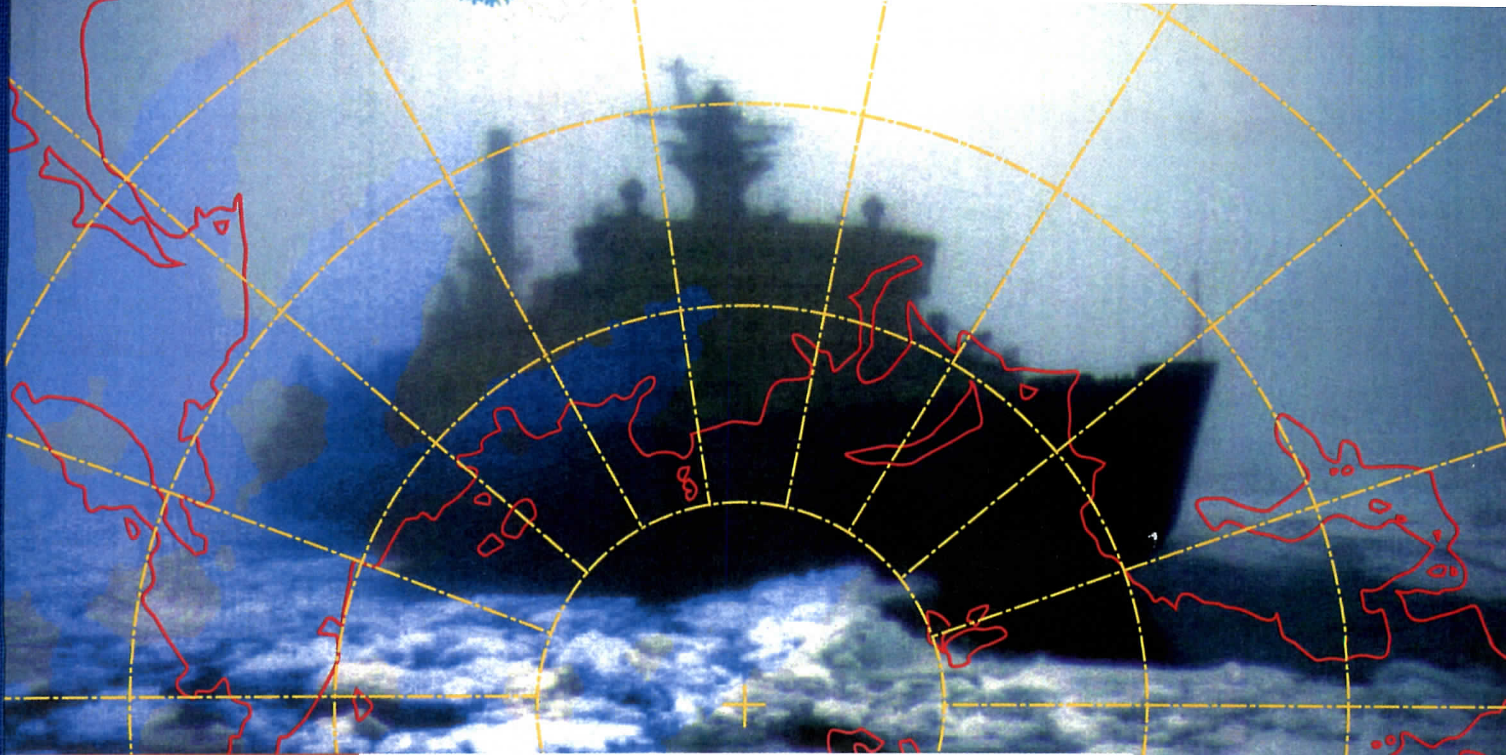
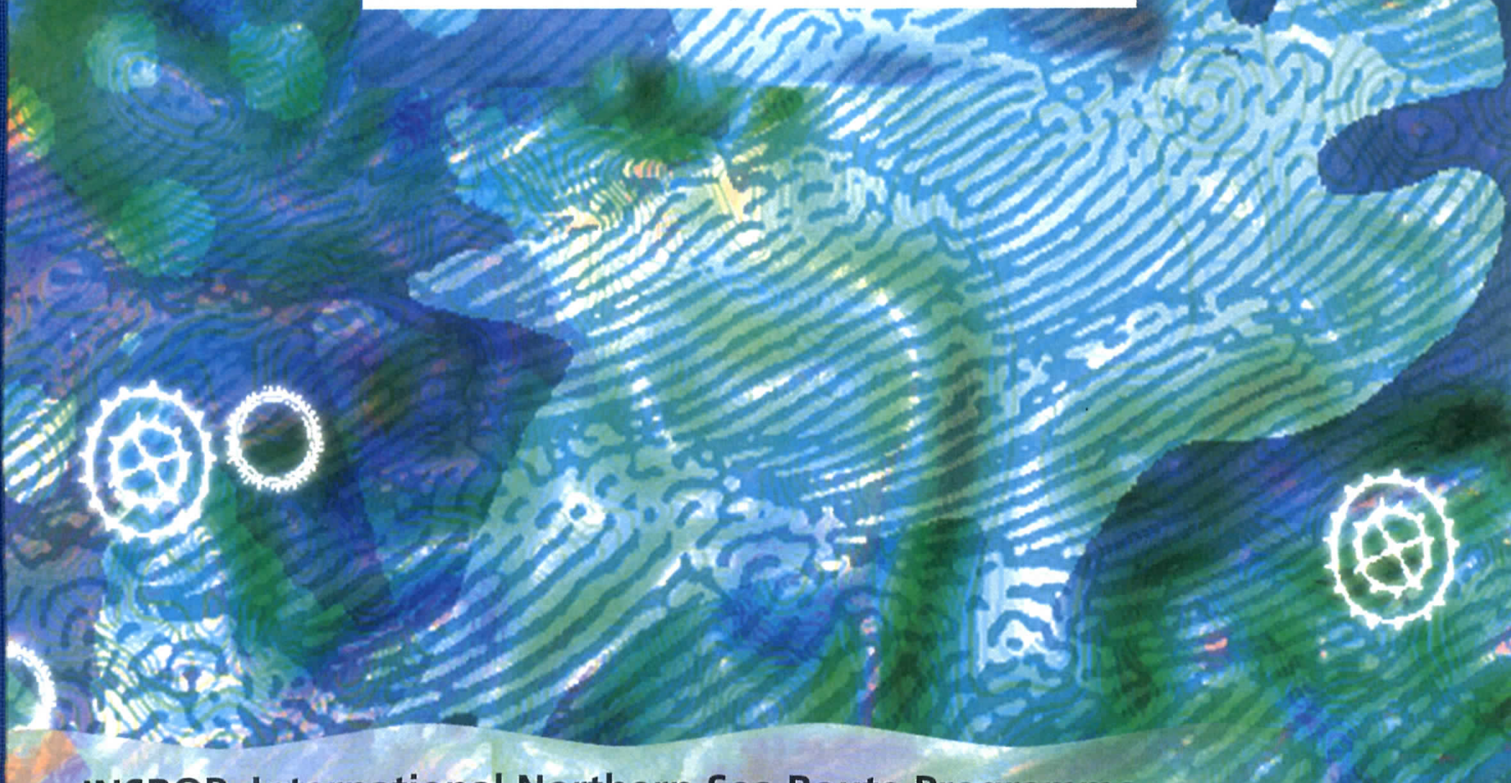


# INSROP WORKING PAPER
## NO. 53 - 1996, II.4.1 & II.4.4

## The Marine Invertebrates, Fish and Coastal Zone Features of the NSR Area

Lars-Henrik Larsen, Rune Palerud, Harvey Goodwin and Boris Sirenko



INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia
The Fridtjof Nansen Institute, Norway
Ship & Ocean Foundation, Japan

# INSROP WORKING PAPER NO.53-1996

**Title:** **The Marine Invertebrates, Fish and Coastal Zone Features of the NSR Area.**

Sub-programme II: Environmental Factors

Projects II.4.1: Marine and Anadromous Fish and Invertebrates
II.4.4: The Coastal Zone

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

This publication forms part of a Working Paper series from the **International Northern Sea Route Programme - INSROP**. This Working Paper has been evaluated by a reviewer and can be circulated for comments both within and outside the INSROP team, as well as be published in parallel by the researching institution. A Working Paper will in some cases be the final documentation of a technical part of a project, and it can also sometimes be published as part of a more comprehensive INSROP Report. For any comments, please contact the author of this Working Paper.

## 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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*Rapporttittel /Report title*

# INSROP:

# The marine invertebrates, fish and coastal zone features of the NSR area

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*Sammendrag / Summary*
During phase I of INSROP (1993-1995) a wide range of information on the Subprogramme II Valued Ecosystem Components (VEC's) has been gathered from Russian datasources. The present Working paper describes distribution, status and selected parts of the information gathered on five of the Subprogramme II VEC's; Benthic invertebrates, Marine, estuarine and anadromous fish, Plant and animal life in polynyas, Human settlements and Water-land border zone.

| *Emneord:* | *Key words:* |
|---|---|
| Nordøst-passasjen | Northern Sea Route |
| fisk | fish |
| evertebrater | invertebrates |
| kystsonen | coastal zone |
| elvedeltaer | estuaries |

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# Preface

The present INSROP Working paper presents the information, jointly collected and included in the INSROP data base by Akvaplan-niva (Apn) and Zoological Institute St. Petersburg (ZISP). The paper presents the outline of the data collected and treated during phase I of INSROP. This work has been performed within three Subprogramme II projects:

- II.4.1: Marine and Anadromous Fish and Invertebrates,
- II.4.4: The Coastal Zone
- II.4.5: Large River Estuaries and Deltas.

(From 1995 the project II.4.5 was included in project II.4.4).

A description of the invertebrate communities and fish resources is given, with special emphasis put on the processes and links between the Valued Ecosystem Components (VEC's). Based on phase I, some of the data are used to give a presentation of each of the VEC's, on which the emphasis has been put. Anyone interested in further information or data on these subjects is encouraged to contact either the authors or the INSROP secretariat at Fridtjof Nansens Institute.

An environmental Atlas is currently being prepared by INSROP subprogramme II, which will present more of the data from all subprogramme II projects (number of records in the database, species distribution etc.).

The budgets for carrying out the work have been limited, which necessarily is reflected in the level of ambition in some contexts, but still we feel that the phase I work has yielded a lot of useful information on the appointed VEC's of the Subprogramme, and which enables the Subprogramme to proceed with the Environmental Impact Assessment.

In addition to the authors, the data collection has been performed by a number of scientists of Zoological Institute. N.V. Chernova, O. Kudersky, V. Khlebovich, A. Neyelov and A. Golikov are acknowlegded for their constructive contributions to this work.

Tromsø 6th June 1996

Lars-Henrik Larsen | Rune Palerud | Harvey Goodwin | Boris Sirenko

# Table of contents



# 1 Introduction

The present Working paper is presenting the results and findings of the three INSROP projects II.4.1 II.4.4 and II.4.5. (from 1995, the projects II.4.4 and II.4.5 were amalgamated to one project entitled "The Coastal zone"). The material presented consists of historic Russian data, collected by a number of institutions, and a limited number of data collected by Akvaplan-niva in the Kara Sea.

Zoological Institute (ZISP), has been responsible for the data collection, while quality assurance and quality control (QA/QC) and preparation for inclusion in the INSROP database have been performed during joint workshops between Akvaplan-niva and Zoological Institute.

The Northern Sea Route (NSR) passes through nearly half the Arctic (Fig. 1.1), and includes vast, more or less permanent ice-infested sea areas, coast and rivers. The remoteness, the harsh climatic conditions and the large extent of the NSR area makes research very difficult. The Kara Sea, Laptev Sea, East Siberian Sea and the Chukchi Sea are some of the least explored and mapped areaws of the world. Thus, even though the projects have recorded information on more than 2000 different species of plants, invertebrates and fish, the data coverage is still fragmentary. This relatively sparse data cover will necessitate some generalisations and assumptions on the extent and severity of possible effects of increasing the use of the Northern Sea Route.

The present work will hopefully make our knowledge less general than hitherto, and make the information more easily useable for advisors, politicians and users of the Northern Sea Route. Hopefully, the collected information will lead to an optimal performance within coastal management, shipping routines and environmental behaviour in the NSR area.

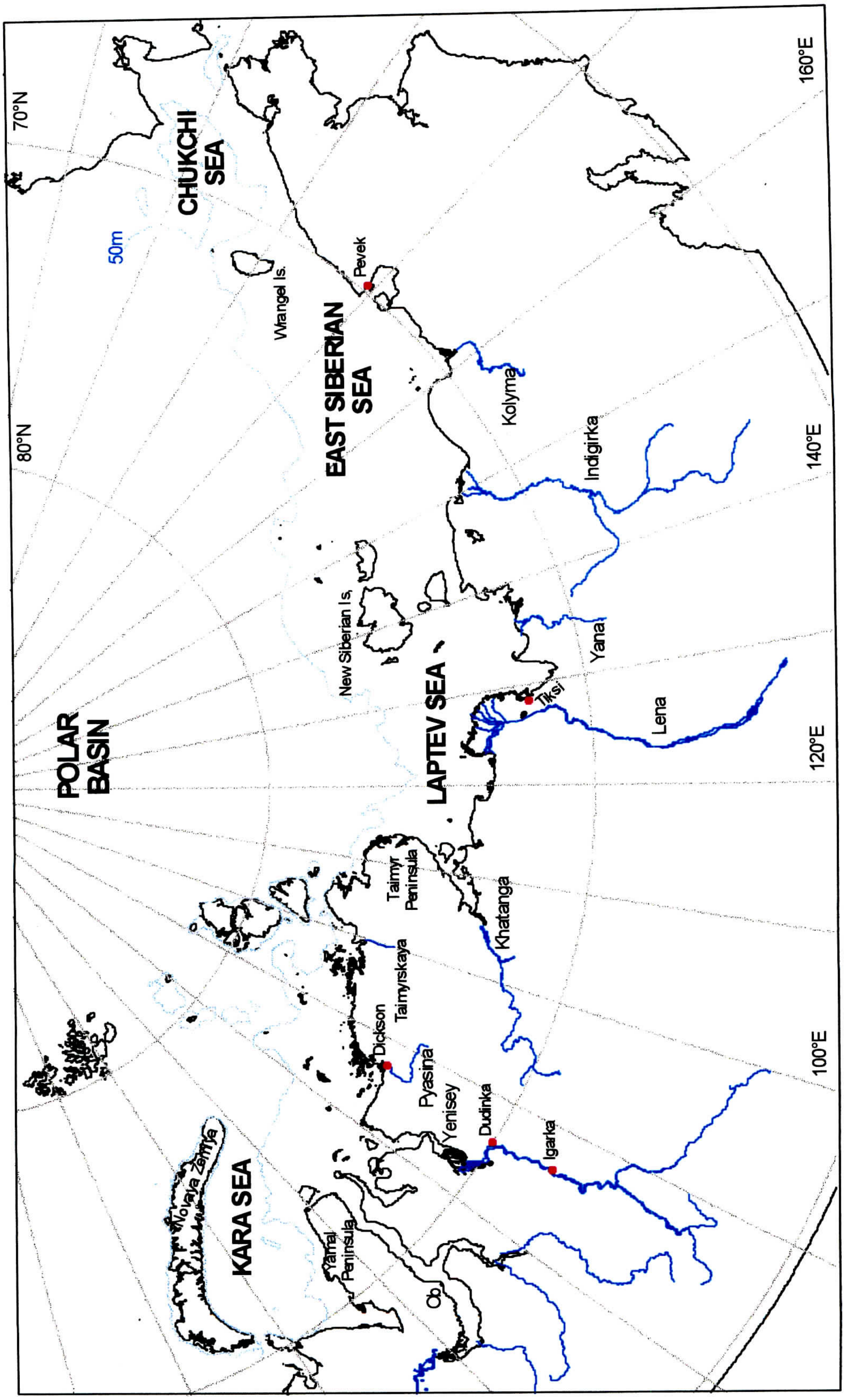


Figure 1.1 The NSR Area: the Kara Sea, Laptev Sea, East Siberian Sea and the Chukchi Sea. The major freshwater tributaries are indicated.

# 2 The Valued Ecosystem Components (VEC's)

The final product of INSROP subprogramme II is, besides the database containing the collected information, the Environmental Impact Assessment (EIA) of increased activity in the NSR area. At an early stage of INSROP it was decided to use the Environmental Assessment and Management Method (AEAM, Holling 1978) to carry out the EIA.

The AEAM method is based on the selection and evaluation of some central parts of the ecosystem, described as "Valued Ecosystem Components", which are treated and analysed on a general level. For each VEC, a set of links from effect causing activities to the VEC is shown in a schematic flowchart (Fig. 2.1). Then a set of impact hypotheses are formulated, and each hypothesis is evaluated according to the available data. A VEC is defined by Hansson *et al.* (1990) as a resource or environmental feature that:

a) is important (not only economically) to a local human population, or
b) has a national or international profile, or
c) if altered from its existing status will be important for:
    the evaluation of environmental impacts of industrial developments
    the focusing of administrative efforts.

The use of the AEAM method in INSROP is described by Thomassen *et al.* (1996), while a description of the VEC's, the flowcharts with effect-causing links (Fig. 2.1) and the evaluated impact hypotheses of the VEC's of the present projects is given by Larsen *et al.* (1995).

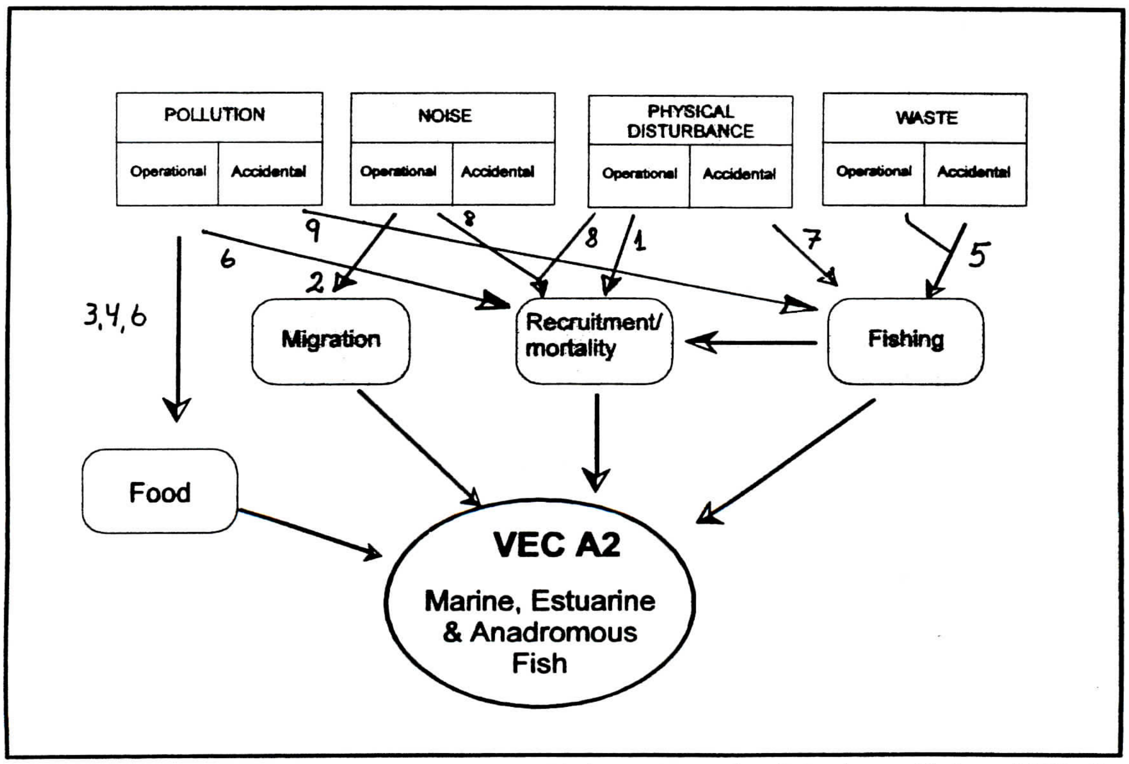


Figure 2.1 An example of a flow chart with impact causing links (page 9) for a VEC, the Marine, estuarine and anadromous fish (Larsen et al. 1995).

