. The depths in the bay are 20- 30 m.

The most important navigational bay is deepwater Komsomolskaya Bay. The entry capes are bold and bordered by a narrow stony beach. The ground in the bay at a depth of more than 20 m is mud, near the cape of Chefan the ground is sand and gravel and in top of the bay the ground is mud and gravel.

The port has internal and external roads. An external road of the port is the road of Slavyanka bay. It is well sheltered from sea swell, and from south winds, prevailing in summer period. In autumn and winter periods the influence of northeast winds can make berthing in the external road restless. An internal road of the port is in Komsomolskaya bay. The internal road is protected from winds of all directions.

Providenya town adjoins the port. The town is a regional center and is connected with Anadyr by a regular air line.

A convoy to sail along the NSR is usually formed in the port of Providenia.

The port works during the period of navigation, which begins at the first decade of May and comes to an end at the first decade of January. The duration of navigation on the average makes 225 days, including 45 days with icebreaker assistance. Pilotage is available on a round-the-clock basis and is compulsory for vessels of 500 tons gross s and upwards. The masters of vessels who have repeatedly visited the port may proceed without pilot.

The port is open for foreign vessels.

The berthing line of the port consists of cargo and auxiliary berths. All of them are located on the Northern side of Komsomolskaya bay. The warehouse facilities of the port consist of warehouses and open storage areas for bulk, wood and general loads. Portal cranes of 5 tons - 40 tons capacity are available. Moreover, caterpillar cranes of 16 tons-25 tons capacity, automobile loaders, special tractors, roll trailers and hold loaders are available.

On masters' request the port supplies vessels with fuel, oils, water and foodstuffs, removes from vessels polluted waters, provides pilotage, cleaning and minor repair of vessels, gives berths, tows, road boats, reloading means, registers arrivals/departures of vessels.

Diving assistance is available, and the divers can make inspection and minor repair of the hull and propelling system of a vessel.

Pevek (69° 42.4'N, 170° 15'E). The port of Pevek is located in the Chaunskaya Guba gulf of the East Siberian Sea in the low-lying northwest part of the Pevek peninsula. The peninsula is separated from the isles of Bolshoy Rautan and Maliy Rautan by the Pevek Strait, which is a road of the port of Pevek. Some deep water anchorages are available. The ground is mud and sand.

Navigation begins in the second half of June and comes to an end late in October. The average duration of navigation is 115-120 days.

Pilotage is compulsory for all vessels, except ice breakers.

The port has cargo berths equipped with portal cranes, metal warehouses and open cargo storage areas with gravel and concrete coverings.

The portal cranes with 5 tons - 40 tons capacity , caterpillar cranes of 25 tons capacity, automobile loaders, port tractors, roll trailers and bulldozers are used as basic loading facilities.

Port fleet incorporate cargo and auxiliary vessels.

The cargo handling operations on berths are carried out with portal cranes and ship cargo devices. Loading operations on roadstead involve ships' crew and equipment.

Tankers are discharged at a special oil berth.

The loads are accepted and handled onboard vessels.

The dangerous loads are handled in the port only by direct method.

The port provides the following services: pilotage; assistance by tugs, boats and vehicles; warnings about the wind of 11 m/s and more; reception from vessels, while berthing, of solid garbage not polluted with oil.

Zelenomyssky (68° 47.5'N, 161° 22'E). The Zelenomyssky port is located in the East Siberian Sea on the right side of the Kolyma River at a distance of 130 km from its mouth. In the mouth there is a bar, the depths on which limit vessels' draft. The length of the port aquatorium is about 2000 m, the width is about 600 m.

To the South of the port, at a distance of 4 km there are Chersky town and Chersky airport.

The port operates only during the navigation. Sea navigation starts early in July and comes up to an end early in October. The duration of sea navigation on the average is 85 days. The duration of river navigation is more than 100 days.

Pilotage of vessels, when coming, mooring and berthing, is compulsory and is available 24 hours a day.

There are loading berths, an oil pier and service pier in the port. A covering of the territory is mass concrete. Warehouse facilities of the port consist of warehouses and open cargo storage areas. The loading equipment includes portal cranes with 5 tons - 40 tons capacity, gantry cranes of 20 tons capacity, gantry cranes for containers of 25 and 30,5 tons capacity, floating cranes of 5 tons and 35 tons capacity, jib cranes with a capacity of 10, 14, 16 and 25 tons. Warehouse loading operations are carried out by fork loaders.

Tugboat assistance at mooring operations in the port is compulsory. The port also provides such services as coastal reloading aids, transfer of seamen and members of their families from a vessel to the coast and vice versa, vehicles for excursions.

The port does not make reception and clearing of oil polluted and feces water. Dry garbage can be taken out by port vehicle at the written request of a vessel when the vessel is berthed.

Hatanga (70° 56'N, 102° 29'E). The Hatanga port is located in the Laptev Sea on the Hatanga River at a distance of 112 miles from its mouth. The port waters extend from the left coast of the Kulema peninsula to the right river side, where the port is situated. In spring the port territory may be flooded for two - three weeks.

The aquatorium bottom configuration near the right river side has a wavy character, near the left river side - a slope character. Anchorage is at the left coast. The depths by the coast are varying smoothly. The ground is mud and sand.

Leading marks and buoyage are provided along the fairway.

The berthing line of the port consists of some shallow water berths, intended for handling of small sea vessels. There are no warehouses in the port. On the floodable part of the port territory in the rear, there are open storage areas arranged on the embankment. The loading equipment of the port includes floating cranes of 5 tons capacities, caterpillar cranes and fork loaders.

Port fleet incorporate cargo, passenger and service auxiliary vessels.

Besides cargo operations, the port provides also the following services: removal from vessels of solid garbage not polluted with oil, (reloading of garbage from a vessel on a motor vehicle is made by the vessel's labor force and equipment); coastal reloading aids; emergency repair of vessels and mechanisms; tugs and passenger boats assistance; cultural service to vessels (at request of shipmasters).

Tiksi (71° 39'N, 128° 48'E). The port of Tiksi is situated in the Laptev Sea on the southeast coast of the Bulunkan gulf in the western part of Tiksi bay. The northeast entrance point of Tiksi bay is Cape Muostah, the southwest - Cape Kosysty. Brusnev Island is situated in the bay. The Sogo and Bulunkan gulfs are located in the western part of the bay.

The depth in the bay is small. The external road is connected with the internal one by a natural fairway. The ground in the bay is mud and clay, somewhere - gravel.

The port operates only in shipping seasons. An optimum term of the beginning of navigation is the second decade of July. The termination is the second decade of October. The average duration of navigation is 90 days. In initial and final periods the navigation is supported by harbor tugs of 1200 HP. Pilotage in the harbor is compulsory, including river vessels, caravans, towed floats and barges. Pilotage is available 24 hours a day.

In the port there is a pier system of berths. The petroleum berth represents two sunken lighters placed in the "crane" form. The port is equipped with portal cranes.

The port carries out pilotage; provides tugs and mooring staffs for berthing operations; supplies vessels with fuel, water, foodstuffs, spare parts (if available at warehouses); takes garbage, bilge and ballast waters from vessels (feces waters are not accepted by the port); provides a road boat; makes minor repair.

The port borders Tiksi town, which is a regional centre of the Bulun region. 6-7 km to the North of the town there is Tiksi airport.

Dikson (73°31'N, 80°28'E). The port of Dikson is situated in the southeast part of the Kara Sea at the entrance into the Yenisey Gulf.

The entrance to the port by the Preven Strait under any conditions of visibility and weather is safe and needs no pilotage.

Mooring operations are supported by harbor tugs.

The port mechanical workshops are capable to carry out minor vessel repair.

A salvage and rescue vessel and a rescue group are available in the port during the navigation.

Dudinka (69°25'N, 86°16'E). The port of Dudinka is situated on the right side of the Yenisey River, 230 miles upstream of its mouth. The port is connected by railway with Norilsk town.

Igarka (67°27'N, 86°36'E). The port of Igarka is located on the right side of the Yenisey River in the Igarskaya lade, 637 km (344 miles) upstream from the mouth of the river.

Navigation lasts from July to October. Ice begins forming in the second half of October. Igarka is navigable for about 110-115 days per year. Pilotage in ice conditions is available up to the early days of December.

The pilotage begins from the Oshmarino point, where a pilot boat is on duty. The extent of pilotage is 360 miles. Therefore, the pilotage is carried out by two pilots. Pilotage is compulsory, including the harbor waters, where harbor pilots do their work.

The port operates 24 hours a day.

The vessels not exceeding 160 m in length and with a draught not exceeding 7,3 m may enter the port.

While mooring, tug assistance is compulsory.

The cargo operations at berth are provided by port cranes, at roadstead - by ship facilities.

The port is capable to carry out minor repair.

The port of Igarka is connected by air transport to airports of the country all the year.

Narjan-Mar (67°38'N, 52°58'E). The port of Narjan-Mar is located in the mouth of the Pechora River, 100 km from Pechorskaya Bay of the Kara Sea. The main part of the port is on the right side of the Gorodetzkiy Shar lade 1.5 km from its merge with the Bolshaya Pechora lade.

The port is open for foreign vessels.

For entering the port, the channels of a total length of 10.2 km and depth of 4.9 m were excavated. The extent of river part of channels is 5.9 km, the depth - is 5,2 m.

The navigation lasts about 3.5 months from the middle of June to the beginning of October.

On the approaches to the Pechora river and in the river there are several anchorages, sheltered from the winds of all directions.

Air service is available all the year round and provides aerial communication with airports of the country.

Arkhangelsk (64°33'N, 40°37'E). The port of Arkhangelsk is one of the oldest Russian ports and is well known to foreign seafarers. The port is located in the mouth of the Severnaya Dvina River, flowing into the Dvinskiy gulf of the White Sea. The numerous polar expeditions and merchant voyages to the Arctic started from this point.

The port is capable to accept vessels with a draft up to 9.0 m.

In the harbor waters a few roads are available: the Maimaksa road -- for vessels with a draft of up to 8.0 m; the Solombalskiy, Krasnoflotskiy and Gorodskoy roads -- for vessels with a draft of up to 8.1 m; the Nizhegorodskiy road -- for vessels with a draft of up to 6.0 m.

Arkhangelsk has an airport and sea, river and railway stations, so that the city is connected with the world by all modes of transport.

Navigation starts in May and lasts till October - November; the navigation may last all the year round, with icebreaker assistance being rendered.

The port provides vessels with all kinds of supply and repair.

Murmansk (69°00'N, 33°04'N). The port of Murmansk is located on the East coast of the Kolskiy gulf, 26 miles from the Barentz Sea. The port is open for foreign vessels and is often visited by them. The port is a base for navigation of vessels along the NSR.

Navigation lasts all the year round.

Having deepwater berths, the port is capable to service vessels of 50 000 tons gross tonnage and downwards.
The port is connected by railway, air, road and sea lines to all regions of Russia.

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I.1.2.6 CREW TRAINING
MATHEMATICAL SOFTWARE AND METHODOLOGICAL SUPPORT FOR ICE SIMULATION TRAINING OF NAVIGATORS AND PILOTS.

KEY PERSONNEL

Dipl.eng.G.Chichev, CNIIMF (Leader)
Dr. E.Yakshevich, CNIIMF

SUMMARY

Mathematical software and methodological support for ice simulation training; ship's and play area's models; problems of ship's models.

KEY WORDS

SOFTWARE, SHIP'S AND PLAY AREA'S MODELS.

Mathematical software and methodological support for simulation training of navigators and pilots in maneuvering and ship handling under conditions of ice navigation offered at the Marine Research and Simulation Centre

Simulation training of navigators and pilots in maneuvering and ship handling under conditions of ice navigation differs to a considerable extent from ordinary simulation training. While handling the ship under limiting conditions of ice navigation the master has to make a decision about maneuvering in narrow water areas affected by the presence of ice, edges of ice channels, as well as about the way of interaction with an icebreaker and other vessels in convoy. Accordingly, mathematical software and methods for simulation training in maneuvering and ship handling under ice conditions require support of specific software and methods for simulation training purposes.

Mathematical software for training in shiphandling under conditions of ice navigation should comprise a detailed description of a mathematical model of the ship moving in the ice whose behavior is affected by external factors. It should be noted that a detailed mathematical model of the ship moving in open waters and of the ship maneuvering in narrow water areas or approaching port channels, whose behavior is affected by wind, currents, shallow waters, passing ships and berth walls has already been provided for training at many simulator centres. Nevertheless, the research into maneuvering characteristics of the ship whose behavior is affected by ice has not been yet accomplished and the development of a mathematical model of the ship to be used for training in shiphandling under ice navigation conditions is a matter of the future. It should be emphasized that the process of development of a mathematical model of navigational areas especially with regard to visual and radar pictures of ice regions is rather labor-consuming process because the ice in these regions in comparison with stationary objects (coastline, beacons, buoys, landmarks) is continuously moving and, thus, the ice conditions affect the process of shiphandling and maneuvering.

Visual and radar navigational areas of the Northern Dvina river have been represented in the mathematical model developed at the Marine Research and Simulation Center (MSRC), namely the region from entrance from the White Sea to bridges next to Bakaritza berths. The meandering and narrows of the Northern Dvina resembles to a certain extent a passage broken through ice. Owing to such aids the trainees can master the complex skill in handling ships of different types moving in train, as well as in obeying pilotage commands given from the icebreaker and in initiating actions in case of emergency. The trainees are enabled to master the same skills when they are trained in handling the ship passing through the channel of the port of St.Petersburg.

Data on the navigational area of the Gulf of Yenisey is being prepared now for computer simulation at the NMS-90 Simulator Centre.

As MSRC library is stocked by more than 20 ship's models it enables the instructors to upgrade training, choose the ship of the required type (timber carrier, dry bulk carrier, tanker) and assign the trainees certain tasks pertaining to handling the ships of different types.

During 13 years of its existence MSRC has gained wide experience from training navigators and pilots according to the IMO Resolutions (Resolutions 17, 18 and 20 adopted by the International Conference on Training and Certification of Seafarers, 1978) as well as from implementation of exclusively specialized training programmes (passage through narrows and channels, maneuvering in regions of intensive traffic and in narrow port water areas, etc.). The experience acquired can be applied in the course of drawing up programmes of simulation training in handling the ship under ice navigation conditions.

Summarizing, it can be pointed out that the development of models of navigational areas is carried out at MSRC by highly skilled specialists who have been trained according to specialized programmes and granted the relevant certificates. They present their work not only to Russian markets but to the foreign markets as well. In order to develop the mathematical models of the ship, and especially those of the ships whose behavior is affected by external factors, it is necessary to call on researchers from other organizations. As a result, additional heavy expenditures would be charged to the Centre account. Additional expenditures would also be required for modernization of the simulation equipment.

At the second stage of the research carried out under the INSROP project it is intended to solve all technical and organization questions concerning establishment of the first simulator centre in the world which could provide support for training of navigators in handling the ship in the Russian Arctic.

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I.1.2.7 VESSEL PERFORMANCE

Development of Main Requirements to Ice Passports of New Generation

KEY PERSONNEL

Dr. S.B.Karavanov, CNIIMF, (Leader)
Dr. L.G. Tsoy, CNIIMF
Dipl.eng. Yu.V.Glebko, CNIIMF

SUMMARY

The main purpose of the work is to develop the requirements of the Russian Marine fleet to the ice passport of new generation.

This work on the basis of the analysis of ice damageability of hull structures suggests the introduction of additional calculations of local strength of bilge and forepeak into the scheme of determination of safe speeds.

It was also suggested for icebreaking cargo ships of highest ice categories to include the verification of side midbody strength for the repelled impact. Structural scheme of the ice passport of new generation was prepared.

KEY WORDS

ice passport, damageability, hull structures, safe speed, local strength, ice belt, bilge, forepeak, plate structures, repelled impact.

INTRODUCTION

Vessel's "ice passport" developed by the Arctic and Antarctic Research Institute in the sixties, was prominent in providing safe sailing in ice conditions in which most of the Russian cargo fleet operated in the Arctic Regions in the seventies.

Then Russian Arctic fleet was reinforced with new powerful icebreakers and icebreaking cargo ships (nuclear icebreaker of *Taimyr* type, cargo ships of *CA-15*, *Vitus Bering*, *Ventspils* and other types). That made it possible to extend the terms of Arctic navigation (up to all-the-year-round in the West), as well as to expand the marine fleet operating area due to essential shallow water areas in the East of the Arctic Regions. Further experience showed that in more strict fleet operating conditions in the Arctic Regions certain difficulties arose in practice of using "ice passports" of this type, mainly due to extremely low level of "safe speed of ice cruising" recommended by the passport and stated by the design procedure given in this document.

Besides this, meeting the requirements of these "ice passports" did not guarantee absence of hull damages caused by ice in the area of bilge strakes, because in the design procedure "structural strength" had been determined by the structural design of only side grillages.

That practically resulted in failure to meet the requirements of ice passports to ships safe cruising speed in ice (especially cruising in convoy) in the conditions of intensification of fleet operation in the Arctic Regions.

The situation resulted in further increase of ship damages by ice.

In modern conditions the circumstances of ice damages have drastically changed, as well as their distribution along the hull underbody. The volumes of ice damages, which vessels following icebreakers have got during the Arctic navigation, continue increasing. These circumstances as well as the transition in modern practice of hull structures design to resilient-plastic methods of calculation of relevant structures, have brought about the necessity of developing "ice passport" of new generation.

MAIN FACTORS TO BE TAKEN INTO ACCOUNT IN "ICE PASSPORTS" OF NEW GENERATION

The main part of hull ice damages of modern arctic ships is concentrated not in the area of side ice reinforcements, but below the edge of ice strake and extends over the bilge and adjacent bottom strakes (Fig.7-1). In this case framing dents, as a rule, have a local (limited) character [1, 2] and are accompanied by buckling of sheet structures supporting the plating near the dent (Fig.7-2).

