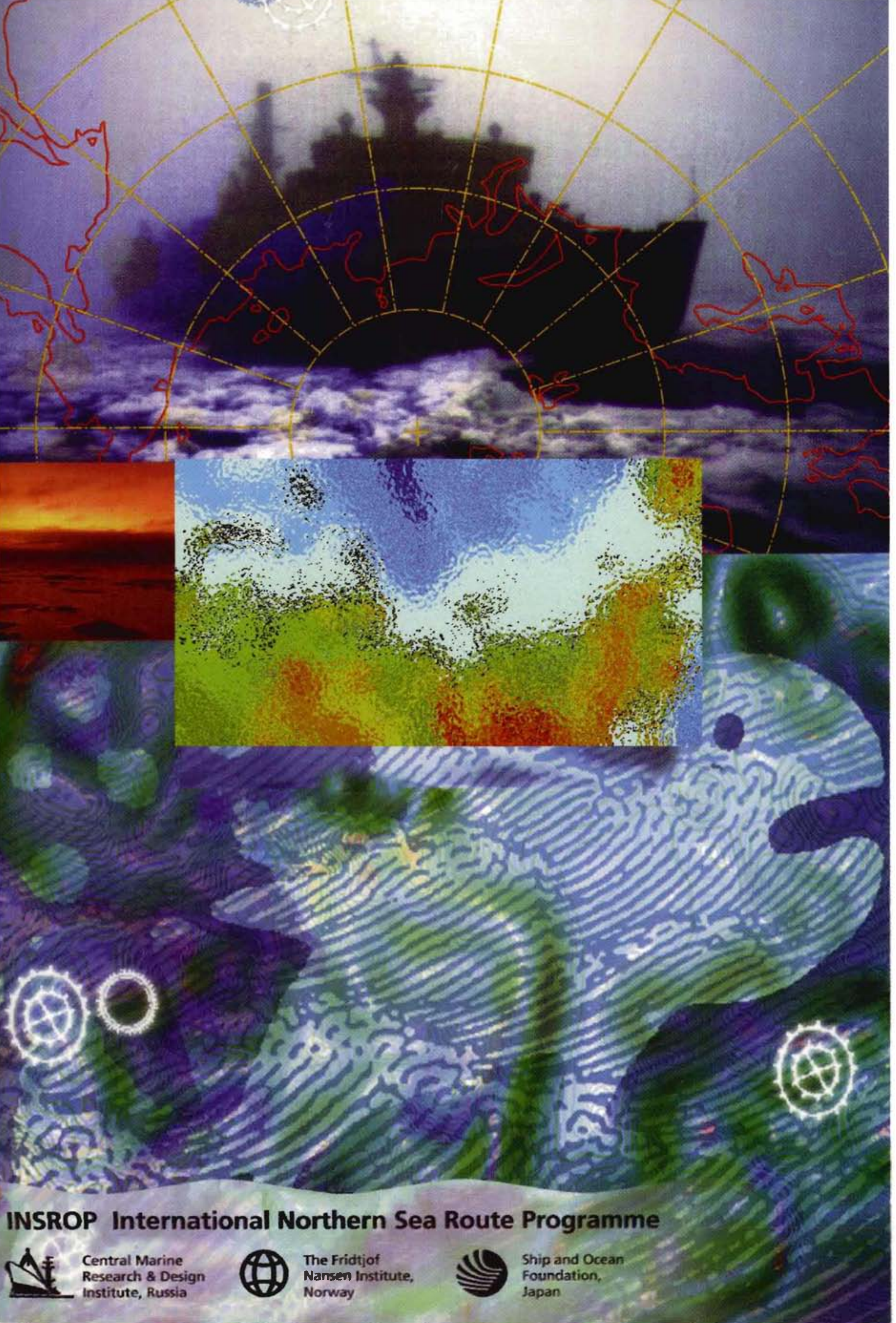


Northern Sea Route Dynamic Environmental Atlas

INSROP WORKING PAPER
NO. 99 - 1998, II.4.10

By
O.W. Brude, K.A. Moe,
V. Bakken, R. Hansson, L.H. Larsen,
S. M. Løvås, J. Thomassen and Ø. Wiig

May 1998

Norsk Polarinstitutt
Meddelelse Nr. 147

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 co-operation 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; 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 decisionmaking 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 co-operation between CNIIMF and FNI in 1988 and resulted in a pilot study in 1991. In 1992 SOF entered INSROP as a third partner on an equal basis with CNIIMF and FNI.

This report is a joint product of Sub-programme II : Environmental Factors and Sub-programme I : Natural Conditions and Ice Navigation. The secreteriats are located at Norwegian Polar Institute (Sub-programme II) and SINTEF Civil and Environmental Engineering (Sub-programme I).

Sponsors for INSROP

JAPAN
Nippon Foundation / Ship & Ocean Foundation

NORWAY
The Research Council of Norway
The Royal Norwegian Ministry of Foreign Affairs
Kvaerner a.s.
The Royal Norwegian Ministry of the Environment
The Royal Norwegian Ministry of Industry and Trade
The Norwegian Regional Development Fund
Norsk Hydro
Norwegian Shipowners' Association
Phillips Petroleum Company Norway
Fridtjof Nansen Institute

RUSSIA
The Russian Federation

Professional organizations permanently attached to INSROP

JAPAN
Ship & Ocean Foundation
Ship Research Institute

NORWAY
Fridtjof Nansen Institute
SINTEF Civil and Environmental Engineering
Norwegian Polar Institute

RUSSIA
Central Marine Research & Design Institute
Arctic and Antarctic Research Institute
Murmansk Shipping Company
Northern Sea Route Administration

Programme coordinators

Yuri Ivanov, CNIIMF
Krasnoy Konnitsy Str. 6
St. Petersburg 193015, Russia

Tel: 7 812 271 5633
Fax: 7 812 274 3864

Willy Østreng, FNI
Box 326
Lysaker, Norway

Tel: 47 67 53 89 12
Fax: 47 67 12 50 47

Ken-Ichi Maruyama, SOF
Senpaku Shinko Building
15-16 Toranomoro 1-chome
Minato-ku, Tokyo 105, Japan
Tel: 81 3 3502 2371
Fax: 81 3 3502 2033

Northern Sea Route Dynamic Environmental Atlas

HARDCOPY
VERSION 1.0 , MAY 1998

Editors :
O.W. Brude[1), K.A. Moe[1), V. Bakken[2), R. Hansson[3),
L.H. Larsen[4), S. M. Løvås[5), J. Thomassen[6) and Ø. Wiig[7)

[1)Alpha Environmental Consultants, N-0152 Oslo, Norway
[2)Norwegian Polar Institute, N-0301 Oslo, Norway
[3)Norwegian Agency for Development Cooperation (NORAD), N-0030 Oslo, Norway
[4)Akvaplan-niva, N-9001 Tromsø, Norway
[5)SINTEF, N-7034 Trondheim, Norway
[6)Norwegian Institute for Nature Research, N-7005 Trondheim, Norway
[7)Zoological Museum, University of Oslo, N-0562 Oslo, Norway

ISBN 82-7666-133-5
ISBN 82-7613-241-3

Table of Contents

Preface

The International Northern Sea Route Programme (INSROP) is a comprehensive multi-national, multi-disciplinary research programme designed to investigate the possibilities for commercial navigation on the Northern Sea Route (NSR) and adjacent waters (cf. the Northeast Passage). After an independent evaluation of Phase 1 (1993-95), the 3 principal partners in INSROP have decided to continue a Phase 2 for two more years (1997-98). (See Introduction for further details on INSROP and the research organisation of the four sub-programmes.)