Impact causing linkages as indicated in figure 2.1 (page 8):

1. Continuous breaking up of ice may exclude fishermen from traditional fishing grounds, leading to reduced mortality and increased recruitment to fish stocks.
2. Noise from ships can affect migration of anadromous fish during certain parts of the year.
3. Pollution and substrate alterations can reduce the number and quality of pelagic and benthic invertebrate prey available to fish, and thus increase fish mortality.
4. Chronic pollution of invertebrates can cause higher body burdens in fish due to ingestion of contaminated prey, and increase mortality in juvenile and adult fish.
5. Dumping of waste can render areas inaccessible for certain types of fishing gear, relieving the fishing pressure on some species.
6. The anti-fouling agents on ship-hulls can be abraded by water and ice and thereby toxic substances can be released to the ice/water environment. This might in turn increase mortality in fish.
7. Major human activities in connection with accidents (clean up), dredging or harbour construction will locally affect fishing activities.
8. Noise from ships, combined with the turbulence of the water from the moving propeller and the breaking up of the ice, is often observed to make fish become trapped on top of the ice.
9. Accidental pollution will affect fishing activities.

# 3 VEC A1: Benthic Invertebrates

### 3.1 Introduction

During phase I of INSROP, information has been gathered on the distribution of benthic (bottom living) invertebrates at some 400 stations throughout the NSR. This information has accumulated during a period of nearly 100 years, and the stations are spread over an area of several millions square kilometres. This means that the data coverage is relatively good in limited areas, while large areas never have been sampled. Even though much of the collected information has not been published internationally, the identifications have been carried out according to international nomenclature. Though incompletely mapped, the relatively stable benthic fauna communities of the NSR area are shown to be the most diverse and species rich habitats of the entire ecosystem, through which the Northern Sea Route passes.

It is assumed that in the shallow Arctic sea areas, the influence of physical, ice-related disturbance will have a significant effect on the structure and stability of the benthic communities. Physical disturbance from ice is anticipated to result in low biomass levels (Golikov & Scarlato 1989), particulartly in shallow areas. Thus sediment gouging by inshore ice flows and frazil (suspension ice) formation are powerful disruptive forces for infaunal and epifaunal communities. Another permissive factor for species composition and biomass of benthic communities of the NSR area is the strong salinity gradient, resulting from the huge volume of freshwater transported to the area by the rivers.

As a consequence of these forces, it is expected that the fauna in shallow areas may be dominated by relatively small, mobile and short-lived taxa and that there may well be a strong relationship with overlying ice fauna. Conversely in deeper, offshore areas under semi-permanent ice cover and relatively undisturbed by hydrodynamic and cryodynamic forces, the benthic communities are expected to be dominated by populations of larger, relatively immobile and long-lived species.

Furthermore, in the large NSR area, an east-west distribution gradient has been shown to exist, where Atlantic species dominate in the western part, and the share of Pacific species gradually increases when going from west to east, particularly through the Chukchi Sea. Such animal distribution patterns are interesting when evaluating a species vulnerability towards any NSR activity, as a given population of a species is expected to be less tolerant towards external stress, the further away from its main distribution area it is found.

The invertebrate fauna along the NSR forms the nutritional base for the organisms of higher trophic levels, and is an important link between planktonic algae (primary producers) and fish, mammals and birds. During the scooping process of the EIA at the onset of phase I of INSROP, benthic invertebrates were appointed as a VEC. This was not only due to the ecological importance of this group, but also because these organisms are useful for monitoring purposes.

Benthic invertebrates are constantly exposed to sub-zero temperatures in most of the NSR area, and permafrost below the sea-bed is common (Keck & Wassmann 1993). Relatively few species are adapted to such life conditions, and high arctic benthic communities are in general relatively low in diversity compared to benthic communities at lower latitudes. As a result, disturbances affecting a dominant population of one species will have major impacts along the entire foodweb. It may therefore be difficult for predators to switch to alternate prey species, should their favourite one(s) be wiped out. This hypothesis is, among others, presented by Larsen *et al.* (1995), and will be evaluated further through the EIA process.

The number of known species of benthic invertebrates along the NSR decreases from west to east (Barents Sea 2499 species, Kara Sea 1580 species, Laptev Sea 1084 species, East Siberian Sea 962 species, and Chukchi Sea 946 species), with more than 2.5 times as many species known from the Barents Sea compared to the Chukchi Sea. This is partly a result of the harsher arctic environmental conditions eastward along the Siberian coast. East of the Laptev Sea, the influence of Pacific species is gradually increasing. A limited number of surveys have been carried out in the eastern parts of the NSR, and currently material from the Chukchi Sea collected in 1976, 1988, 1989 and 1995 is being identified at Zoological Institute, and the number of known species from that sea is expected to increase.

The continental shelf off the Siberian north coast, including the Chukchi, East Siberian, Laptev and Kara shelves is many kilometres wide, and generally very shallow (less than 50 meters; Fig. 1.1 and Weber (1989)). The Chukchi Sea shelf covers an area of 9000 km$^2$ and is characterised by nearshore sand bars, ice gouges, and large sediment dunes. The continental shelf of the East Siberian Sea, up to 800 km wide, is a flat, very shallow plain. Thus, 350 km off-shore from the Kolyma Valley, the water depth is still not more than 30 meters. Only the Indigirka and Kolyma submarine valleys, which reflect submerged river channels, provide relief. West of the Indigirka Valley, the water depth as far as 250 km off-shore, range from 10 to 15 m. The major topographic features of the sea floor were shaped by grounded ice and subaerial erosion during glacial periods, as well as by river sedimentary discharges. The Laptev Sea is cut by numerous transverse submarine valleys of erosional and tectonic origin that can be traced also on land (Holmes & Craeger 1974).

### 3.2 Material and methods

We have chosen to exemplify the hypotheses by showing some distributional features of a number of selected species and stations from the material entered into the INSROP database. 110 stations from the Laptev Sea and eastward were selected (App. 1). Of these stations; 16 were sampled in the Laptev Sea in 1993. From the East Siberian Sea, 73 stations were used (23 stations are sampled in 1937, 14 stations sampled in 1973, 34 stations in 1986 and 2 stations sampled in 1992). From Chukchi Sea 21 stations sampled in 1976 were used (Fig. 3.1). The samples have been collected by different equipment, such as grabs, trawls and by scuba diving. This indicates that some care should be taken when comparing the quantitative information.

Presence/absence information on the benthic invertebrate species were used in a numerical clustering analysis to group stations according to faunal similarities. Correspondence analysis was performed using the program CANOCO, version 3.12 (terBraak 1988, terBraak 1991).

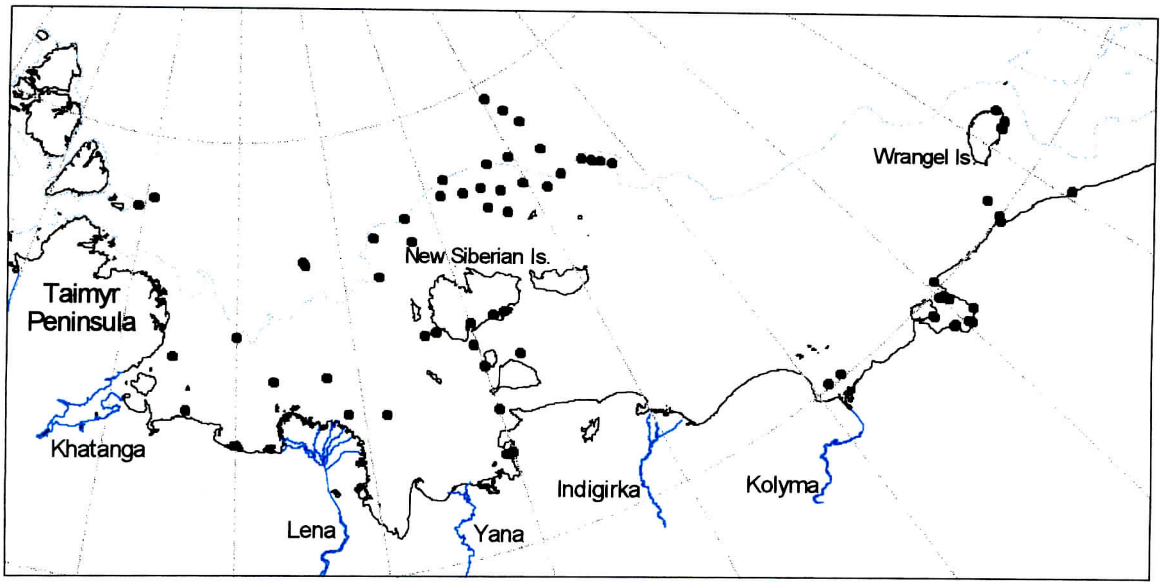


Figure. 3.1 Location of benthic stations selected from the INSROP database.

## 3.3 Results and Discussion

In total, 1207 different benthic taxa (mainly species) were recorded at the selected stations. The number of taxa at each station ranged from 217 at station 78 to 2 at station 39 (App. 1). More than 50 % of the stations had more than 30 different taxa. Approximately 50 % of the taxa were only found at one or two stations. The 10 most frequent species (taxa) are listed in Table 3.1

Of the most common taxa, 6 belong to the molluscs, 4 to the polychaetes, 3 to echinoderms, 2 to the bryozoans and crustaceans, and 1 to the cnidarian and porifera.

Table 3.1 The most frequently recorded species at the 110 selected benthos stations from the Laptev, East Siberian and Chukchi Seas.

| Species | Class | Phylum | Found on no. of stations |
|---|---|---|---|
| *Eucratea loricata* | | BRYOZOA | 45 |
| *Ophiocten sericeum* | Ophiuroidea | ECHINODERMATA | 38 |
| *Terebellides stroemi* | Polychaeta | ANNELIDA | 38 |
| *Tridonta borealis* | Bivalvia | MOLLUSCA | 35 |
| *Scoloplos armiger* | Polychaeta | ANNELIDA | 33 |
| *Cylichna occulta* | Gastropoda | MOLLUSCA | 31 |
| *Micronephtys minuta* | Polychaeta | ANNELIDA | 30 |
| *Myriotrochus rinkii* | Holothuroidea | ECHINODERMATA | 28 |
| *Nicania montagui* | Bivalvia | MOLLUSCA | 28 |

On the shelf, the number of species recorded versus depth show a positive correlation (Fig. 3.2) for depths lower than approximately 60 meters, with generally fewer benthic species in the shallow areas, compared to the deeper parts. When looking at the deeper parts of the area, although the present material only contains limited information on the number of species, data collected in 1995 indicate that the number of species is decreasing (Expeditions with participation from ZISP in 1995). As stated by our hypothesis, a higher stress level is expected in the shallower areas due to disturbances from ice and temperature and salinity variations. The correlation found seems to support this hypothesis.

The effect of ice-related physical disturbance can thus be a significant influence on the structure and stability of the benthic communities. This has to be kept in mind when evaluating possible effects of any NSR activities in the nearshore areas.

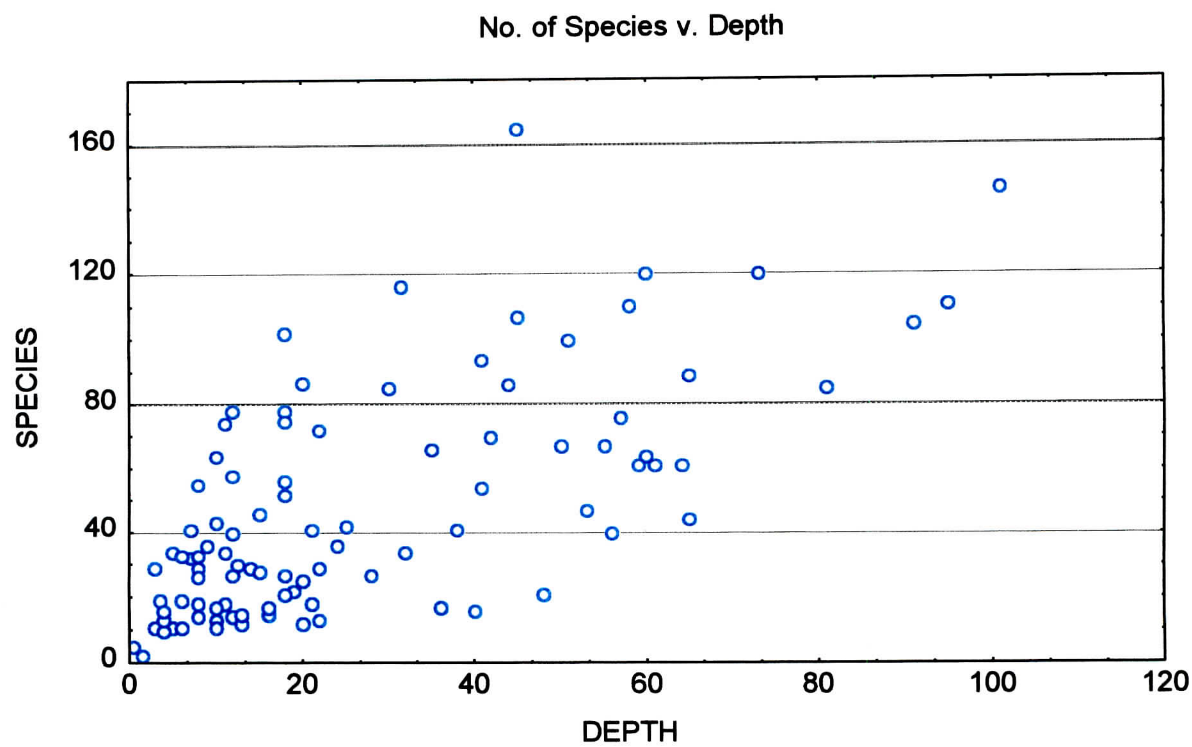


Figure 3.2 **Number of species plotted against sampling depth. Two stations are excluded from the plot; Station 78 (54 m depth and 217 species) and station 180 (170 m depth and 39 species).**

The species distribution along NSR is not uniform. Biogeographic boundaries have been discovered in the area. A major part of the Atlantic boreal-Arctic species do not spread into the eastern Laptev Sea, and most Pacific boreal-Arctic species are not found further westward than the New Siberian Shoals (Sirenko & Piepenburg 1994). Figure 3.3 presents the distribution of some selected species. Some species have a westerly distribution (like *Arctinula groenlandica*) while other species are distributed throughout the whole area (like *Ophiocten sericeum*, *Hiatella arctica*, and *Myriothrochus rinkii*), and still others have an easterly distribution like *Cylichna occulata*.

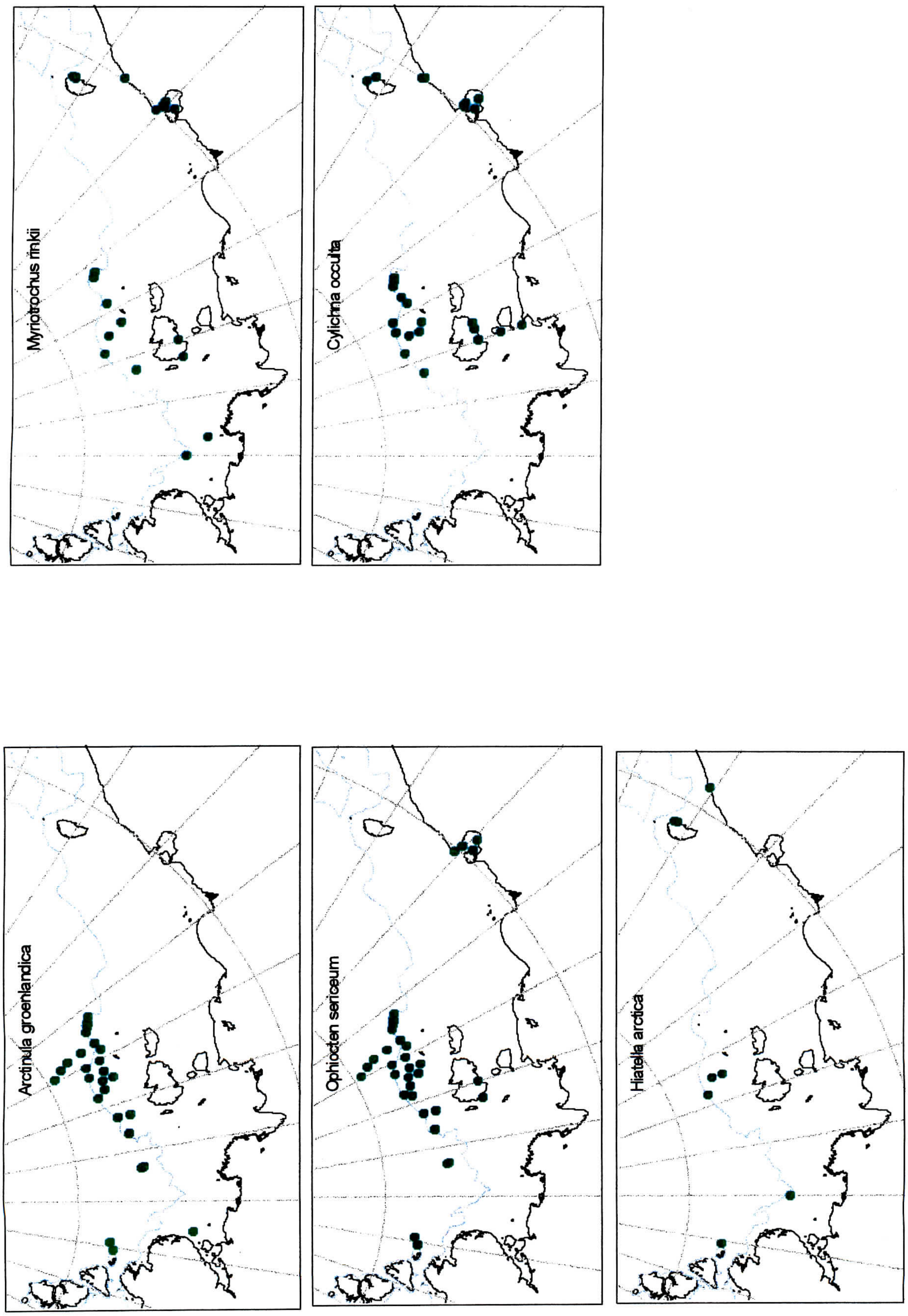


Figure 3.3 Recordings of selected species based on the material stored in the INSROP database.