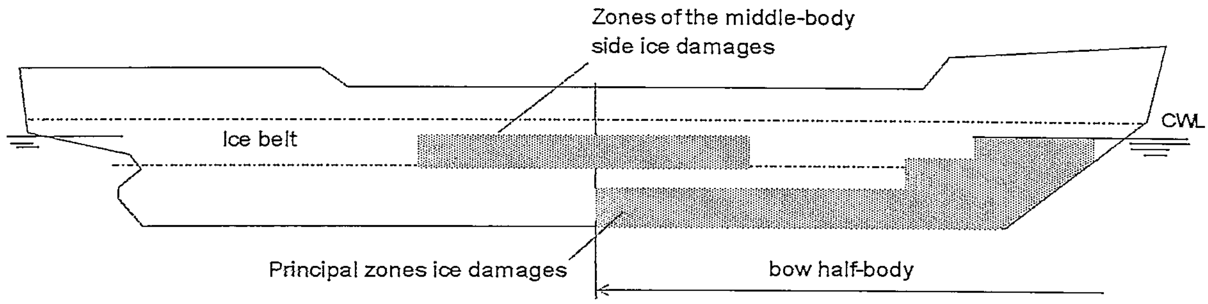

Fig.7-1. Generalized scheme of distribution of ice damages

In view of the mentioned peculiarity, it is reasonable to consider, when making structural strength analysis, a total function of side grillages, to estimate stability of plane framing members normal to the plating in the ice load area and to reflect the analysis in the "ice passport". If these sheet structures stability is insufficient, the hull structural strength parameters should be corrected and the values of safe ship's speed in ice should be decreased respectively.

Ships cruising in early periods of navigation in the Eastern regions of NSR revealed the necessity to take into account structural strength of middlebody in determining safe speed. In heavy ice conditions just in this part of the ship vast ice damages of side grillages occurred with big deflections due to "repelled" impacts against ice. Side structures damages of such kind were also observed even on the strongest modern cargo ships of ULA class of *Norilsk* and *Vitus Bering* type (Fig.7-3).

Obviously, the experience of cargo fleet operation in new conditions should be reflected in the structure of "ice passports" of new generation, mainly by enlarging the list of requirements to hull structures strength, taking into account different variants of ice operation tactics.

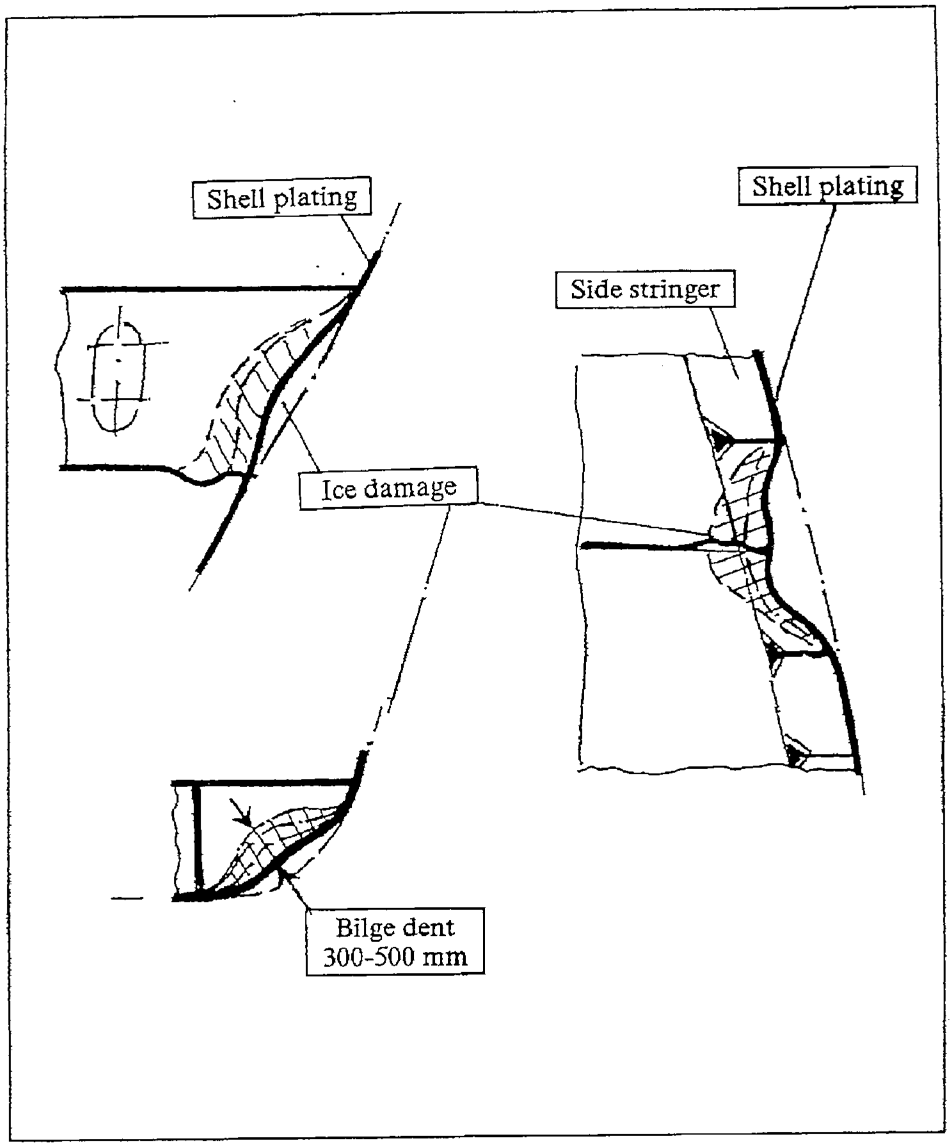

Fig. 7-2. Ice damages to plate hull construction

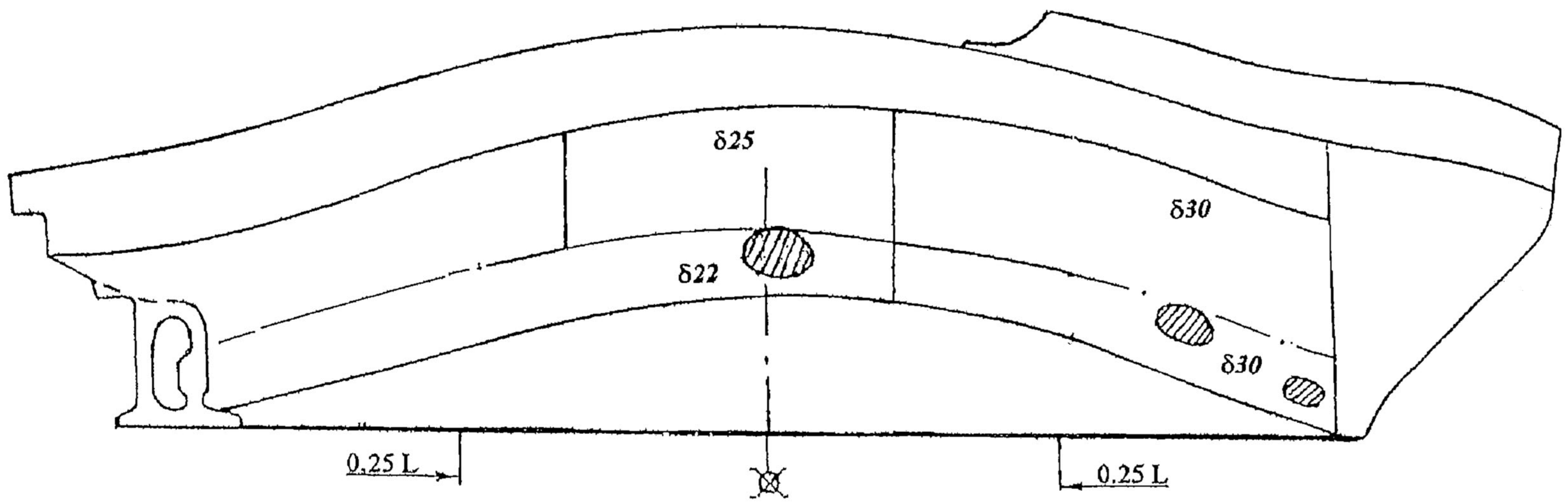

Fig. 7-3. Location of hull ice damages to m/s *Vitus Bering*

It is also necessary to envisage:

- repelled impact calculations for ULA class ships and the ships intended specially for transit navigation along the NSR without icebreaker's assistance;
- elastic-plastic character of structures deformation, which allows us to define better-grounded margins of strength in calculation of safe cruising speed.

When designing hull structural strength, it is also reasonable to take into account an influence of possible loss of stability of plane framing members (beam webs, brackets, etc.) supporting the plating in ice load area [2,3]. In ice passports of old type the "structure strength" was determined for only side grillages strength. Special attention should be paid to areas of forepeak and bilge strake in the bow half of the hull, where the main part of hull ice damages of arctic ships is concentrated. For bilge ice loads calculations it is necessary to correct the procedure.

The obtained by now experience of Russian fleet operation in Arctic Regions shows that modern arctic ships (built in accordance with the requirements of the Register Rules) don't get damages in the "ice strake" area or they are of isolated character and caused not only by structural errors, but frequently by mistakes of operators of the vessels as well.

Thus it is expedient to introduce into the ice passport general recommendations for captain on the preferable ice operation tactics for different combinations of ice and weather conditions en routes. With ship escorted by icebreaker these recommendations should also take account of the icebreaker type, power and ship position in a convoy.

CONCLUSIONS

Proposals on Ice Passport Composition

It is considered expedient to retain traditional general contents of "ice passport" formed during the period of usage and development of these documents.

It should include the following main provisions:

1. Instruction for passport user (operator of a vessel).

2. Main characteristics of the ship including its ice performance:
   - ship class (ice reinforcement category);
   - maximum possible speed in ice of different thickness, age (strength) and compaction;
   - structural strength of different hull areas.

3. Strength parameters of ice of different thickness and age in the foreseen ship operation area (season should be taken into account).

4. Diagrams of safe distances in convoy cruising as well as diagrams of safe speeds during the independent sailing and under the icebreaker support in ice of different thickness and compaction (for various seasons). These diagrams should be plotted for vessel with cargo and in ballast.

While determining safe speed, all calculations should be accomplished taking into account the wear of the main strength members providing for ice strength of the structures as of the middle and of the end of the ship operating service life.

In prospect, while accumulating processed statistic data, it seems reasonable to define more precisely the laws of distribution of main design parameters (ice thickness and ice strength on routes, characteristics, damages of different areas of hull, values of real speeds of ships moving through ice etc.), to develop a probability method for safe speed determination using the total probability model.

Taking into account a prospect of NSR cruising for ships and icebreakers with non-traditional dimensions and bow end lines (angles of slope to central plane being close correspondingly to 0° for frames and to 90° for bow perpendicular water-line), it is necessary to improve the procedure for ice load determination for its use for similar ships.

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I.1.2.8 MARINE CASUALTY

KEY PERSONNEL

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SUMMARY

The main tendencies in marine casualties and some statistic data were presented in the 1993 and 1994 reports. In 1995 the authors made the draft "Actions of crews in emergencies" and submitted it to the Ministry of Transport. Three chapters of the draft are presented in the current report.

KEY WORDS

Stability loss, Icing, Deicing, Supercooling

STABILITY LOSS PREVENTION

In international practice, ship casualties due to loss of stability are divided into three types:

sudden capsizing,
slow heeling,
flooding with heeling.

With sudden capsizing the time of casualty is so short that effective measures (crew action) to prevent the wreck of a vessel are impossible. Prevention of such casualties consists in observance of procedures concerning loading, securing and carriage of cargo and in ship stability control at all stages of voyage.

In case of large heeling of a ship (more than 10°), the officer in charge of the ship not waiting for additional information or order of the master, immediately raises the general emergency alarm. If heeling continues to grow fast, and the reasons for it are not clear, the crew abandons the ship by order of the master.

The crew escape may be delayed only on condition, that the increase in heel is slowing down and the master is fully confident that the actions related to determination of the origin of the heel and emergency control actions do result in loss of human life.

If the circumstances force us to ballast the vessel in storm, it is necessary to be sure that the following inequality is not infringed:

$$h - \Delta h > h_{min},$$

in which:

in which:	h	- transverse metacentric height prior to the beginning of ballasting, m;
	Δh	- correction for influence of free surface, m;
	h_{min}	- allowable minimum transverse metacentric height at given displacement according to "Information on Stability," m.

To prevent opposite heeling, ship equalization must be terminated when the list is about 5 degrees.

Sometimes the crew tries to improve the position of the vessel by trimming the displaced bulk cargo. In marine condition such measures succeed very seldom. People, working in holds, are exposed to additional risk. As for open holds, there comes the risk of flooding by waves. At timely detection of signs of rarefaction of bulk ore cargo, it is possible to prevent its displacement by pumping the water out of wells dug from the surface of the cargo. Simultaneously the cargo should be dried by powerful ventilation.

With icing, the capsizing of small vessels can occur when a weight of ice is equal only 2% of vessel's displacement. In no time the ice covers outside holes, obstructing flow of water and exposes the ship to danger of capsizing by flooding deck by waves. While normalizing stability with due regard to icing, one cannot guarantee the safety of the ship because actual icing sometimes is much greater than estimated values of icing. The drastic measures of icing control should be taken as early as possible. Before an icing storm breaks out it is necessary to lessen ship's flooding, to clear the deck from all objects which can block the flow of water and, if necessary, to carry out ship's ballasting in order to gain the maximum stability.

ICE CONTROL

The formation of a layer of ice on surface part of the hull unfavorably affects floatability, draught, list and trim of the vessel, restricts vessel's manoeuvrability, disables radiocommunication equipment and radars, impedes the use of boats and deck gears. Owing to elevation of the center of gravity of the vessel due to ice accretion, vessel's stability comes down so that the danger of capsizing arises. Ice accretion is especially dangerous for vessels of small displacement carrying deck cargo, in particular, for timber carriers.

Ice accretion depends on many factors and among them there are such key factors as air and water surface layer temperature, wind speed and sea conditions.

Experience shows, that the threat of capsizing comes, when the weight of ice on a vessel exceeds 10% of vessel's displacement. At the same time, on ships of large displacement, the weight of ice even with heavy icing seldom exceeds 8%. This implies that the loss of floatability does not reach a dangerous level.

With heavy ice accretion, the growth rate of an ice layer is more than 6 cm per day, and with a very heavy - more than 15 cm per day. With fast ice accretion, the weight of ice accrues up to 4 tons per hour, and the vessel reaches a certain critical margin of stability within a period of 0.5 - 1 day. Favorable conditions of fast ice formation involve wind speed of more than 5 m/s, temperatures of outside air lower than -4°C and temperature of water close to the freezing point.

The master in the periods when ice formation is expected, analyzes data on temperature of water and air, direction and speed of wind and seas which are capable to produce splashing of water onto the vessel, with a view to find out in due time an initial stage of icing of the vessel. The actual beginning of icing is established by systematic observation.

Ship's stability is controlled by making a comparison between rolling period of the vessel prior to the beginning of ice formation and during the process of ice formation. Any increase of rolling period is dangerous.

Changing the course and speed of the vessel is one of the most effective methods of reduction of ice accretion. It should be kept in mind that navigation in the following sea contributes to decrease of stability.

With detection of ice formation, deicing measures must be taken: the chipping-off, hot water (within the range of small negative air temperatures), water under pressure and water steam are to be used. The aim of deicing is not to allow accumulation and hardening of ice. With chipping off the ice on tankers, gas and chemical carriers, measures should be taken to prevent sparking. If necessary, ship-to-ship or ship-to-shore radiocommunication should be established.

First of all, the vital parts of the ship (radioaerial, navigational lights, lifesaving appliances, etc.)

should be deiced.

Deicing of the ship begins with highly located structures so as not to impair the stability of the ship. The chipping-off should begin with the listed side of the ship, from bow to stern.

In critical situations the necessary effect can be achieved by throwing the deck cargo overboard.

HOW TO SURVIVE IN COLD WATER

Internal temperature of human body is about 37-38 °C. In water, with temperature below 30 °C, the temperature of body will quickly drop, which results in hypothermia. Cooling of body in water goes very fast, as the heat capacity of water is much more than that of air. Even if the temperature of air is far lower than the temperature of sea surface, the heat transfer in air will be far less than that in water. This is why the survivor should always try get out of water.

In cold water, self regulation of human body reduces the heat transfer into environment. This effect is produced by reduction of blood supply to the skin and, in particular, to the limbs. In this case the increase of isolation of the skin and drop in temperature of the skin of hands and legs will happen.

If a person is in marine water with temperature below +10°C, his hands and legs are paralyzed with cold and the person is not able even to take a hold of a line thrown to him or to climb aboard a rescue craft by himself. In this situation, when a person in distress becomes absolutely helpless, the most important things are: whether the life jacket is donned correctly or not and how high is the head of the person kept over the water by his life jacket.

Hypothermia symptoms can manifest itself individually with each person. However, a general sign of menace of supercooling to human life is absence of tremor. This indicates that human body has stopped protecting itself against supercooling.

