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INTERNATIONAL NORTHERN SEA ROUTE PROGRAMME: INSROP

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ABSTRACT

This paper is a brief summary, with particular emphasis on the technical aspects, of the International Northern Sea Route Programme(INSROP), five-year multidisciplinary research projects to build up a scientific knowledge-base encompassing almost all relevant aspects of navigation on the Northern Sea Route(NSR). The primary objective of the INSROP is to provide useful and sufficient data and information to enable public authorities and private interests to make rational decisions based upon them.

1. INTRODUCTION

A five-year multidisciplinary and multi-national research programme consisted of the Phase I from 1993 to 1995, Evaluation of the results in Phase I in 1996 and Phase II from 1997 to 1998, with the international cooperation of three main organizations, Ship & Ocean Foundation/Nippon Foundation in Japan, Central Marine Research and Design Institute in Russia and The Fridtjof Nansen Institute in Norway. Nearly 170 researchers in nine countries were involved in the INSROP.

The Phase I research was organized in four Sub-Programmes, namely "I. Natural Conditions and Ice Navigation", "II. Environmental Factors", "III. Trade and Commercial Shipping Aspects", and "IV. Political, Legal and Strategic Factors", to examine the global feasibility of the NSR.

The INSROP organized an International Evaluation Committee in which members were requested out of the INSROP community, and the Committee evaluated the Phase I research results and made a recommendation for continuity and progress of the INSROP toward Phase II. In the Phase II, the results in the Phase I and several supplementary projects in the Phase II had formed the basis for three major projects in Phase II, i.e., "Simulation Project", "INSROP GIS" and "Integration Book Project". All of the research works were completed in March, 1999.

2. HISTORICAL BACKGROUND OF NSR

The NSR and the alternative shipping route between Europe and Far East Asia is illustrated in Fig.1.

The Northern Sea Route, or the Northeast Passage in more historic words, from the Atlantic to the Pacific Ocean, has captured men's imaginations throughout the ages. First European overseas explorers were probably Irish monks of the 7th and 8th centuries, who set sail in small oxhide curraghs. From the 14th century inward a new brand of European explorer appeared along the Arctic coasts, making summer voyages northward in sturdy, well-equipped sailing ship.

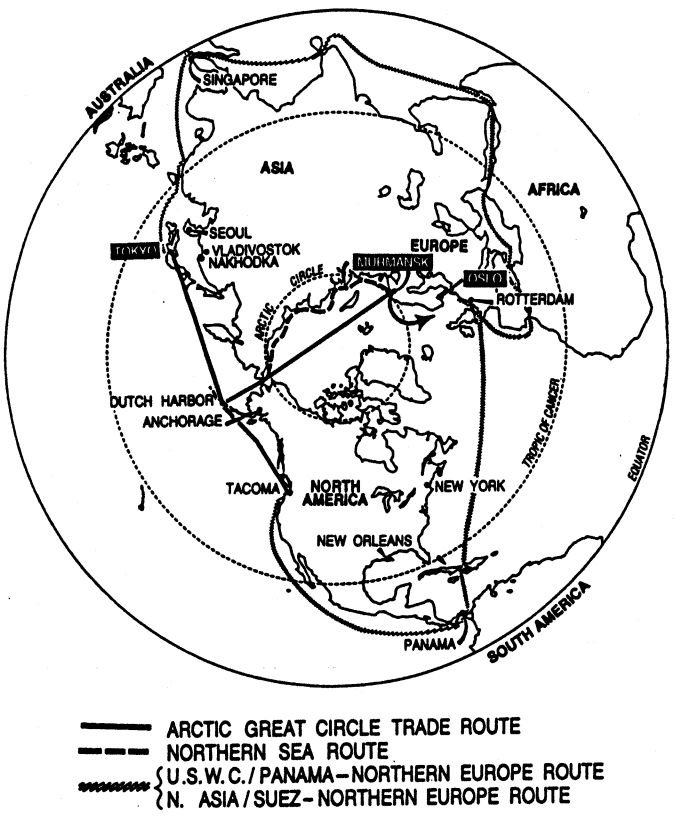


Fig. 1 Northern Sea Route

British and Dutch navigators, inspired by the pioneering voyages of their whaling captains, were among the first to seek trade routes to China via the north. The information of the Arctic became highly relevant during the next phase of world discovery, when the most knowledgeable navigators of several nations set out to find sea routes to the Orient.