To carry out a correspondence analysis, 445 species present at more than 3 stations were used. The results show that the stations can be arranged in three different clusters (Figure 3.4 and 3.5). The first cluster (I) represents stations from the Chukchi Sea, group II represents the deeper stations of the Laptev and East Siberian Seas. Cluster III represents the shallower stations in the coastal parts of the Laptev and East Siberian Seas. Group I and III are separated from group II along the first (horizontal) axis. This is the strongest axis in a correspondence analysis, and the separation might reflect a salinity gradient since shallow station along the coast are more influenced by the rivers (Zenkevitch 1963). Popov (1932) (in Zenkevitch 1963) notes a remarkable similarity between the fauna of the south-eastern part of the Laptev Sea and that of the Ob and Yenisei Bays of the Kara Sea. Results from an investigation in the Ob Bay in 1993 (Jørgensen *& al. in prep*) suggests that strong salinity gradients in inshore areas may have a considerable influence on benthic faunal distribution and production. This pattern is also known from the Baltic Sea.

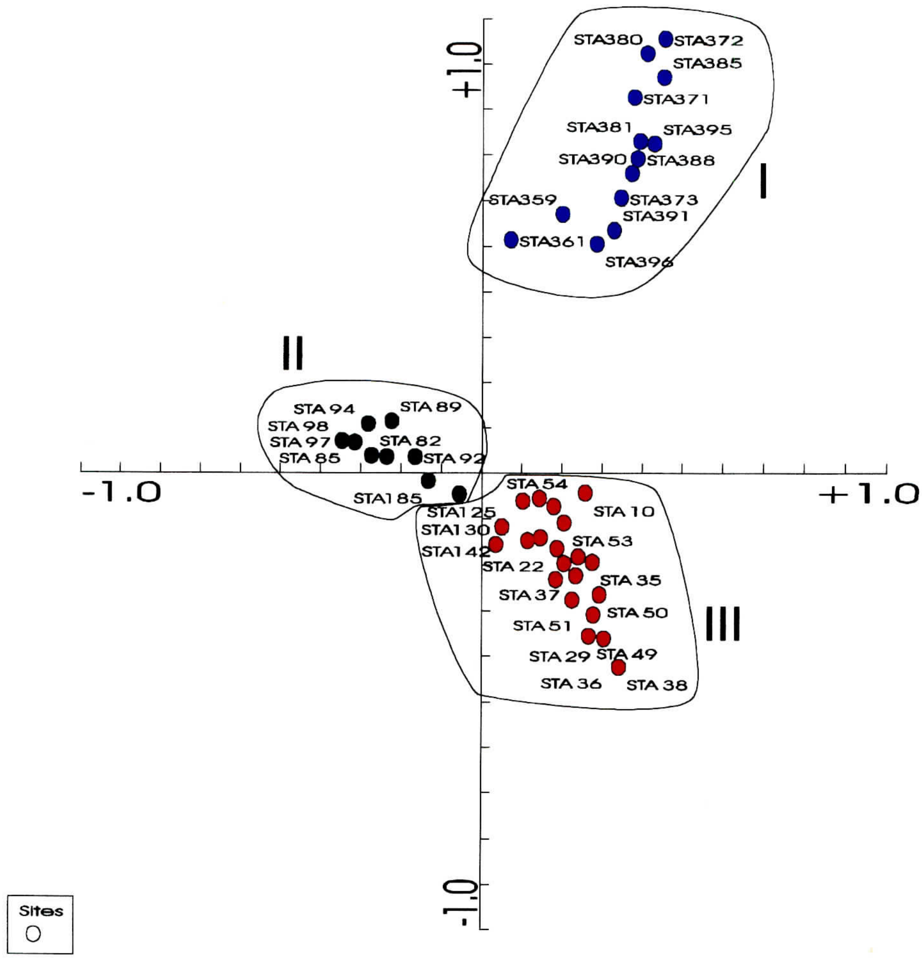


Figure 3.4 Correspondence analysis based on benthic invertebrate species recorded at more than 3 stations in the Laptev, East Siberian and Chukchi Seas.

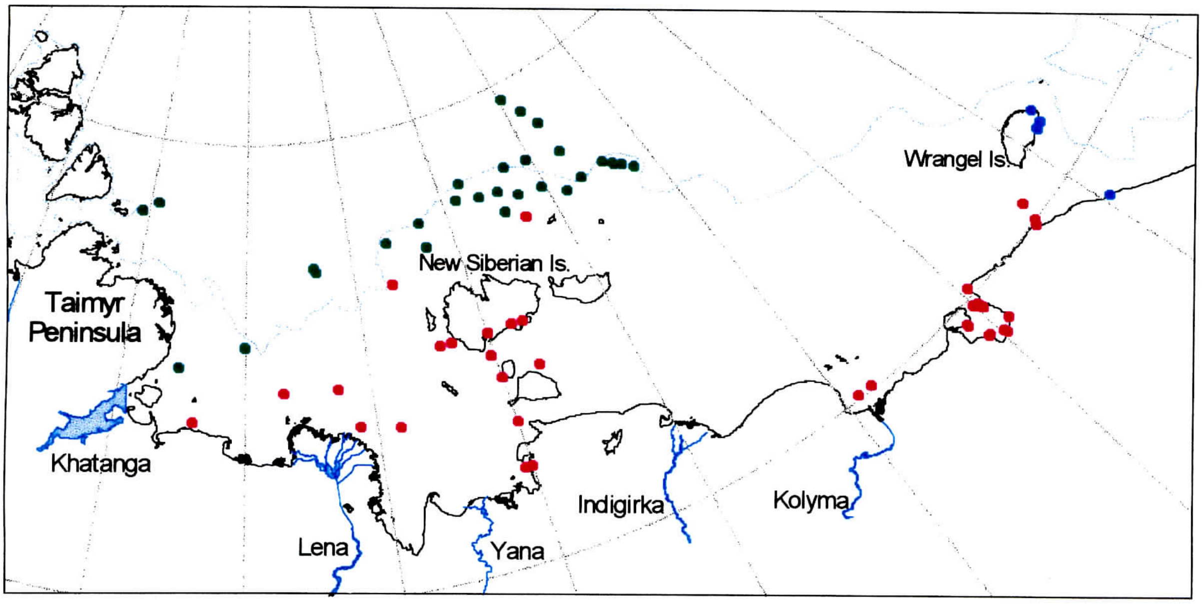


Figure. 3.5 Location of the stations selected from the INSROP database. The colour code show the results of the correspondence analysis. ● stations in cluster I, ● stations in cluster II, and ● stations in cluster III.

Invertebrates are the food source for animals at higher trophic levels, such as fish, which are in turn preyed upon by birds and seals. Invertebrates are also eaten directly by mammals and birds. Thus, the main diet of walrus is bivalve molluscs. Figure 3.6 shows the known distribution of bivalve molluscs. In the area around Wrangel island the biomass of one bivalve (*Macoma calcarea*) was up to 266 g/m$^2$ at one station. In Chaun Bay *Tridonta borealis* (Bivalvia; Mollusca) was found at maximum levels of up to 439.8 g/m$^2$. Conversely, the biomass of bivalves along the coast of the East Siberian Sea was considerably smaller. The information on biomass of potential prey organisms and the feed-preferences of marine mammals can thus be used for mapping of particularly rich areas, not only rich in invertebrates, but also potential feeding areas for marine mammals.

The grey whale (*Eschrichtius robustus*), the only mysticete whale that feeds mainly upon benthic organisms, relies on the amphipod crustacean assemblages of the northern Bering Sea and the Chukchi Sea for most of its annual food intake. Foraging whales leave distinct depressions 0.6 to 3 m in length in the bottom sediments in their wake. Patterns in the infaunal community composition appeared to be correlated to the size of the pit and by inference, to the age of the pit. The fauna of large, deep pits were characterised by species considered early colonists of disturbed areas. Smaller, shallow depressions did not have elevated numbers of early colonists. Low abundance of *Ampelisca macrocephala*, the dominant bottom organism and whale prey item, was observed in all the sampled pits (Nerini & Oliver 1983). The data coverage on the benthos from the eastern Chukchi is very sparse in the INSROP material, and thus a quantitative evaluation of the findings of Nerini & Oliver (op cit.) has not been possible.

Cairns (1978) examined diet and selection of foraging area by Black Guillemots (*Cepphus grylle*) in the eastern Canadian arctic. The birds fed on fish (*Boreogadus saida, Stichaeus punctatus, Eumesogrammus praecisus*) mysids, amphipods, and other decapod crustaceans.

Guillemots congregated at landfast ice edges early in the breeding season. Open-water foraging occurred principally in water 10-30 m deep within 13 km off the breeding colonies. Guillemots assembled on the water, but their distribution was not correlated with that of schooling prey. Guillemots in open water obtained much of their food on the bottom, but the example shows that there is not always a clear correlation between distribution of prey and predators, and other factors also influence the choice of feeding area.

The mapping of the distribution of bivalves and decapods were based on presence/absence data, giving no information on biomasses and numbers. Thus, areas with particular attractive concentrations for feeding birds and mammals will not appear in the present presentation. However, as previously described biomass data of the different species have been recorded at some of the stations, and are available from the INSROP database.

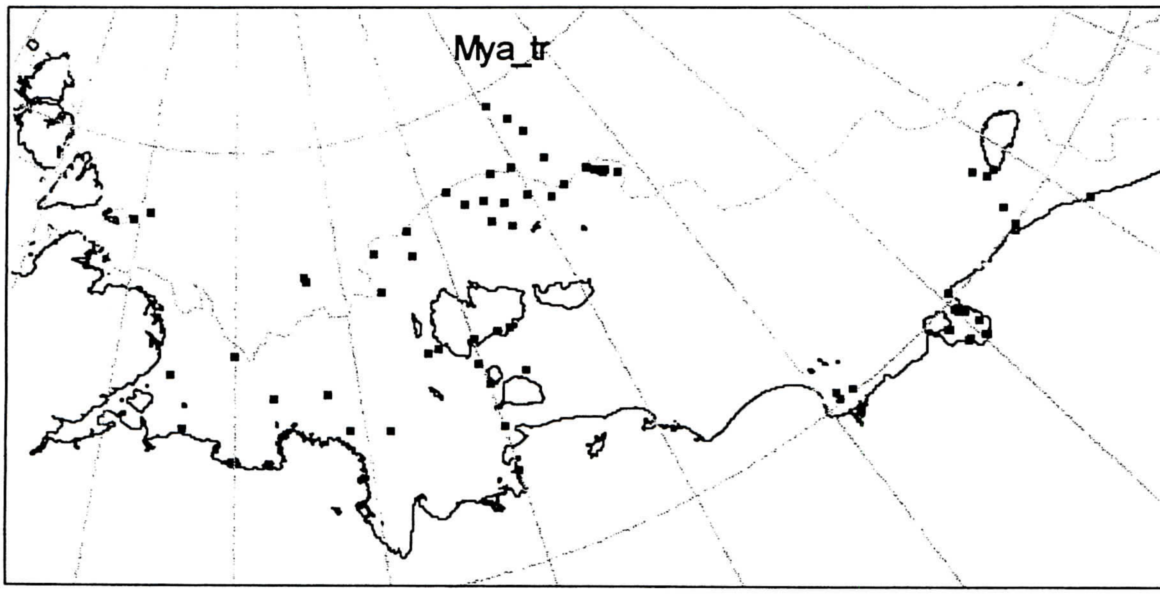


Figure 3.6 Stations where bivalve molluscs have been recorded in the Laptev, East Siberian and Chukchi Seas.

In conclusion, it seems tempting to speculate that due to the large area involved, and the low extent of human activity, even the most serious accident involving a NSR ship, is unlikely to cause more than local damage to the invertebrate VEC itself. However, long term, chronic discharges from shipping traffic may have overall negative effects far more serious than any single accidental event.

# 4 VEC A2: Marine, estuarine and anadromous fish

The NSR area comprises four major Arctic seas; the Kara-, Laptev-, East Siberian- and Chukchi Seas. The fish fauna of these areas has only been sporadically mapped, and only a few quantitative investigations covering parts area have been performed by Russian scientists. The marine fish fauna is too sparse and so difficult to access that no commercial fishing is taking place in the open parts of neither of the seas, except for the westernmost area of the Kara Sea, and occasionally in the Bering Strait. The fishery of the Arctic seas is restricted to the rivers and estuaries, where the main species caught are anadromous whitefish (Coregonids) and Salmonids, and strictly freshwater species like burbot (*Lota lota*) and pike (*Esox lucius*) further upstream.

Though quantitatively minor, the fish resources of the NSR are playing an important role for local human consumption in these remote areas with difficult communication with the rest of the world. However, on a global scale, landings from these Arctic areas are insignificant. No resource mapping of the anadromous or riverine fish stocks is taking place, and no data on stock sizes, structure, or estimates of sustainable yields exist. At best statistics of total landings from specific geographic areas are available, and fishery restrictions are often based on declining values of Catch per Unit of Effort.

During phase I of INSROP, a check-list of fish recorded in each of the four seas and their major tributaries has been created from existing literature and data. The first monograph on fishes of the northern seas of the USSR was published by Andriyashev in 1954, and a revised list was published in 1994 (Andriyashev & Chernova 1994). These two publications are the major sources of information on fishes of the NSR area. A total of 152 species of marine, anadromous and rarely occurring freshwater species of fish have been recorded in the four seas of the NSR. Compared to the adjacent Barents Sea, housing some 150 species (Gjøsæther *et al.* 1992), and the Bering Sea with approximately 300 species (Raymond 1988), the NSR area has a relatively poor fish fauna. The low number of recorded species is not only a result of lack of investigations, but reflects the harsh Arctic living conditions compared to the neighbouring seas influenced by water currents from more southern latitudes.

The most dominant group of anadromous fish of the NSR area is the whitefish. Eight species of this family have been recorded, from which 6 species make up 70 to 90 % of the total recorded landings from the area. These species are *Coregonus nasus* (Broad Whitefish, Chir), *C. autumnalis* (Omul), *C. muksun* (Muksun), *C. peled* (Peled (a freshwater species)), *C. sardinella* (Siberian cisco) and *C. lavaretus* (Humpback Whitefish). Throughout this chapter, data on whitefish landings are presented to illustrate the extent of the fishing activities in different areas. Data on landings of other species and the check-list of species are available from the INSROP database. The statistics on landings have been provided by the State Institute of Lake and River Fisheries (GOSNIORKH), which is the official fishery recording agency in Russia.

In the strictly marine fish fauna the Arctic cod (*Boreogadus saida*) is the biologically most important species of the NSR area. This circumpolar species lives in and close under the ice, and is an ecologically important link between invertebrates, upon which it preys, and mammals and birds eating it. Scorpion-fishes make up the largest species group of the NSR fish fauna, comprising 25 different taxa, followed by salmonids and gadoids, with 17 and 16 species respectively. The fourhorned Scorpion-fish (*Triglopsis quadricornis*) is another species of major ecological importance, as the commercially important Omul (*Coregonus autumnalis*) preys intensively on juvenile scorpion-fish during its summer feeding in the coastal marine areas.

There are two main reasons for the selection of fish as a VEC. First, the fish resources and the practical fishing activities might be affected by increased traffic and associated activities in the area. Secondly, the non-transit NSR traffic might serve as a mean of transporting fish products to markets outside the area, and also ensure a supply of equipment and provisions. This might increase the exploitation of remote resources, presently not attractive. The Siberian fishermen might thus benefit from an increased NSR traffic, while the local fisheries probably will have little or no significance for the NSR traffic. The importance of NSR for transportation of fish and fish products was analysed by Høifødt *et al.* (1995), and the conclusion was that even the several orders of magnitude larger fishery of the Barents Sea is too small to contribute significantly to sustaining any NSR traffic.

Figure 4.1 The whitefish (Coregonids) is the most important group of anadromous fish for local fisheries along the Northern Sea Route (Photo: P-A. Amundsen).

## 4.1 Fish and fishery of the Kara Sea area

Since 1878, Russian scientists have recorded 62 species of fish in the Kara Sea, including the Ob Bay and the lower Yenisey River.

Anadromous coregonids feed in the Ob Bay and the Yenisey estuary, and in coastal areas of the Kara Sea during summer. Fishing takes place during the spawning migration in late summer and autumn. Data on landings of the most important fish species were collected from the Ob Bay, the lower Yenisei river, the Pyasina and the Taymyrskaya rivers (Fig. 4.1.1 and Tab. 4.1.1). The data indicate a significant decline in landings of whitefish in all four tributaries to the Kara Sea (Tab. 4.1.1). This tendency is most evident in the western parts of the NSR area (Kara Sea), compared to the eastern parts (Chap. 4.2 and 4.3) For example, the landings of whitefish from the Ob Bay has suffered a 42 % reduction during the period 1990-1994. In the lower Yenisei river, the decline was 35 % during the same period. Compared to the average landings of the period 1981-85, the recorded landings of whitefish from Ob Bay in 1994 make up only 46 % of the landings recorded ten years earlier.

Until 1968 longnose Siberian sturgeon (*Acipenser baeri*) was caught in the Ob Bay and the lower Yenisei river. The annual yield in the 1960's was approximately 300 tons, until the species became protected in Ob Bay in 1968. The sturgeon is presently caught in the lower Yenisei, with a catch of 31 tons recorded in 1994. For comparison, the catch of sturgeon in Yenisei was 398 tons in 1957, gradually falling to 56 tons in 1966. The sturgeon breeds in the river, and feeds mainly in the Yenisei estuary and Yenisey Bay, where its primary prey is the isopod *Saduria sibirica* (See VEC A1). The decrease in sturgeon catches is claimed to have arisen from a combination of several factors; construction of dams, pollution and overfishing. Today whitefish are more important than sturgeon in the fisheries in the Yenisei river and estuary.

Another important fishery in the lower Yenisey river is the late-winter - early spring (April - May) ice fishery for smelt (korjuska, *Osmerus mordax*). This fishery is popular among the inhabitants of cities like Dudinka, and the fishery often takes place along the shipping lanes, as the ice in these areas is thinner. A conflict might arise between the fishermen and the ice-breaking traffic, as many people fishing on the river ice are an obstacle to navigation. No data are available on the landings of smelt in the Yenisei river, but as much of the fish is caught for direct consumption by private persons (non-fishermen), the landings from this seasonal fishery would hardly appear in any statistics. However, in Ob Bay, the catch of smelt has varied from 516 tons in 1989 to 28 tons in 1991.

The decline in landings in the fisheries of the NSR area, reflects to a certain extent the emigration of people from the Siberian countryside, which has been triggered by the recent economical crisis in the Russian community. Most people leaving Siberia are of non-indigenous origin, and move back to newly independent republics, or to central parts of Russia. The more stable yield in the fishery in the eastern parts of the NSR area might be a result of a relatively larger share of indigenous people inhabiting these areas, people who are not emigrating due to economical problems.