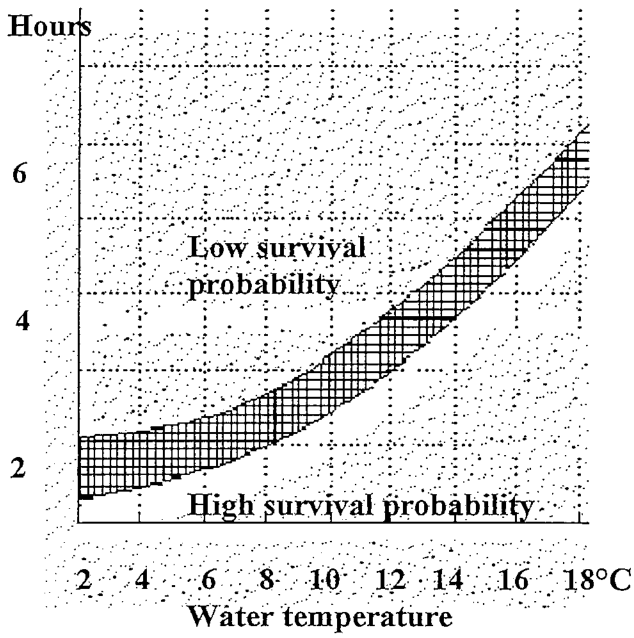
With deep supercooling, a human being can happen to show no signs of life, however that should not be taken as a reason for rendering no aid to the victim. The history of navigation knew many cases, when persons, taken out of water without any sign of life, successfully came to life.

Absence of signs of life is not the sign of death from hypothermia.

As the temperature of body during supercooling is dropping, it gives a certain protection to the vital organs, especially to the heart and brain, because their needs in oxygen and nutritives are reducing. Thus, the fall of temperature of body can be of particular importance for self-protection of the victim from hypothermia and for his returning to life. With children this protection manifests itself more distinctly than with adults.

Survival of persons in water depends on many factors. The most important of them are clothes. Even being completely wet, clothes give some thermal protection, as some warm water is kept in the layers of clothes, reducing the heat loss of body.

The death from supercooling comes, when the temperature of victim's body falls to 20-27°C, but this is not always the case. Survival time in water can be represented in the following graph:



The graph shows the time that is rather approximate and cannot serve as unequivocal criterion for organization of a search of people in distress. In navigation history there were cases, when seafarers were found alive after they had been in cold water more than 24 hours!

Liferaft survival principles

Modern lifesaving appliances belong basically to covered types. But all the same, the survivors are exposed to adverse weather, they are getting wet through, and they should begin to struggle with cold, otherwise they will break down in short time. If there is no water in the raft, one should take off and wring out one's clothes. It should be kept in mind that woolen things are the things of perfect thermal protection, even if they are wet through. Therefore woolen clothes should be put directly on naked body, and then cotton clothes and other things, previously wrung out, should be put on.

It should be emphasized that the person has a very large loss of heat from the uncovered head. So, with an outside temperature of +5°C, the heat loss of a person with unprotected head reaches approximately a half of the whole quantity of heat produced by the body. Therefore, the head and neck should be well sheltered.

Boots should be taken off because they can hinder good blood circulation in legs. Sockets should be put on up to the half of the length, so that toes are in the heels of sockets to keep them warm.

When a person begins to freeze, measures should be taken to preserve warmth of the body, and to this effect one should cover oneself with blankets and subsequently with polyethylene film over them in order to prevent heat transfer to the top part of the liferaft. Whenever possibly, the survivors should protect the bottom of the liferaft from the water by spreading polyethylene film, blankets, and other suitable materials over the bottom.

The persons in liferaft should cuddle up close to each other to conserve the warmth. Besides, a person should warm the legs of the opposite neighbor putting them under his (person's) clothes and placing them against his body.

Aid in case of hypothermia (supercooling)

A person, taken out of water, has different temperatures of different parts of the body. So, the temperature of his hands and legs can be far below, than that of the body, and of such vital organs as the heart and brain.

The victim should be treated carefully: if his breathing ducts are clear, and he is breathing, one should not hurry while rendering him medical aid. Careless treatment can cause sharp activation of blood circulation, the activation may result in sudden equalization of temperature of the body, that is, the blood will flow from his vital internal organs to the outside layers of the skin, the temperature of the heart and brain drops and the fatal outcome is inevitable.

Therefore one must:

avoid sharp treatment of a victim and
not massage his skin.

A victim should, whenever possible, be drawn out of cold water in horizontal position. Experience has shown, that lifting of a person in vertical position can result in his death because of heart paralysis.

In case of several victims, first of all, one should come to the aid of a person who has no tremor. This person is in extremely life-dangerous condition. The loss of heat involves a great loss of energy that results in a sharp fall of sugar content in blood, as the sugar is a source of energy. Externally it can manifest itself in loss of consciousness, cramps, unpleasant acetone scent from mouth. Therefore, a person affected by cold should be given a hot drink (tea, coffee etc.). But one shall keep the following principle in mind: never try to give something to swallow to an unconscious person.

In case of hypothermia, the aid involves returning of warmth to human being. After rescuing, further heat loss from the victim's body should be prevented.

It is quite possible that a survivor is supercooled, but it is also likely that his lungs are filled with water.

If he does not breath, one should immediately start artificial breathing with the use of "mouth to mouth" or "mouth to nose" technique.

If there are no signs of cordial activity, indirect massage of the heart should be started.

At the same time the victim should be warmed. The most effective way to warm quickly the victim is the use of hot baths with a temperature of about 42-44°C. In this case, the whole body of the victim, including hands and legs should be immersed in water. Temperature in the bath at the very beginning can be about 37°C, and then during several minutes it should be raised up to 42-44°C. Hot water should be added to provide the constancy of temperature.

The victim should stay in the bath until he comes to consciousness, then it is necessary to carry him in horizontal position onto a warm berth and secure him. Otherwise, if he suddenly stands up, he will be lost.

The victim should not be placed suddenly in a hot bath, only step-by-step method of warming may be used.

The victim should be wrapped up in blankets to get warm slowly by his own inner resources. The blankets of good wool are preferable.

One should not warm them, the warmed blankets can bring about a false sensation of warmth, that can result in sudden intensification of blood circulation with unfavorable consequences.

Moreover, the procedure should be conducted in a room with low temperature. If possible, the person should be undressed and wrapped up with polyethylene film to prevent cooling from evaporation, and after that he may be wrapped with a blanket.

So, the sequence of actions of slow warming technique is the following:

a victim should be isolated from any external source of heat;

then the victim should be undressed carefully to avoid excessive movements of his hands and legs, his clothes may be cut with scissors or knife;

the victim should be wrapped up in polyethylene film;

then he should be wrapped up in woolen blankets;

his head should be covered, but his face is uncovered;

continuous careful attention should be given to any victim;

hot sweet drinks should be given to him after his coming to consciousness.

The following method of warming is successfully used for persons who were affected by sea and supercooling but have not lost consciousness:

a patient is wrapped up in blankets and made comfortable in recline position;

his hands and legs are immersed in the water heated up to 44°C;

after his hands and legs are warmed, they are also wrapped up in blankets. This is very important, because the warming has made blood vessels enlarged and when the procedure is over, they will intensively release warmth and this, in its turn, can result in sharp fall of temperature of the body;

the patient (victim) is placed in a warm berth.

Contrary to existing opinions, alcohol is inapplicable at rendering assistance to the victim suffered from hypothermia. It will depress the response of human body and its resistance to cold.

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Recommendations on actions of crews in emergencies. CNIIMF. 1995. St.Petersburg.

PART II
PREPARED BY AARI

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TABLE OF CONTENTS

PREFACE

The present project is being developed in two main directions. The first one is connected with technical and organizational aspects of the NSR exploitation. It is executed by the specialists of CNIIMF (A. Baskin and Ye. Yakshevich being supervisors of this part of the project).

The second direction deals with the study of environmental aspects of the NSR exploitation (supervisor - A. Buzuyev, AARI). The results of the said study are under discussion below. The main attention is paid to the materials obtained during the period from March, 1995 to January, 1996.

As the present report covers the research work being held since 1993, the results obtained before 1995 are used as well when necessary.

INTRODUCTION

Within the frames of the reported research the concept and principles of dividing the NSR zone into regions according to the difficulties and safety of shipping are elaborated (1993/94). In 1994/95 the concept of dividing the environmental conditions in the NSR eastern segment into types was elaborated and the first stage of work was executed. In 1995/96 the similar research was carried out for the western segment between the Novaya Zemlya straits (the traverse of the Zhelaniya Cape) up to 125° of eastern longitude.

In contrast to the eastern segment where the main obstacle for shipping is drifting ice, at the western one the most significant difficulties are connected with sailing through fast ice in the B.Vilkitsky Strait and to the west of it. In this connection the typical conditions of fast ice formation in this region were under consideration.

To divide the NSR into regions and natural conditions into types all available ice observation data were used. This enables us to obtain a complete description of distribution and spatial-temporal variability of practically all ice cover parameters (stage of development, concentration, hummockness, etc) for every type.

While dividing the NSR into regions for the first time, the calculated values of operational and safe speeds of ice shipping were used along with characteristics of environmental conditions.

The methods for calculating the operational speeds in particular ice conditions have been elaborated in the AARI (Adamovich, Buzuyev, Fedyakov, 1995).

In 1994/95 the results of operational speed calculations for different types of ice conditions were presented in the report.

It is worth mentioning that the calculation results for mean ice conditions are in good agreement with the generalized natural data which were widely used in Subprogram III.

At the same time under adverse conditions of navigation the operational speeds (as well as the time spent on sea operations) were shown to differ significantly from those under average conditions.

Thus when estimating the safety of the NSR shipping it is necessary to take into account the probability of hard conditions in different segments of the Route as well as the performance indicators of shipping (speed, time expenditure, forced demurrages, accidents, etc) connected with these conditions.

In the research of 1995/96 the special attention was paid to safe operation of ships of particular types.

The methods of calculation of safe speeds for particular conditions have been elaborated in the AARI (Likhomanov, Timofeev, Faddeyev, 1993); these speeds are the basic element of ice passport for ice ships.

In 1995/96 the elaboration of mathematical support of "Onboard Ice Passport" was completed. A special software block takes into account the main parameters of a ship. It allows us to calculate the propulsion characteristics necessary for estimating the attainable speeds. It can also provide for the propulsion complex when the power plant works at full capacity. This software also enables us to calculate the working hull strength and estimate the ice loads regarding the hull shape and the wear of construction elements of side and bottom structures.

Finally the "Onboard Ice Passport" gives an opportunity to determine the safe speed in particular ice conditions during free sailing or following an icebreaker along the lead.

Besides, the information provided by the ice passport gives a technically substantiated estimate of necessity of icebreaker pilotage under particular operational conditions.

Ice shipping is inevitably accompanied by ice damages. In this connection in 1994/95 the generalization of damage data for all regions of the NSR was executed, the segments of maximum damage probability were revealed (Reports, 1993-1994 and 1994-1995).

In 1995/96 attention was paid to the damages which practically give continuous growth in number. Such kind of damages were, as a rule, residual deformations of the side framing and plating.

The designing rules for ice belt of all the classification societies are based on the assumption that any damage is a result of a single ice impact. The accumulation of damage parameters is not taken into account due to physical complication of such process and due to the difficulties of ice impact description during the operational period, because the accumulation process of plastic deformations depends on the "history" of loading.

In the research of 1994/95 the probability approach to the accumulated damage parameters was suggested.

In 1995/96 the calculations of probable damage accumulation for a particular ship were executed for two regions of the NSR.

Thus the research work executed by the AARI allowed to obtain the following results:

- generalized information about ice shipping conditions represented as the types of ice cover distribution in the regions of shipping;
- technologies for calculation of operational and safe speeds of ships under typical conditions;
- stochastic estimation of ice damages risk for a particular ship (including the wear of the hull) under particular ice conditions.

Such approach gives an opportunity to elaborate the techniques for numerical estimate of the risk of navigation along the NSR based on the probability distribution of the main environment parameters peculiar to every type.

Besides, the completion of research in relation to ice passports allows us to select the optimal regimes of shipping under typical or particular ice conditions. Unfortunately the financial support for these above-mentioned labor-consuming work (Project 1.1.2 (and Subprogram I)) was too poor (Karklin et al, 1983). That is why in 1996 the executors were reduced to description only of the basic features of every type of environmental conditions in the western part of the NSR and to calculation of the operational indicators and the damage probabilities only for particular, but rather frequent cases.

At the same time, taking into account the importance of the above research aimed at the effectiveness and serviceability of the NSR, such and more detailed studies are planned and partly being executed within the frames of Russian scientific programs. No doubt if the INSROP research being continued, the results of mentioned studies will be included into the INSROP program as well.

1.1. DIVIDING INTO TYPES OF ICE CONDITIONS IN THE WESTERN REGION OF THE NSR

While solving the most important problems of using the NSR (optimal location of icebreakers in different periods of navigation season, the choice of optimal terms for conducting the concrete operations, estimating of risks, etc.), the information about ice cover typical distribution in the region as a whole is necessary (remember, in this case the Western region of the NSR is under consideration). The difficulties connected with such kind of large-scale dividing into types are evident. For the seas of the Western region of the NSR (Kara Sea, Laptev Sea) the large spatial-temporal variability of ice cover distribution is typical even within the local areas. That is the reason for the majority of researchers to pay much attention to dividing into types the ice (as well as hydrological and synoptic) processes for separate regions of these seas (Likhomanov et al., 1993; Ryvlin, Kheisin, 1980).

In particular, as for the southwestern part of the Kara Sea, three types of ice cover distribution are usually revealed, as for the north-eastern part - two basic types. In the Laptev Sea the quantity of typical distributions, according to different researchers, varies from 4 to 6. Nevertheless just for solving the operation problems of shipping via the NSR the method of classification of ice cover distribution by I.Kuznetsov (Kuznetsov, 1967) (4 types) appears to be the most suitable one. Rather detailed description of the peculiarities of every type for mentioned above areas of the Western region as well as the information about typical distribution of the ice cover parameters are presented in literature (Likhomanov et al., 1993; Ryvlin, Kheisin, 1980).

As for classification of ice cover distribution at the Western NSR as a whole (and all seas of the Siberian shelf as well), the first effort was likely to be done in the paper (Krutskikh, 1982). Ice-hydrological regime of the Arctic seas was presented as a continuous alternation of consequent large-scale synchronous meteorological, hydrological and ice processes in the homogeneous regions of a sea.

As a quantitative criterion for the dynamic processes, the regular data of wind-origin level fluctuations observed at the polar stations were used.

The entire variety of the dynamic processes in the Arctic seas was grouped into 7 types. The probability of formation in a particular year, inter-annual and seasonal duration, stability and so on were estimated for every type.

Unfortunately, with this method of classification, the peculiarities of ice cover distribution and development were poorly taken into account. That is why the search for the most objective classification method for the Western NSR ice cover was continued. This research work was based on 850 composite ice charts involving the whole period of regular ice observations in the Siberian shelf seas made at intervals of 10 days (in winter period - 1 month).

The expert-empiric method elaborated by V.Ye.Borodachev (Report INSROP 1993-1994, 1994-1995) and earlier used for the similar problem regarding the Eastern NSR was taken as the basis of classification. The main point of the method - ice distribution patterns within a particular region for every 10-days period of calendar month are united according to the following parameters:

- similarity of geographical location of zones with prevalence or(and) inclusion of ice of different development stage;
- distribution and developing of fast ice and flaw polynyas;
- location of ice edges.

Finally, in the same way as it had been done for the Eastern NSR, six types of ice cover distribution were revealed. In the most general form the peculiarities of this classification for the ice cover of Russia's Euro-Asian shelf executed by V.Ye.Borodachev were presented in the paper (The Manual, 1951). Below one may see more detailed description of every type.

Type I (fig. 1) is characterized by the most northerly location of ice edge in the Barents Sea during the year cycle of ice cover evolution, low ice cover extent, high-latitude location of the Central Polar ice massif and small area of old (mainly second-year) ice in the north-eastern Kara Sea and in the Laptev Sea. Its negative anomalies are equal 8-9% for the northeastern Kara Sea and 11-15% for the Laptev Sea. Fast ice area is close to standard value in the Barents Sea and southwestern Kara Sea, 2-5% less than standard value in the northeastern Kara Sea and in the western Laptev Sea. The area of young ice which is closely correlated with flaw polynya areas, to the contrary, appears 1-12% larger than normal value in all seas from January to May. Moreover, the positive anomaly of the young ice area grows from February to May. It is characteristic that the absolute maximum of the young ice area corresponds to the years of the type I. For example, in February, 1960, the area of young ice was equal 83% of that of the southwestern Kara Sea area.