The Arctic regions were still but little known in the mid-19th century. Numerous scientific and governmental expeditions in the Arctic had then been carried out during 19th and 20th centuries. Trials and operations of Russian vessels had also been performed along the NSR. Finally the NSR was officially opened for international shipping on 1st July, 1991. The conditions to undertake a feasibility study of the NSR was well prepared, enjoying the advantage of advanced technology in ship design and navigation in ice-infested waters, with a stimulus of developments of natural resources in the Arctic regions.

The NSR history and some related issues are available in the INSROP Working Papers and a few published books(e.g. Armstrong, 1996).

3. A BRIEF SUMMARY OF RESULTS

3.1 Natural Conditions and Ice Navigation(Sub-programme I)

Major issues were as follows; ice navigation and ship technology in the Arctic waters, basic data and operational information on natural conditions, geographic information system

(GIS), collection, evaluation and preparation of data bases natural conditions along the NSR in views of ship design and operation, forecast and simulation of the natural conditions, planning and risk assessment, and future perspectives.

A knowledge base on natural conditions along the NSR such as meteorological, oceanographical, and ice conditions has been established, by the use of various collected data. The effects of ice conditions on the NSR navigation was discussed in various aspects, mainly through Russian operating experiences(Baskin, et al.,1995). Major technical factors affecting the navigation were analyzed and discussed. Recommendations were made for future improvement and development of navigation technology. The knowledge base contains the discussions on major technical factors affecting the navigation(Makarov, et al., 1995).

It should be noted, however, that the present INSROP data base on ice conditions are still partial and gradual, particularly poor on ridges and their distributions and encounter frequency along certain ship routes. These defects might affect safety of navigation, but the satellite-based remote-sensing technology in the near future will hopefully be able to eliminate them

3.2 Environmental Factors(Sub-programme II)

A major assessment was carried out of potential impacts of shipping, navigation and related activities of exploitation and development around the NSR upon the arctic ecosystem.

Three main components of the assessment were acted on step by step:

(1) The Dynamic Environmental Atlas(DEA) provides baseline information on the ecosystem and the components to the NSR Environmental Impact Assessment (EIA). The data was stored in the INSROP GIS.

(2) The Environmental Safety of Ship and Navigation(ESSN) produced regulatory framework for pollution control measures in the NSR. Guidelines to control shipboard pollution in the NSR, including discharge standards, in harmony with IMO/MARPOL 73/78 were presented. Shipboard oil pollution contingency plan was discussed in conformity to the Annex 1 of MARPOL 73/78 and a preliminary emergency plan was presented(Semanov, et al.1999).

(3) The Environmental Impact Assessment(EIA) developed tailored assessment methods for analyses of possible impact and environmental risks(Thomassen, et al., 1999). The methods are operative.

In the Phase II, supplementary data, information and analyses were provided for the INSROP GIS and this has refined upon users abilities of the GIS, coastal oil spill contingency plan, guideline for shipboard waste management, which enabled to provide decision-making basis, mitigating measures, monitoring system, future work, etc.

3.3 Trade and Commercial Shipping Aspects (Sub-programme III)

Assessment of cargo potential and shipping operations on the NSR, both domestic and international, was carried out to identify commercially viable solutions to the international

shipping community by comparison of existing alternative solutions via the Suez or Panama Canal.

Transit and regional operations and their perspectives were analyzed. On transit operations maximum size of the NSR vessels was supposed to be 50,000DWT of ULA class(Tsoy, et al., 1999) in possible eight months operations, mainly due to shallow water along the NSR. Present commodities via NSR were mostly chemical fertilizers, fabricated metals agricultural and forest products, each volume of which was found to be too low to make reliable predictions of potential cargo movements in the near future(Isakov, N.A., et al., 1999).

Regional operations stand on cargo generations in the northwest Russia, Timan Pechora, Yamal-Nenets and the Yenisey basin and their marine transportation(Bandman, et al., 1999). Oil and natural gas are main commodities for domestic and exporting marine transportation. The size of the tankers is to be smaller than 120,000DWT in year-round operation (Tsoy, et al., 1999).