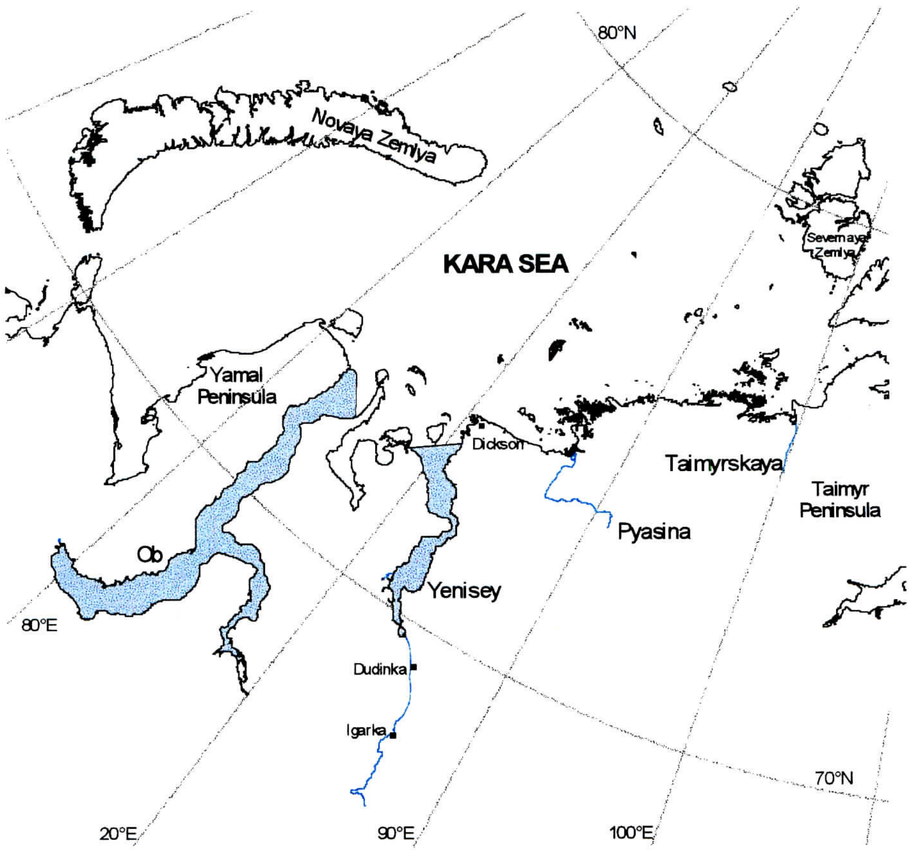


Figure 4.1.1 The Kara Sea with major tributaries. Data on landings of fish are available from the areas marked in blue through GOSNIORKH.

Table 4.1.1 Official catches of Whitefish (Coregonids) from the four tributaries to the Kara Sea (Ob Bay and the lower Yenisei, Pyasina and Taymyrskaya rivers). All figures are given in tons. Empty cells indicate lack of data. Species abbreviations: C. nasus. = *Coregonus nasus* (Broad Whitefish, Chir), C. autum. = *C. autumnalis* (Omul), C. muk. = *C. muksun* (Muksun), C. peled = *C. peled* (Peled), C. sardin. = *C. sardinella* (Siberian cisco), C. lavaret. = *C. lavaretus* (Humpback Whitefish).

| **Ob Bay** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **year** | **C. nasus** | **C. autum** | **C. muk** | **C. peled** | **C. sardin** | **C. lavaret** | **total** |
| **1980** | 199 | | 45 | 445 | 2972 | 144 | 3805 |
| **1981** | 46 | | 108 | 158 | 1544 | 5 | 1861 |
| **1982** | 11 | | 5 | 316 | 1527 | 4 | 1863 |
| **1983** | | | | | | | |
| **1984** | 80 | | 56 | 145 | 1607 | 5 | 1893 |
| **1985** | 19 | | 17 | 68 | 1356 | 6 | 1466 |
| **1986** | 52 | | 11 | 91 | 981 | 29 | 1164 |
| **1987** | 81 | | 77 | 242 | 1265 | 7 | 1672 |
| **1988** | 14 | | 14 | 230 | 968 | 3 | 1229 |
| **1989** | 31 | | 17 | 20 | 1209 | 9 | 1286 |
| **1990** | 41 | | 18 | 105 | 1217 | 11 | 1392 |
| **1991** | 84 | | 13 | 122 | 1040 | 2 | 1261 |
| **1992** | 42 | | 30 | 23 | 670 | 8 | 773 |
| **1993** | 131 | | 30 | 107 | 380 | 18 | 666 |
| **1994** | 122 | | 31 | 130 | 515 | 18 | 816 |
| **total** | 953 | | 472 | 2202 | 17251 | 269 | 21147 |

Table 4.1.1 continued

| Lower Yenisei river | | | | | | | |
|---|---|---|---|---|---|---|---|
| year | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1934 | | | 740 | | | | |
| 1935 | | | 780 | | | | |
| 1936 | | | 780 | | | | |
| 1937 | | | 460 | | | | |
| | | | | | | | |
| 1940 | | | 440 | | | | |
| 1941 | | | 360 | | | | |
| 1942 | | | 620 | | | | |
| 1943 | | | 570 | | | | |
| | | | | | | | |
| 1990 | 64.7 | 158.3 | 368 | 38.3 | 68 | 235.7 | 933.0 |
| 1991 | 39.4 | 161.4 | 324 | 27.1 | 90.8 | 229.8 | 872.5 |
| 1992 | 33.4 | 126.3 | 333 | 3.5 | 100.5 | 222.5 | 819.2 |
| 1993 | 26.4 | 115 | 276 | 7.3 | 122.5 | 194.5 | 741.7 |
| 1994 | 33.7 | 68.7 | 264 | 6.6 | 48.7 | 192.8 | 614.5 |
| total | 197.6 | 629.7 | 1565 | 82.8 | 430.5 | 1075.3 | 3980.9 |

Table 4.1.1 continued.

| Lower Pyasina river | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1989 | 48 | 5 | 15 | 5 | | 77 | 150 |
| 1990 | 36 | 17 | 7 | 4 | | 107 | 171 |
| 1991 | 38 | 21 | 20 | 4 | | 63 | 146 |
| 1992 | 25 | 21 | 20 | 2 | | 65 | 133 |
| 1993 | 33 | 14 | 24 | 12 | | 57 | 140 |
| 1994 | 18 | 1 | 6 | 10 | | 51 | 86 |
| total | 198 | 79 | 92 | 37 | | 420 | 826 |

Table 4.1.1 continued.

| Lower Taimyrskaya river | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1991 | 33 | | 57 | | | 49 | 139 |
| 1992 | 39 | | 28 | | | 38 | 105 |
| 1993 | 31 | | 3 | | | 35 | 69 |
| 1994 | 23 | | 1 | | | 39 | 63 |
| total | 126 | | 89 | | | 161 | 376 |

Even though the quantitatively most important fishing area of the Kara Sea basin is the Ob Bay, the 1994 yield of 816 tons of whitefish from the 5 316 800 hectares large Ob Bay only means an average yield of 0.15 kg/ha. Even the yield of 3805 tons recorded in 1980 (Tab. 4.1.1) only equals an average of 0.7 kg/ha. For comparison, a yield of 3 - 5 kg/ha is normally reported by whitefish fisheries in northern Norway. In that perspective the whitefish stocks of Ob Bay seems to be relatively underexploited.

## 4.2 Fish and fishery of the Laptev Sea area

To day, 59 species of marine fish have been recorded in the Laptev Sea, some only once, like the Greenland halibut (*Reinhardtius hippoglossoides*), while 15 freshwater fish species have been recorded from estuarine areas of the Laptev Sea. Like in the Kara Sea, no off-shore fishery takes place in the Laptev Sea. Fishery is restricted to the river estuaries and deltas (Fig. 4.2.1), where anadromous whitefish are the most important species. For the Laptev Sea area, data on landings were gathered from the Khatanga Bay, the lower Lena river and Yana river. The following map (Fig. 4.2.1) shows the rivers (or parts of rivers) from which fishing data were collected.

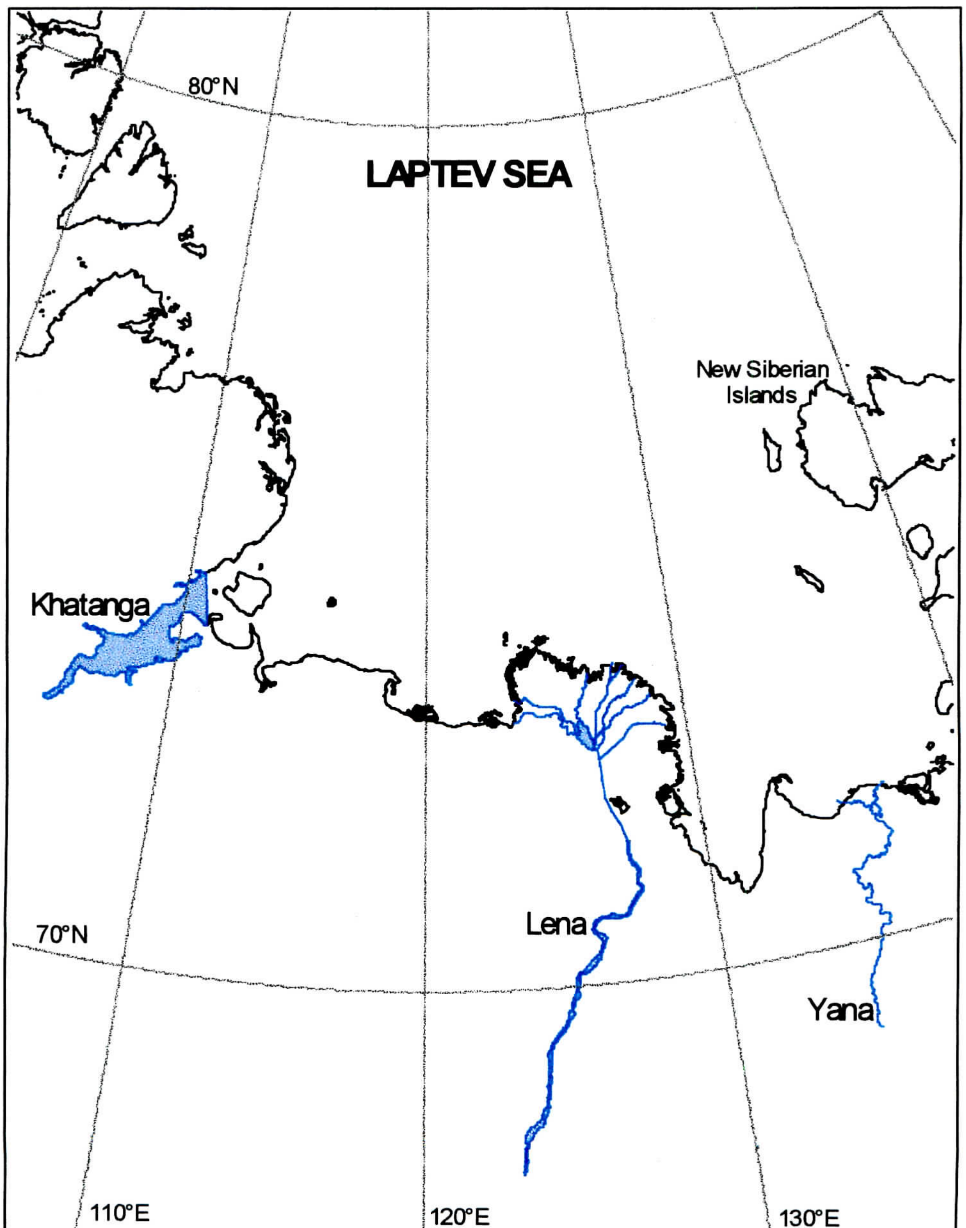


Figure 4.2.1 The Laptev Sea with major tributaries. Data on landings of fish are available from the areas marked in blue through GOSNIORKH.

Table 4.2.1 Official catches of Whitefish (Coregonids) from the major tributaries to the Laptev Sea (Khatanga Bay and the lower Lena and Yana rivers). All figures are given in tons. Empty cells indicate lack of data. Species abbreviations as in Table 4.1.1.

| Khatanga Bay | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1981 | 121 | | 72 | 16 | 605 | 108 | 922 |
| 1982 | 101 | | 87 | 15 | 675 | 161 | 1039 |
| 1983 | 112 | | 69 | 30 | 714 | 142 | 1067 |
| 1984 | 86 | | 43 | 23 | 762 | 88 | 1002 |
| 1985 | 74 | | 82 | 34 | 815 | 116 | 1121 |
| 1986 | 22 | | 65 | 5 | 916 | 19 | 1027 |
| 1987 | 75 | | 79 | 37 | 628 | 108 | 927 |
| 1988 | 76 | | 72 | 58 | 546 | 118 | 870 |
| 1989 | 101 | | 117 | 44 | 620 | 110 | 992 |
| 1990 | 81 | | 53 | 21 | 450 | 60 | 665 |
| total | 849 | | 739 | 283 | 6731 | 1030 | 9632 |

| Lena river | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1981 | 37 | 967 | 185 | 76 | 424 | 33 | 1722 |
| 1982 | 55 | 619 | 380 | 32 | 274 | 60 | 1420 |
| 1983 | 67 | 704 | 440 | | 373 | 66 | 1650 |
| 1984 | 53 | 778 | 349 | 86 | 322 | 73 | 1661 |
| 1985 | 26 | 930 | 429 | 111 | 491 | 90 | 2077 |
| 1986 | 59 | 865 | 422 | 108 | 383 | 78 | 1915 |
| 1987 | 60 | 849 | 424 | 52 | 462 | 58 | 1905 |
| 1988 | 42 | 618 | 623 | 59 | 495 | 58 | 1895 |
| 1989 | 32 | 513 | 501 | 48 | 415 | 22 | 1531 |
| 1990 | 57 | 520 | 565 | 36 | 391 | 40 | 1609 |
| total | 488 | 7363 | 4318 | 608 | 4030 | 578 | 17385 |

| Yana river. | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1982 | 77 | 13 | | 13 | 190 | 15 | 308 |
| 1983 | 137 | 12 | | | 187 | 27 | 363 |
| 1984 | 12 | 132 | | 3 | 111 | 4 | 262 |
| 1985 | 158 | | | 12 | 115 | 6 | 291 |
| 1986 | 91 | 12 | | 19 | 130 | 15 | 267 |
| 1987 | 102 | 3 | | 29 | 150 | 19 | 303 |
| 1988 | 105 | 7 | | 25 | 104 | 19 | 260 |
| 1989 | 127 | 6 | | 43 | 72 | 56 | 304 |
| 1990 | 120 | 11 | | 44 | 81 | 42 | 298 |
| 1991 | 132 | 4 | | 33 | 49 | 77 | 295 |
| total | 984 | 187 | | 208 | 999 | 265 | 2643 |

The tendency towards decreasing yields is less pronounced in the Laptev Sea area compared to the Kara Sea. However, the available data only cover the period up to 1990 (1991), during which the yields have been relatively stable, also in the Kara Sea. The largest drop in landings is visible in areas, from which data are available for the period 1991-94. The case might thus be the same in the Laptev Sea area.

## 4.3 Fish and fishery of the East Siberian and Chukchi Sea area

The fish fauna of the East Siberian Sea has been studied even less than the fishes of the Laptev Sea. 45 marine and anadromous species have been reported in the literature, some of which only in small numbers many years ago. In addition, 10 freshwater species have been recorded from river mouths and estuaries along the coastal East Siberian Sea. From the Chukchi Sea, 89 marine and anadromous species of fish have been reported, and 6 freshwater species have occasionally been found in brackish parts of the sea. The higher number of fish species known from the Chukchi Sea compared to the East-Siberian Sea is partly made up by pacific species entering the southern parts of the Chukchi Sea from the Bering Sea.

Canadian investigations of the eastern Chukchi Sea fish fauna in the seventies found that growth and densities of demersal fishes in general was lover compared to the Bering Sea (Wolotira *et al.* 1977 in Raymond 1988). No data on landings from tributaries east of the Kolyma river are available through GOSNIORKH.

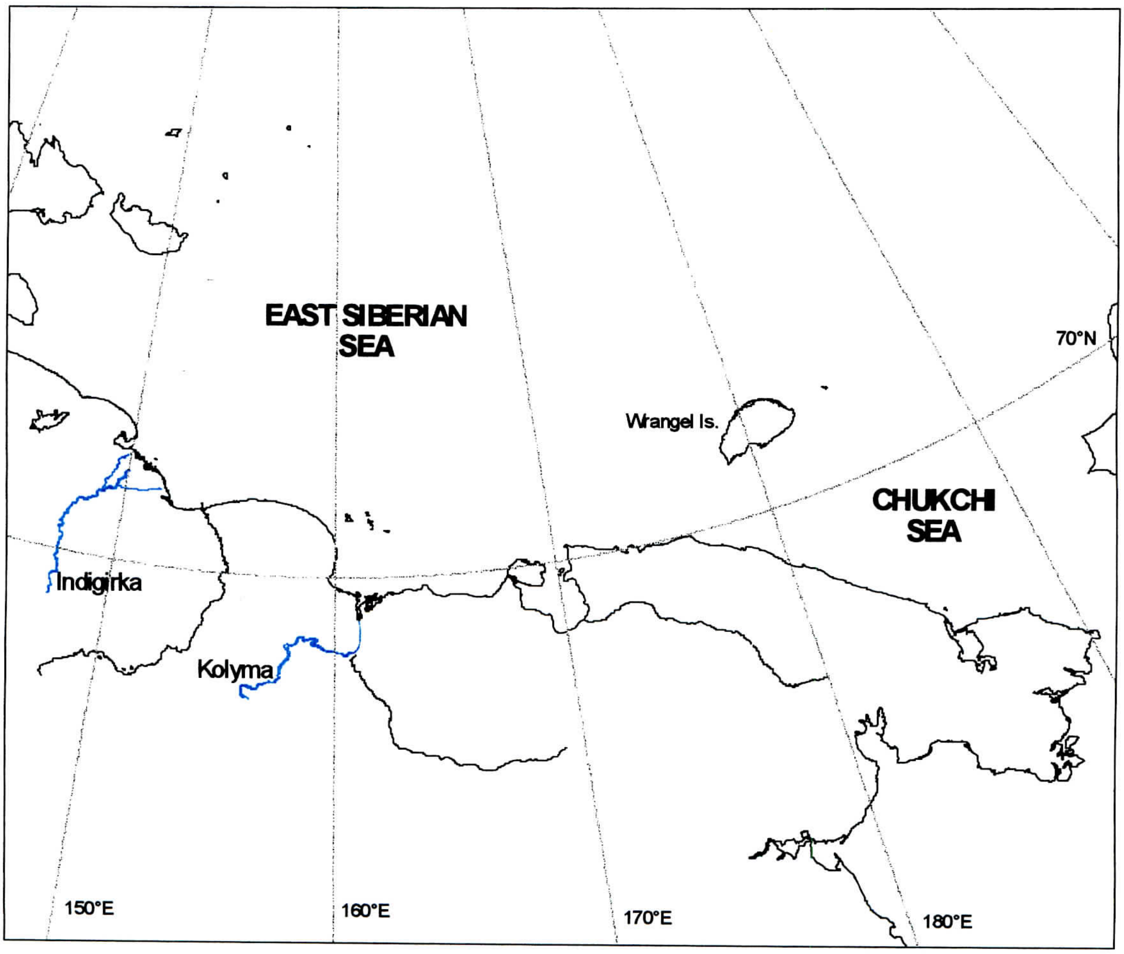


Figure 4.3.1 The East Siberian and Chukchi Seas with major tributaries. Data on landings of fish are available from the Indigirka and Kolyma rivers which are marked in blue through GOSNIORKH.