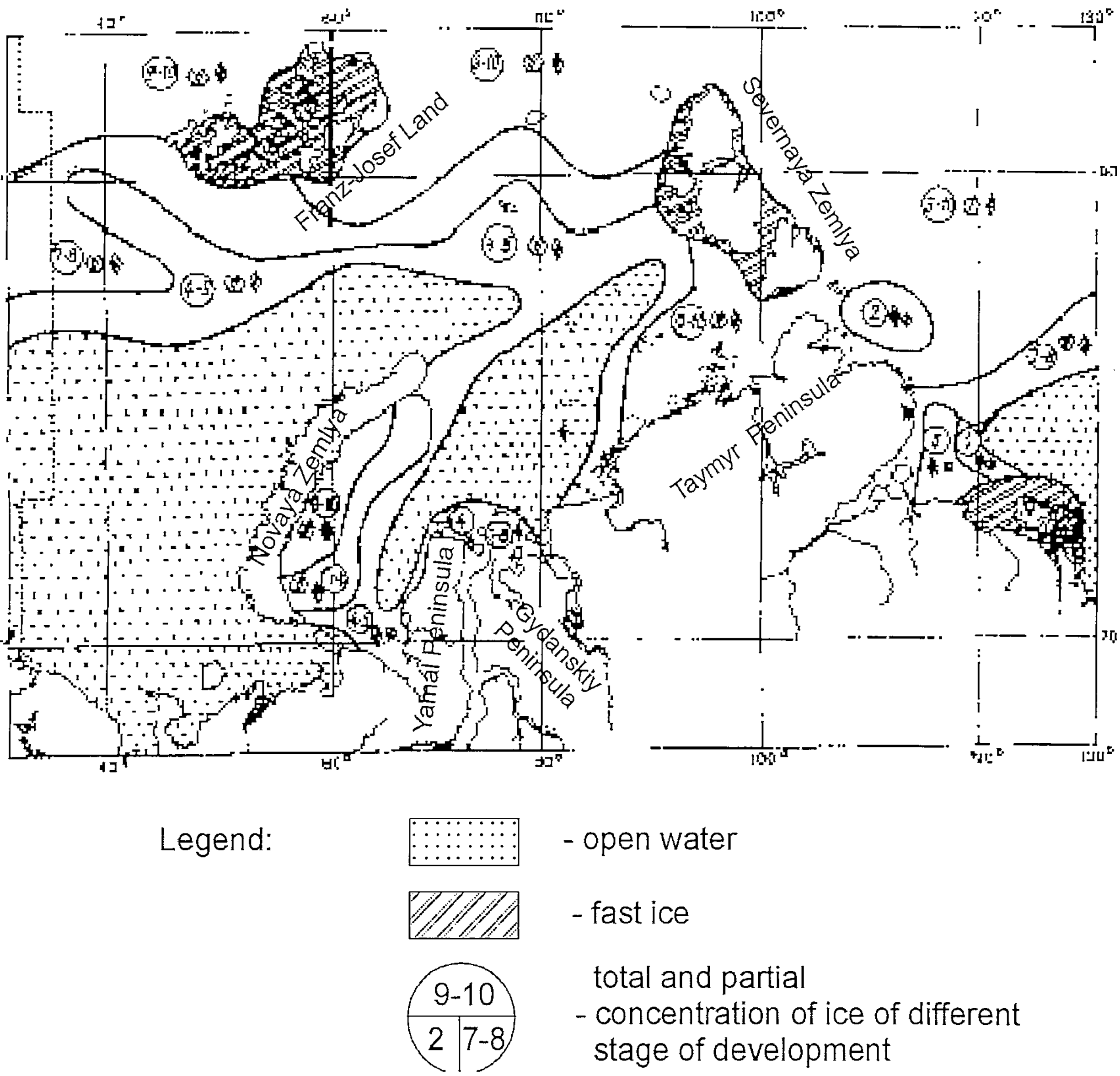


Fig. 1. Ice cover distribution in the western region in May (type I)

According to polar stations observation data the ice of lower thickness is formed in winter period in all seas of the region. In the southwestern Kara Sea the mean negative anomaly is -24 cm (amplitude varies from -11 to -52 cm) in February, and -26 cm in May. In the north-eastern Kara Sea mean ice thickness anomaly is -27 cm (amplitude: -16 - -44 cm) in February and -33 cm in May; this fact indicates the generally slower growth of ice thickness in the Kara Sea as a whole. In the western Laptev Sea the mean ice thickness anomaly varies from -20 cm in February to -13 cm in May, that indicates the intensification of ice thickness growth from February to May in this sea.

In May the process of ice melting and thermal destruction begins. In the Barents Sea the frontal ice melting goes in northern and northeastern directions. Already by the middle of June close ice disappears here. As for the Kara Sea the ice melting goes from three sides:

- from southern Novaya Zemlya straits and from the Yamal Peninsula;
- from the Barents Sea north of Zhelaniya cape to Vize and Ushakov islands;
- finally, from Ob'-Yenisey region and the Central Kara polynya.

In the Laptev Sea the ice melting process develops as a rule from south to north with secondary melting center located to the east of B.Vilkitsky Strait.

The areas of all ice massifs (Gudkovich et al., 1972) are much lower than mean values. Only the Taimyr ice massif area in July-August can be excluded. In this connection the type I is divided into two sub-types.
In general with the type I of ice cover distribution the extremely favorable ice conditions from shipping viewpoint are observed in the western seas of the Euro-Asian shelf..

Type II (fig. 2). In winter period the type II of distribution of ice age, fast ice areas, flaw polynyas and ice edges in the Barents Sea differ slightly from those for the type I. In these years the Central Polar ice massif only in March-April goes southward to the Laptev Sea in the form of inclusions of old ice and makes the area of the old ice 3% larger.

The ice edge in the Barents Sea is situated 30-50 nautical miles to the south of its location peculiar to the type I. However the ice cover extent of the whole Barents Sea and its parts still remains less than 50%.

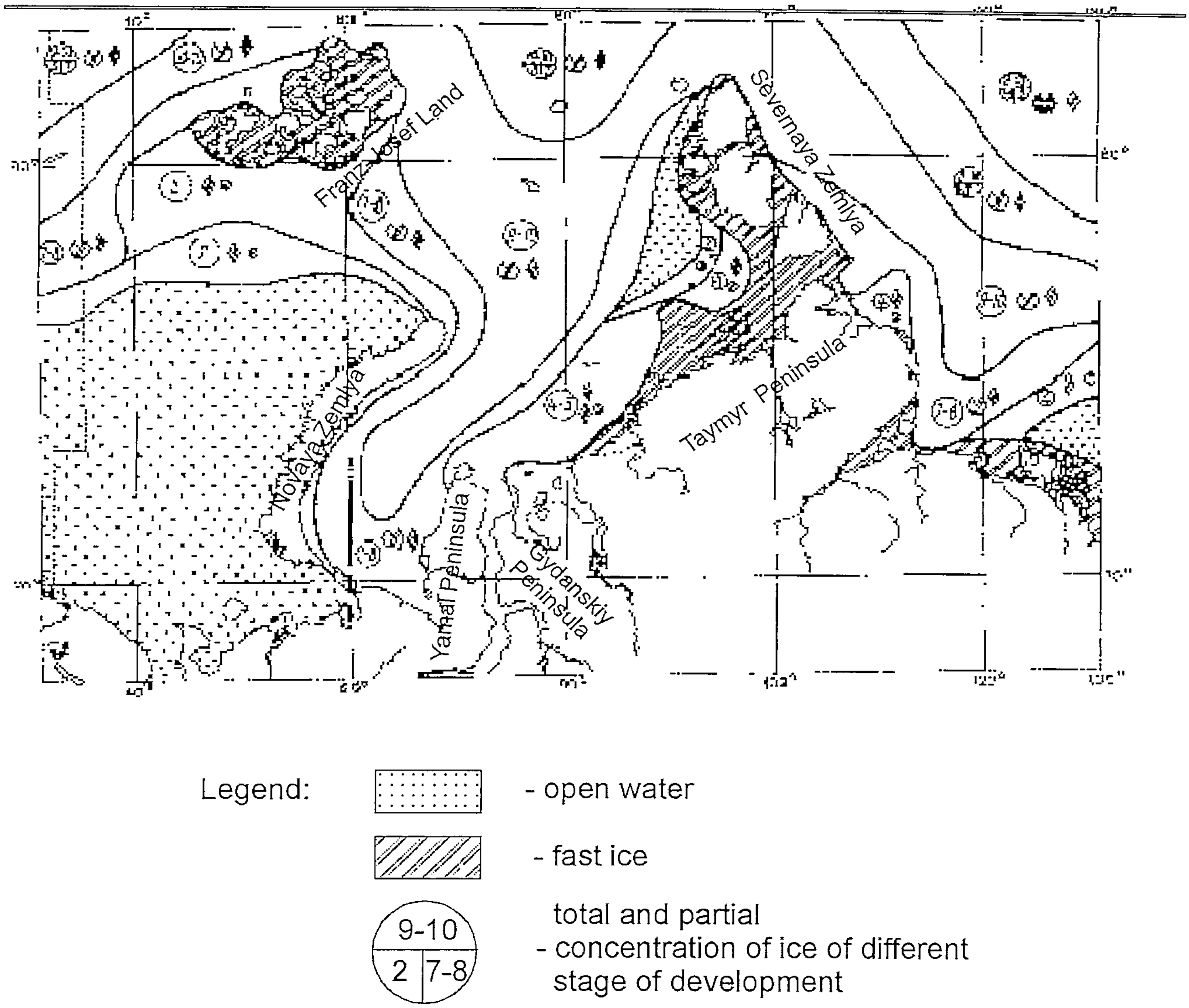


Fig. 2. Ice cover distribution in the western region in May (type II)

Flaw polynyas are developed weaker than those with the type I, although at the beginning of winter their areas use to exceed the mean value. That is why the area of young ice is close to the standard. In the western Laptev Sea in April-May it can appear to be even lower than standard.

The process of melting and destruction begins early especially in the Barents Sea and around the Amderma coast. The most intensive ice melting takes place in June, that leads to the nilas and young ice melting; ice massifs' concentration reduces to 90-100%, and somewhere even to 70-90%. According to the ice thickness observations executed at the polar stations of the Kara and Laptev Seas, lower ice thickness is typical for the type II.

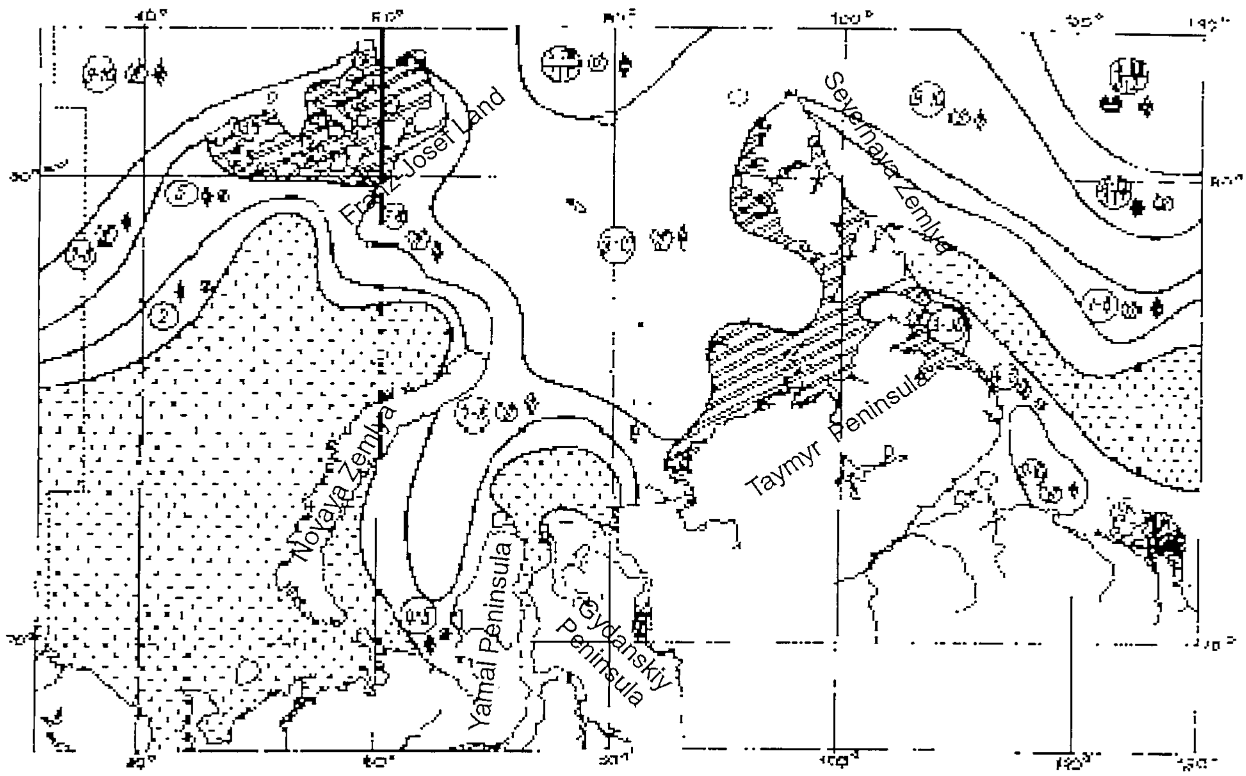
The positive anomaly of the ice thickness reaches 20-29 cm and keeps up rather stable till June. The characteristic property of spring ice processes on the type II is comparatively quick ice melting in the southwestern Kara Sea and western Laptev Sea. The most significant specific feature of ice situation development in summer period is a large area of close ice in the northeastern Kara Sea. Moreover the Severozemelsky and the North Kara ice massifs keep united till the end of melting period. The most indicative example of the type II of ice conditions evolution was the year 1959, when the food, fuel and other necessary materials were brought to the stations of the Sedov Archipelago from the east through the Red Army Strait.

The general regularity of seasonal variation of ice distribution for the type II is also seen in the evolution of the ice massifs.

For instance, the area of the Novozemelsky ice massif by the beginning of July is equal only one third of the southwestern Kara Sea area. The Taimyr ice massif area at the beginning of July is 20% lower than standard while by the end of August this anomaly already equals 40-44%.

On the contrary, with the type II of ice processes the areas of the Severozemelsky and Northern Kara ice massifs (which keep united) are 15-20% larger than the mean value. Thus with the type II of ice processes the easy ice conditions are formed in the Barents Sea, the south-western Kara Sea and the western Laptev Sea. In the northeastern Kara Sea the ice of larger thickness is formed during the winter season. In spring the weaker process of ice melting and destruction leads to formation of larger than standard ice massif areas, to their united state and to more complicated shipping conditions.

Type III (fig. 3). With the type III of ice processes the Central Polar massif of old ice gets nearer to the northern boundaries of the western Arctic seas; the tongues of the Central Polar ice massif come into the western Laptev sea and the old ice area in winter sometimes reaches 30-40% of the sea area. Fast ice area usually remains close to standard. The flaw polynyas are developed weakly, the anomalies of the young ice areas vary from -9% to +11%.



Legend:
- open water
- fast ice
- 9-10 / 2 | 7-8 — total and partial concentration of ice of different stage of development

Fig. 3. Ice cover distribution in the western region in May (type III)

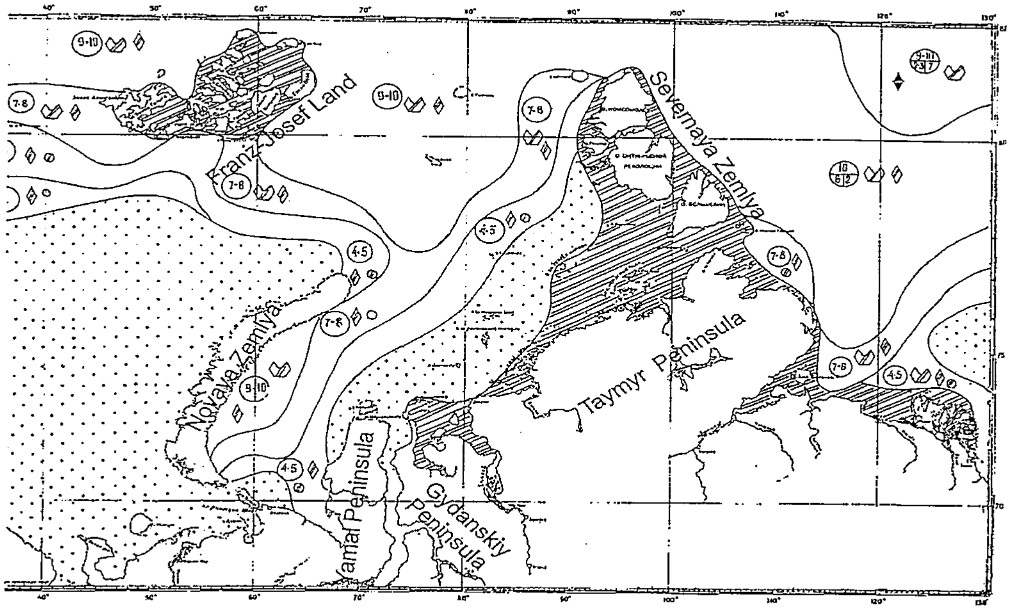
In summer period the ice cover extent of the Barents Sea increases quickly, the Novozemelsky ice massif disappears, the Northern Kara and Severozemelsky ice massifs become less than average, but the Taimyr ice massif area remains larger than standard till the end of navigation period. With this type, the getting-free-of-ice process of the western seas goes from west to northeast.

With the type III the ice conditions are close to normal values, though they are favorable enough from navigation point of view in the Barents and Kara seas. Some difficulties can be expected in the western Laptev Sea, where in the region between Psov Cape and

M.Pronchischeva Harbor the coast can be blocked by the compact ice.

Type IV (fig. 4). Unlike the type II, with the type IV of ice processes, the ice cover in the Kara and Laptev Seas is displaced to the west. Here high thickness and great amount of hummocks characterize fast ice. On the contrary, the ice thickness in the eastern and southern parts of the seas is lower than standard, the ice is more level, fast ice area is also less.

In the summer period the ice massifs in the western parts of the seas remain stable for longer time, the Novozemelsky ice massif is usually united with Northern Kara one till September. That is why in some years the compact ice locks the Karskiye Vorota Strait from the eastern side. In summer the areas of the Novozemelsky, Northern Kara and Taimyr ice massifs are larger than normal value or close to it, while Severozemelsky ice massif area is less than mean value. That is why the navigation conditions between the straits south of Novaya Zemlya and the B.Vilkitsky Strait are rather favorable. However, to the east of the B.Vilkitsky Strait the serious problems are probable even in September.



Legend:
- open water
- fast ice
- total and partial concentration of ice of different stage of development (9-10 / 2 | 7-8)

Fig. 4. Ice cover distribution in the western region in May (type IV)

Type V (fig. 5). The most characteristic property of ice distribution of the type V is a significant extension of the old ice tongue in the northeastern Kara Sea and in the central Laptev Sea. The large tongue of this ice is directed to the northwestern Barents Sea. The higher than standard values of ice thickness are observed in the northern half of the Barents Sea, the north-eastern Kara Sea and north-western Laptev Sea. In the mentioned parts of the western seas of the Euro-Asian shelf in winter one can observe a slight increasing of fractures concentration, high values of hummockness and frequent compactings. In summer the weak melting process and almost unchanged state of all ice massifs (the Barents Sea massifs as well as North Kara and Severozemelsky ones) are observed here. At the same time the decreasing of the North Kara and Taimyr ice massif areas takes place in common terms, though the latter can remain higher than standard till the end of a season.