INSROP Sub-programme II is a large-scale strategic assessment of the potential environmental impacts of shipping, navigation and related activities on the NSR. To carry out confident environmental impact assessments for human activities however, knowledge of the occurrence of natural resources in the area of the activity, their ecological dynamics and significance, as well as their vulnerability to the given activity in the short and the long term, is of significant importance. In this context, the Dynamic Environmental Atlas (DEA) forms the baseline environmental data sets for the impact analyses and assessments.

The information stored and integrated in the database of the DEA is the result of a 4 years data inventory (1993-1996). The database is a joint product of Russian - Norwegian co-operation within the INSROP Sub-programme II and between the Sub-programmes I and II. The process has much relied on the Russian co-partners ability to provide baseline data; - most of the data in the database are supplied by Russian institutions and experts. *Primo* 1998, the DEA has grown into a substantial base of systemised environmental information, containing more than 4,000 individual georeferenced registrations on the temporal and spatial distribution of selected ecosystem components.

The current version of the DEA is derived from the INSROP Geographical Information System (INSROP GIS), and includes examples of the information stored as well as presentation abilities of the textual documentation, tables, charts and maps.

Please note that this issue is a "version 1.0" of the DEA. From the initial data collection, via thematic integration, quality control/quality assurance of the data, to implementation of the database, the compilation of this hard-copy forms one of the milestones in the sequential data inventory process.

Obviously, environmental data surveys are dynamic processes as new data are generated continuously. To maintain the DEA at an acceptable, operative standard, it is the intention of the editors to include regular routines for updating and expanding the database as well as upgrading the system user interface. Selected INSROP GIS routines and data sets of the DEA are planned for distribution on CD-ROM at the end of Phase 2.

Of more importance to the internal INSROP use of the DEA, is the realisation of this knowledge base by the various NSR users and stakeholders. In the NSR, a significant number of development activities is currently being planned or is in the early implementation phases. For many of these activities, such as offshore and land-based oil and gas developments, the DEA may form a significant contribution to the baseline for environmental assessments, decision making and management strategies. It is the overall intention of the Sub-programme staff that the INSROP DEA and the tailored Environmental Impact Assessment (EIA) concept shall be appropriate tools when considering development activities and environmental concerns in the NSR and adjacent seas.

For any questions regarding the INSROP DEA and EIA concepts, please contact the INSROP Sub-programme II secretariat at the Norwegian Polar Institute, Storgata 25A. P.O.Box 399, N-9001 Tromsø. Phone: (+47) 77 60 67 00, Fax: (+47) 77 60 67 01.

May, 1998

Odd Willy Brude
Main editor DEA
oddbr@alphaenv.com

Kjell A. Moe
Sub-programme II Co-ordinator
kamoe@alphaenv.com

Acknowledgment

The editors sincerely acknowledge the stimulating co-operation with all the participants of the INSROP Sub-programme II: Environmental Factors. The Russian co-partners, scientist and experts, technicians and assistants, all contributing to the baseline data organisation of the DEA are especially acknowledged; without their contribution realisation of the Dynamic Environmental Atlas would have been very difficult. The acknowledged Sub-programme participants are (in alphabetic order):

Akvaplan-niva, Norway
Alfred Wegener Institut, Germany
All-Union Research Institute for Nature and Research, Russia
Alpha Environmental Consultants, Norway
Arctic and Antarctic Research Institute, Russia
Central Marine Research & Design Institute, Russia
Department of Indian Affairs and Northern Development, Canada
Det Norske Veritas, Norway
Far East Shipping Company, Russia
GRID Arendal, Norway
Joint Stock Company of Murmansk Shipping Company, Russia
Komarov Botanical Institute, Russia
Krylov Research Institute, Russia
Kvaerner Masa-Yard, Finland
Kurchatov Institute, Russia
Marine Pollution Control and Salvage Administration, Russia
Moscow State University, Russia
National Biological Service, USA
National Institute of Polar Research, Japan
Norwegian Institute for Nature Research, Norway
Norwegian Polar Institute, Norway
NSR Administration, Russia
RSC Kurchatov Institute, Russia
Research Institute of Nature Conservation of Arctic and the North, Russia
SINTEF, Norway
State Marine Academy, Russia
State Marine Research Institute, Russia
St. Petersburg State University, Russia
World Conservation Monitoring Centre, UK
Zoological Institute, Russia
Zoological Museum, Russia

The editors would like to thank the sponsors of INSROP: The Nippon Foundation/Ship & Ocean Foundation, the Russian Federation, the Research Council of Norway, the Royal Norwegian Ministry of Foreign Affairs, the Royal Norwegian Ministry of Environment, the Royal Ministry of Industry and Trade, the Norwegian Regional Development Fund, Norsk Hydro, Norwegian Shipowners' Association, Kværner, the Fridtjof Nansen Institute and the Norwegian Polar Institute for their support.

Chapter 1

The INSROP Environmental Assessment

Author:
Kjell A. Moe, Alpha Environmental Consultants
Rasmus Hansson, Norwegian Agency for Development Cooperation

Introduction - The Northern Sea Route

The Northern Sea Route (NSR) is a collective term for a series of shipping lanes along the coast of the Russian arctic; from Novaya Zemlya in the west to the Bering Strait in the east. The lanes are running in ice-infested waters more or less within Russia's 200 mile economic zone, its territorial or inner waters, and vary in total length between 2,200 and 2,900 nautical miles (figure 1.1).

The NSR is called *"Russia's national transportation artery in the Arctic"*; - in 1991 more than 250 vessels were engaged in cargo operations along the NSR, making a total of more than 900 voyages in the Arctic (Mikhailichenko & Ushakov 1993). For the period 1950-1970, the cargo volume averaged between one or two mill. tons per year. By the mid-1980s this figure had risen to somewhat more than 6 mill. tons (Granberg 1992). Between the peak in 1987 and 1994 however, the volume dropped by a factor between two and three. Statistics for 1994 and 1995 indicate a shift in this tendency, with a total cargo volume of about 2.5 mill. tons on an annual basis (Ivanov et al. 1998).

All cargo transportation is carried out by Russian vessels (Ivanov et al. 1998). Ice-strengthened vessels, including 17 of the ULA and 97 of the UL class transport the major volume. In 1997 the average age of these vessels was 9.3 and 12.2 years. The remaining fleet consists of small conventional vessels of the L-1 and L-3 classes (3-5,000 tons). Compared to the number and age of the vessels in 1991-1992, when the average age was 14 years and more than 50% of the vessels were 20 years and older (Mikhailichenko & Ushakov 1993), the current number (in total 190) and average age indicate that some of the older vessels have been phased out in parallel to the freight reductions. In total 7 nuclear and 13 diesel icebreakers are dedicated for ice-breaking support on the NSR. In 1997, the average age of this fleet was 13.3 and 21.1 years, respectively.