Table 4.3.1 Official catches of Whitefish (Coregonids) from the major tributaries to the East Siberian Sea (Indigirka and Kolyma rivers). All figures in tons. Empty cells indicate lack of data. Species abbreviations as in Table 4.1.1.

| Indigirka river | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1981 | 126 | 314 | 13 | 135 | 210 | 74 | 872 |
| 1982 | 205 | 346 | 9 | 197 | 167 | 81 | 1005 |
| 1983 | 110 | 409 | 17 | | 159 | 71 | 766 |
| 1984 | 93 | 596 | 19 | 114 | 184 | 101 | 1107 |
| 1985 | 399 | 483 | 21 | 100 | 164 | 117 | 1284 |
| 1986 | 373 | 380 | 33 | 161 | 285 | 97 | 1329 |
| 1987 | 227 | 318 | 55 | 246 | 309 | 90 | 1245 |
| 1988 | 171 | 247 | 43 | 301 | 299 | 127 | 1188 |
| 1989 | 240 | 122 | 61 | 273 | 404 | 162 | 1262 |
| 1990 | 139 | 428 | 56 | 151 | 587 | 86 | 1447 |
| total | 2083 | 3643 | 327 | 1678 | 2768 | 1006 | 11505 |

| Kolyma river | | | | | | | |
|---|---|---|---|---|---|---|---|
| | C. nasus | C. autum | C. muk | C. peled | C. sardin | C. lavaret | total |
| 1981 | 59 | | 29 | 476 | 555 | 294 | 1413 |
| 1982 | 126 | | 27 | 502 | 662 | 119 | 1436 |
| 1983 | 23 | | 65 | | 662 | 146 | 896 |
| 1984 | 74 | | 61 | 286 | 733 | 198 | 1352 |
| 1985 | 246 | | 30 | 501 | 856 | 163 | 1796 |
| 1986 | 317 | | 25 | 604 | 1146 | 688 | 2780 |
| 1987 | 198 | | 49 | 390 | 1032 | 203 | 1872 |
| 1988 | 168 | | 33 | 248 | 1133 | 211 | 1793 |
| 1989 | 265 | | 61 | 348 | 1309 | 289 | 2272 |
| 1990 | 218 | | 99 | 279 | 1142 | 203 | 1941 |
| total | 1694 | | 479 | 3634 | 9230 | 2514 | 17551 |

# 5 VEC A3: Plant and animal life in polynyas

Polynyas are more or less regularly occurring apertures in the Arctic ice cover. Polynyas are caused by currents, upwelling or meteorological factors like wind and wave action, and often occur in the same area each year. Polynyas, or areas of multiple polynyas, are easily manoverable for ships, due to lighter ice conditions, and they are thus attractive shipping lanes. The plant and animal life associated with polynyas includes all trophic groups and all levels of the arctic marine food chains, from algae to polar bears.

When the sun returns in spring, the first spring light, together with accumulated nutrients trigger an early spring bloom in the phytoplankton of the polynyas. This bloom is parallel to what can be observed along the edge of the sea ice. For that reason the polynyas are considered by many scientists to be important for the understanding of climatic, oceanographic, and biological processes in the Arctic. Sea ice flora and fauna occurring in polynyas are thought to play an important role in the high Arctic food web (Horner 1989) and form the basis of food chains culminating in the circumpolar polar cod (Lønne & Gulliksen 1989), and different species of seals and sea-birds (Dunbar 1981; Lønne & Gabrielsen 1992). As many of the arctic animal taxa are present in large numbers in the polynyas, contaminants entering this food web may reach its higher trophic levels relatively fast.

The distribution of sea ice biota in the seasonally and permanently ice covered areas along NSR is largely unknown. The areas with highest frequency of polynyas have partly been mapped by subprogramme I, and are presented in fig. 5.1.1. The extent of the polynyas in the Laptev Sea in 1992 is presented in figure 5.1.2.

In many respects, the surface under the ice resembles the sea bed as substrate for invertebrates. Work on Arctic shelf areas in Canada and Alaska has suggested that colonisation of ice by the benthos generally occurs in shallow water areas (Carey 1985) like most of the NSR area. The presence of vast shallow areas along the Russian Arctic coast, which are net exporters of ice to the Arctic basin, suggest that these areas might be the origin of the ice biota and that the recruitment of such biota might be facilitated by some of the same processes responsible for the incorporation of sediment particles into the ice.

Suspension freezing and ice-induced gouging of the seafloor and seafloor ice formation are believed to be the most important mechanisms in the transfer of sediment and biota suspended in water column and residing on the sea floor to the ice. Resent observations indicate that the process of suspension freezing is capable of transporting material from the sea floor to the overlying ice in water up to 50 m deep, and that such conditions are found where latent heat polynyas occur. Such polynyas above shallow water are found along the fast ice edge in the NSR area (Fig. 5.1.1).

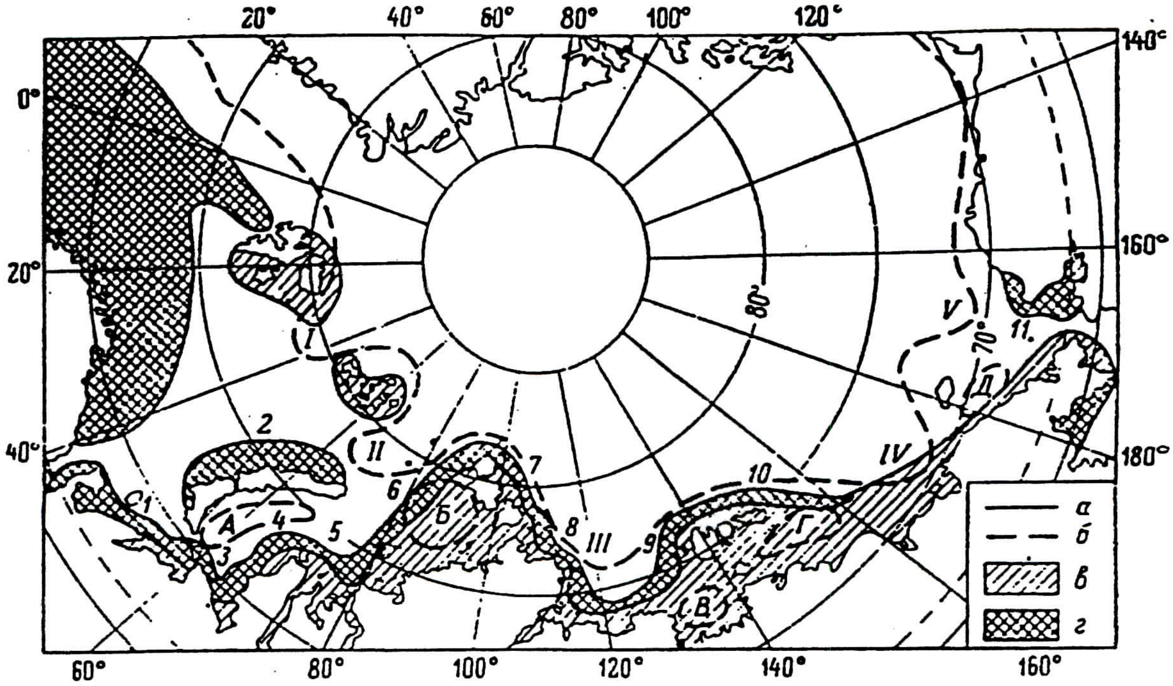


Figure 5.1.1 Ice cover of the Arctic Ocean. Areas of regularly occurring winter polynyas (open water) are indicated by hatching (Soviet Arctic 1970). a: Ice edge in winter, b: Ice edge in summer, v: Fast ice, g: Polynya.

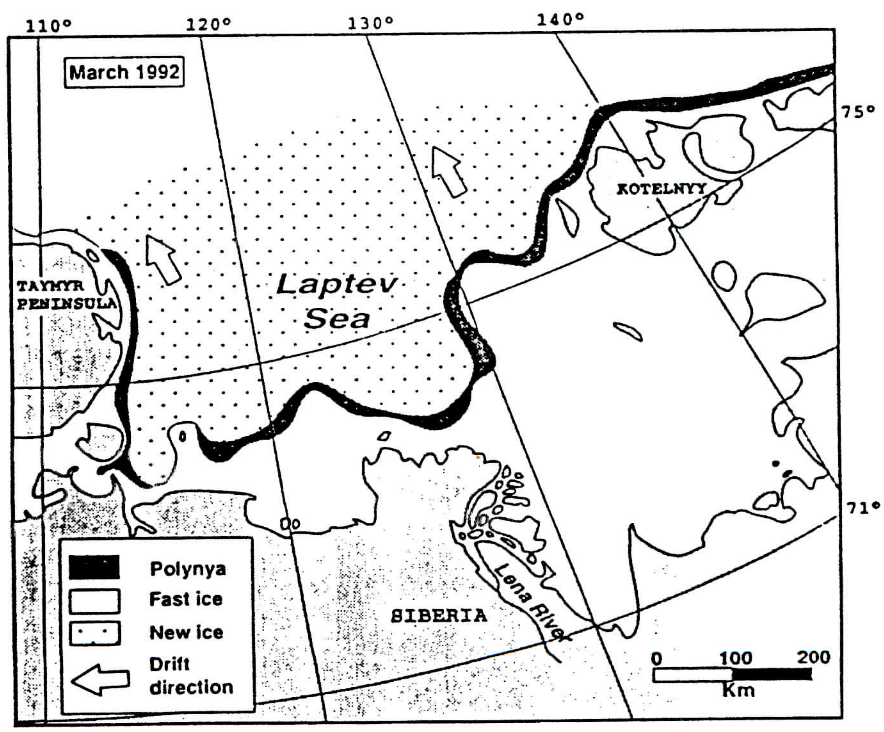


Figure 5.1.2 The ice conditions of the Laptev Sea during March 20- 24 1992, mapped by AARI, St. Petersburg. (Reimnitz 1995).

# 6 VEC D1: Human settlements

Human settlements along the NSR area comprise a large variety of communities, from small villages and camps of nomadic groups of indigenous people to large communities with several tens of thousands of inhabitants concentrated around a harbour, a factory or a mineral resource.

Even though more than 1100 permanent human settlements exist in the Siberian North (Friis pers. comm.) the area is among the least populated in the world. The selection of human settlements as a VEC in the present context is based on the fact that not only indigenous, but also people of Russian or other former Soviet heritage are dependent on the natural resources of this remote and climatic harsh region. Although reindeer herding, fur hunting and fishing are most common among the indigenous populations, fishing and fur-hunting is also important trades for people of non-indigenous heritage.

Within INSROP, the subprogram IV project entitled "Social and Cultural Impact on Indigenous Peoples of Expanded Use of the NSR" is responsible for the analysis of any expected impacts on indigenous communities arising from increased use of the NSR. However, being dependent on e.g. the fish resources, any impacts on these will also affect the indigenous populations. That is the major link between Subprogramme II and IV.

Table 6.1 **Major human settlements along the coastal areas of the NSR**

| Settlement | Sea | Location | No. of inhabitants 1994 | Comments |
|---|---|---|---|---|
| Amderma | Kara Sea | Baidaratskaya Bay | ~5000 | Nenetsky national district, airport, hydrometeorological center |
| Ust'-Kara | Kara Sea | Kara River | ~200 | Nenetsky national district |
| Droviyanoi | Kara Sea | Obskaya Bay | some | Polar station, Yamalo-Nenetsky national distr. local fisheries (whitefish) |
| Seyakha | Kara Sea | Obskaya Bay | >1000 | Polar station, Yamalo-Nenetsky national distr. local fisheries (whitefish) |
| Tambay | Kara Sea | Obskaya Bay | ~1000 | Polar station, Yamalo-Nenetsky national distr. local fisheries (whitefish) |
| Kamenny cape | Kara Sea | Obskaya Bay | ~2000 | Yamalo-Nenetsky national distr. airport |
| Novyi Port | Kara Sea | Obskaya Bay | ~2000 | Yamalo-Nenetsky national distr. |
| Juribay | Kara Sea | Gyganskaya Bay | some | Yamalo-Nenetsky national distr. |
| Dikson | Kara Sea | Yenisey Bay | 1600 | Taimyrsky national district, airport, hydrometeorological center, local fisheries |
| Sopochnaya Karga | Kara Sea | Yenisey Bay | >100 | Taimyrsky national district, local fisheries |
| Laida | Kara Sea | Yenisey Bay | >500 | Taimyrsky national district, local fisheries |
| Vorontsovo | Kara Sea | Yenisey Bay | >1000 | Taimyrsky national district, local fisheries |
| Baikalovsk | Kara Sea | Yenisey Delta | ~1000 | |
| Karaul | Kara Sea | Yenisey Delta | ~1000 | Taimyrsky national district, airport, local fisheries-whitefish, sturgeon |

Table 6.1 continued

| | | | | |
|---|---|---|---|---|
| Dudinka | Kara Sea | Yenisey | 31 300 | Capital of Taimyrsky national district, port (coppel-nicel ore), railway (from Norilsk), fisheries-whitefish, sturgeon |
| Potapovo | Kara Sea | Yenisey | >1000 | Taimyrsky national district, local fisheries |
| Igarka | Kara Sea | Yenisey | 14 500 | Evenkyisky national district airport, port (mainly wood shipping) |
| Turukhansk | Kara Sea | Yenisei | ~5000 | |
| Lipatnikovo | Kara Sea | Yenisei | ~200 | |
| Dorofeyevski | Kara Sea | Yenisei | ~100 | |
| sakolevskaya Korga | Kara Sea | Yenisei | ~100 | |
| Munguy | Kara Sea | Yenisei | ~100 | |
| Novorybnoe | Laptev Sea | Khatanga Bay | ~1000 | Sakha-Jakutia, local fisheries whitefish |
| Ust'-Olenyok | Laptev Sea | Olenyok mouth | ~50 | Sakha-Jakutia, local fisheries whitefish |
| Tiksi | Laptev Sea | Buor-Khaya Bay | 8 000 | Sakha-Jakutia, airport, port, hydrometeorological center, local fisheries |
| Nizhneyansk | Laptev Sea | Yana River | ~5000 | Sakha-Jakutia, local fisheries |
| Cherskii | East-Siberian Sea | Kolyma River | 8 500 | Sakha-Jakutia, airport, port |
| Pevek | East-Siberian Sea | | 9300 | Chukotsky national district, port, airport, hydro-meteorogical center |
| Billings | East-Siberian Sea | | 2-3000 | Chukotsky national district |
| Schmidt Cape | Chukchi Sea | | 5-8000 | Chukotsky national district, airport |
| Vankarem | Chukchi Sea | | 2-3000 | Chukotsky national district |
| Enukmino | Chukchi Sea | | ~1000 | Chukotsky national district |
| Uellen | Chukchi Sea | | ~5000 | Chukotsky national district (escimos settlement), airport |

The above list were prepared by ZISP, while data from Granberg (1995) are included for the larger cities: Dikson, Dudinka, Igarka, Tiksi, Pevek and Cherskii. The Number of inhabitants in most settlements are given approximately according to opinions of polar scientists and personal observations made during recent visits in the area. More accurate data cannot be presented because there are contemporary great migrations out of the area. The indigenous villages and the active working harbours like Dudinka and Pevek has the most stable number of inhabitants in the area.

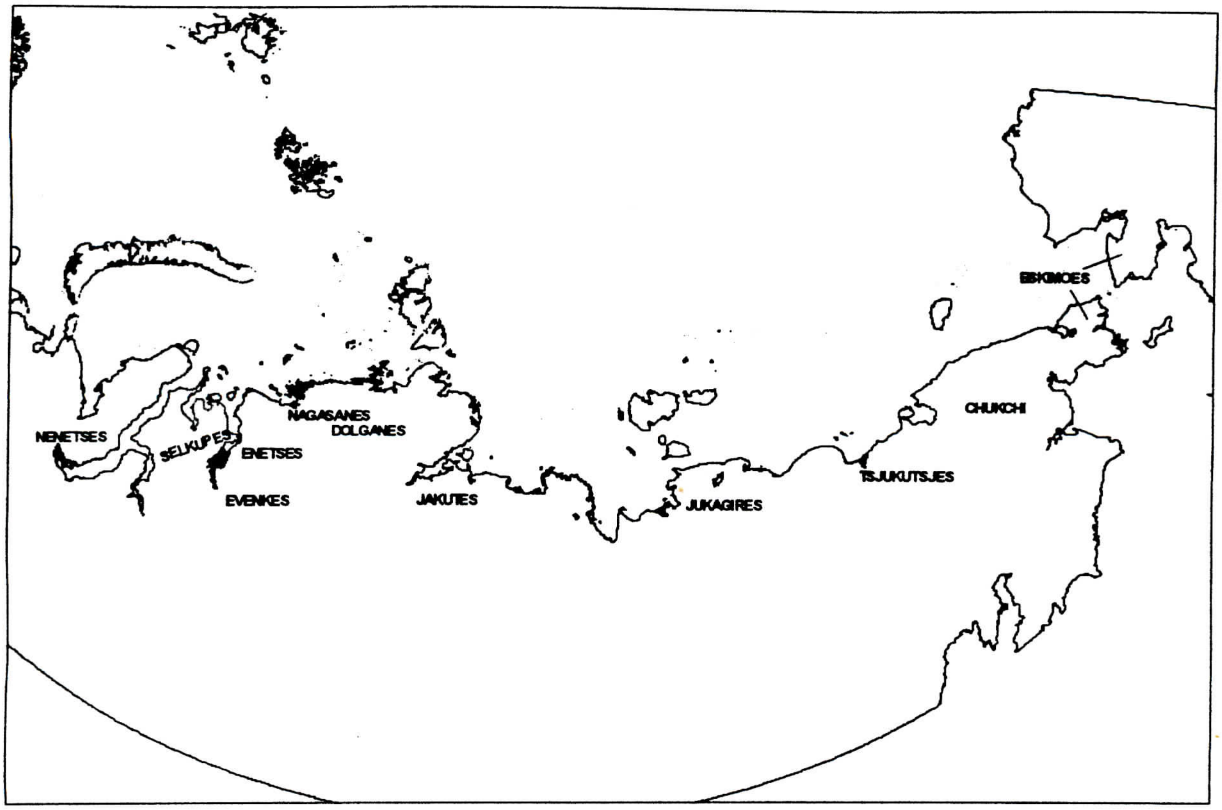


Figure 6.1 Geographic location of major settlements of different indigenous populations along the NSR. Modified from Dallmann (1994), and Aasheim (1991).

The different indigenous populations are few in numbers, the largest group in the NSR area is the nenetses, constituting 34 190 persons in 1989 (Leksin & Andreyeva 1995). Table 6.2 gives the number of people (1989) making up the indigenous populations shown in fig. 6.1. (Leksin & Andreyeva 1995).

Table 6.2 Number of people belonging to the major indigenous populations of the NSR area in 1989 (Leksin & Andreyeva 1995).

| Population group | Number of people | Population group | Number of people |
|---|---|---|---|
| Nenetses | 34190 | Dolganes | 6854 |
| Selkupes | 3564 | Jukagires | 1112 |
| Evenkes | 29900 | Chukckees | 15107 |
| Enetses | 198 | Eskimoes | 1704 |
| Nagasanes | 1262 | | |

* No data on numbers of Jakutes and Tsjukutsjes presented.

# 7 VEC D2: Water-land border zone (Sensitive areas)

Much of the littoral zone along the coast of the NSR is exposed to heavy ice scouring, freezing-erosion and summertime decrease in surface salinity. These factors render many areas "inhospitable to colonisation by plants and animals" (Menzies *et al.* 1973), and consequently, most of the coastal zone is only sparsely populated by plants and animals. Those forms of pollution that float on the sea surface or are quickly distributed in the water column or are adhesive to sediment particles (e.g. crude oil, refined oil products, chemicals etc.) sooner or later end up in the water-land border zone. Such pollution may also affect man made installations, such as harbours, water intake to the fishing industry and processing plants, fishing equipment etc.

If, for example, the exposed coastal zone along the NSR is affected by oil, wind and wave action will rapidly wash it away, and only a short time exposure of the intertidal commun9ities will occur. On a world-wide scale, the exposed littoral zone has been shown to be highly "self-cleaning," with any oil being washed away to more sheltered areas within months to years. A Norwegian exposed seashore has shown to recover from an oilspill within 3 years (Lein *et al.* 1992), except for long-lived plants and animals, which will only be present as small/juvenile stages after that time. The comparison of the intertidal zone of the NSR area and a Norwegian intertidal zone is not completely correct, as the intertidal communities along the NSR are seasonal (summer), and consist mostly of amphipods and diatoms. Evaluation of potential impacts of NSR activities on such seasonal communities might better be compared with other seasonal, amphipod-diatom communities like the cryopelagic communites of the open arctic seas.