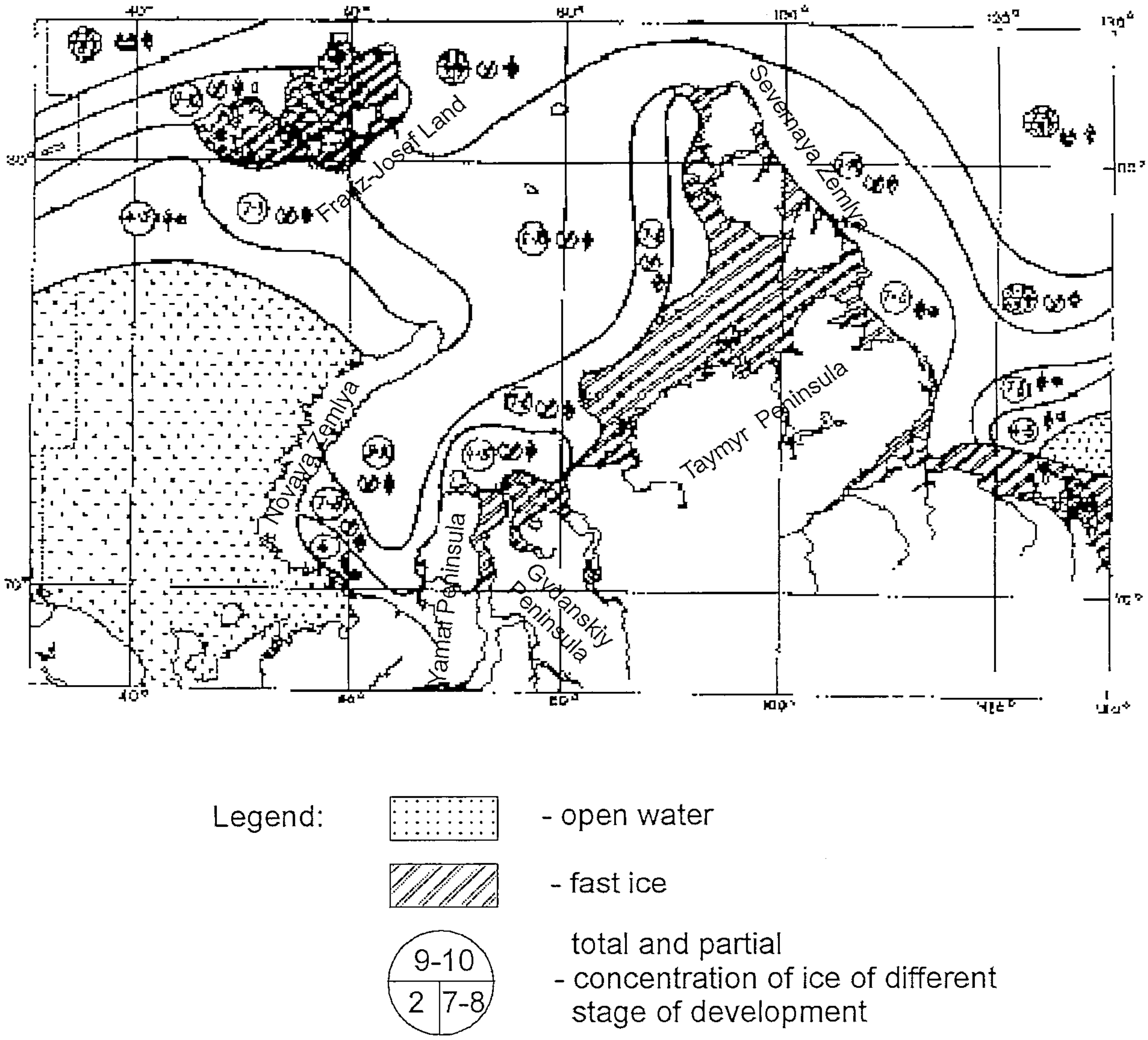


Fig. 5. Ice cover distribution in the western region in May (type V)

Thus, with the type V of ice processes the hardest ice shipping conditions during the entire navigation period remain in the north-eastern Kara Sea, where the Severozemelsky ice massif can block the B.Vilkitsky Strait and rather often a part of this massive can be even brought out to the Laptev Sea.

Type VI (fig. 6). With the type VI, the ice cover of the Arctic seas of Euro-Asian shelf is especially closely connected with the ice of the Central Arctic Basin. The tongues of the Central Polar old ice massif extends far into areas of the shelf seas preventing the development of the first-year ice, flaw leads and, consequently, the young ice areas. The long atmospheric transport from Central Arctic Basin contributes to the development of the type VI of ice processes. In winter period higher ice thickness and the most southern location of ice edge are observed.

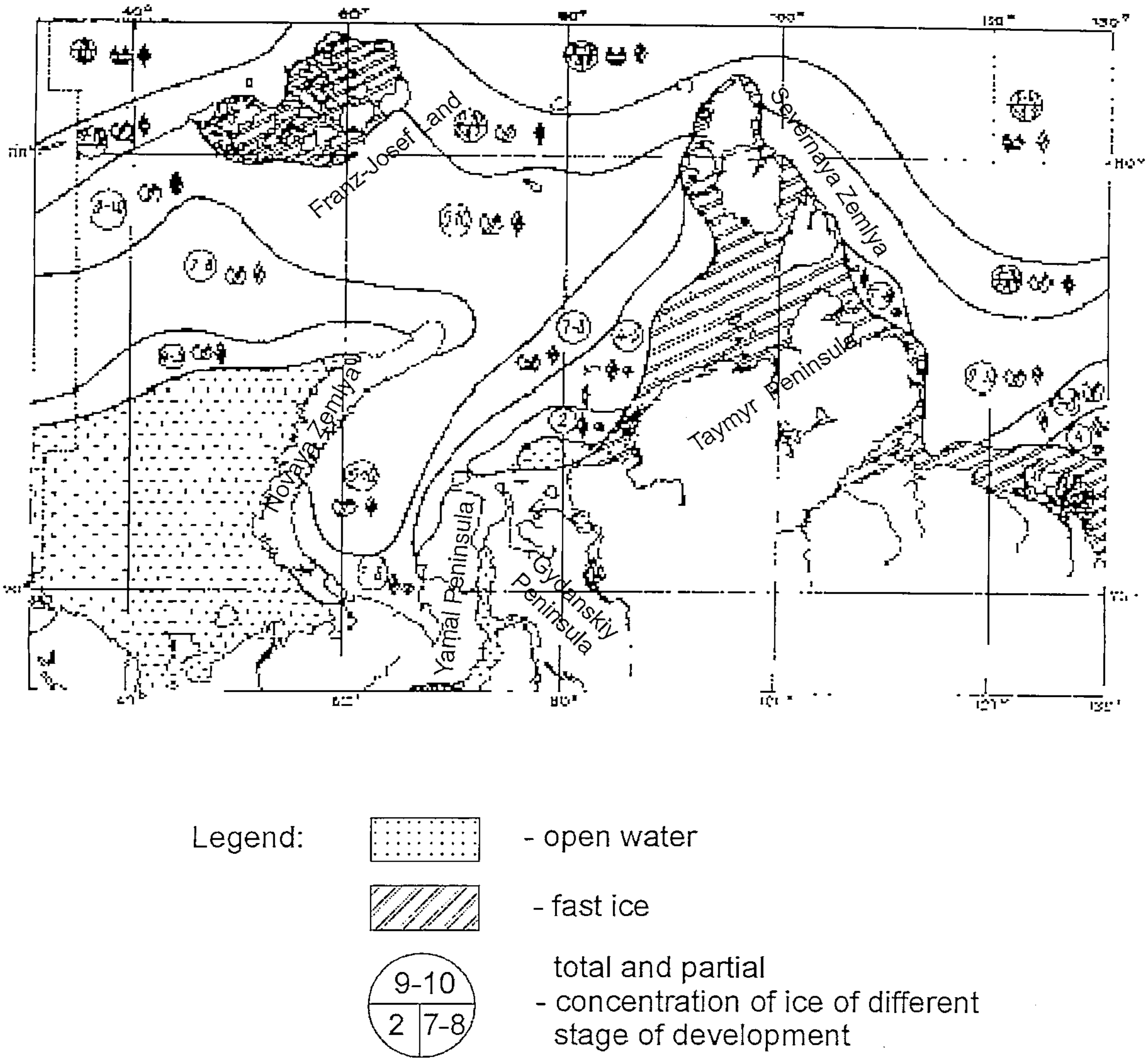


Fig. 6. Ice cover distribution in the western region in May (type VI)

The weak ice melting and destruction processes in the spring-summer period cause the preservation of high ice massif areas.

Thus, with the type VI the most unfavorable ice shipping conditions are formed at all routes of the western seas of the Euro-Asian shelf.

Very complicated ice conditions are formed in the western Laptev Sea in the summer-autumn period, because the Taimyr ice massive surrounds the Taimyr Peninsula and consists mainly of old ice.

So, the method of classification elaborated by V.Ye.Borodachev gives the description of general principles of ice cover distribution during the whole year cycle for all seas of western Euro-Asian shelf of Russia. The generalized estimate of ice shipping conditions at the western NSR is obtained for every type of ice cover distribution.

However such kind of estimate is necessary but not sufficient condition for objective characteristic of environmental features and shipping difficulties; first of all, it is caused by the possibility of selective motion using small-scale zones favorable for shipping (lower ice thickness, higher fracture concentration, etc.).

In this connection, for more complete description of typical environmental conditions of the western NSR exploitation, two more indicators are considered, namely: types of fast ice development and typical variations of distances of sailing through close ice.

1.1.2 TYPES OF FAST ICE FORMATION IN THE WESTERN NSR

The beginning of intensive ice formation in the seas of the Siberian shelf (usually it happens in October) is accompanied by fast ice formation along the coastline, among the isles, in the straits and in the Siberian river mouths. By the moment of the maximum fast ice development (the end of May - the beginning of June) it seriously impedes the shipping. Fast ice break-up (the second half of June) usually leads the shipping conditions to get worse.

The significant influence of fast ice on the sea operations effectiveness was in the focus of the research work for all navigation regions (Yamal and Amderma coasts, Ob' mouth, Yenisey Bay, etc.). However within the Project 1.1.2. close attention was paid to the research of fast ice distribution peculiarities in the northeastern Kara Sea where the NSR goes through fast ice during the major part of a year.

Since 1961 shipping through fast ice at this segment of the NSR was held regularly. During 1961-92 the specialists of the AARI carried out the expeditions connected with making the icebreaker canal and escorting the ships along it practically every year. Besides during 1961-71 the spring (March-May) ice measurement surveys were held in the northeastern Kara Sea also every year. While holding these surveys and observing the ice from icebreakers such important parameters as the stage of ice development, ice thickness, snow height, hummockness, etc were recorded.

Finally along with traditional remote sensing of ice data (satellite images, visual air ice reconnaissance) very representative materials concerning ice thickness, snow height and other parameters at the shipping routes have been collected.

The statistical analysis of the above materials and previous findings make it possible to ascertain that there are three main types of fast ice formation process within each region of considered zone.

Type I. Fast ice is formed after the relatively short time interval (from 10 days to two months) after the final ice formation happened; this fast ice stays during 7-9 months - just till the beginning of the ice melting.

Type II. Fast ice formation is prolonged and accompanied with episodical breaks and shearings. In extremal case fast ice is not formed at all.

Type III. In summer-autumn period fast ice does not break; so, in such case one may talk about the second year (sometimes - multiyear) fast ice.

As for the first and second types, two variants of fast ice formation can be revealed:

a) fast ice is formed on the open water after the ice thickness has reached some threshold value;

b) fast ice is formed within the body of residual ice of different concentration.

On the basis of the above method of classification, analysis of ice measurement surveys and other materials, the zone under consideration (fig. 7) was divided into regions more precisely than it had been done before (Buzuyev, 1981). Every type and region (fig. 7) has its own specific distribution of ice thickness at different stages of fast ice existence (fig. 8).

Significant differences between the types are found in hummockness, stage of melting and other fast ice parameters. Hence, the conditions and difficulties of shipping also vary significantly from one type to another. The peculiarities of the most important ice cover parameters within region I (fig. 7) are considered hereafter. The higher values of hummockness are characteristical for the second type of fast ice formation (table 1). Besides, the hummockness is correlated with the age composition of fast ice (table 1).

Table 1. Distribution of hummockness (predominant, minimum and maximum) in region versus the ice age composition

Fast ice formation type	First year ice			First and second year (old) ice		
	predom.	min	max	Predom.	min	Max
I	0-1	0	2	1-2	1	2-3
II	1-2	0-1	2-3	2-3	1-2	3-4

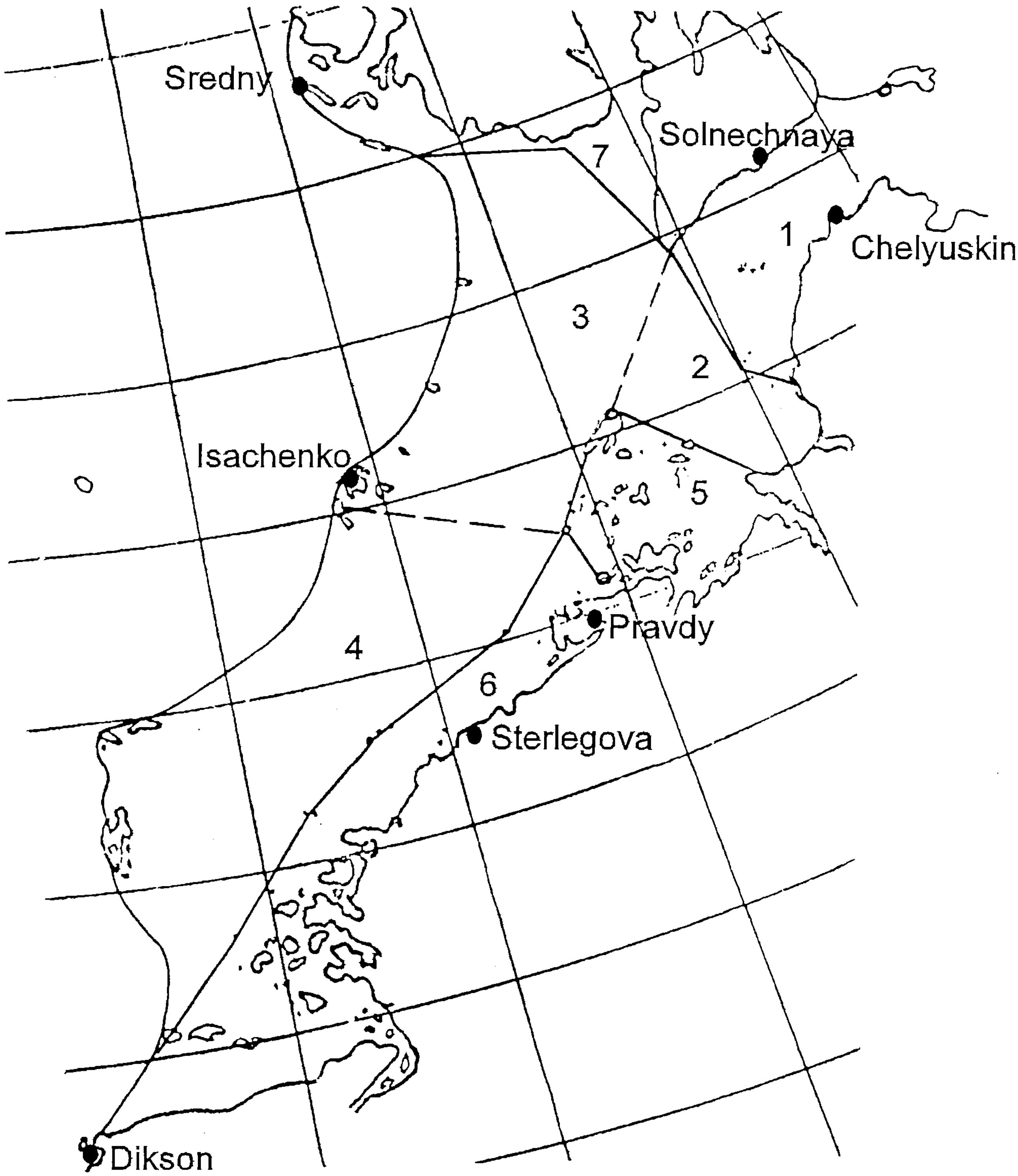


Fig. 7. The fast ice regions of the north-eastern Kara Sea (1-7 - the regions with different conditions of fast ice formation and state)

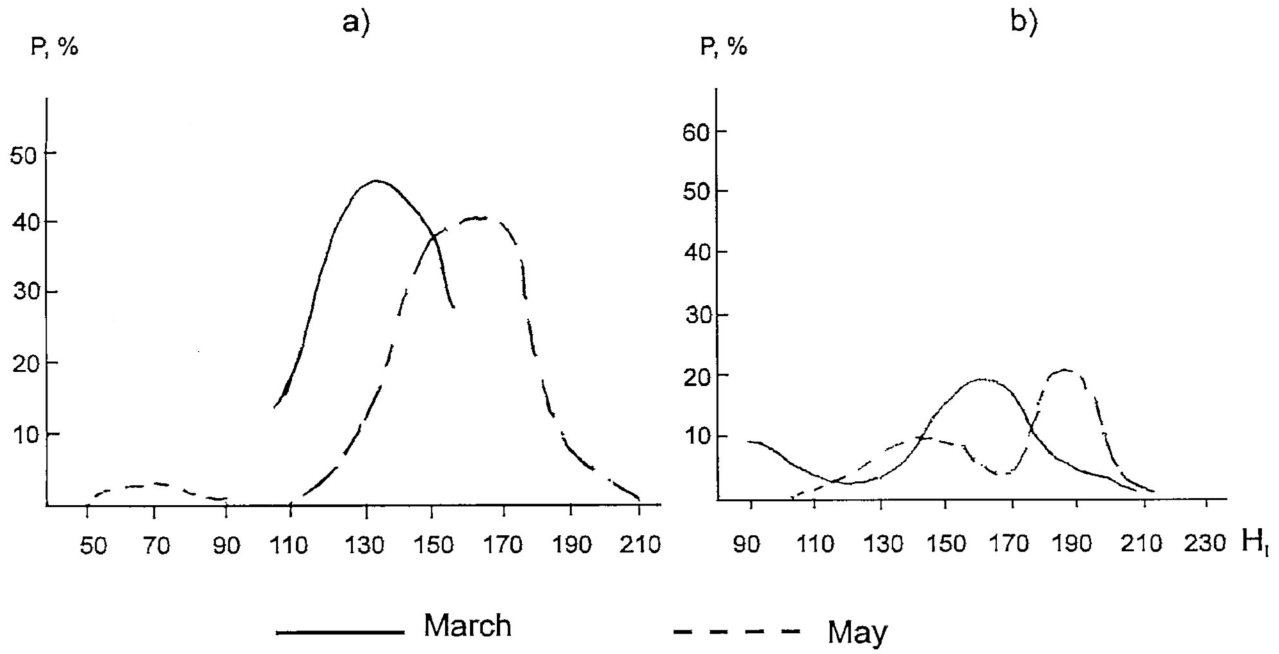


Fig. 8. Characteristic distribution (P, %) of ice thickness at 1 (a) and 2 (b) types of fast ice formation in region I (see fig. 7)

Old (second year and multi-year) ice may occur in any part of the region in point. But their most probable location is the northern part of the strait. For instance, according to special ice measurement surveys, 1961-71, in 70% of cases the old ice (from not significant inclusions to 30-70% partial concentration) was observed in the northern part of the strait. The predominant hummockness in these zones was equal to 2-3 arbitrary units. As a rule, the old ice is correlated with higher values of hummockness (>2 arbitrary units). Besides, the hummockness distribution is generally connected with the type of fast ice formation. "Quick" formation (type I) promotes the lower hummockness (table 1). With the second type and, especially if the old ice is present, one can note higher hummockness. As a rule, the most significant values of snow heights are fixed in the zones of higher hummockness. The specific terms and duration (table 2) as well as specific age composition (table 3) are peculiar to every type of fast ice formation.