The NSR was officially opened by the government of the Soviet Union to international shipping on 1 July 1991. Commercial utilisation by non-Russian vessels however, has so far been insignificant.

For transcontinental transit, 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. According to 1986 UN transportation statistics, a potential transit volume of 21 mill. ton is estimated (Granberg 1992). 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 (Østreng 1991; 1992). Most likely, improvement and optimilization of several economical, logistical and technical aspects are necessary to make the NSR really international and economically feasible (Wergeland 1991; Ramsland & Hedels 1996).

In longer-term perspectives, it would probably be a mistake to underestimate the potential for increased activity along the NSR, especially with respect of regional development. The Northern Russia holds among the world's richest reserves of petroleum hydrocarbons, 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. Some regulations have been adopted to incite foreign trade and investments in the North, and several initiatives and plans for development and export of these resources have been raised.

Today, the oil and gas sector seems to be most promising. In 1994 the sea-borne export of oil from the Russian Arctic was about one mill. tons. Most of this oil was transported by railway from the

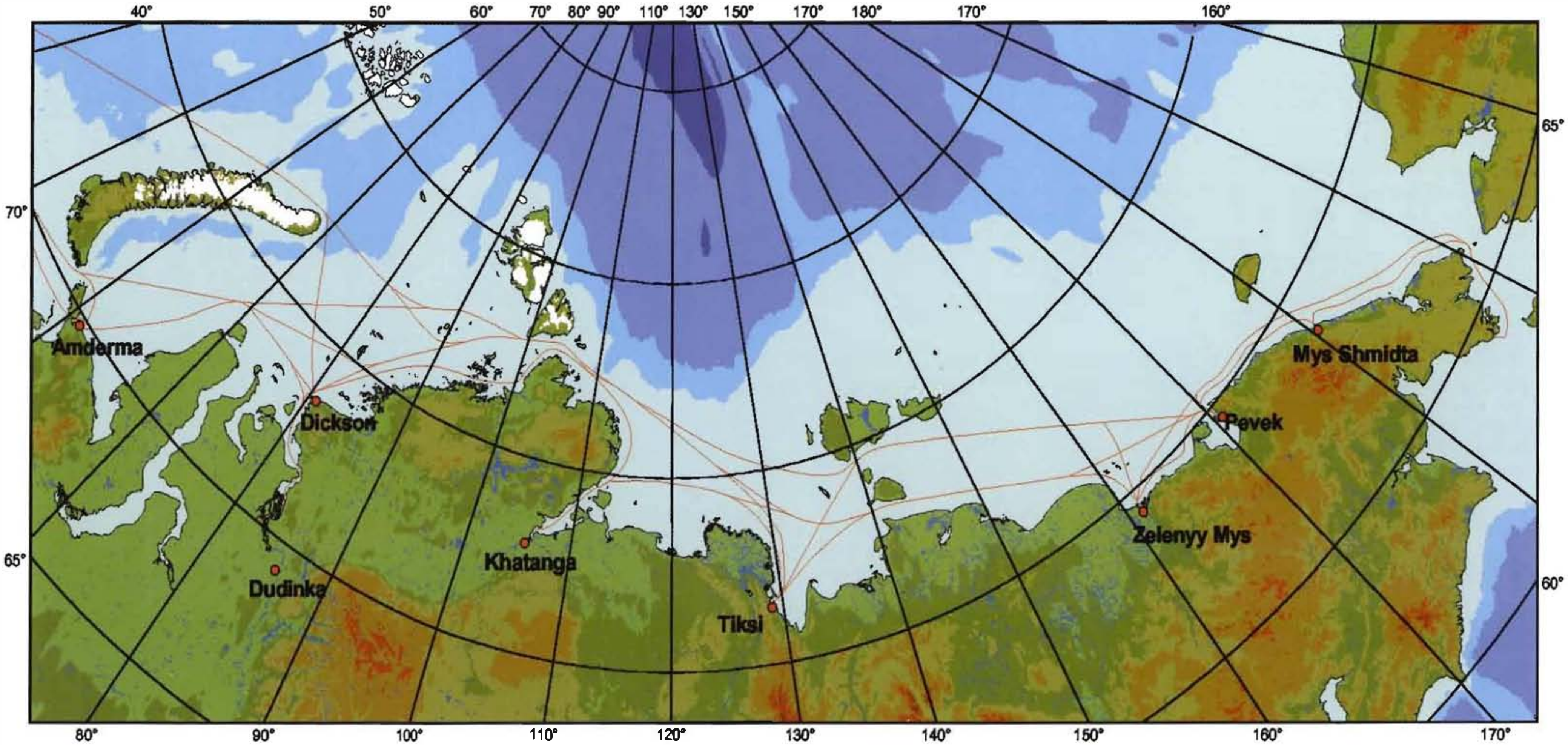


Figure 1.1. *The Northern Sea Route. Historical sailing routes are indicated.*

north-western and central Russia to the large ports of Murmansk and Archangel. The feasibility of sea-borne transportation of oil and gas, from the rich fields in Yamal and Petchora via coastal harbours or loading facilities, as well as from the central Siberia via the large rivers of Ob and Yenisey, has recently been demonstrated both theoretically and practically (Backlund 1995; Ramsland 1995; 1996;EPPR 1997). Correspondingly, the sea-borne export of oil is expected to exceed 4 mill. tons by the end of the century (EPPR 1997).

Environmental concerns

The seas of the NSR are objects to significant regular discharges from local sources both directly and via the large rivers, as well as to long-range transport of contaminants via the atmosphere and ocean currents. Contaminants are widely, but not evenly distributed. Several examples of local contamination by e.g. hydrocarbons, metals, PCB-DDT, and radioactivity are reported by AMAP (1997). For some pollutants, the combined effect of instrinsic (-within the Arctic) and extrinsic (-outside of the Arctic) factors, give rise to concern in certain ecosystem and for some human populations (Hansen et al. 1996; Macdonald & Bewers 1996; AMAP 1997).

The NSR activities may interact with the environment in several ways. Primarily, the regular operations are a point source of long-term/ low level exposure by emissions to air as well as discharges to sea. Oil slicks have proven to be common along sea lanes. E.g. in a narrow, but densely navigated area like the North Sea, the annual amount of petroleum hydrocarbons discharged to the sea by operational shipping activity, is estimated to 2,000 tons (Anon. 1993). At the end of the 1980s, plastic litter was recognised as a major cause of immediate concern (GESAMP 1990). Noise and physical disturbance are other impact factors generated by frequent navigation in ice-infested waters. Release of organo-tin compounds (e.g. tributyltin - TBT) from antifouling paint is likely if non-Russian vessels are introduced to the NSR. TBT is known to cause deleterious effects on several marine organisms (Berge 1997), and was part of the AMAP-priorities.