If competitive marine insurance system and reasonable tariff structure can be established and the cost of NSR vessel construction can be reduced to competing on the world shipping market , the NSR would be a promising commercial sea-lane.

3.4 Political, Legal and Strategic Aspects(Sub-programme IV)

Through extensive studies of influences of legal, political and security aspects on extended use of the NSR for international commercial navigation, some preliminary conclusions were obtained as follows:

(1) Security policy is no longer an obstacle to international use of the NSR, although a sort of illusion of Cold War policy still exists(Ostreng, et al.,1997).

(2) If sufficient data of the NSR operation experience such as ship damage statistics, icebreaker escort frequencies, etc. is opened to the international insurance community, a new marine insurance risk regime for the NSR would be developed(Gold, et al.,1996).

(3) Navigation through ice-infested straits on the NSR has a legislation issue to be solved. For the legal regime governing the NSR straits the situation is less than desirable, since it appears to reflect the same conflicts previously existing within the international strait regime, polarization(Brubaker, R.D., 1996).

(4) Indigenous society and the NSR influences on the society in any aspect should be one of key factors in the decision process(Sokolova and Yakovlev, 1998).

Some issues on the NSR jurisdiction, NSR marine insurance, social and cultural impacts on indigenous peoples, NSR administration, NSR environmental law and harmonization of rules for ice-transiting vessels were more practically reviewed in the Phase II.

4. INSROP GIS

The INSROP GIS, Geographical Information System, contains data sets on climate, ice

conditions, shipping routes, ports, economy and infrastructure in the North Russia, administrative and jurisdictional borders, indigenous population(Lovas, et al.,1994). The INSROP GIS was refined by the Phase II projects.

The GIS provides a vast fund of general information about the NSR for analytical, statistical and presentational purposes, which is available for external users through the software of ArcView(Brude, et al.,1998).

5. INTEGRATION OF INSROP

Every project performed in the INSROP framework was compiled into four reports and integrated into one multi-disciplinary report on target for political, commercial and administrative decision-makings(Ostreng, et al.,1999).

6. OPERATION SIMULATION

6.1 Simulation Workpackages

The simulation project was set up to perform a more technically oriented integration of INSROP results by numerically simulating different scenarios of the NSR shipping. The objectives are to identify and quantify main factors and obstacles that make shipping on the NSR economically infeasible and to make recommendations on preferable scenarios, and measures to be taken to make the NSR navigation feasible.