In sheltered littoral areas, and specially in estuarine areas, accumulation of fine sediments occurs. In such areas, biological productivity is high, and the invertebrate fauna is an important food source for wading birds. Oil reaching such areas of fine sediments may penetrate into the sediments, where it will stay for years (Laubier 1980; Vandermeulen 1982). Due to low temperatures, the breakdown of oil proceeds extremely slowly in arctic areas, particularly in fine grained sediments, where oxygen supply is often limited. The rate of decay of different polluting substances resulting from ships traffic will vary. Radioactive isotopes will, however, decay at known rates independently of temperature.

In case of an accident, the release of ships cargo such as timber, ore, crude oil or fertiliser, which are all highly probable cargoes of the NSR, might lead to adverse effects on animal and plant life in the littoral zone. Via evaporation and precipitation, effects might also arise on the neighbouring tundra. Also the release of bunker oil, fuel or cooling water from nuclear powered vessels might cause environmental stress in the coastal zone. Above the littoral zone there is often a zone called "layda" zone (partly supra littoral), which is similar to a salt-marsh. Here permafrost renders vertical watermovement impossible, but this zone is influenced by the tide. In summer, many small brackish pools occur in the layda zone, and pollutants in the sea water can affect for instance survival of mosquito larvae in such pools.

During periods of extreme weather conditions, wind and surf may spread oil and other pollutants up onto the supralittoral zone, thus affecting areas that may be used as grazing land. This phenomena was observed in the Shetland Icelands after the "Braer" accident in January 1993 (Wills & Warner 1993), and similar effects might arise in the NSR.

The phase I of INSROP has mapped the sediment composition of the entire shore-line of the NSR (an example is shown in Fig. 7.1.1). The shoreline from the Kara Strait to the Yenisei river is subject to thermal erosion (abrasion) and a combination of erosion and accumulation processes. The shore is mainly composed of a mixture of fine sediments like sand, silt and clay.

The shoreline from Dikson to the Boris Vilkitsky Strait is straight and consists of steep cliffs, with some sharp angular projections, gulfs and bays. Some parts of the shoreline are characterised by numerous, widely spread islands separated by shallow straits. The shore is composed of rocks and coarse sediment (gravel, pebbles and boulders).

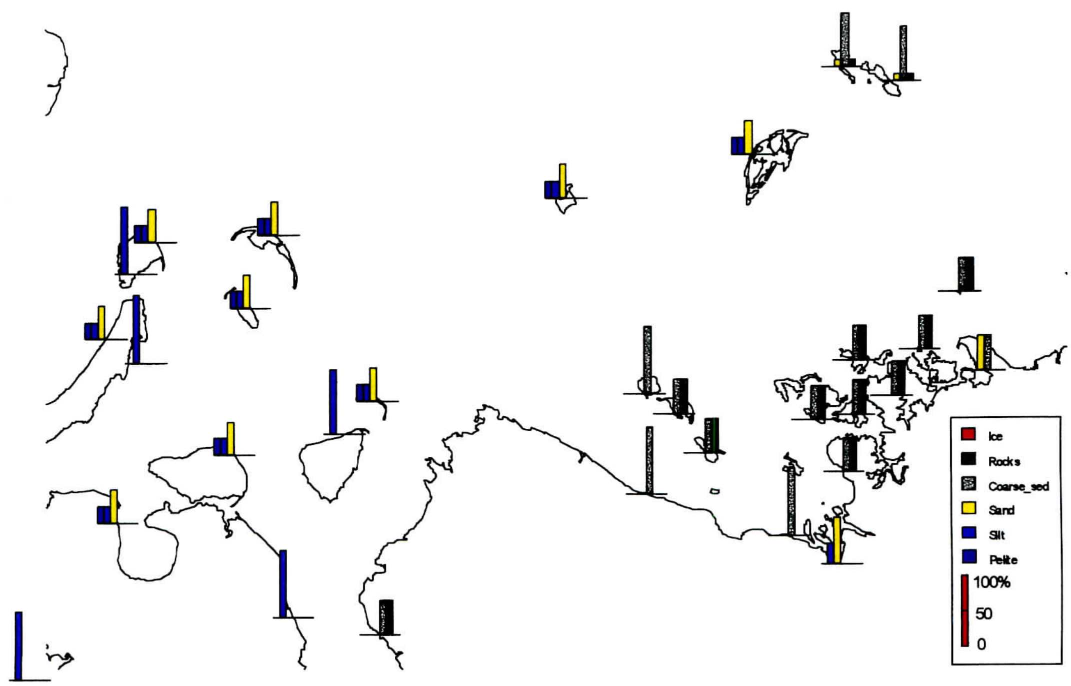


Figure 7.1.1 Sediment composition of the littoral zone along the central and eastern Kara Sea, from Ob Bay to Boris Vilkitsky Strait.

## 7.1 Inundated river areas

During the ice melting season, an enormous increase in water flow of the Siberian rivers occur. The water level can increase with several tens of meters in rivers like Yenisey. As a consequence, large inland areas surrounding the lower parts of the rivers become inundated and may be affected, should an accidental oil spill take palce during that period. The extent and location of inundated riverine areas in the lower Yenisei valley were mapped by use of satellite images; two NOAA Advanced Very High Resolution Radiometer (AVHRR) images covering the same river area were superimposed on each other, one from the spring flow period, and one from summer (Fig. 7.1.2). Unfortunately it was not possible to find two usefull images from the same year, due to frequent cloud cover of the area. As a result, an image from the 25$^{th}$ June 1988 and another from the 29$^{th}$ July 1994 (Fig. 7.1.2) were used. The images were subsectioned, radiometrically calibrated and geometrically corrected. The near-infrared channel (channel 2) which generally provides the best discrimination between land, water and clouds was used.

Clouds, land and ice masses were masked and a specific reflectance value was assigned to the river water on each image. The two images were then merged and the resulting image was superimposed onto a grey level image from the near-infrared channel in order to show information on land cover. When calculating the area corresponding to land, river and inundated areas on the resulting image, it was important to take into account the presence of clouds which obscure a part of the river on the image from the 29$^{th}$ July 1994. Approximately 120 pixels were added to the total number of pixels for the river, compensating for the clouds. The surface area was then calculated to 11.612 km$^2$ (9597 pixels x 1.21 km$^2$).

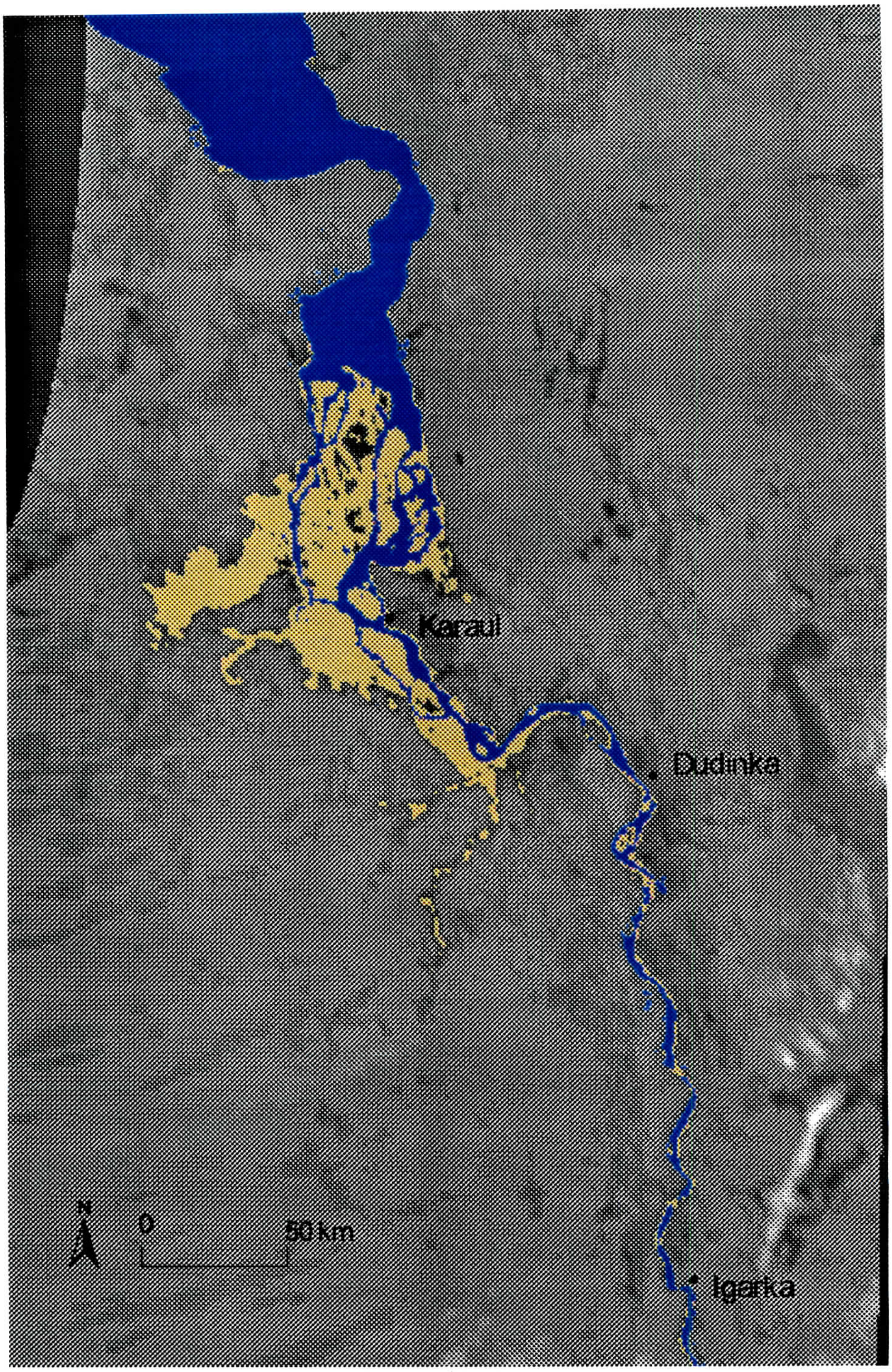


**Figure 7.1.2** Inundated areas of the lower Yenisei valley mapped and calculated by remote sensing technique. The yellow area was inundated during high water flow on 25th June 1988, while the blue area is the river at "normal" water level on 29th July 1994.

# 8 Conclusions and recommendations for further work

The data collected during the first phase of INSROP are described in the previous chapters. Even though information on more than 2200 different species of animals have been recorded, and more than 100 years of research and mapping of the area have been analysed, the NSR area is still one of the least explored parts of the world. Quantitative data are particularly sparse.

However, to evaluate the possible impacts from an increased use of the NSR, it is not necessary to know every corner of the area in detail. A series of hypotheses conserning the potential impacts of increased shipping activity along the NSR are presented and evaluated by Larsen *et al* (1995). Hovever, data presented in the present report, and data collected by the other projects and subprogrammes of INSROP might very well make a re-evaluation and re-formulation of some these hypotheses necessary. This is the last remaining task of the Subprogramme II, phase I work, which is scheduled to be performed during 1996.

- Russian scientists have collected data on benthic invertebrates in the NSR area for more than 100 years, but little has been published internationally, and the animal life of vast areas of the ocean floor is essentially unknown.

- For areas where the distribution and species composition have been mapped, there is a lack of important fundamental biological information concerning the benthic invertebrate fauna. This lack of knowledge also includes vulnerability to human activities, pollution etc.

- Almost no commercial fishingkes place in the offshore areas of the NSR. The yields of several riverine and estuarine fisheries have recently dropped by as much as 50 % total catch compared to 20-30 years ago.

- Local fishing, mostly for white fishes (Coregonids), is of increasing importance to indigenous and non-indigenous settlements in northern Siberia.

- Lack of organised and accessible data makes the evaluation and documentation of impacts of the increased use of the NSR difficult.

- This study gives a preliminary view of the use of satellite remote sensing for mapping flooded areas. However, good, affordable data are sparse, but some data sets have been identified, but the use ogf these has hitherto been impossible due to limited financial resources. The use of these data during a phase II is recommended.

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# 10 List of figures and tables

# APPENDIX

# Appendix 1

| Station ID | Orig-stat | Sea | Latitude | Longitude | Date | Vessel | Expedition | Max depth (m) | No spec. |
|---|---|---|---|---|---|---|---|---|---|
| STA0003 | 3 | East-Siberian Sea | 75.00 | 143.00 | 1-Aug-73 | | | 9 | 36 |
| STA0004 | 4 | East-Siberian Sea | 75.00 | 140.00 | 1-Aug-73 | | | 6 | 19 |
| STA0005 | 5 | East-Siberian Sea | 74.00 | 140.00 | 1-Aug-73 | | | 10 | 64 |
| STA0006 | 6 | East-Siberian Sea | 75.00 | 140.00 | 1-Aug-73 | | | 7 | 32 |
| STA0007 | 7 | East-Siberian Sea | 73.00 | 140.00 | 1-Aug-73 | | | 11 | 74 |
| STA0008 | 8 | East-Siberian Sea | 74.00 | 140.00 | 1-Aug-73 | | | 8 | 18 |
| STA0009 | 9 | East-Siberian Sea | 72.00 | 143.00 | 1-Aug-73 | | | 5 | 11 |
| STA0010 | 10 | East-Siberian Sea | 72.00 | 140.00 | 1-Aug-73 | | | 8 | 14 |
| STA0011 | 11 | East-Siberian Sea | 75.00 | 143.00 | 1-Aug-73 | | | 18 | 78 |
| STA0012 | 12 | East-Siberian Sea | 75.00 | 142.00 | 1-Aug-73 | | | 10 | 43 |
| STA0013 | 13 | East-Siberian Sea | 74.00 | 143.00 | 1-Aug-73 | | | 18 | 27 |
| STA0014 | 14 | East-Siberian Sea | 75.00 | 140.00 | 1-Aug-73 | | | 21 | 41 |
| STA0015 | 15 | East-Siberian Sea | 77.00 | 147.00 | 1-Aug-73 | | | 31.5 | 116 |
| STA0016 | 16 | East-Siberian Sea | 75.00 | 137.00 | 1-Aug-73 | | | 22 | 72 |
| STA0017 | 1 (1) | East-Siberian Sea | 70.08 | 170.50 | 10-Aug-86 | | | 12 | 58 |
| STA0018 | 1 (2) | East-Siberian Sea | 69.68 | 170.18 | 15-Aug-86 | | | 12 | 78 |
| STA0019 | 2 | East-Siberian Sea | 70.08 | 170.50 | 10-Aug-86 | | | 18 | 52 |
| STA0020 | 3 | East-Siberian Sea | 70.08 | 170.50 | 10-Aug-86 | | | 24 | 36 |
| STA0021 | 4 | East-Siberian Sea | 69.70 | 170.30 | 2-Jul-86 | | | 3.5 | 19 |
| STA0022 | 5 (1) | East-Siberian Sea | 69.70 | 170.30 | 2-Jul-86 | | | 18 | 102 |
| STA0023 | 5 (2) | East-Siberian Sea | 69.75 | 169.98 | 8-Jul-86 | | | 20 | 87 |
| STA0024 | 5 (3) | East-Siberian Sea | 69.58 | 170.33 | 26-Aug-86 | | | 12 | 40 |
| STA0025 | 5 (4) | East-Siberian Sea | 68.92 | 170.18 | 12-Aug-86 | | | 18 | 56 |
| STA0027 | 5 (6) | East-Siberian Sea | 69.07 | 169.47 | 27-Aug-86 | | | 18 | 78 |
| STA0028 | 5 (7) | East-Siberian Sea | 69.52 | 168.88 | 19-Aug-86 | | | 18 | 75 |
| STA0029 | 6 | East-Siberian Sea | 69.68 | 170.18 | 15-Aug-86 | | | 3 | 11 |
| STA0030 | 7 | East-Siberian Sea | 69.68 | 170.18 | 15-Aug-86 | | | 18 | 73 |
| STA0031 | 8 | East-Siberian Sea | 69.75 | 169.99 | 8-Jul-86 | | | 8 | 55 |
| STA0034 | 11 | East-Siberian Sea | 69.67 | 170.17 | 7-Aug-86 | | | 8 | 14 |
| STA0035 | 12 | East-Siberian Sea | 69.68 | 170.17 | 7-Aug-86 | | | 10 | 13 |
| STA0036 | 13 | East-Siberian Sea | 69.68 | 170.17 | 22-Aug-86 | | | 0.5 | 5 |
| STA0037 | 14 | East-Siberian Sea | 69.68 | 170.17 | 29-Aug-86 | | | 5 | 34 |
| STA0038 | 15 | East-Siberian Sea | 69.68 | 170.25 | 23-Aug-86 | | | 0.5 | 4 |
| STA0039 | 16 | East-Siberian Sea | 69.68 | 170.25 | 23-Aug-86 | | | 1.5 | 2 |
| STA0040 | 17 | East-Siberian Sea | 69.68 | 170.25 | 25-Aug-86 | | | 3 | 20 |
| STA0041 | 18 | East-Siberian Sea | 69.68 | 170.25 | 25-Aug-86 | | | 8 | 33 |
| STA0042 | 19 | East-Siberian Sea | 69.58 | 170.33 | 26-Aug-86 | | | 3 | 11 |
| STA0043 | 20 | East-Siberian Sea | 69.58 | 170.33 | 26-Aug-86 | | | 8 | 29 |
| STA0044 | 21 | East-Siberian Sea | 69.57 | 170.33 | 26-Aug-86 | | | 14 | 29 |
| STA0046 | 23 | East-Siberian Sea | 68.87 | 170.30 | 12-Aug-86 | | | 8 | 16 |
| STA0047 | 24 | East-Siberian Sea | 69.03 | 170.98 | 17-Jul-86 | | | 3 | 10 |
| STA0049 | 26 | East-Siberian Sea | 69.08 | 169.35 | 27-Aug-86 | | | 4 | 10 |
| STA0050 | 27 | East-Siberian Sea | 69.08 | 169.35 | 27-Aug-86 | | | 6 | 33 |
| STA0051 | 28 | East-Siberian Sea | 69.55 | 168.88 | 19-Aug-86 | | | 5 | 10 |
| STA0052 | 29 | East-Siberian Sea | 69.53 | 168.88 | 19-Aug-86 | | | 8 | 26 |
| STA0053 | 1 | East-Siberian Sea | 69.83 | 176.33 | 25-Aug-89 | | | 15 | 28 |
| STA0054 | 2 | East-Siberian Sea | 69.92 | 176.58 | 25-Aug-89 | | | 35 | 66 |
| STA0055 | 3 | East-Siberian Sea | 70.33 | 176.92 | 25-Aug-89 | | | 50 | 67 |
| STA0073 | 1 | East-Siberian Sea | 70.00 | 161.00 | 25-Apr-92 | | | 12.5 | 30 |
| STA0075 | 3 | East-Siberian Sea | 70.00 | 162.00 | 5-May-92 | | | 11 | 18 |
| STA0076 | 24 | East-Siberian Sea | 77.27 | 145.40 | 22-Aug-37 | | | 45 | 165 |
| STA0077 | 25 | East-Siberian Sea | 77.78 | 143.58 | 23-Aug-37 | | | 45 | 107 |
| STA0078 | 26 | East-Siberian Sea | 77.73 | 145.53 | 23-Aug-37 | | | 54 | 217 |
| STA0079 | 27 | East-Siberian Sea | 77.52 | 147.28 | 23-Aug-37 | | | 41 | 94 |
| STA0080 | 28 | East-Siberian Sea | 77.44 | 149.63 | 24-Aug-37 | | | 44 | 86 |
| STA0081 | 29 | East-Siberian Sea | 77.12 | 151.56 | 24-Aug-37 | | | 38 | 41 |
| STA0082 | 30 | East-Siberian Sea | 77.22 | 153.32 | 24-Aug-37 | | | 56 | 40 |
| STA0083 | 31 | East-Siberian Sea | 77.25 | 155.85 | 24-Aug-37 | | | 64 | 61 |
| STA0084 | 32 | East-Siberian Sea | 77.13 | 156.62 | 2-Sep-37 | | | 40 | 16 |