Secondary, there is an obvious environmental risk concerning accidental events. Although the Russian NSR administration and crews 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.

For the period 1954-1990 the number of ship accidents in the NSR exceeded 800 (Lensky 1992). Severe acute marine pollution due to accidental events however, is not reported (EPPR 1997). The link between accidents and chronic pollution is indicated by Timms et al. (1995), for the *Lenin* case in 1965, as well as for several other reactor accidents in former Soviet Union nuclear submarines and icebreakers. The dumping of these reactors as well as the low-level liquid radioactive waste discharged into the Barents, White and Kara Seas are focal points in Arctic pollution context (Hansen et al. 1996; AMAP 1997).

Indirectly, there is a link between the sea-borne transportation and land-based industrial and infrastructure maintenance and development. Encroachment of the coastal zone is a growing concern worldwide (GESAMP 1990), and habitats are known to be lost irretrievably to the construction of harbours and industrial installations. In tundra areas, disturbance to the thin layer of vegetation covering the frozen soil, can precipitate into dramatic meeting of the underlying ice and result in extensive thermokarst erosion. Infrastructure constructions are perceived as physical hindrances and disturbance to migratory species. In some areas of Western Siberia with extensive petroleum activity, the landscape is made up of narrow strips cleared for pipelines, power lines, roads and survey tracks; - natural habitats are significantly fragmented (Pearce 1993). The impact on wildlife has been observed in the western Taimyr, where pipelines deflected the migration of some 75,000 wild reindeer from the herd (Klein & Kuzyakin 1982).

Onshore petroleum operations are known to produce large volumes of sand, oily wastes and brine. In Western Siberia, several accidental spills and pipeline leaks are reported (Pearce 1993). The Arctic freshwater systems are poorly buffered, with limited ability to withstand pollutants (Atlas 1985). In a pipeline rupture in Komi 1994, the combined mechanisms of the frozen ground as a barrier to and the waterway systems facilitating the vertical transport of oil, were observed when between 14,000 and 270,000 tons of oil were spilled at the tundra, and the rivers of Kolva, Khatayanka and Usa were fouled (Anon. 1994; Sagers 1994).

Adverse environmental effects can be recognised at different ecological levels. If an organism's ability to break down, deactivate and excrete contaminants is exceeded, the constituents, or constituent residues, are accumulated in the organism. As a consequence, constituent residues may pass up the food chain through one or more trophic levels. An ultimate effect of the bioaccumulation, is the exposure of indigenous peoples closely linked to local resources. Their dependence on wildlife harvesting and traditional foods makes arctic population groups particularly vulnerable to certain contaminants.

International Northern Sea Route Programme

Based on the assumption that knowledge of human, cultural, ecological, economical and political parameters is essential before the NSR is exposed to a sharp increase in use, the International Northern Sea Route Programme (INSROP) is designed to: *build up a scientifically based knowledge foundation encompassing all relevant aspects of the shipping and the navigation complex in the NSR, to enable public authorities and private interest to make rational decisions based upon scientific insight rather than mythology and insufficient knowledge* (Østreng 1993).

However, it is *not* the task of INSROP to legitimise an increased use of the NSR based upon economic interests, or for that matter, a closing of it based on environmental interests. Such decisions are entirely up to the Russian government at any time.

In the Phase 1 (1993-95), the INSROP was organised in four equivalent sub-programmes:

- I Natural Conditions and Ice Navigation
- II Environmental Factors
- III Trade and Commercial Shipping Aspects
- IV Political, Legal and Strategic Factors

This research resulted in some 120 INSROP Working Papers, about 10 scientific and technical papers, in addition to a hardcover volume containing the proceedings of the INSROP Symposium Tokyo '95. A complete list of the INSROP publications, as well as the individual reports of interest, can be ordered through the programme secretariat at the Fridtjof Nansen Institute, Norway.

After an independent evaluation by an eight-member international evaluation committee of scientists chaired by retired US Coast Guard captain and scholar Lawson Brigham, the three co-operating partners in INSROP have decided to carry out a two-year Phase 2 in 1997-98. The research within the auspices of the four sub-programmes will continue. Correspondingly, a large-scale simulation of NSR sailing based on different scenarios will be carried out, and digitised information about the NSR in the form of the INSROP Geographical Information System (INSROP GIS) will be developed. In addition to 2-4 newsletter per year, the Phase 2 will produce more Working Papers on the selected project research issues and one or two books based on the analysis and integration of five years of multi-national and multi-disciplinary research.

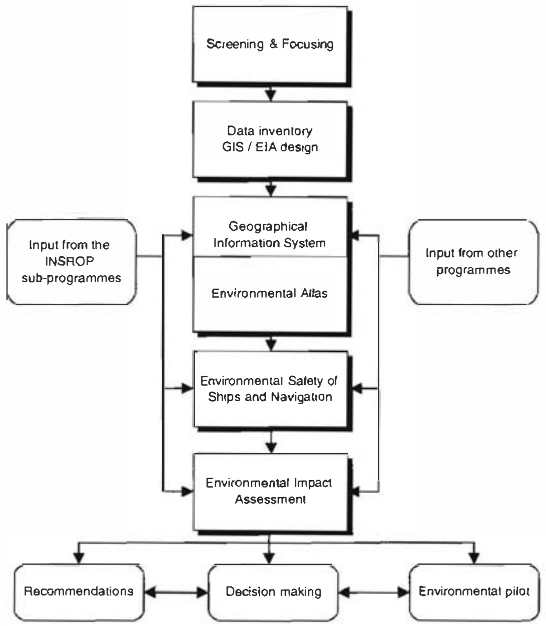


Figure 1.2. *The conceptual design of INSROP Sub-programme II: Environmental Factors - main components and interactions.*

The INSROP SEA-EIA

The INSROP Environmental Factors (Sub-programme II) is a large-scale strategic assessment of the potential environmental impacts of shipping, navigation and related activities on the NSR. The Sub-programme is designed to produce the foundation for political and commercial decision making on environmental conditions in the NSR to reflect national and international concerns for the arctic environment and for Northern indigenous peoples (Hansson & Moe 1996).

At the start in 1993, four main components were included in the Sub-programme. The study was organised for implementation in three conceptual phases (see figure 2). The information generated by the Dynamic Environmental Atlas (DEA), the Environmental Safety of Ships and Navigation (ESSN), as well as the other INSROP sub-programmes, are stored and integrated in the INSROP GIS, and analysed within the Environmental Impact Assessment (EIA). The ESSN represents selected guidelines, procedural manuals and emergency plans (Semanov 1996), while the EIA forms the basis for public information, recommendations, decision making and environmental management strategies in line with the INSROP aims (Hansson & Moe 1996).

The principle for such priorities is simple and logic; - to carry out consistent impact assessments for a given human activity, it is necessary 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 human activity in the short and the long term. Developing mitigating measures, either as precautionary principles or task-specific measures, is logically tiled to this kind of resource-impact relationships (Hansson & Moe 1996; Moe et al. 1995; 1997). In the INSROP EIA, tailored methods are developed to obtain maximum transparency and reliability of these analyses (Thomassen et al., this issue).