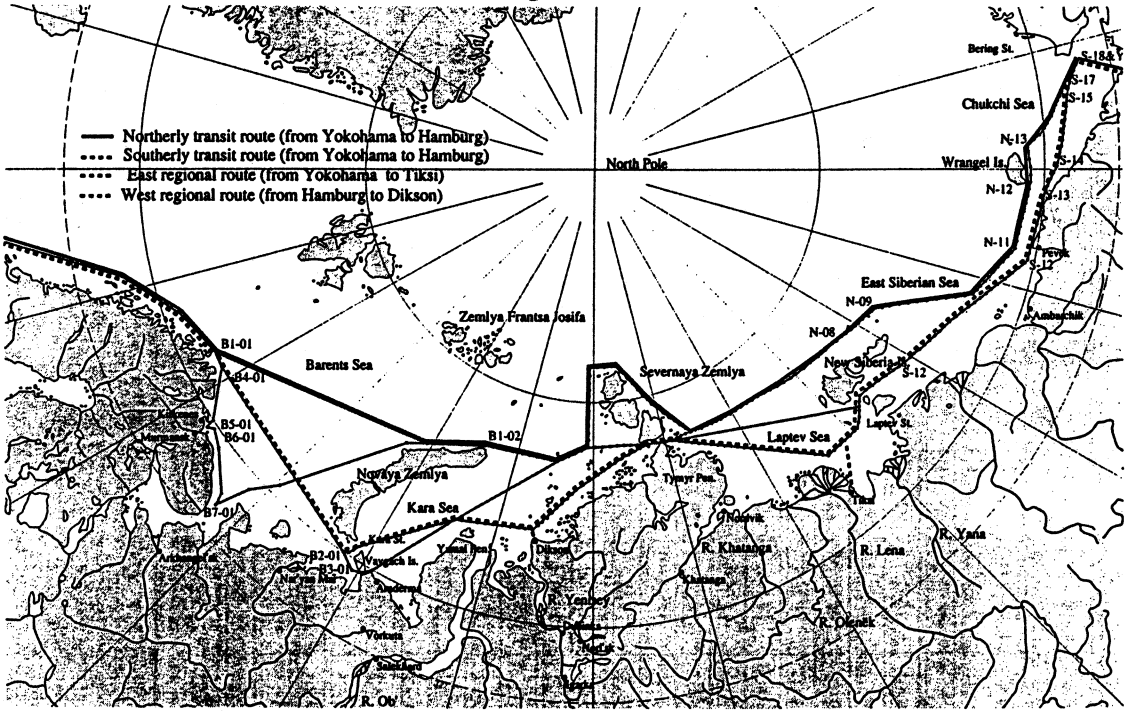


Fig. 2 Selected NSR Routes

The simulation project consisted of eight workpackages. The routes in the simulation were carefully examined through discussions between the workpackages. A northerly transit route with a deep draft ship, southerly transit route and two regional routes with a shallow draft ship were determined. Complete transit route data for the four routes as well as major ports were provided by WP1(Baskin, et al.,1998), in collaboration with WP7(Yakovlev, et al.,1999). The routes were divided into several segments and the sub-segments. Ice data in past years were analyzed in WP2(Brestkin, et al., 1998) and tabulated for each segment and sub-segment along the routes.

Both year-round and seasonal operations were evaluated , and optimum operation scenarios for the service vessels were selected. The seasonal operations naturally depend to some extent on the results of the simulation. Data-base for economic evaluation was established by WP3(Ramsland, 1999, Isakov, et al., 1999), through collecting data of Russian foreign trade in recent years and cargo movements between Russia and South-East Asia via the Suez. In WP7 legal and environmental evaluations for the selected routes were performed. The four NSR routes are shown in Fig.2.

WP4(Forsen, et al.,1998) designed open/bulk carriers for the simulation. Cargo capacity and main particulars were determined after a deep discussion. The shallow draft bulk/container has a cargo capacity of 25,000DWT, and a draft bulk/container of 40,000DWT and a bulk carrier of 50,000DWT were also designed for the simulation.

Table 1 Main Particulars of the NSR Vessels and a Typical Icebreaker

Parameter	Unit	Ship			
		25000 DWT bulk/container	40000 DWT bulk/container	50000DWT bulk	Arktika
Loa	m	199.9	206.5	252.0	148.0
Lpp	m	184.1	186.1	240.0	136.0
Length of bow region	m	36.8	51.1	24.6	35.5
Length of parallel part	m	86.1	50.0	62.6	65.0
B	m	25.1	27.5	30.0	28.0
D	m	15.0	16.0	18.8	17.2
d	m	9.0	12.5	12.5	11.0
Stem angle	deg	30.0	30.0	25.0	24.0
Waterline entrance angle	deg	52.0	50.0	43.0	40.0
Cb		0.813	0.751	0.767	0.546
Cm		0.995	0.998	0.978	0.900
Cp		0.817	0.751	0.784	0.607
Cwp		0.949	0.932	0.847	0.701
Speed in open water	knot	14.50	14.50	17.00	20.80
Number of propellers		2	2	1	3
Propeller diameter	m	5.2	5.8	7.1	5.3
Shaft power	kw	24000	28000	16578	49000
Lcb from midship (+ forward)	m	2.94	3.44	0.34	0.00
Displacement	MT	35700	52000	70960	23460
Gross tonnage	GT	21000	22600	31000	-
Cargo tonnage	MT	21500	36000	47000	-
Fuel consumption of main engine	g/ps/hour	187.1	187.1	171.2	-
Fuel consumption of generator (sea going)	MT/day	-	-	1.54	-
Fuel consumption of generator (port)	MT/day	3.81	3.81	3.08	-

The main particulars of these cargo vessels together with a Russian typical icebreaker "Arktika" are tabulated in Table 1 and the outline of 40,000DWT bulk carrier, for instance, is shown in Fig.3. As shown in Fig. 3, the ship features the DAS(Double-Acting-Azipod Ship) with Azipod which rotates 360 degrees and works in pulling mode as well.