| Station ID | Orig-stat | Sea | Latitude | Longitude | Date | Vessel | Expedition | Max depth (m) | No spec. |
|---|---|---|---|---|---|---|---|---|---|
| STA0085 | 33 | East-Siberian Sea | 77.08 | 156.67 | 4-Sep-37 | | | 60 | 120 |
| STA0086 | 34 | East-Siberian Sea | 77.00 | 157.00 | 5-Sep-37 | | | 65 | 89 |
| STA0087 | 35 | East-Siberian Sea | 76.98 | 157.23 | 5-Sep-37 | | | 65 | 44 |
| STA0089 | 37 | East-Siberian Sea | 76.80 | 158.08 | 6-Sep-37 | | | 20 | 12 |
| STA0091 | 39 | East-Siberian Sea | 76.80 | 158.08 | 6-Sep-37 | | | 60 | 64 |
| STA0092 | 85 | East-Siberian Sea | 77.67 | 137.10 | 2-Dec-37 | | | 53 | 47 |
| STA0093 | 86 | East-Siberian Sea | 77.88 | 141.37 | 7-Dec-37 | | | 48 | 21 |
| STA0094 | 87 | East-Siberian Sea | 78.22 | 142.22 | 19-Dec-37 | | | 57 | 76 |
| STA0095 | 88 | East-Siberian Sea | 78.18 | 147.15 | 13-Jan-38 | | | 59 | 61 |
| STA0096 | 89 | East-Siberian Sea | 78.10 | 149.53 | 20-Jan-38 | | | 58 | 110 |
| STA0097 | 90 | East-Siberian Sea | 77.93 | 152.97 | 25-Jan-38 | | | 61 | 61 |
| STA0098 | 91 | East-Siberian Sea | 78.68 | 152.53 | 12-Mar-38 | | | 73 | 120 |
| STA0099 | 92 | East-Siberian Sea | 79.08 | 151.67 | 1-Apr-38 | | | 81 | 85 |
| STA0100 | 93 | East-Siberian Sea | 79.50 | 150.37 | 12-Apr-38 | | | 91 | 105 |
| STA0117 | 1\61 | Laptev Sea | 75.00 | 114.52 | 10-Aug-93 | R/V "I. Kireev" 1993 | | 42 | 70 |
| STA0119 | 3\26 | Laptev Sea | 73.85 | 115.95 | 12-Aug-93 | R/V "I. Kireev" 1993 | | 15 | 46 |
| STA0124 | 8\40 | Laptev Sea | 74.50 | 123.00 | 15-Aug-93 | R/V "I. Kireev" 1993 | | 12 | 14 |
| STA0125 | 9\42 | Laptev Sea | 74.50 | 127.33 | 16-Aug-93 | R/V "I. Kireev" 1993 | | 32 | 34 |
| STA0130 | 14\49 | Laptev Sea | 74.50 | 139.67 | 18-Aug-93 | R/V "I. Kireev" 1993 | | 19 | 22 |
| STA0132 | 16\23 | Laptev Sea | 73.63 | 128.67 | 20-Aug-93 | R/V "I. Kireev" 1993 | | 11 | 34 |
| STA0133 | 17\21 | Laptev Sea | 73.50 | 131.67 | 20-Aug-93 | R/V "I. Kireev" 1993 | | 22 | 13 |
| STA0142 | 27\81 | Laptev Sea | 76.53 | 133.32 | 1-Sep-93 | R/V "I. Kireev" 1993 | | 36 | 17 |
| STA014[illegible] | 30\50 | Laptev Sea | 75.00 | 136.00 | 3-Sep-93 | R/V "I. Kireev" 1993 | | 28 | 27 |
| STA0149 | 34\65 | Laptev Sea | 75.48 | 119.90 | 6-Sep-93 | R/V "I. Kireev" 1993 | | 41 | 54 |
| STA0153 | 39\84 | Laptev Sea | 77.13 | 137.17 | 13-Sep-93 | R/V "I. Kireev" 1993 | | 30 | 85 |
| STA0176 | 43 | Laptev Sea | 77.40 | 133.53 | 7-Sep-93 | R/V "Polarstern" 1993 | | 55 | 67 |
| STA0177 | 44 | Laptev Sea | 77.03 | 126.42 | 7-Sep-93 | R/V "Polarstern" 1993 | | 95 | 111 |
| STA0180 | 49 | Laptev Sea | 77.10 | 126.28 | 9-Sep-93 | R/V "Polarstern" 1993 | | 170 | 39 |
| STA0184 | 67 | Laptev Sea | 78.25 | 109.24 | 20-Sep-93 | R/V "Polarstern" 1993 | | 51 | 100 |
| STA0185 | 68 | Laptev Sea | 78.47 | 110.77 | 20-Sep-93 | R/V "Polarstern" 1993 | | 101 | 146 |
| STA0359 | 1 | Chuckchi Sea | 68.92 | -179.50 | 28-Jul-76 | | ZISP RAS | 6 | 11 |
| STA0361 | 3 | Chuckchi Sea | 68.92 | -179.50 | 30-Jul-76 | | ZISP RAS | 13 | 12 |
| STA0366 | 8 | Chuckchi Sea | 68.92 | -179.50 | 30-Jul-76 | | ZISP RAS | 21 | 18 |
| STA0371 | 13 | Chuckchi Sea | 70.97 | 178.47 | 13-Aug-76 | | ZISP RAS | 8 | 33 |
| STA0372 | 14 | Chuckchi Sea | 70.97 | 178.47 | 13-Aug-76 | | ZISP RAS | 10 | 11 |
| STA0373 | 15 | Chuckchi Sea | 70.97 | 178.47 | 13-Aug-76 | | ZISP RAS | 12 | 31 |
| STA0374 | 16 | Chuckchi Sea | 70.97 | 178.47 | 13-Aug-76 | | ZISP RAS | 16 | 15 |
| STA0375 | 17 | Chuckchi Sea | 70.97 | 178.47 | 13-Aug-76 | | ZISP RAS | 22 | 29 |
| STA0378 | 20 | Chuckchi Sea | 71.00 | 178.00 | 15-Aug-76 | | ZISP RAS | 16 | 17 |
| STA0379 | 21 | Chuckchi Sea | 71.00 | 178.00 | 15-Aug-76 | | ZISP RAS | 10 | 17 |
| STA0380 | 22 | Chuckchi Sea | 71.00 | 178.00 | 15-Aug-76 | | ZISP RAS | 13 | 15 |
| STA0381 | 23 | Chuckchi Sea | 71.00 | 178.00 | 15-Aug-76 | | ZISP RAS | 20 | 25 |
| STA0385 | 27 | Chuckchi Sea | 70.97 | 178.47 | 17-Aug-76 | | ZISP RAS | 4 | 13 |
| STA0386 | 28 | Chuckchi Sea | 70.97 | 178.47 | 17-Aug-76 | | ZISP RAS | 9 | 37 |
| STA0387 | 29 | Chuckchi Sea | 70.97 | 178.47 | 17-Aug-76 | | ZISP RAS | 12 | 27 |
| STA0388 | 30 | Chuckchi Sea | 70.97 | 178.47 | 17-Aug-76 | | ZISP RAS | 18 | 21 |
| STA0389 | 31 | Chuckchi Sea | 70.97 | 178.47 | 17-Aug-76 | | ZISP RAS | 25 | 42 |
| STA0390 | 32 | Chuckchi Sea | 70.97 | 178.47 | 20-Aug-76 | | ZISP RAS | 3 | 29 |
| STA0391 | 33 | Chuckchi Sea | 70.97 | 178.47 | 20-Aug-76 | | ZISP RAS | 4 | 16 |
| STA0395 | 37 | Chuckchi Sea | 71.30 | 177.62 | 25-Aug-76 | | ZISP RAS | 4 | 10 |
| STA0396 | 38 | Chuckchi Sea | 71.30 | 177.62 | 25-Aug-76 | | ZISP RAS | 7 | 41 |

# Appendix 2

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24.04.1996

INSROP PAPER REVIEW
Your ref. APN752/LHL/sd

Dear Lars-Henrik Larsen,

enclosed you will find the original manuscript of the INSROP working paper with a number of comments directly made by me in the ms.

In principle, I think the paper is well organized and covering the main aspects explored so far. May be that a few more international papers on the Arctic biota should be cited and discussed; a first step into this direction could be a consideration of such reviews like from P.K. DAYTON (1990) on "Polar Benthos" in "Polar Oceanography", Acad. Press. and also that of K. DUNTON (see below: *).

The text should be readable also for newcomers. Therefore, abbreviations like "VEC" and "EIA" (but also "QA/QC") are to be explained when they are used for the first time in the paper.

Since the very shallow and inshore areas are subjected to a strong natural stress (fast ice coverage, ice groundings, uplift of anchor ice, perma frost situation with strong erosion possible, strong turbulence down to the sea floor in case of storms, large fluctuations in salinity (winter: may be some brine-formation; summer: estuarine influences) and in temperature,
their benthic invertebrate biota (impoverished in species*) may have a remarkable recovery (and "endurance") potential - resilience/elasticity (s. page 12).
Nevertheless, these biota can be strongly harmed in case of an oil or other (under natural conditions not occurring) chemical accident. Therefore, there should at least be a hint in chapter 3 (VEC A1) to chapter 7 (VEC D2), where such possible problems are indicated.

* see K. DUNTON (1992): "Arctic biogeography: The paradox of the marine benthic fauna and Flora", in: Trends in Ecology and Evolution 7 (6), pp. 183-189.

With regard to the fish stocks, it is not clear, how far fishing itself influenced the stocks (overfishing). There is a hint on page 19 about the sturgeon; but, (e.g.) why did the Ob landings decrease already after 1984 or the Khatanga catches after 1986 ?

Some figs. seem not to be necessary, since they are well included in Fig. 1.1. Also the legends of some tables may be shortened, as they are repeating informations (esp. Coregonid species abbreviations).

In Fig. 3.1.1 it would be helpful to know, in what season of the year the polynyas are there. To my knowledge the winter polynya in the Laptev Sea is found more to the north than indicated. Schwartz (1995) is not found in the references.

The conclusions should take up some more points made in the text, e.g. conclusions on "vulnerability" like found on pages 16 or 32 (3rd para), although a general evaluation of the vulnerability of the VECs according to the assumptions in Larsen et al. 1995 will be made in another contribution. The reviewer will be very much interested in that evaluation and how it may compare with known changes in Arctic or other remote areas under similar shipping activities.

Yours sincerely,

Eike Rachor

# Appendix 3

SSII-1

# Environmental Factors Conceptual Design and Current Status

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**Kjell A. Moe,** Det Norske Veritas Industry AS
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ABSTRACT

The INSROP Sub-programme II: Environmental Factors is a large scale assessment of the potential environmental impacts of shipping, navigation and related activities on the Northern Sea Route (NSR). The Sub-programme is designed to produce the foundation for political and commercial decision making regarding environmental conditions in the NSR - to reflect national and international concerns for the Arctic environment and for Northern Indigenous peoples. Four main components are included, organized for implementation in three conceptual phases. Based on a mulitidisciplinary and dynamic approach, the information generated by The Environmental Atlas, The Environmental Safety of Ships and Navigation, as well as the other INSROP sub-programmes, will be stored and intergrated in The Geographical Information System and analyzed in The Environmental Impact Assessment. The latter will subsequently form the basis for public information, recommendations, and decision making. *Medio* 1995, more than 50 experts distributed amongst 30 different institutions in 8 countries, have been participating in the execution of the 29 Sub-programme projects since the start in 1993.

1. INTRODUCTION

Environmental Impact Assessment (EIA) is perhaps the most important predictive tool which can prevent today's decisions resulting in unacceptable environmental impacts tomorrow. In Norway, as well as in the EC countries, the application of EIA in development and management of industrial activities is regulated (cf. Directive 85/337/EEC). Legislation on EIA has recently been enacted or is planned in most of the countries in central Europe [1]. The situation in Russia however, is more obscure. There are extensive regulatory frameworks, but the implementation and results obtained are variable. Except for Estonia, Latvia and Lithuaunia, all the countries in the northern hemisphere have signed "The Espoo Convention" (1991), concerned with environmental impact assessment in a transboundary context.

Even if there are similarities in the methodology, the differences between the sectorial and the national standards, legislation and practice are highly significant. All countries however have one element in common; EIAs applied to the entire sector of shipping and navigation activities are not mandatory.

The EIA in INSROP is regarded as a process [2]. This included the initial step of identifying, from a broad range of potential problems, a limited number of priority issues to be adressed by the EIA. Subsequent to the identification of these issues, further effort has been placed on surveys to provide information concerning the selections made in the scoping process [3, 4]. The concluding assess-ment will rely on confident impact prediction and significance that can occur in the interface between the environment and the given anthropogenic activities. Consequently, the open, dynamic process provided to produce the base for rational decision making and recommendations, both for the public and private sector, calls for intergration of results across disciplinary lines.

INSROP faciliates such multidisciplinary, scientific research. This is reflected on sub-programme level, with the four equivalent sub-programmes, as well as the collaboration between the sub-programmes on project level (e.g. [5, 6] in developing the INSROP GIS). This inter-action between technological, environmental, economic, political and legislative aspects in the Arctic is also in line with ideas of the Rovaniemi-process. In INSROP however, the concept has developed from theory into practice [7].

**2. THE ENVIRONMENT OF THE NSR**

Stretching from Novaya Zemlya to the Bering Strait, the Northern Sea Route (NSR) covers some 2,200-2,900 nautical miles of ice-infested waters and the whole northern coast of Eurasia (figure 1).

This makes up some of the largest relatively un-disturbed wilderness areas in the world. The topography is relatively uniform, forming a wide, shallow shelf and low relief shoreland landscape. Large estuaries and deltas are created by the big rivers of northern Russia, which provide almost all of the freshwater that enters the Arctic ocean.

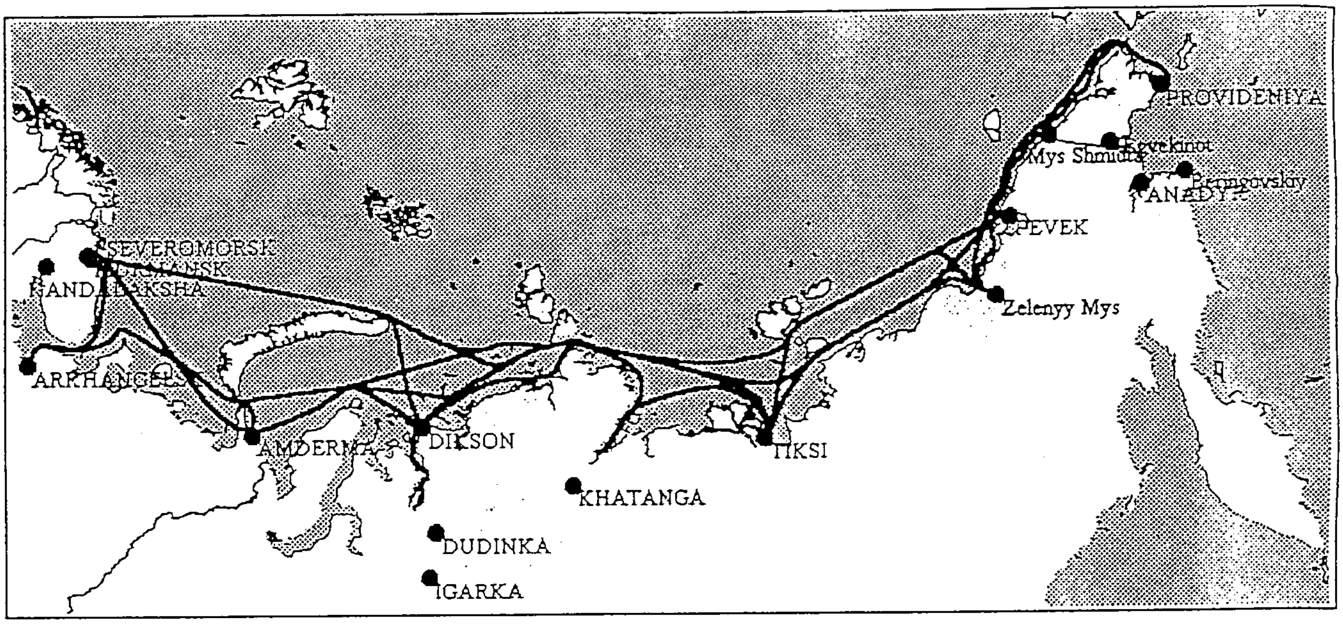


Figure 1. The NSR area. Historical sailing routes are indicated.

Low temperatures, long periods with sparce or no daylight, and vasts areas covered by sea ice and permafrost, make extremely hard conditions for the Arctic flora and fauna. Except for the estuaries, the biological production in the Kara, Laptev, East Siberian and Chuckhi Seas is low. Within all areas, the production is characterized by significant temporal and spatial fluctuations. The flux rates however, are in general low.

The uniformity of the Arctic provides only a limited range of biological niches. The number of plant and animal species adapted to this environment is accordingly low. The chosen few however, are well adapted. Prospering from lack of competition, large and important populations of saltwater and anadromous fish, seabirds and other waterfowl (particularly in the summer), and marine mammals are patchily distributed all over the NSR area [5].

In general, Arctic marine and terrestrial species are probably no more vulnerable to anthropogenic impact than species in temperate regions. These species are adapted to dramatic environmental fluctuations, long periods without nutrient or food, and several seasons of reproductive failure. However, because of: - low rates of biological and chemical processes; - low reproduction potential; - simple food webs (e.g. few species at each trophic level), as well as; - temporal and spatial aggregations, far more serious consequences may be generated in the Arctic than in other areas [8, 9]. In case of pertubation of environmental damage at the "wrong" place and at the "wrong" time, the recovery may last for decades - at the best.

Today, official Russian documents such as the "Environmental issues 1991", prepared by Yablokov & Danilov-Danilyan in 1993, describe a grave environmental situation in the Russian North. The water in Russian rivers is in many cases severly polluted by petroleum, metallurgic and timber processing industries. In several areas there are severe landscape, forest and soil desctruction, as well as littering. Equally alarming, according to the report, is the economic crisis "which has blurred guidelines for society's long term value priorities". Except for some areas, like the recently protected Taimyr "Great Arctic" reserve, most of the northern Russia wilderness is not protected by environmental regulations [10].

## 3. SHIPPING, NAVIGATION AND RELATED ACTIVITIES IN THE NSR

Today, "*NSR is Russia's national transportation artery in the Arctic*"; - in 1991 more than 250 ships were engaged in cargo operations along the NSR, making a total of more than 900 voyages in the Arctic [11]. For the period 1950-1970, cargo volume averaged between one or two mill. tons; by the mid-1980s this figure had risen to somewhat more than six mill. tons. Since then however, it has dropped, and there is much to indicate that this tendency will continue [12].