Table 2. The statistical characteristics of final ice formation, terms and duration of fast ice formation for different types (region I)

Type of fast ice formation	Final ice formation			Fast ice formation			Duration of fast ice formation		
	Earlier	later	mean	earlier	Later	mean	earlier	later	mean
I	24.08	4.10	13.09	25.11	5.12	1.12	31	103	70
II	26.08	8.10	18.09	6.12	14.03	2.01	102	199	106

Table 3. The ice age composition in fast ice of the B.Vilkitsky Strait (region I) at different types of fast ice formation

Type of fast ice formation	First year ice								
	Thin			Middle			Thick (with inclusions of the second-year ice)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
I	0	0	0	0	3.0	1	99.5	100	100
II	0	44.0	6.0	0	56.7	21.0	28.0	95	73.0
III	0	0	0	0	0	0	0	0	100*

* Second year (old) ice

No doubt, that the distribution of ice thickness obtained from precise measurements is of the most interest. A great amount of measurement data has been obtained from special vessel observations and ice measurement surveys.

Unfortunately, within the frames of present research the detailed analysis and complete presentation of results are impossible due to existing restrictions. With different types of fast ice formation ice thickness distributions by the end of freezing period are noted to differ significantly from one another (fig. 5).

1.1.3 TYPES OF CLOSE DRIFTING ICE DISTRIBUTION ON THE SHIPPING ROUTE OF THE WESTERN NSR

The presence of close floating ice in fact determines all operation indicators of shipping in a particular region (average speed, time expenditures, forced demurrages, damages, etc.). That is why the distance of sailing through the close ice is often used as an indicator of dividing of the environmental conditions into types. It should be stressed that here we are talking about the most favorable variants of shipping from the ice conditions viewpoint.

The peculiarities of geographical location of these variants with respect to seasonal and other factors are described in literature in detail. General principles for classification of sailing conditions based on the data of traveled distance through the close ice have been elaborated (A.Buzuyev, 1982). Finally the chronological consequence of typical distances of sailing through the close ice in the navigation period in the main segments of the western NSR has been determined.

It is clear that every type of close ice distribution along the shipping route corresponds to the specific distribution of other ice cover parameters (hummockness, stages of development, predominant sizes of ice floes, etc.). A very detailed study of peculiarities of stability and inter-annual variations of every type characteristics is executed in the AARI within the framework of national scientific programs. Taking into account that at solving the NSR exploitation problems the objectiveness of type determination has the greatest importance, the calculations of typical distances of sailing through the close ice are executed within the present research work (table 4, 5). Commenting these calculation results, one can affirm that the increasing of initial time-series from ~20 years (1946-65) to ~40 years (1946-87) practically did not change the values of typical characteristics. Thus we may still talk about preservation of modern climatic epoch background (Zaharov, Buzuyev, 1995; Alekseev et al., 1991).

Table 4. Typical distance of sailing through close ice (70-100%) in the segment: ice edge - Dikson (nautical miles)

Parameter	Type	June	July	August	September	October
Average distance 1946-65	Standard	240	55	3	0	81
Average distance 1946-87	Standard	245	65	5	0	115
Typical distances 1946-65	Easy	55	25	0	0	0
	Middle	230	40	0	0	66
	Hard	380	60	5	0	100
Typical distances 1946-87	Easy	50	10	0	0	0
	Middle	240	40	2	0	130
	Hard	390	100	15	5	200
Frequency of occurrence of types (%), 1946-87	Easy	24	43	62	6	40
	Middle	38	37	19	5	40
	Hard	38	20	19	89	20
Typical calculated thickness of first-year thick ice, cm	Easy	129	80	0	-	0
	Middle	145	85	48	-	15
	Hard	176	124	74	-	20

Table 5. Typical distance of sailing through close ice (70-100%, including fast ice) in the segment between Dikson and 125° of east longitude

Characteristic	Type	June	July	August	September	October
Average distance 1946-65	Standard	645	440	150	145	686
Average distance 1946-87	Standard	690	460	145	85	740
Typical distances 1946-65	Easy	400	280	32	0	270
	Middle	780	410	130	21	650
	Hard	850	660	240	195	900
Typical distances 1946-87	Easy	300	180	10	0	245
	Middle	700	420	130	30	680
	Hard	820	700	260	220	950
Frequency of occurrence of types (%), 1946-87	Easy	15	25	40	60	20
	Middle	40	50	20	20	45
	Hard	45	25	20	20	35
Typical calculated thickness of first-year thick ice, cm	Easy	178	131	80	60	15
	Middle	187	141	90	65	20
	Hard	204	158	105	90	30

1.2. UTILIZATION OF CLASSIFICATION OF ENVIRONMENTAL CONDITIONS FOR THE NSR EXPLOITATION

So, the large spatial-temporal variability of ice cover parameters, meteorological and hydrological elements distribution caused the necessity at all stages of research to divide the environmental conditions into types on different scales using various indicators. Dividing the floating and fast ice distribution in the Western region into types discussed in the previous section is a continuation of the research work executed by the AARI.

Unfortunately, in spite of some achievements (usage of more representative materials, applying of objective methods and so on) now it is not possible to apply the results of the classification method to solution of the exploitation problems. The main reason is the objective difficulties in elaborating such kind of method of classification (in particular, ice cover distribution and evolution), which would take into account both the homogeneity of factors determining the type formation and the ice-navigation conditions peculiar for the particular type. But nevertheless the results of classifying of ice conditions into types find rather wide application for solution of exploitation problems.

There are two main directions for application of the results:

- current planning and organizing of sea operations in a given region; in this case the temporal stability of some types of ice distribution is used [12]; finally the output information is presented as the forecasted distribution of ice cover in the region of shipping and just along the route of shipping, calculated exploitation speeds, etc.;
- elaborating the strategy of sea transportation (for the existing or future lines), their technical and economic substantiation.

In this case the climatic (generalized over long period of time) information of the environmental conditions along the transportation line under study is usually used.

The output information is presented as the multi-year mean values and variability of the most important environmental parameters (distance of shipping through the close ice, thickness, hummockness, etc.). On the basis of this information the main operation indicators of ice shipping are calculated: speeds, time expenditures, duration of demurrage caused by unfavorable environmental conditions and so on. It is worth mentioning that such approach is also used in the present program (Subprogram III). Being aware of the difficulties of complex accounting of not only multiyear mean values, but also some other typical environmental indicators, one should substantiate the necessity of hard type special analysis.

There are at least two premises that prove the importance of special research of hard and extreme conditions probability in every region of the NSR, necessity of detailed analysis of causes of their formation and description of environment under such conditions.

First, in the materials and publications regarding the INSROP Program the multi-year mean values and (sometimes) their variability were under discussion. Too little attention was paid to the questions of formation of complicated environmental conditions, their influence on the shipping effectiveness and safety, ecological situation, etc.

The second (and main) premise is as follows. During the entire history of the NSR discovery and exploitation the complicated or very complicated (extreme) environmental conditions were episodically observed in its different segments.

Consequently that leads to disorders of all the aspects of Arctic transportation system activities: disruptions in cargo delivery schedule, increase of ice damages, growth of probability of negative ecological effects. The following examples confirm that.

In 1937 twenty five cargo vessels and nearly the whole icebreaking fleet remained to spend the winter season in different, somewhere uncontemplated, places of the NSR. Besides the complicated ice conditions, some other factors played their role (absence of regular information, lack of experience and so on).

In 1957 hard ice conditions were formed in the western Laptev Sea, the next year - in the northeastern Kara Sea and western Laptev Sea. The consequences of hard ice conditions were seen immediately: nearly half of cargo fleet (29 vessels) got damages.

In August, 31, 1958, the motor ship "Sevan" sank crushed by the ice in the B.Vilkitsky Strait; earlier ice formation (27 days earlier than mean term) made a large number of cargo vessels to sail from the Laptev Sea eastward (instead of westward) to the Bering Strait.

In August, 1983, more than 20 ships were trapped in the ice prison in the very eastern segment of the NSR (Shelagsky Cape - Bering Strait). Nearly all powerful icebreakers were used to avoid the winter stay of vessels, but one ship was crushed by the ice.

The list of such kind of hard ice shipping situations can be continued. Thus during even the ordinary navigation period (June-September) the hard and extreme navigation conditions may occur episodically in different segments of the NSR. The question arises: how frequently such conditions may occur at the NSR and which segments are more dangerous from this point of view? The preliminary analysis has shown the probability of the most complicated conditions to be equal to 16 % and 10 % for the western and eastern NSR respectively (period 1936-90).

At present the detailed analysis of the reasons causing the most hard ice conditions and corresponding specific features of sea operations has been carried out only for some particular cases (Karklin et al., 1984).

It is clear that the research of this problem is very difficult because, as it was mentioned above, the frequency of occurrence of very complicated conditions is rather little and the amount of data is limited. On the other hand, the ships were often not present in the segments with very hard conditions Hence, the question concerning the sailing difficulties should be solved using not only the data of sea operations, but also on the basis of estimations and individual experience as well. But nevertheless the main aims of research work can be seen already now. The ice sailing via the NSR is known to be carried out through fast ice, drifting ice and along the flaw polynyas (coastal divergings). Complicated sailing conditions have their specific features in every enumerated zone.

In fast ice these features are: higher ice thickness, snow height and hummockness. In some regions limited depth also plays important role.

In drifting ice - strong and long compactings, ice "jets" (somewhere), ice adhesion and other phenomena dangerous for sailing.

In flaw polynyas - their width and stability. The formation of narrow, unstable flaw polynyas typical for the eastern NSR is of especial importance for sailing. During long period of the NSR exploitation a lot of material concerning hard sailing conditions in each of the above mentioned zones have been accumulated.

We believe that the INSROP Project will be completed fully and effectively only if the analysis of years with hard and extreme ice conditions at separate segments and at the NSR as a whole has been carried out.

Such analysis should naturally involve not only Subprogram I, but the other INSROP Subprograms as well, because, as it was mentioned above, under the complicated environmental conditions the probability of negative ecological phenomena grows, and while organizing the sea operations one should solve the problems of optimal icebreaking support, most suitable non-standard routes of shipping and finally find non-ordinary decisions.

In conclusion we should emphasize that complicated natural conditions may appear practically in any segment of the NSR. In this connection one should consider as the main aims of the further research the analysis of reliability and possibility of regular shipping as well as increasing of navigation period in particular segments of the NSR (for example, "western ice edge - Yamal Peninsula - Ob'mouth", or "Bering Strait - town of Tiksi", etc.). It is evident that the choice of the most promising and probable directions for international shipping via the NSR is an exclusive right of Subprogram III.

2.1 PREDICTION OF THE ACCUMULATION OF PERMANENT DEFORMATION IN THE ICE BELT STRUCTURES

The observation of ice belt during repair and diver's examination show that the parameters of certain kind of damages smoothly increase with time of ship service. First of all this is relevant to all the permanent deformation of envelope shell and framing.

The rules of every classification society are based on the assumption that any damage is a result of a single action of ice load. The accumulation of damage parameters used not to be taken into account because the physics of the process is too much involved and there are many difficulties relating to ice loads description during service life of ship because the plastic deformation accumulation process depends on the loading history.

Accumulation plastic deformation in ice belt members can be brought by three reasons:

1. Progressive wear of hull structures causing the reducing of sizes of flanges, webs, plates which makes the building strength parameters change for the worse.

2. Taking into account the deformation anisotropy under cycle loading in plastic area. The strength structure analysis on the theory of cinematic strengthening shows that with a certain ice loading parameters combination the cumulated deformation value for a shell plating during loading cycle is about 10^{-3} mm. That means increase of permanent deformation by dozens of millimeters during 10^{4} cycles. Another peculiarity which was investigated under analysis is that hard loading do not always result in the accumulation of deformation i.e. there is an adaptation of structure within a certain range of loading parameters. The adaptation factor is known in mechanics. There is an analogy with the elastic structure area (under the curve of yield) and the area of structure failure (above the curve of ultimate strength).

The analysis was made in the ANSYS 5.0 software system. The main member of structure under study is a panel of shell plating. Unfortunately the possibilities of such software system are limited because it is capable to take into account only the ideal Boushinger effect.

3. The accumulation of deformation results from the residual stresses relaxation after plastic deformation and before following loading in plastic area. In practice the relaxation used not to be taken into account under common operational temperature. But the vibration of structure increases relaxation process. There is an estimation of vibration stresses with which relaxation becomes to be noticeable. For steel the value of such stresses is about 0.3-0.4 MPa. Such stresses level usually occurs in the plating at stern during main engine operation or at impact against the ice. Consideration of the stress relaxation demands an additional information on ship steels and modernization of existing software systems.

The above three mechanics of deformation accumulation could be used within the scope of the method of reliability estimation (see Report on the Project I.1.2 INSROP, 1994/95). The changes will concern the second, third and forth calculation steps. The new approach to realization of the third step was described above. The second step concerning calculation of probabilistic parameters of ice loads demands description of ice loads for stochastic process. That allows to use the loading history. The forth step is possible to develop on the base of the Markov chains method which was created to study the response of a system with a great number of degrees of freedom to the stochastic process action. There is an experience of reliability estimation according to Markov theory in domestic and foreign technical sciences.

Let us consider the reliability estimation method to be applied to the outside plating panel of merchant ship "Pavlin Vinogradov". The sizes of a panel are 400 mm × 900 mm and thickness - 15 mm. The reliability criteria: yield, absence of adaptation in plastic area and the fatigue of plating under ice loading. The material diagram σ-ε is shown on fig. 9. The material yield stress is 300 MPa.

The plating strength was calculated by means of the finite element method in ANSYS 5.0A software system. To start with let us consider the peculiarities of the deformation cummulation mechanism which have been found out during this study. Under cycle loading by the same pressure which is distributed on a certain width ***b***, which is less than the largest side of the plate there is a field of residual stresses and permanent deformation in the plate. By a certain pressure the plate deformation value begins to increase (fig. 10), and the residual stresses after every loading cycle are stabilized (fig. 11). Hereafter such a pressure will be determined as the pressure of cummulation. Fig. 12 gives a function of residual stresses in a plate against the pressure acted on the part of the plate. Fig. 13 shows the diagrams of plate state with loading applied at the center of largest side, the area of deformation cummulation is marked. The plate state surfaces with reference to reliability criteria mentioned above are shown on fig. 14. The surfaces are developed taking into account the deviation of loading area from the center of plate. The probabilities of failure depend on ship motion speed, on arrangement of plate on the ice belt and on ice conditions in the navigation area. The main factors are distribution of ice cover parameters (age, thickness, hummock degree and etc.) along the ship motion.

As it was shown above (section 1), for each NSR region ship operation the ice cover parameters vary over a wide range. This circumstance makes practically impossible within the framework of INSROP-project (for the reason of a great volume of calculations) the investigation of failure probability for particular ship navigating in a given region under different types of ice conditions.

Nevertheless the technique of such calculations is developed and, as an example, the results for the m/v "Pavlin Vinogradov" while sailing in the south-east of Kara sea under the middle ice condition (type IV) are presented (table 6).

Table 6. The probability of failure for various ship speeds and failure criterion

Speed, Ln	Failure probability		
	Yield	Deformation cummulation	Fatigue
3	0.12	0.004	$1.3 \cdot 10^{-9}$
6	0.25	0.005	$1.8 \cdot 10^{-7}$
9	0.35	0.022	$4.5 \cdot 10^{-4}$

Further development of described approaches is supposed to be carried out in the following directions:

1. Taking into account the relaxation mechanism of cummulation.

2. Common consideration of relaxation and cinematic mechanism and prediction of increasing of speed of permanent deformation in relation to the region of navigation, ice belt structure and ship speed.