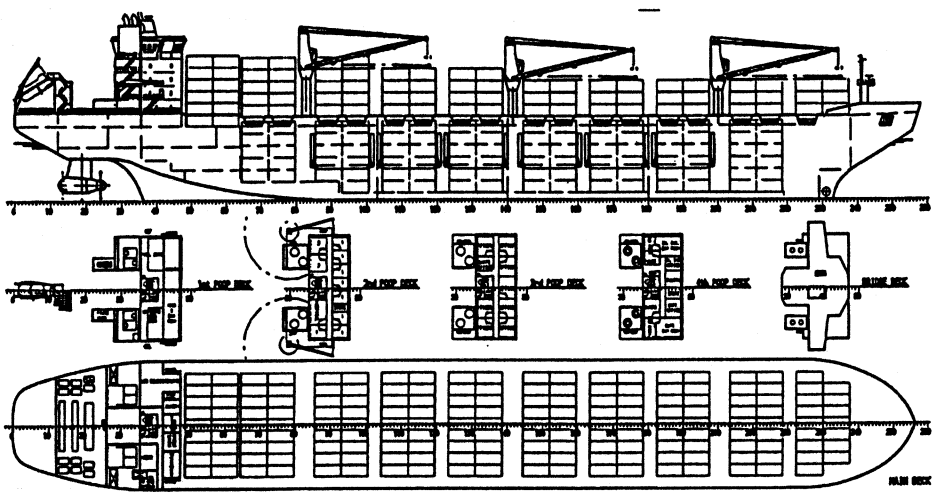
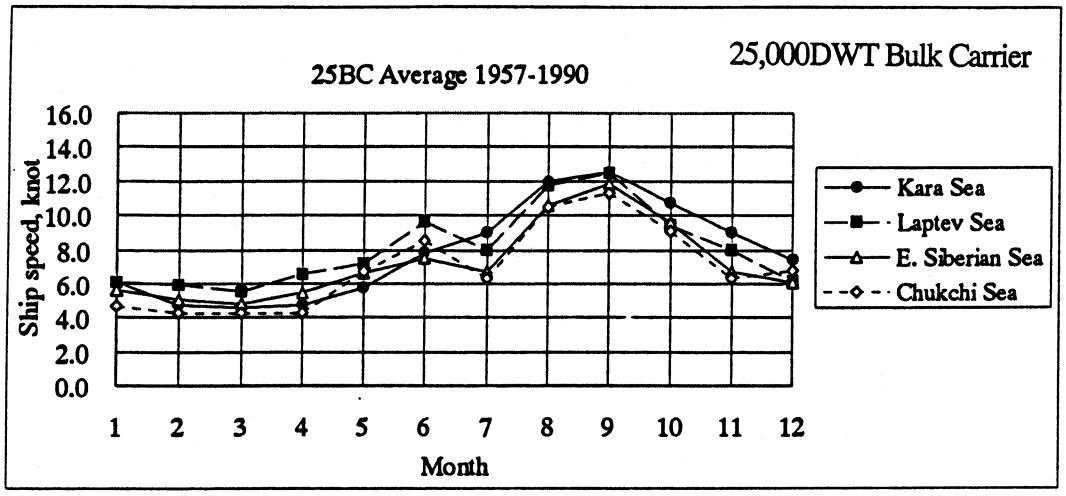
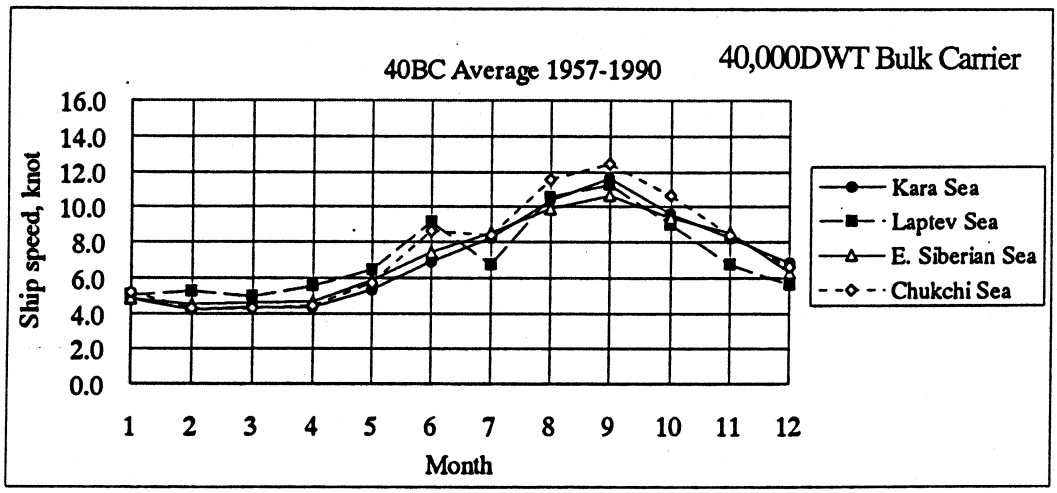