The perspectives of transcontinental transit is considered to be more optimistic. According to 1986 UN transportation statistics, a potential transit volume of 21 mill. ton is estimated [13]. There is an obvious, and at times considerable distance advantage involved in using the NSR between ports in the Pacific and in the Atlantic, as compared to the Suez and Panama Canals. To date, Russian vessels have demonstrated that reduced distances can be translated into reduced carrying time during certain periods of the year. What remains to be shown however, is whether it is possible to achieve reduced freight times all year round at costs lower than those involved in using the existing routes [12, 14]. Most probably, improvement and optimilization of several logistical and technical aspects are necessary to make the NSR really international and economically feasible [15].

Both in short- and long-term perspectives, it would probably be a mistake to underestimate the potential for increased activity along the NSR, especially with respect of regional development. Northern Russia holds among the world's richest reserves of petroleum hydrocarbons (e.g. the oil and gas reservoirs in Komi), coal, minerals and timber, all goods in great demand in the East and the West. Russian authorities are presently placing significant effort in improving the crucial economic sector. Regulations have been adopted to incite foreign trade and investments in the North, and several initiatives and plans for increased exploration and export of these resources have been raised (cf. the recent formation of "The Russian Union of Oil Exporters", RUOE, as well as the plans of Texaco, placing a 200,000 tons oil tanker in ice-free waters for intermediate storage of oil from NW and central parts of Russia.

NSR activity may cause physical disturbance, noise, landscape destruction (harbour activity), and regular operations will be a source of long-term/low level exposure by emissions to air as well as discharges to sea. E.g., in the North Sea, annual amount of petroleum hydrocarbons discharged to the sea by operational shipping activity, is estimated to 2,000 tons [16].

In 1992, the average age of the fleet was 14 years and increasing, more than 50% of the ships were 20 years and older [13]. The assumption that the standard of maintainance is less than satisfactory, is probably close to reality. Although the Russian NSR crews and the administration are uniquely experienced with large scale operations in ice-infested waters, it is not unrealistic to expect an increased probability for accidents along the NSR unless the ship standard is dramatically improved.

## 4. CONCEPTUAL DESIGN AND METHODS APPLIED

Facing the challenges of founding a knowledgebase for decision making concerning the interface between the relatively pristine environment in the vast area of NSR and hardly predictable scenarios for the NSR activity, baseline data acessibility and credibility were considered as crucial for the success of the Sub-programme. The information, as well as the results obtained should not be kept static, but compiled for continuously updating, revisions and calibration towards the dynamics in the NSR activity and results generated by the other INSROP sub-programmes. Finally, the methods applied and progamme progress should ensure transparency for preparation of reliable assumptions and confident recommendations.

### 4.1 Main components

At the start in 1993, four main components were included in the Sub-programme, organized for implementation in three conceptual phases (figure 2):

* *Dynamic Environmental Atlas*; identification, recording and mapping of valuable ecosystem components and their temporal and spatial distribution in the NSR area
* *Geographical Information System*; developing a tool to store, retrieve, integrate and analyse the environmental information
* *Environmental Safety of Ship and Navigation*; contribution to the EIA and implementation of efficient pollution control measures in the NSR area
* *Environmental Impact Assessment*; assessing the environmental impact of relevant NSR activities on the valued ecological resources.

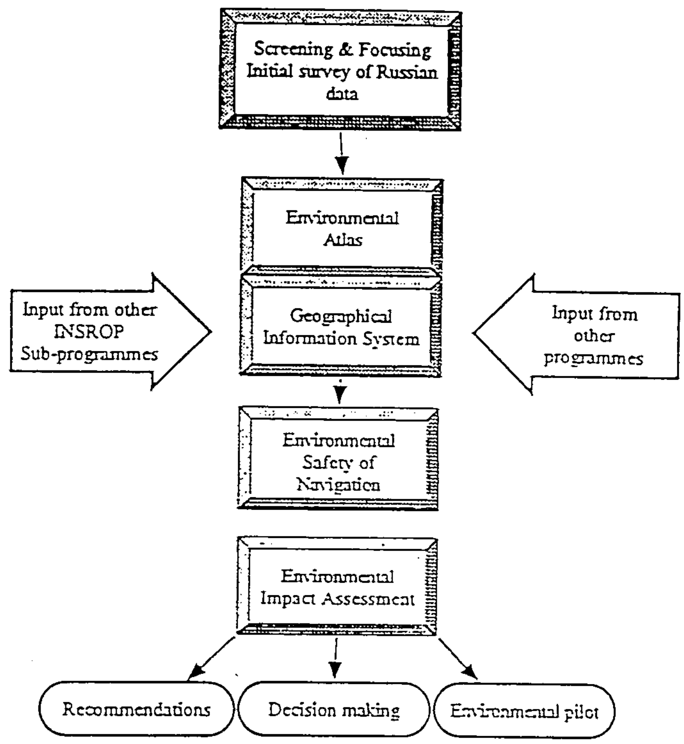


Figure 2. The conceptual design of INSROP Sub-programme II: Environmental Factors - some main components and interactions.

The information generated by The Environmental Atlas (EA), The Environmental Safety of Ships and Navigation (ESSN), as well as the other INSROP sub-programmes, will be stored and integrated in The Geographical Information System (GIS), and analyzed within The Environmental Impact Assessment (EIA). The latter will subsequently form the basis for public information, recommendations, and decision making. The "Environmental Pilot", is the IT-based framework for an environmentally friendly navigation system for NSR activities, and will form a synopsis of the EIA-results, designed for the extraction and realization of this information to support operational purposes.

The principle for such priorities is simple. To carry out confident impact assessment for a given activity, it is neccessary to know the temporal and spatial distribution of the natural resources in the area of the activity, their ecological dynamics and importance, as well as their vulnerability to the given anthropogenic activity in the short and the long term. At this point, the identification of the NSR scenarios, is crucial for the understanding of the impact factors involved. Developing mitigating measures, either as precautionary principles or task-specific measures, is logically tiled to this kind of resource-impact relationships [7, 17].

The Sub-programme is broken down into 29 separate projects (see APPENDIX). Each project is designed as independent, but interrelated parts of the Sub-programme, in order to provide the successive integration of the results. In all phases, work is carried out in close cooperation within the Sub-programme and between the other INSROP sub-programmes, advancing information of mutual interest to the project participants. Tasks and obligations are evaluated continuously, by regular correspondence and meeting activity among the project supervisors as well as key personnel of the other sub-programmes.

### 4.2 Methods applied

#### 4.2.1 INSROP GIS as part of Sub-programme II

Primarily designed for thematic integration and implementation of the environmental information in the EIA, the INSROP GIS forms a central part of the Sub-programme. Once organized into the GIS, the information can be retrieved and combined for further processing and analyses. However, having a great potential for mulitidisciplinary integration, the GIS is also considered to be of equal importance for communication within INSROP, as well as communicating the EIA to the recipients.

A complete description of the INSROP GIS is given by [5, 6]. Because of new and improved software releases and results from other projects in the course of INSROP, the system design in [5] has been somewhat modified, but the basic principles are maintained. The major change is that ArcView, rather than ARC/INFO, has become the major software platform for the INSROP GIS.

The organisation of the data flow is discipline oriented. The institutions responsible for the EA-projects are also responsible of supplying the baseline data in specified formats, including information on the data itself (metadata). The Russian co-partners of these projects are key-personnel in the data flow, the entire Sub-programme rely on the ability to obtain the required baseline information. Quality Assurance/ Quality Control (QA/QC) are carried out by Thematic Integrators, e.g. the institutions responsible for integrating the data from their respective sources as well as tranferring the data for Overall Integration and Distribution. A Manual on standards have been prepared as part of the QA/QC, see [4]. Presently the participants in INSROP projects are defined as Data Users, having access to the most recent accepted data sets from different sources within a common framework.

#### 4.2.2 The INSROP EIA

The INSROP EIA is based on a slightly modified version of the Adaptive Environmental Assessment and Management (AEAM)-method developed by [18], a method formerly used at Svalbard [17], and in the Beaufort Region, Canada [19]. A complete description of the INSROP EIA is given by [2].

The method includes identifcation and selection of certain ecosystem components (e.g. Valued Ecosystem Components - VECs) as priority issues of the EIA. The principle background of this process, as well as VECs' role in the EA and EIA, including developing the linkages between the VECs and NSR activity, are described in detail by [2, 4].

The EIA concept relies on the identification of the various NSR scenarios to identify the Impact Factors (IFs) and develop Impact Hypothesis (IHs). So far, two main cathegories have been examined; - Operational activities, and Accidental activities.

The operational scenarios addresses the environmental impact causing relatively low, but long-term exposure. The main impact factors from the operational scenarios may be divided into pollution, noise, physical disturbance and wastes.

The accident scenarios are closely related to the operational scenarios as the sailing routes and physical conditions are the same. The accident scenarios will address the environmental impact of acute pollution - significant exposure. These scenarios will also involve a risk assessment of the operational scenario for identification of high risk areas and seasons.

The scenario of zero alternative, is derived from operational activity, and reflects the present status of NSR activity.

Both land-, river- and seabased activity, as well as emission to air and discharges to sea, are included in the scenario concept. For all scenarios, the type, frequency and volume of cargo, are important factors, and if possible cargo characterization will be calibrated towards IMO standards.

In the process of scoping and identifying, the core area to which the Sub-programme will apply is defined as the summer ice-free zone between the north coast of Russia and the ice edge from the Kara Gate to the Bering Strait. Depending on the results provided by the survey on the distribution of ecological resources, alternative sailing routes, and additional information brought forward by other sub-programmes in course of INSROP, substantial drift ice areas, polynias north of the ice edge, river estuaries and deltas, as well as some other focal geographical areas, will be included..

### 4.3 Progress and current status

The *initial phase* of the Sub-programme (1993-1994), including the identification of existing Russian data sources (project II.1), and the screening and focusing process of the EIA (project II.2), was completed in 1994. The results of the latter are implemented in the EA (as selected VECs) and the EIA, while the results of the data survey have been reviewed, and are now accessible in an INSROP Working paper [3].

In parallel, the design of the INSROP GIS was developed in collaboration with Sub-programme I. The preparation of summary reports on the screening and focusing process (see Hansson et al., INSROP Discussion paper) and GIS design [5], concluded the initial phase.

The baseline data inventory of the EA made up the gradual transition to the *second phase* (1994-1996), where the main effort of the Sub-programme is devoted to mapping of the selected VECs. The data inventory will reach a maximum in 1995, and then subsequently decrease and gradually change towards validation and analyses of the data in the GIS. *Medio* 1995, more than 1,500 registrations on species occurence, including the type of species (VECs), their temporal and spatial distribution given by geographical positions etc., have been entered into the GIS. A complete discription of these data is given in [4]. The work on implementation of the INSROP GIS has been correspondingly strengthened, and manuals have been prepared as part of the QA/QC.

The ESSN is the group of projects dealing with the review of the current status and contribute towards implementation of relevant pollution control measures in the NSR area. Pollution emergency plans and guidelines for environmentally safe ship operations and associated activities on the NSR, are prepared to improve the environmental safety of ongoing NSR operations. Implementation however, still remains.

The EIA is the *third phase* of the Sub-programme (1995-1997), and will conclude the results from the EA and ESSN. Relevant information from the other INSROP sub-programmes integrated in the GIS, e.g. selected scenarios based on ice and physical conditions, trade and commercial aspects, and political and legal aspects, will form a multidisciplinary base in assessing potential environmental impact. In cooperation with Sub-programme I, a module has been developed in the GIS, especially designed for testing and analysing the impact hypothesis. The results achieved so far can be considered as state-of-the-art methodology, reflecting the synergy effects of cooperation across sub-programme boundaries.

*Medio* 1995, more than 50 experts from 30 different institutions in 8 countries, have been participating in the Sub-programme work. So far, 3 INSROP Working Papers, 14 INSROP Discussion Papers (revised and up-graded Discussion papers not included), and 8 reports/papers published in other, international scientific/public/authority fora, have been prepared.

### 4.3 Relationship to other programmes

Issues such as baseline contamination studies, surveys and analyses, long term pollution studies, pollution fate and effect studies, as well as long term environmental monitoring, are generally beyond the scope of the Sub-programme. Selected information and results will be imported from programmes and activities other than INSROP (see figure 2).

In this context, the Sub-programme will cooperate closely with the environmental authority bodies in the countries involved, and operate in liason with and exchange information and results with relevant international and national organisations and institutions. These are the working groups under the Arctic Environmental Protection Strategy (AEPS), including the Arctic Monitoring and Assessment Programme (AMAP) and the Conservation of Arctic Flora and Fauna (CAFF), as well as the Joint Russian-Norwegian Commission on Environment, the International Arctic Science Committee (IASC), the Ministry of Industry and Energy Programme of Impact Assessments (AKUP), and others.

Expanded cooperation with the AMAP secretariat, both regarding information system design/data strategy and analytical approach, has been initiated. Relevant data from the AMAP status reports produced in the course of INSROP, according to schedule in 1996, will be included in the EA/GIS and the EIA.

## ACKNOWLEDGEMENTS

The Sub-programme secretariat at the Norwegian Polar Institute are grateful to the INSROP Steering Committee of Sponsors, the International Advisory Group, and the Joint Research Committee for funding Sub-programme II. By stating that "Environmental Factors" is equivalent to the other sub-programmes, "Ice and Navigation", "Trade and Commercial Aspects", and "Political, Legal and Strategic Factors", INSROP is in line with, and even ahead of, international standards on work within the sector of industrial activity and environmental concerns.

The Sub-programme secretariat at the Norwegian Polar Institute are highly appreciated the stimulating cooperation with all the assistants, technicians and scientist involved in the Sub-programme, coordinators and key personnel of the other INSROP sub-programmes, as well as the INSROP secretariat at FNI. Thanks to all of you for your contributions.

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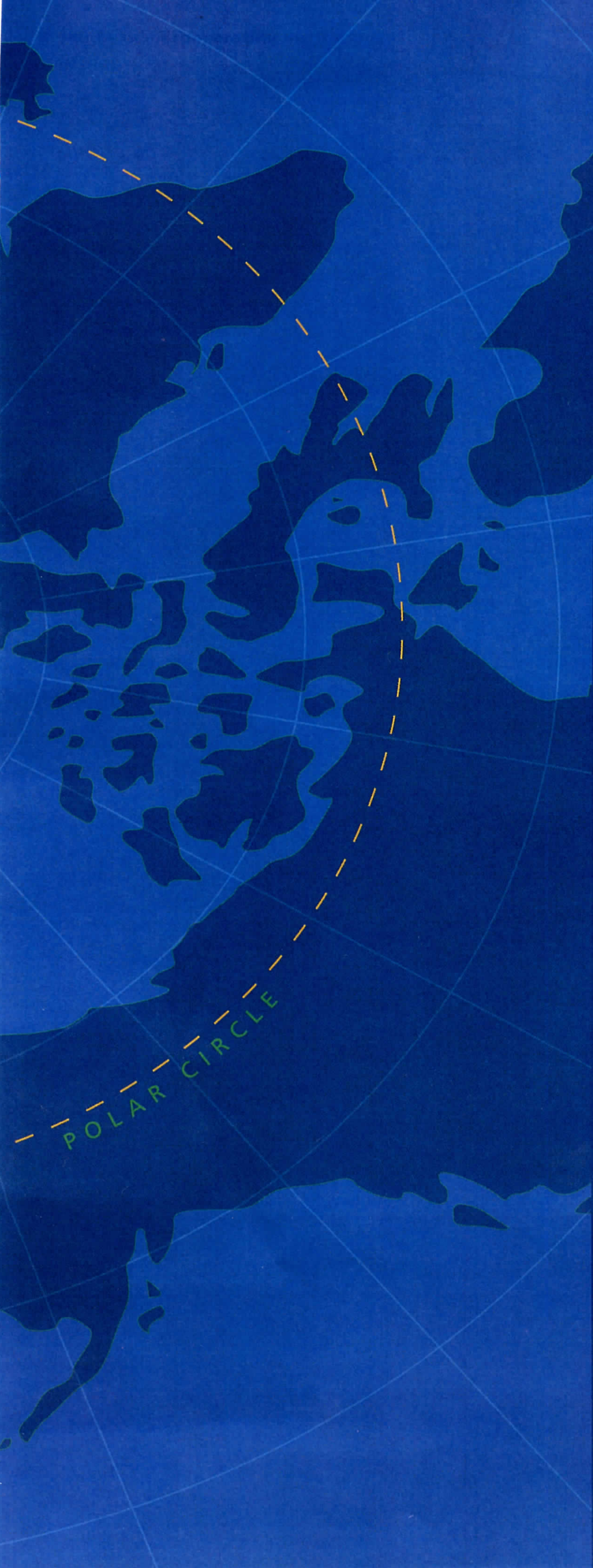
APPENDIX

Projects within INSROP Sub-programme II: Environmental Factor (as per August 1995). 1) Projects carried out in other INSROP sub-programmes; 2) Projects carried out in other programmes; 3) Projects will be started later.

| Projects | Duration | Responsible |
|---|---|---|
| II.1 Initial survey of Russian data sources | 1993 | AARI |
| II.2 Screening and focusing workshop | 1993 | NP |
| **II.3 GIS** | | |
| II.3.1 GIS design | 1993-1994 | GRID/DNVI |
| II.3.2 Implementation of data base | 1994-1996 | NP |
| **II.4 Environmental Atlas (EA)** | | |
| II.4.1 Invertebrates and Fish | 1993-1997 | Akvaplan-niva |
| II.4.2 Marine Birds | 1993-1997 | NP |
| II.4.3 Marine Mammals | 1993-1997 | NP |
| II.4.4 The Coastal Zone | 1993-1997 | Akvaplan-niva |
| II.4.5 River, Estuaries and Deltas | 1993-1994 | Akvaplan-niva |
| II.4.6 Physical and Chemical Factors | - | 1/2 |
| II.4.7 Indigenous Peoples | - | 1/2 |
| **II.5 Environmental Impact Assessment** | | |
| II.5.1 Assessment design | 1993-1994 | NINA-NIKU |
| II.5.2 Sensitivity modelling | 1994 | NINA-NIKU |
| II.5.3 Pollution levels | - | 2 |
| II.5.4 Oil drift modelling | - | 1 |
| II.5.5 Scenarios for NSR activities | 1994 | NINA-NIKU |
| II.5.6 Environmental impact assessment | 1994-1997 | NINA-NIKU |
| **II.6 Environmental Safety; Ship and Navigation** | | |
| II.6.0 Navigation in ice covered waters | 1994 | Kvaerner M-Y |
| II.6.1 Control of pollution from ships | 1993-1994 | CNIIMF |
| II.6.2 Environmental safety of ships | 1993-1995 | CNIIMF |
| II.6.3 Shore reception facilities | 1993-1994 | CNIIMF |
| II.6.4 Ship pollution emergency plan | 1993-1994 | CNIIMF |
| II.6.5 Coastal pollution emergency plan | 1995-1996 | CNIIMF |
| II.6.6 Oil spill combatting techniques in ice | - | 2 |
| II.6.7 Environmental safety of nuclear icebreakers | 1994-1996 | CNIIMF |
| **II.7-10. Coordination, activation of results** | | |
| II.7 Recommendation, public info. | 3 | - |
| II.8 Environmental pilot | 3 | - |
| II.9 Coordination Norway | 1993-1997 | NP |
| II.10 Coordination Russia | 1993-1997 | CNIIMF |

**The three main cooperating institutions of INSROP**




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

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

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