The concept and role of the DEA and INSROP GIS

The DEA forms the baseline environmental data sets for the impact analyses and the assessments.

Focusing on the natural environment, Sub-programme I on a geophysical approach - Sub-programme II from an ecological point of view, the sub-programmes have a common foundation for their study. Consequently, joint effort has been placed on baseline data inventories and development of convenient information systems for storage, retrieval, integration and analyses of the information obtained.

The INSROP GIS is a result of such sub-programme collaboration. The system is intended to serve two correlated purposes: a) during INSROP, to serve as a IT-tool for organisation and storage of INSROP data and for project-related analytical work; and b) to grow into a computerised up-to-date realisation of the INSROP knowledge base (Løvås & Smith 1996).

The INSROP EIA is concentrated on a limited number of priority issues; - Valued Ecosystem Components (VECs), which have been carefully selected from a large and complex biogeographical region and potential NSR activities-impact relationships (Thomassen et al. 1996a; b). In this context, indigenous peoples form an individual component, in terms of their regional and local distribution, current status, development, and subsistence/ utilisation of natural resources, respectively (Dallmann 1997a; b).

The first step of the baseline data inventory on the selected VECs was carried out in 1993-94, in form of a pilot survey on identification of existing Russian and other relevant data (Gavrilo & Sirenko 1995). All the references are stored in a database, including 963 titles of Russian monographs and papers; each supported by key words for taxa, geographical area and main ecological issues discussed.

The INSROP GIS design was developed in parallel (Løvås et al. 1994), with outlines on system infrastructure, data format specifications, and the thematic integration. The organisation of data flow is discipline oriented. The institutions responsible for the five DEA-projects have also been responsible of supplying the baseline data, including information of the data itself (metadata). The Russian co-partners of these projects are key personnel in the data flow, and personnel and institutional network building is emphasised (Bakken et al. 1996a). In the second step of the data inventory (1994-96), significant effort was devoted to mapping of the selected VECs; i.e. collecting data on the temporal and spatial distribution of coastal zone attributes, invertebrates, fish, birds and marine mammals (see table 1.1). Quality Assurance/Quality Control (QA/QC) have been carried out by the thematic integrators, e.g. the DEA project responsible in collaboration with the GIS co-ordinator at the Norwegian Polar Institute, who has been responsible for the overall data integration and distribution (Løvås & Brude 1996). A simplified scheme of the data flow and integration is given in figure 1.3.

Data content

The success of the DEA has relied on the Russian co-partners ability to provide baseline data; - most of the data in the database are supplied by Russian institutions and experts. *Primo* 1998, the DEA has grown into a substantial base of systemised information, containing more than 4,000 individual georeferenced registrations on the temporal and spatial distribution of the selected VECs (see table 1.1). The standard tabular information includes attributes like species name, observation counts (mean, minimum and maximum number), observation time, trend, source reference etc. Detailed descriptions and analyses of the data obtained are given in INSROP Working Papers by Bakken et al. (1996b); Dallmann (1997a); Gavrilo & Sirenko (1995); Larsen et al. (1995; 1996) and Wiig et al. (1996).

Much of the information in the DEA is published for the first time abroad of Russia, which makes the DEA an unique product. Even there are still gaps to fill, the database provides the best available data for the analyses and the assessments of the INSROP EIA.

However, environmental data surveys are dynamic processes. Older data my be reassessed and recompiled, as well as new data are generated by the field studies carried out in the NSR area each year. Both types of information may contribute to improved understanding of the arctic environment in the long term. Hence, to maintain the database at an operative, acceptable standard, continuously maintenance is quite necessary. Regular routines for updating and expanding the database as well as upgrading the system user interface are therefore included in the scope of work of INSROP Phase 2.

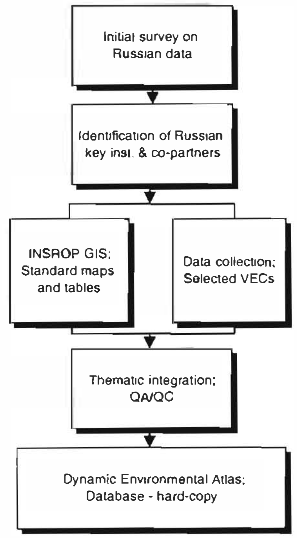


Figure 1.3. *A simplified scheme of the Dynamic Environmental Atlas conceptual data flow.*

Table 1.1. *Selected Valued Ecosystem Components of the DEA, including Indigenous-local peoples; water-border zone; benthic invertebrates; fish, birds and marine mammals. The data sets are presented in details in the following sections and additional information can be found in Bakken et al. (1996b); Dallmann (1997a); Gavrilo & Sirenko (1995); Larsen et al. (1995a; 1996); Wiig et al. (1996).*

Selected Valued Ecosystem Components - VECs

Indigenous-local, native peoples: Human settlements; residence and subsistence areas of in total 16 northern indigenous minorities + 2 additional major ethnic groups

Water-land border zone:
- Shoreline features
- Substrate - topography
- Inundated riverine areas, also including polynyas

Benhtic Invertebrates, incl. distribution of:
- Sampling and monitoring stations
- Sediment features
- Biocenosis
- Species name and numbers (more than 2,000 different taxa)

Marine, Estuarine and Anadromous Fish, incl. distribution of:
- Scorpion fishes (25 taxa)
- Salmonids (17 taxa)
- Gadoids (16 taxa)
- Whitefish (6 taxa), incl. recorded landings

Birds, incl. breeding/non-breeding distribution of:
- Brunnichs guillemot
- Black guillemot
- Common guillemot
- Ivory gull
- Ross gull
- Kittiwake
- Common eider
- King eider
- Stellers eider
- Spectacled eider
- White-fronted goose
- Barnacle goose
- Brent goose, incl. dark bellied B. goose
- Bean goose
- Emporer goose
- Long-tailed duck
- Waders; feeding and resting areas

Marine mammals, incl. distribution, abundance, migrations, feeding and breeding areas of:
- PolarBear
- Walrus
- Bearded seal
- Ringed seal
- White whale
- Gray whale
- Bowhead whale

INSROP Geographical Information System

Authors:
Stig Magnar Løvås, SINTEF Civil and Environmental Engineeing
Odd Willy Brude, Alpha Environmental Consultants

Introduction

The geographical information system (GIS) within INSROP is intended to serve two correlated purposes: 1) during INSROP, to serve as a tool for organization and storage of INSROP data and for project-related analysis work; and 2), to grow into a computerized up-to-date realization of the INSROP knowledge base. In Sub-programme II, the INSROP GIS integrates data from the Dynamic Environmental Atlas (DEA) with other INSROP derived information and will serve a tool for integrated analyses and documentation on the final outcome in the Environmental Impact Assessment (EIA). All maps presented in this DEA are direct outcomes of the information available in the database of INSROP GIS. In addition to storage of georeferenced information for various topics, related tabular information are included for optional characterisation and analyses of the spatial elements. This tabular information can be linked or joined to the specific spatial data. An example from the INSROP GIS *layout* module is presented in figure 1.4.