Fig. 3 Outline of 40,000DWT Bulk Carrier

The Russian SA-15 operations data was presented by WP5(Tsoy, et al., 1998), hopefully to be useful references to the simulation. Utilizing the SA-15 data and other various data sources, ship transit algorithms were developed by WP6(Riska and Patey, 1999) where estimations of ice resistance, analyses of ice parameters and elaboration of the numerical codes were derived and verified. Unfortunately WP2 could not provide appropriate digital data sets to the algorithm of WP6. Lack of those digital data resulted in a slight modification of the algorithm. The first modification was an application of a probabilistic concept of assessment.

A numerical code for the simulation was developed by WP8(Kamesaki, et al., 1999), by introduction of ice index concept which is similar to Canadian ice regime, reflecting the data and information obtained through the WPs activities. Two modes of ship operation were discussed, i.e., monthly voyage simulation and annual serial voyage simulation. In the monthly voyage simulation, a voyage was supposed to start at Yokohama and terminals in Hamburg on transit voyage, and Dickson and Yokohama was the starting ports on regional routes. A ship operation cost varies with season and year particularly on the NSR. A cost required for one voyage was carefully estimated for capital cost, ship operating cost including crew cost, maintenance cost and insurance cost, icebreaker escort cost as a sum of tariff and ice pilot fee, fuel cost and port charge. Intensive sensitivity analyses were conducted to clarify major factors and stoppers that would make the NSR operations unfeasible from an economic view point. Examples of navigation speed and voyage cost components are shown in Figs. 4 and 5, respectively. In Fig. 5, the unit of voyage cost is 1,000 US$ and the voyage cost components, icebreaker charge, fuel, port, operating and capital costs, are arranged topically, from the top to the bottom, in each column.