3. Taking into account the peculiarities of ice cover parameters distributions in a particular ship operation region.

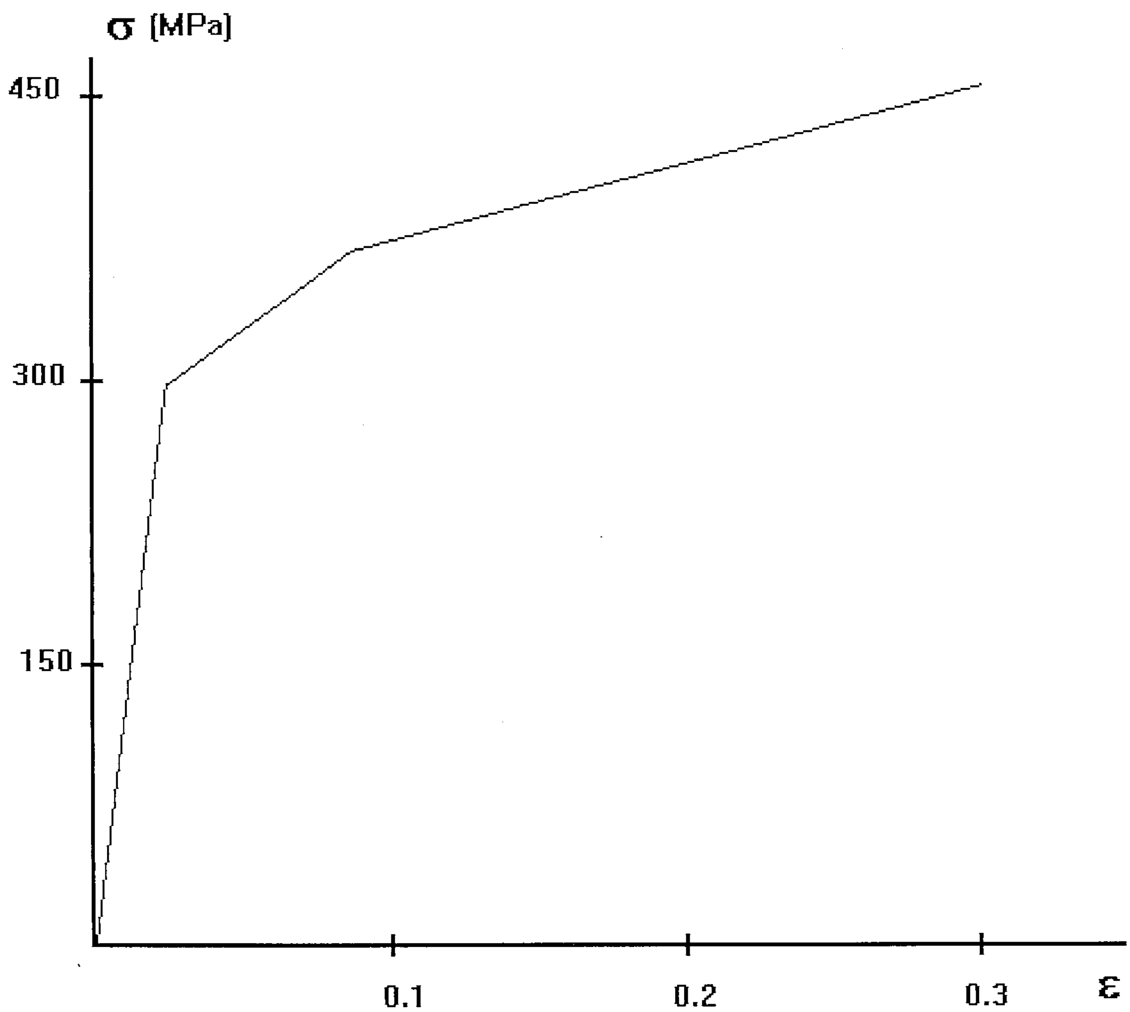


Fig. 9. Diagram σ-ε of using steel

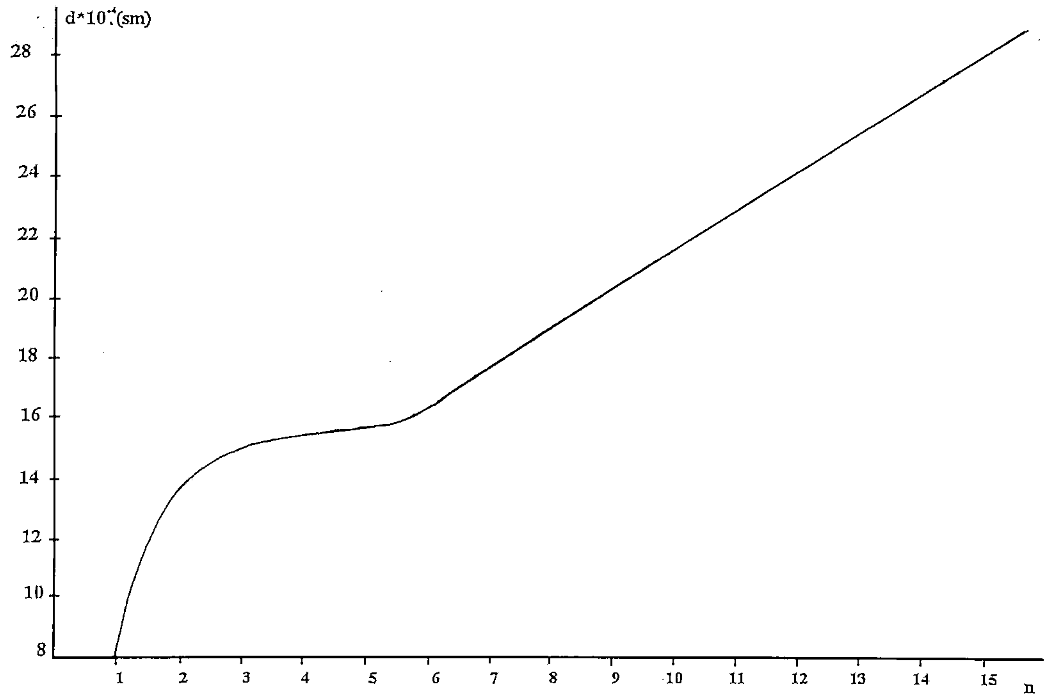


Fig. 10. Function of deformation increment ***d*** versus the number of circle of loading ***n***. ***d***; relative permanent deformation is calculated after the first loading circle

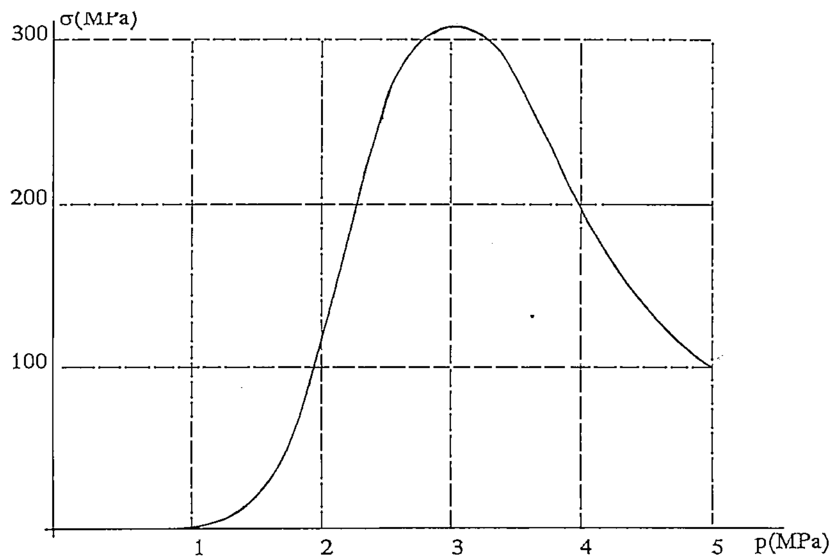


Fig. 11. Function of the plate residual stresses σ versus the number of loading circle ***n***. σ is the first principal stresses

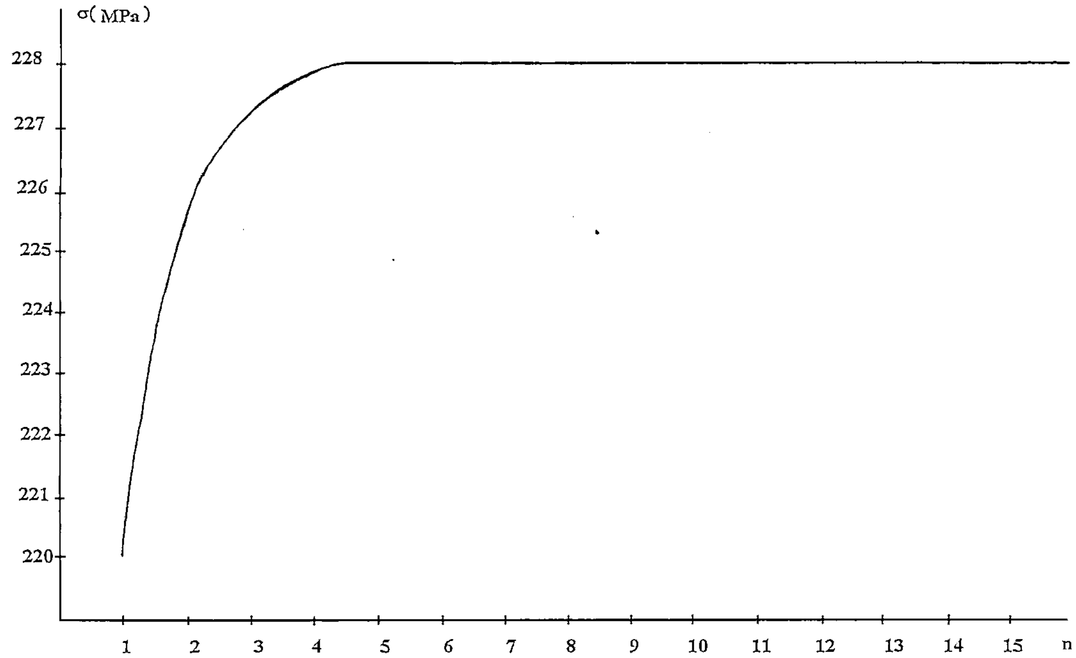


Fig 12. Plate residual stresses σ after the first loading circle as a function of maximal pressure in the circle ***p*** at a fixed width of load distribution ***b*** and a fixed position of the center of loaded area along the largest plate side

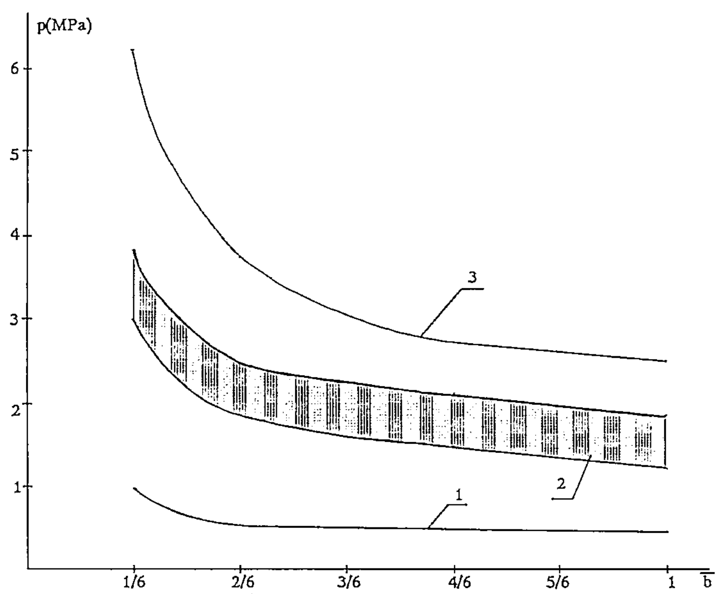


Fig. 13. Diagrams of plate state at a fixed position of the center of loaded area along the largest plate side. 1 - diagram of yield, 2 - area of deformation cummulation (manifestation of the Baushinger effect), 3 - plate fatigue. ***p*** - ice pressure, Install Equation Editor and double-click here to view equation. - relative distribution width, ***b=b/l***, ***b*** - pressure distribution width, ***l*** - largest plate side size

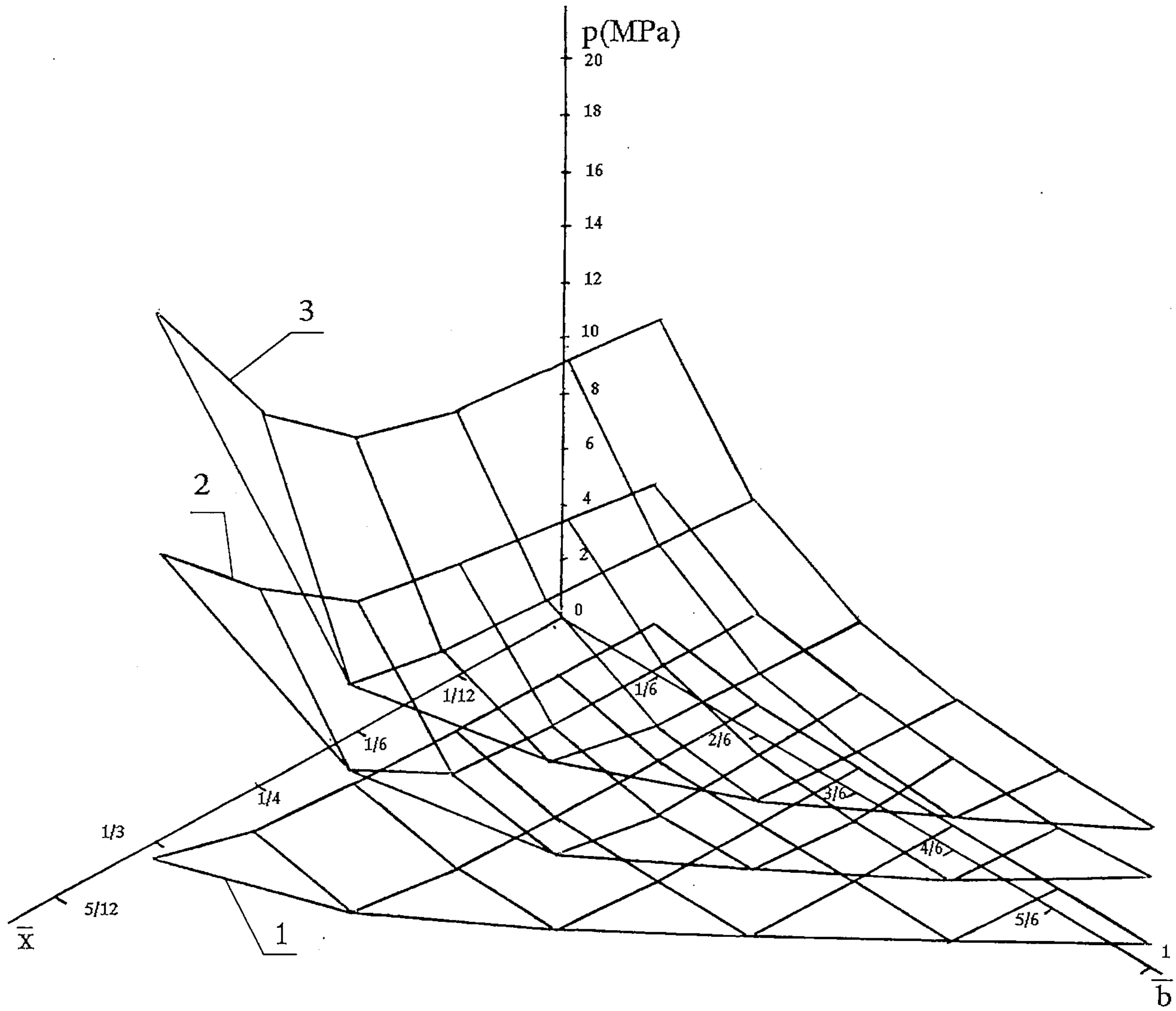


Fig. 14. Plate state surfaces. 1 - surface of yield, 2 - the middle surface of deformation cummulation, 3 - fatigue surface, ***p*** - pressure in the loaded area. **= *b/l*** - relative pressure distribution width, ***b*** - pressure

distribution width, **=*2x/l*** - relative coordinate on the position of the center of loaded area, ***x*** - distance between the center of load area to the plate center, ***l*** - the largest plate side size

2.2. ONBOARD ICE PASSPORT

In the fifties the Ship Ice Performance Department suggested a concept and detailed method for development of ice passport. This document contains data on technical abilities of a particular ship and recommendations on choosing safe and effective ship motion in particular ice conditions. The ice passports were developed on the order of shipping companies for 16 types of ship of different ice categories of the Russian Maritime Register of Shipping (table 7).

Table 7. Ice passports developed by AARI

N	Sister ships	Ice category	Year of ice passport issue
1	Pioneer	UL	1973
2	Volga	UL	1974
3	Belomorskles	UL	1974
4	Amguema	ULA	1975
5	Vytegrales	UL	1976
6	Pioneer of Moscow	UL	1977
7	Samotlor	UL	1978
8	Dmitriy Donskoy	UL	1979
9	Belomorskles	UL	1981
10	Norilsk (SA-15)	ULA	1984
11	Professor Pashkov	UL	1987
12	R/V project 2119	UL	1988
13	Captain Sakharov	UL	1989
14	Vlas Nichkov	UL	1990
15	Pavlin Vinogradov	UL	1992
16	Mechanic Yarzev	L1	1993

There is a description of ice passport of new generation in this chapter which is a part of software on board and which shows safe and dangerous parameters of ship motions both in transit and in caravan sailing. The onboard ice passport takes into account the hull structures wear, real shaft power, wide range of ice condition parameters: ice thickness, water and air temperatures, water salinity, average size of ice floes, ice fracture, ice compacting. The software has data about ice conditions along the NSR. The information on ice condition along the NSR and statistical parameters of ice cover for every region could be recorded in the ice passport.