All data deliverables, with Russian Institutions as major sources, have been made on standardized INSROP maps with additional tabular information. These data are implemented into the INSROP GIS according to standards described in Bakken et al. (1995). The result of establishing a structure protocol for automating digital information will ensure potential INSROP users that automated data in the GIS database have been created using one set of standards and that detailed information about this process is available for further review.

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 transferring the data for overall integration and distribution. After implementation, all maps and tables are printed and distributed to the project supervisors for QA / QC. In addition, there are also produced descriptive data (metadata), e.g. documentation of all the implemented datasets, describing basic data characteristics and providing the user to assess data quality and determine missing or suspect information.

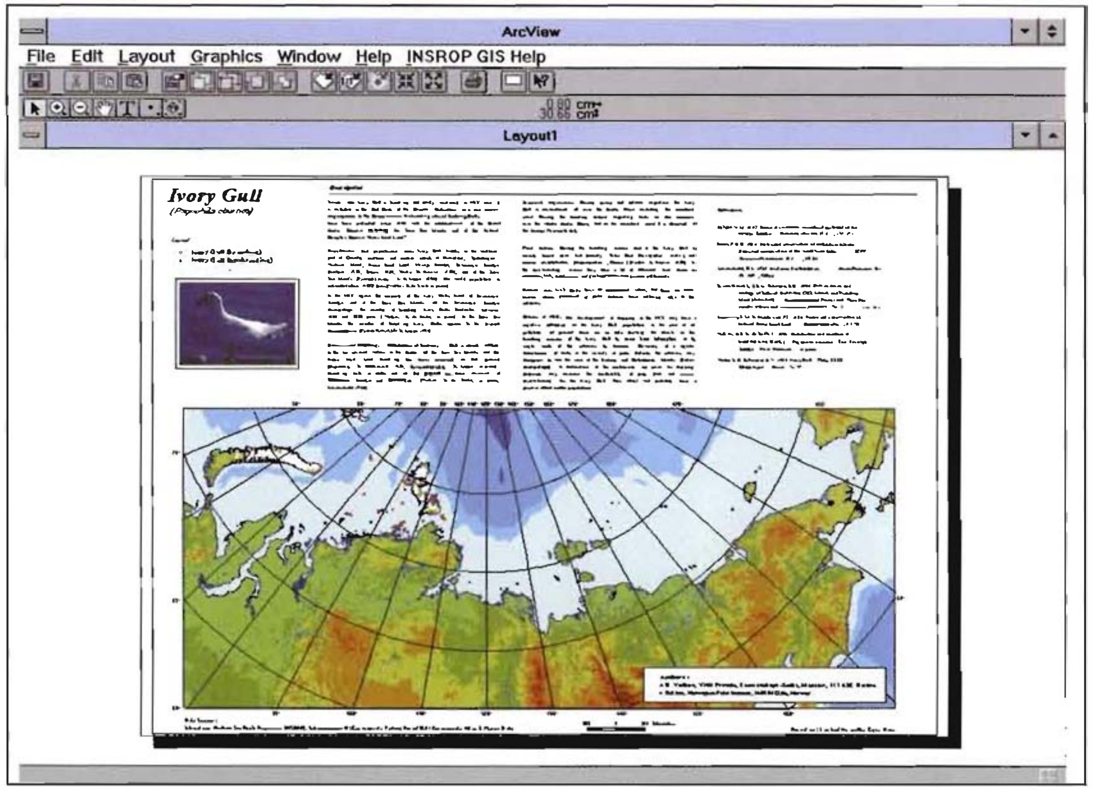


Figure 1.4 : *INSROP GIS layout showing an example of the cartographic possibilities for output from the system.*

INSROP GIS Basics

INSROP GIS is a customized GIS application based on ArcView® 3.0 software for use on PCs (486 or better) running Microsoft Windows. However, as part of the INSROP GIS concept, ARC/INFO®, running on UNIX workstations, is used to prepare the data sets for use by ArcView and to carry out analysis tasks beyond the capabilities of ArcView on a PC. These products, developed by ESRI (Environmental Systems Research Institute, Redlands, California, USA) are widely used by the GIS community and provide the necessary tools required to develop a comprehensive GIS application. INSROP GIS (as ArcView) works with *views, tables, charts, layouts, and scripts*, stored in one file called a *project*. A project file store information about the content and status of each project component, including storage locations of the data sets used in the project. Spatial data can be ArcView shapefiles or Arc/Info coverages, but routines are also made for converting plain ASCII files or Excel tables with coodinates into ArcView shapefiles (points, lines or polygons). Shapefiles can also be created interactively.

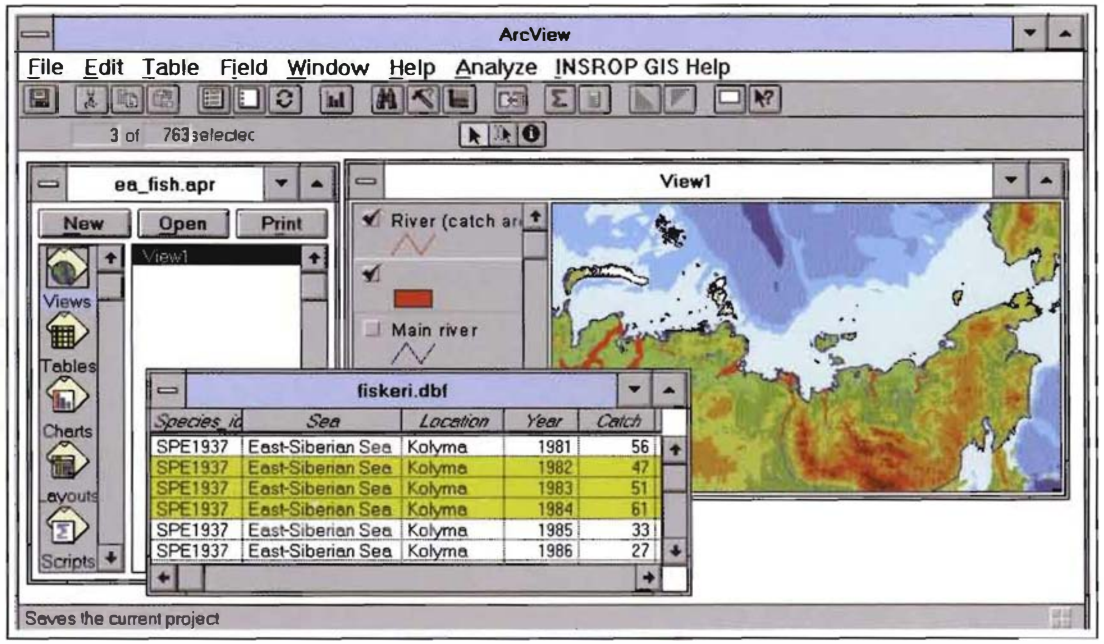


Figure 1.5 : *INSROP GIS interface showing a project vindow (left) a view (right) and a table (bottom). INSROP GIS documentation and help files are included as hypertext (top right menu).*

In addition tabular data or attribute data can easily be imported (dBase, INFO or ASCII format) and joined /linked to the existing spatial data attribute tables. Figure 1.5 shows an example of the INSROP GIS interface.