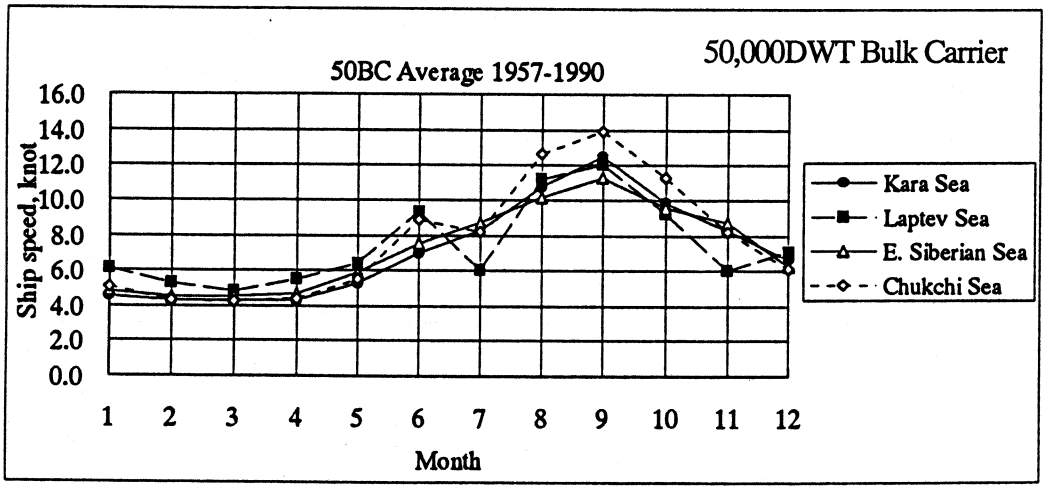
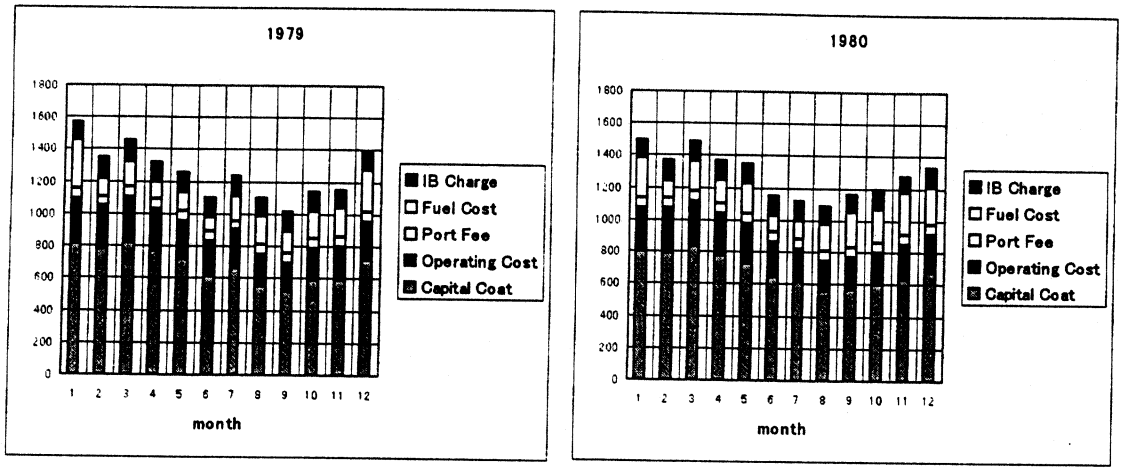
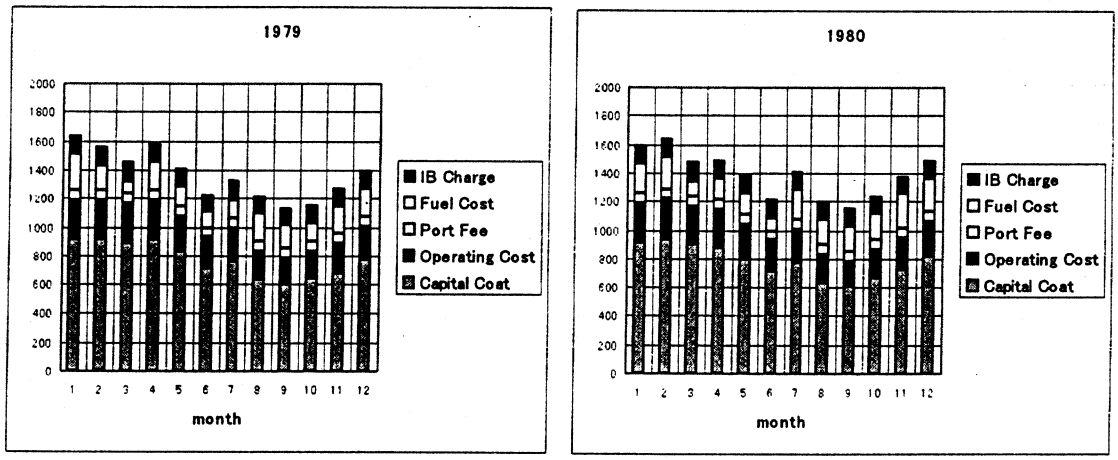