Calculations involving the data arrays of passport are based on the concept of safe navigation and could be done with the help of special developed software designed for analysis of ship performance in ice and strength of ice belt structures (Likhomanov et al., 1993).

Ice passport is a document containing information about the main ice properties of ship: ship performance in ice and ship strength in ice and as well as the resulting diagram of safe speeds. The ice passport has been developed by AARI for the Russian fleet during period of more than 20 years. Being used in urgent conditions the conventional ice passport can confuse some navigator. Computers on board ships and icebreakers allow the ice passport to be designed on qualitatively new level. Such level must provide the navigator with information about safe and dangerous sailing conditions in the widest possible range of ice conditions and navigation modes (transit or escorted). The old ice passport had parameters of motion for limited number of parameters of ice conditions. The necessity to meet such requirements has resulted in creation of software of two levels:

The software for preparation and calculation of ice passport diagrams used by the ice passport designer. The calculation results are information arrays that will be applied with the software of the next level.

Onboard ice passport is a software for the computer on captain bridge showing to navigator the range of recommended motion regimes in particular ice conditions under selected navigation mode.

The software of the first level is a set of separated procedures which could be divided into two groups: calculation of ship performance in ice and calculation of the ship hull structures strength in ice.

The procedures of calculation of ship performance in ice allow us to compute the following tasks: the calculation of thrust characteristics of propeller, the calculation of ship resistance on open water, the calculation of ship resistance in ice for different ice conditions, the development of diagrams of possible speeds for different ice conditions. A set of procedures for analysis of ship hull strength in ice allows us to determine the ice load within the frames of hydrodynamic model of impact of ship against ice, determine the loads which corresponds to yield and the ultimate loads for a multi span beam with arbitrary or standard cross section with belt attached. More complicated structures are processed by the system ANSYS 5.0. Both sets of procedures are connected through computer data base to ice ships and icebreakers which allows us to input data on new ships into computers, to look through and to edit data on main dimensions, ice belt topology, ice belt structures parameters, principal drawing, propeller characteristic, as well as to delete record on particular ships if necessary, to display a principal drawing, to create a file with input data for the main calculation of ship performance in ice and ship strength in ice conditions.

Let us consider the first set of procedure. The procedure of calculation of propeller characteristics allows us to calculate the thrust values for propeller of certain geometry for one of 12 types (series) taking into account the ship hull influence for a certain range of shaft power. The output data are diagrams of shaft moment and propeller thrust versus shaft power and ship speed (fig. 15). The procedure uses the method of approximation polynomials for the dimensionless moment and thrust diagrams on the propeller series tests data. The procedure of the open water ship resistance calculation uses the conventional Shtrumf method and under a necessary data set generates the ship open water resistance as a function of ship speed. The ship ice resistance procedure uses the original AARI - methods and allows us to predict the ship resistance in ice cake, ice floes and level ice. The ice resistance in ice cake could be calculated with the following variable parameters of ice cover and ice conditions: ice thickness, average floe diameter, ice compacting, ice compressing degree, ice density, coefficient of friction of ship board on ice, width of channel. The ice resistance in ice floes could be calculated by varying of ice thickness or average floe diameter. The procedure allows us to calculate ice resistance of the ship in level ice for different parameters of ice thickness, ice density and ice strength. In any case, the results are the diagrams of ice resistance against ship speed with an assumed constant parameter of ice conditions (fig. 16). The procedure of generating of diagrams of possible speed could calculate curves in the ***H*** - ice thickness and ***V*** - ship speed - coordinates, which show the abilities of propulsion ship complex while sailing in ice conditions defined by a particular set of parameters.

With the help of the described software the ice passports has been developed for the merchant ship "Mechanic Yarzev" and partly for the research vessel "Akademik Fedorov". The large set of information, which is obtained as a result of the first level software running is too complicated to be successfully applied by navigators in ice conditions both in free and in caravan sailing. The software of the second level is an onboard ice passport which allows to use all information generated by the first level procedure. The onboard ice passport transforms the information into the form convenient for navigators. The onboard ice passport has three options: information about vessel, recommendation for free sailing, recommendation for sailing under icebreaker pilotage. Making use of two last modes of sailing the following several parameters of ice conditions are to be given: ice thickness, ice compacting etc. to display two boundary characteristics of motion: safe speed i.e. a speed with no risk to get any hull structure damages and dangerous speed i.e. a speed which leads to a great increase in ice belt structures damages when exceeded. If a caravan mode is selected, an additional parameter shall be displayed. It is a safe distance to the icebreaker or to the stem of a ship ahead, maintained with due regard to an unpredictable stopping of the latter and maneuvering "Full ahead - Stop".

The onboard ice passport was tested during expedition of the "Akademik Fedorov" vessel in summer 1994. The test showed that the onboard ice passport should have both information about vessel and information with average parameters of ice condition in navigation regions. With a caravan escorted by an icebreaker, it is wise to have the caravan ice passport which displays to the icebreaker master the limiting speed for the caravan, safe distance in the caravan, the maximum draught of ship in the caravan.

It is necessary to mention that the information, which is provided by the onboard ice passport must be displayed in a form understandable for a navigator of average skill (fig. 17). Output data are advisable to be recorded automatically. It will increase the responsibility of navigator in the event of great damages to ship structures produced by the ice and will allow more objectively to settle disputes between the ship owner and the navigator when heavy losses are suffered from abortive transport operations.

On the whole the onboard ice passport helps to conduct the vessel or the caravan in ice and will open new possibilities for increasing profitability of transport operations.

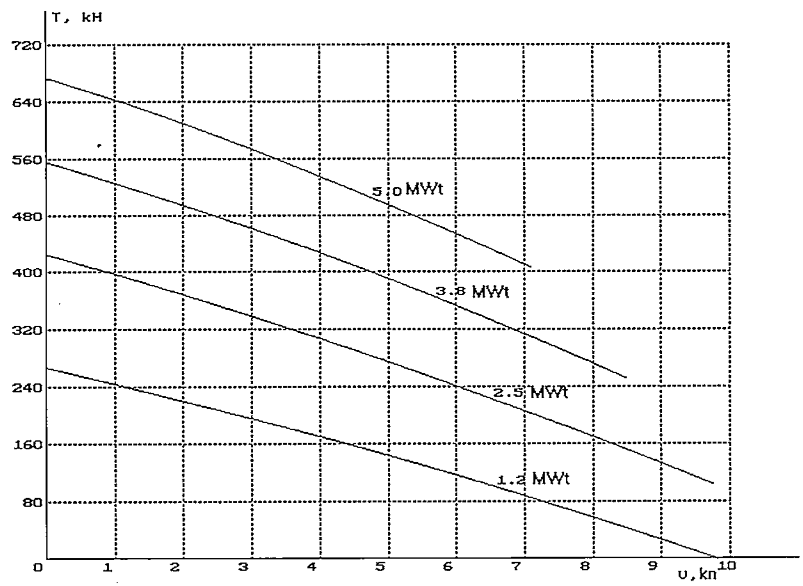


Fig. 15. The diagram of the propeller thrust as a function of speed and power.

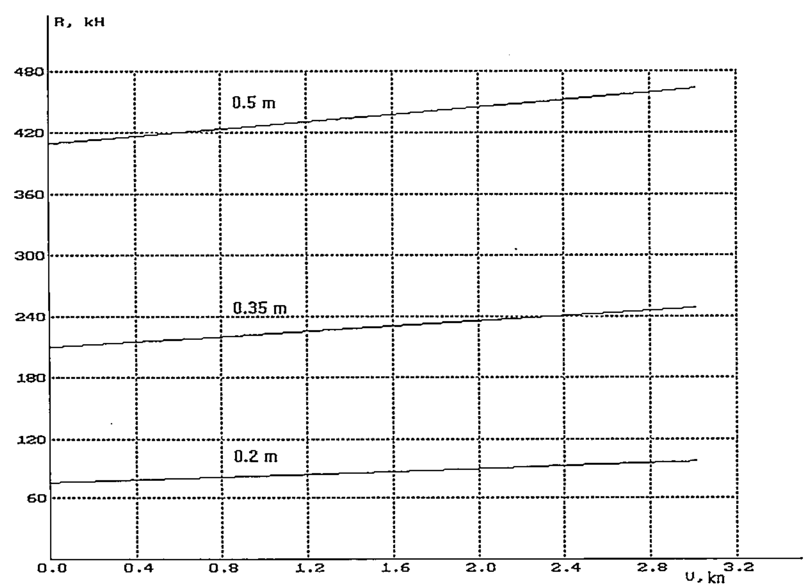


Fig. 16. The diagram of the resistance as a function of speed and ice thickness

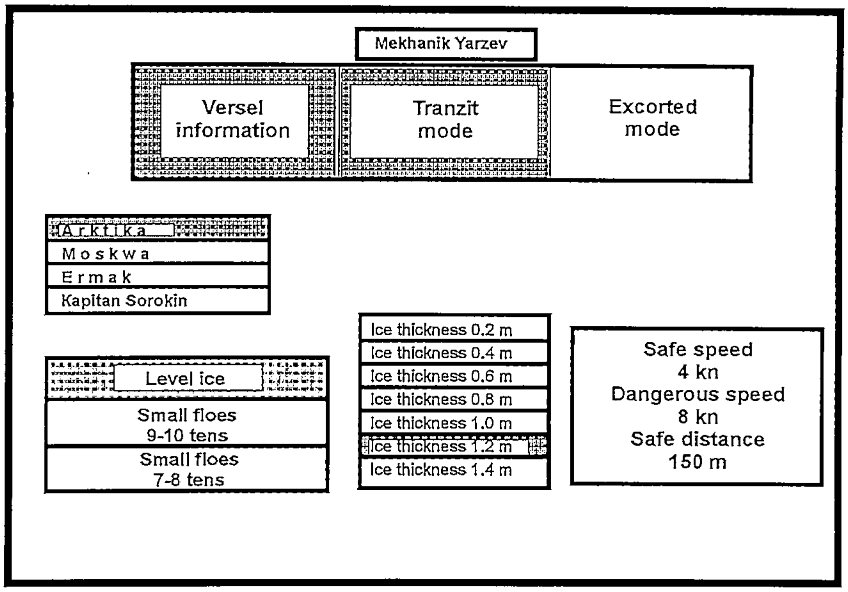


Fig. 17. The display of the onboard ice passport of m/v "Mechanic Yarzev" escorting by the icebreaker of "Arctic"-type in level ice.

SUMMARY

The detailed description of ice conditions along the NSR has been carried out with the use of complex classification that takes into consideration:

- the distribution law of drift ice and fast ice in Siberian offshore seas;
- the peculiarities of fast ice forming;
- the variability of way length in the ice cover of various parameters.

The results of such classification allow us to estimate objectively the probabilities of forming and features of ice distribution along routes of navigation in various scenarios of development of ice conditions.

Thus, the background for prediction of reliability, risks and economical profitability of different types of ships operation along NSR has been developed. Some aspects of the permanent deformation cummulation in ice belt structure members have been studied. The above results can be used for practical purposes in the onboard ice passport which has been described heretofore.

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REVIEW of the International Northern Sea Route Programme (INSROP) Working Paper
Sub-Programme I: Natural Conditions and Ice Navigation
Project I.1.2 Operational Aspects
Volume 2 - 1994 project work and Volume 3 - 1995 project work

Reviewer: James W. St. John,
Science and Technology Corporation
9650 Santiago Road, Suite 2, Columbia, MD, 21045, USA

This is a fine collection of work on the Northern Sea Route (NSR). The data presented is valuable and not generally known, at least in the western body of literature. It makes a valuable contribution toward understanding the operational issues of navigating the northern sea route.

The paper reviewed is presented as two volumes, the results from the work in 1994 and 1995. Each of the two volumes contain two parts, one prepared by CNIIMF and one prepared by AARI. The authors considered many operational issues on the Northern Sea Route such as legal and cartographic support, communication, vessel performance, etc. The reader is aware that each volume contains a collection of single independent reports which cover a range of somewhat unrelated topics, linked by the fact that they all relate in some manner to operation along the NSR. It is supposed that the objective of this project is an attempt to put together information about all the operational aspects connected with planning and conducting shipping on the NSR so that the most important issues can be selected for further development. If this is an intent of this research, it would be desirable to state this clearly in the introduction of each volume. The whole work may benefit by having an introduction that explains that the work was done over several years, is presented in two volumes, and combines the descriptions of the individual volume introductions.

Specific comments for individual sections of the paper are given below:

Section I.1.2.4 Communication in the Volume 3 (1995).
Taking into account that one of main elements of maintaining reliable communication on the NSR is the satcom systems, it would be useful to show in detail how reliable SES Inmarsat-A and C reception is in various modes because of the low elevations of satellites.

Section I.1.2.7 Vessel Performance of the part prepared by CNIIMF. Volume 3 (1995).
It is very hard to read the lettering on Figure 7-1.

Section 1.1 of the part prepared by AARI. Volume 3 (1995).
Figures 2 and 4 are identical.

Section 1.1 of the part prepared by AARI. Volume 3 (1995).
Three types of description of the ice conditions are considered. There is no description of the criteria for select these types. Some basis for the frequency of occurrence should be described.

Section 2.1 of the part prepared by AARI. Volume 3 (1995).
The word "remind" is used in connection with deflections and stresses. I believe the proper terms in English are permanent deflections and residual stresses for what the author is trying to describe.

Section 2.2 of the part prepared by AARI. Volume 3 (1995).
Figure 17 is illegible and should be translated

General comments are as follows:

- Summary and key words are absent in sections I.1.2.2, I.1.2.5 and Part II;
- some sections have no conclusions;
- there aren't numbers and titles on the tables in section I.1.2.5;
- some sections do not have references.

The publication of the INSROP Discussion Papers "Operational Aspects" by Dr. A.Baskin et al. are recommended for publication after editorial changes. The reports contain the valuable technical information for Northern Sea Route shipping development. I appreciate the opportunity to provide comments on this report.

James W. St. John

Comments for Reviewer James W. St. John for Project 1.1.2

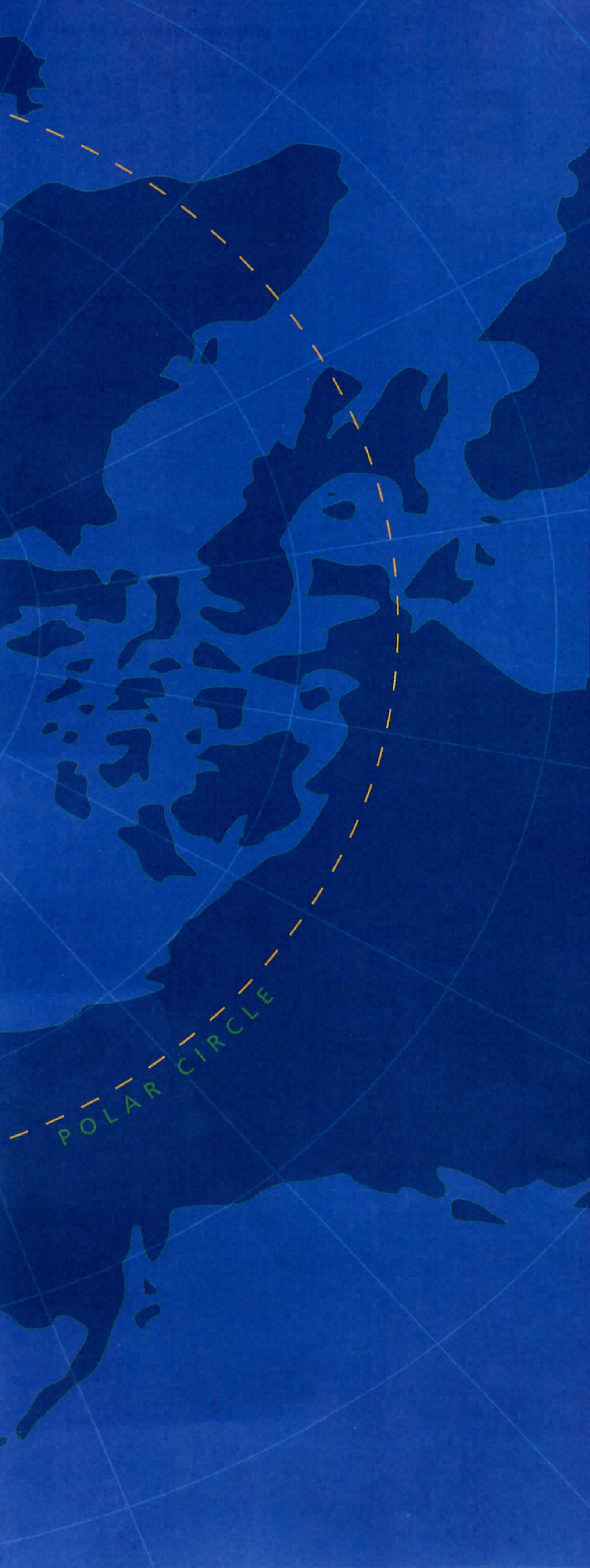
Thank you very much for detailed review. We took into account you remarks:

- the tables were prescribed;
- the fig. 14 was changed;
- the summary was prepared for the project 1.1 which prepared by AARI.

The principals of typisation of ice conditions (types I-VI) briefly described of the page... May be suitable to make this more detailed but it is described in references (Latukhov S., 1995).

The references for the project 1.1.2 are containing in unit list from smaller part of project.

A.Buzuyev



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 multidisciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.