Queries And Analyses

Both queries and analyses are aimed at processing available data to provide new insight or new higher-level information. ArcView provides a general set of options for tabular queries and spatial analyses. However, both these types are in fact selections, in the sense that they isolate the part of the data base that satisfies certain criteria.

The INSROP GIS analyses are developed to serve special INSROP needs, and may also include a set of selections. However, they generally form more complete operations by asking the user for input data required to run the analysis, run the analysis as a pre-defined sequence of analysis steps, and report/display the outcome of the analysis. The INSROP GIS analyses are developed to solve tasks specified in co-operation with the responsible INSROP data sets / projects and are found under the tiltle heading Analyses or Queries in the INSROP GIS *view* interface (for example of the INSROP GIS use in the EIA, see Thomassen et al., this issue).

Arctic Ocean - Some Physical Characteristics

Author :
Kjell A. Moe, Alpha Environmental Consultants

Introduction

The Arctic Ocean comprises the deep central basins and the marginal seas; Chukchi-, East Siberian-, Laptev-, Kara-, Barents- and Beaufort Sea, a total area of 14 million km². Four passages are connecting the seas to the world oceans. The Bering Strait opens to the Pacific, while the other three, the Canadian Arctic Archipelago, the Fram Strait and the Barents Sea, communicate with the North Atlantic.

A dominant characteristic of the Arctic Ocean is the year-round presence of a dynamic ice cover, which substantially alters heat, salt, and momentum transfers between the atmosphere and the ocean, and hence has the potential to alter atmospheric and oceanic circulation (Hibler 1989). (For details on the ice conditions, see next section.)

The seas at high latitude are also areas of deep-water formation (Rudels 1987). This renewal and ventilation of the deeper layers play a part in the global carbon dioxide system and add a further climatological aspect to the oceanic conditions in the Arctic.

An estimated total of 3,300 km³ fresh water enters the Arctic Ocean annually from the major rivers surrounding the basin (Aagaard & Carmack 1989). The contributions by the Russian rivers, as indicated in figure 1, are more than two thirds of this volume. The individual contributions of the major rivers are given in table 1.2.

Table 1.2. *Mean annual runoff to the Arctic Ocean in cubic kilometers per year. After Aagaard & Carmack (1989). There are significant annual and interannual variations in the flows.*

River	Volume
Yenisey	603
Ob	530
Lena	520
Pechora	130
Northern Severnaya Dvina	110
Kotuy	105
Kolyma	102
Pyasina	86
Indigirka	57
Mackenzie River	340
Other, smaller rivers	720
Total	3303

The physical characteristics of the Arctic Ocean, in terms of the stratification and processes on the shelves, are probably the primary oceanographic controls of contaminant transport and distributions (Macdonald & Bewers 1996; AMAP 1997).

Bottom topography

The Arctic Ocean is divided into two basins separated by the Lomonosov ridge (1,200-1,400 m below the surface); the Canadian Basin with depth about 3,800 m, and the Eurasian Basin with depth about 4,200 m. These basins are to some degree decoupled from one another allowing distinct differences in salinity, water-mass structure, and current patterns (Aagaard & Carmack 1989; Rudels et al. 1992).

The broad continental shelf off Siberia, 200 to 800 km wide and with water depths down to 100 m, occupies about 36 % of the area of the Arctic Ocean, but containing only 2 % of the total volume of water in the sea (Pichard 1975). The bathymetry of Arctic Ocean is shown in figure 1.6

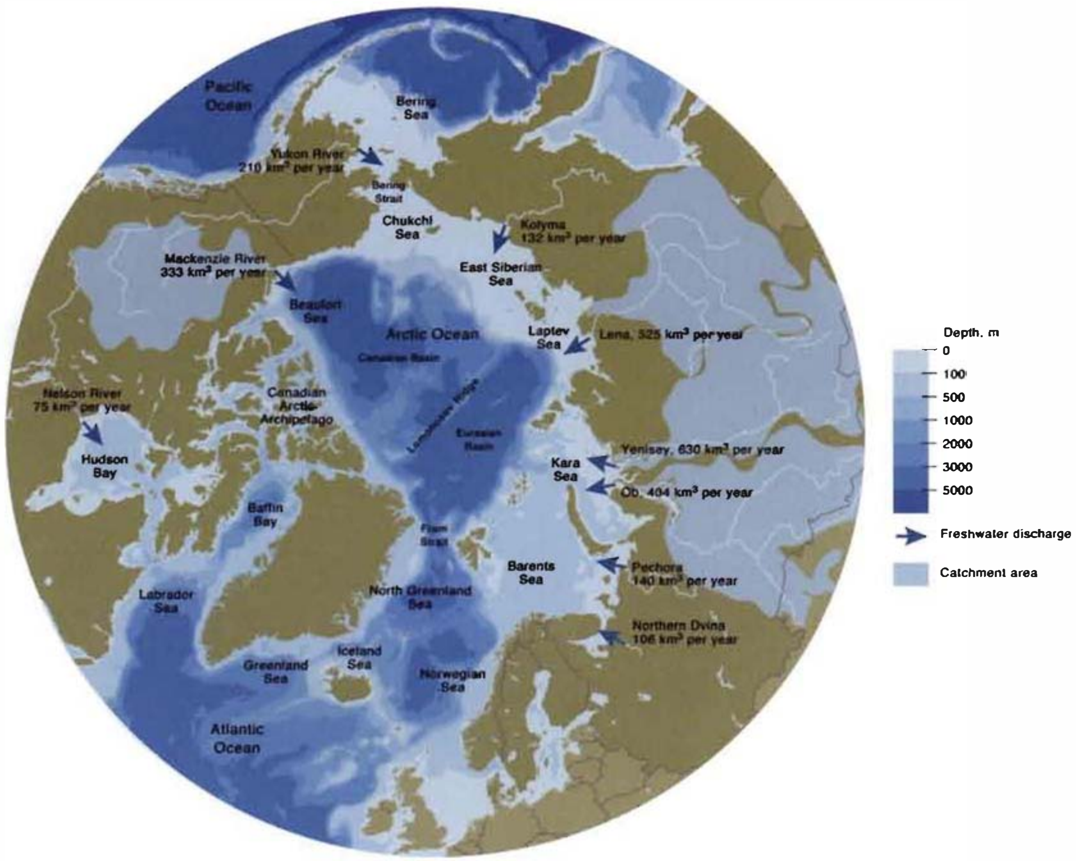


Figure 1.6. *The bathymetry of the Arctic Ocean and adjacent seas and freshwater input from major rivers. After AMAP (1997).*

Oceanography

The oceanography of the Arctic Ocean is dominated by two contending processes (Rudels 1987):

- The fresh water discharge inhibits vertical mixing and drives an estuarine circulation between the Arctic Ocean and the Atlantic.
- The heat loss in the winter results in ice formation and water mass transformations. The transformations, which occur on the shelves, may be substantial and create water masses dense enough to sink down to the deeper layers of the water column and induce a deep circulation.