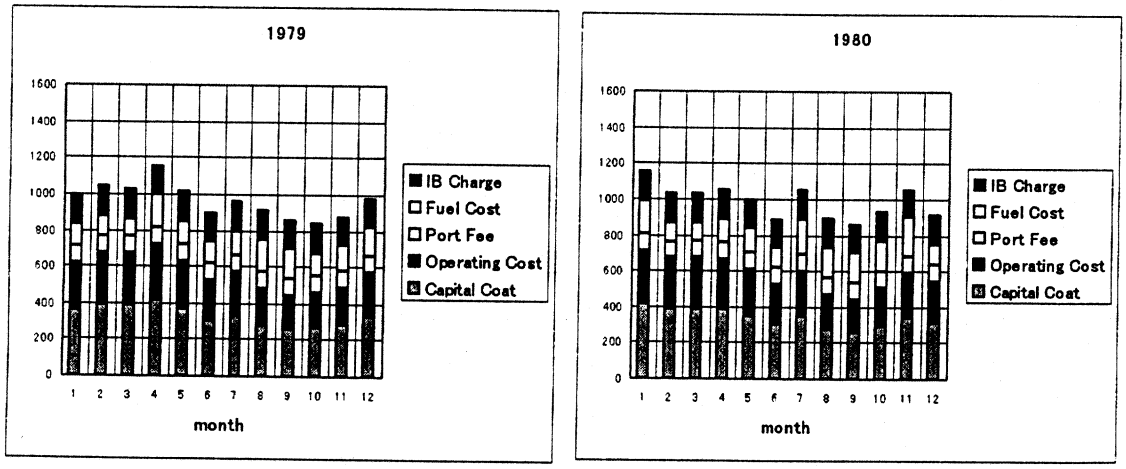
Fig. 4 Navigation Speed via NSR



25,000DWT Bulk Carrier



40,000DWT Bulk Carrier



50,000DWT Bulk Carrier

Fig. 5 Voyage Cost Components

6.2 Conclusions of the Simulation

The report of WP8(Kamesaki et al, 1999) derived important conclusions through the comprehensive simulation. The major conclusions are as follows:

(1) The capital costs have one of the most effective factors among the cost parameters. 50,000DWT bulk carrier has advantages to the other two powerful icebreaking cargo vessels, if the assumed icebreaker tariff is realistic. The difference in transit days between the northerly and southerly routes was found to be negligible, and the escort day on the northerly route is slightly longer than the southerly one, but the difference is one day, which indicates that the northerly route can be promising for the larger capacity ships developed in future.

(2) As for the regional routes, the western route is far easier than the eastern one. Almost independent navigation will be possible by using 25,000DWT ship. This fact well explains the experience gained in the past Russian operations.

(3) The tariff for icebreaker escort is one of the most significant factors among the various cost parameters. The tariff rate slightly less than 5.0US$/ton seems to make the NSR economically feasible.

(4) The insurance cost on the NSR was eventually assumed to twice expensive as the Suez route. Clear digital information of the accidents and ship damages and their statistics should be provided to the marine insurance community to ensure the NSR insurance at an internationally competitive level.

(5) The appropriate route switching from and to the Suez route could considerably improve the cost performance.

7. CONCLUDING REMARKS

The history of the Arctic exploration has been a fascinating tale of man's struggle in ice-infested waters to expand his environment. The ocean is now regarded as the last major frontier on earth for the exploration, exploitation and development of natural resources and space for human activities to sustain mankind in the future. The NSR has been developed for this particular reason. The possibility of more use of the Arctic Ocean in due course could emerge with development of marine technology allowing complexity of natural resources and advances in the sciences of oceanography, marine geology and earth science as well. These developments should be accompanied by concern for their impacts on the natural and ecological environment of the Ocean due to any accident, discharge of waste and any kind of serious disturbances. Recent changes in jurisdiction over environment and promote efficient and peaceful uses of the ocean. This should be the case for the Arctic Ocean and the NSR.

The INSROP had been carried out by world experts in their respective fields on technical, ecological , environmental, economic, political and security aspects of the Northern Sea Route. This is undoubtedly one of the most comprehensive researches on the Northern Sea Route and

probably the Arctic as well. Every detailed information of the NSR can be obtained through nearly160 INSROP Working Papers, Proceedings of ITS'95, and other related publications.

ACKNOWLEDGEMENTS

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