The effects of these two processes are seen in the stratification of the Arctic Ocean. The strong stability inhibits vertical mixing and allows the water masses, which enter from the North Atlantic, the warm Atlantic and the deep waters, to be distinguished beneath the fresher upper layer comprising the Polar Mixed Layer (PML), the Halocline and the Pacific inflow. Still, the characteristics of the advective water masses depart substantially from their "source" values and thus reveal the deep injections of dense water created on the shelves by the ice formation (Rudels 1987).

Except for the river outlets and estuaries, the surface layer is much the same across the whole Arctic (Pichard 1975). However, significantly influenced by the melting and freezing of ice, the salinity in the upper 25-50 m range from 28 to 33.5 ‰. The temperature also is controlled by melting and freezing of ice which involves considerable heat transfer. In consequence, the temperature remains close to the freezing point of the water (÷1.5 °C at a salinity of 28 ‰ to ÷1.8 °C at a salinity of 33.5 ‰).

The seasonally cycling of the PML include brine produced by ice formation in winter which tends to destabilise the water column, allowing it to mix, while in summer, melting ice and freshwater runoff produce stratification with a fresher surface layer (5-10 m). Hence, it is the PML that is in immediate (annual) communication with the atmosphere and ice, and it is here and within the ice that most of the biological primary production occur.

Beneath the PML there is region of increasing salinity (e.g. the halocline), which act as a barrier between the upper ocean and the deeper ocean.

In the Eurasian Basin the subsurface layer has shown to be isothermal to 100 m, but with a strong halocline between 25 and 100 m. Below 100 m the temperature increases markedly but the salinity only increases slowly. This complex region, with Atlantic water thought to be supported by insertion of water masses produced on the shelves, has been called the lower halocline to distinguish it from the Pacific layer (Schlosser et al. 1995).

The Atlantic water, which pervades both Arctic basins, is found at depth from about 200 to 900 m. This water is recognised by having a higher temperature than the water above and below. When entering on the Spitzbergen side of the Greenland-Spitzbergen gap, its temperature is up to 3 °C and its salinity is 34.8 to 35.1 ‰. Both temperature and salinity decreases gradually as the water flow within the Arctic Ocean.

In the Canadian Basin, the Pacific water, which has been modified as it passes over the Chukchi shelf, is found between about 50 to 250 meters (Macdonald et al. 1989). A similar halocline is recognised, but its temperature structure is different. Attributed to the Pacific inflow, there is a characteristic temperature maximum at 75-100 m depth. The inflow water is warmer than the Arctic surface water, but slightly denser because of its salinity, and presents one of the few examples of a subsurface temperature maximum occurring in the Ocean.

The Arctic bottom water extends from about 900 m depth to the bottom and comprises about 60% of the total water volume of the Arctic Ocean (Pichard 1975). The salinity variations are small, from 34.9 to 34.99‰, and the temperatures reaches minimum of ÷0.8 °C at 2,500 m and ÷0.4 °C at 2,000 m in the Eurasian and Canadian Basin, respectively.

Circulation and transport

The surface layer movement is best described as a clockwise circulation in the Canadian Basin (the Beaufort Gyre) leading out to the East Greenland current, and, in the Eurasian Basin, a movement by the Transpolar Current, the most direct path towards Greenland and out in the East Greenland Current (Pickard 1975). In the marginal seas and the Russian shelf waters, less significant gyres and counter-clockwise circulation are recognised. The surface water circulation pattern is shown in figure 1.7.

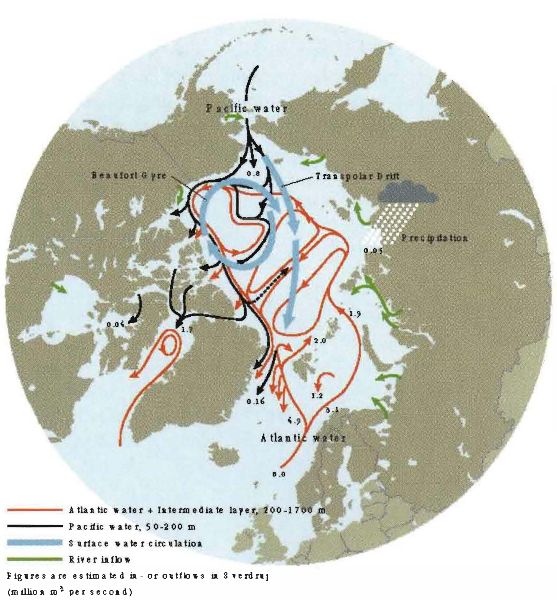


Figure 1.7. *The circulation pattern of surface water in the Arctic Ocean. After AMAP (1997).*

The largest transport is generally assumed to take place through the Fram strait, with depths of 2,500 m. The two most important components of the exchange are the warm Atlantic water carried by the West Spitzbergen Current (estimated inflow: $1x10^6$ m^3 s^{-1} to $7.1x10^6$ m^3 s^{-1}) and the export of cold Polar Surface Water and ice (estimated outflow: $2x10^6$ m^3 s^{-1}) in the East Greenland Current (Rudels 1987). In addition, all deep water exchange occurs in the Fram Strait.

The time scale of transport or replacement of water masses varies among the layers. The surface current speeds are of the order of 1 to 4 cm/sec (300-1,200 km year). In relation to the size of the Arctic Ocean, which is approximately 4,000 km across, the upper layers has an estimated residence time of 3-10 years, compared with about 5 years, on average, for the ice (Pichard 1975; Barry 1989; AMAP 1997).

The haloclines also have residence times of 10 years order (Macdonald & Bewers 1995), but in the deeper Atlantic layer the residence time increases to perhaps 30 years (figure 1.8). The basin waters have the longest time scale, measured in centuries (Schlosser et al. 1994).

Fate of pollution

For many contaminants, such as most persistent organic pollutants, local sources within the Arctic cannot explain their occurrence. Long-range transport is evident. According to Macdonald & Bewers (1996); AMAP (1997), there are five main modes of contaminant entry into the Arctic Ocean. These are:

- Deposition from the atmosphere
- Inflowing ocean currents
- Northward flowing rivers
- Direct runoff from the land
- Direct disposal into the sea

The distinguishing characteristic of the Arctic is its comparatively low temperature. Because low temperatures reduce volatilisation, semi-volatile compounds can be preferentially transported to the Arctic by a "global distillation" process in much the same way as there exist a net transport of heat from the equatorial to polar regions (Ottar 1981; Mackay & Wania 1995; Macdonald & Bewers 1996). The primary medium of such transport for semi-volatile and insoluble substances is the atmosphere rather than the sea (Barrie et al. 1992). For more soluble and less volatile substances however, oceanic transport may be more important.

substances in the Russian northern rivers, especially in the Ob (oil, ammonium and nitrogen), in the Yenisey (oil and zinc), and in the Indigarka (phenols). Dissolved contaminants are free to travel directly into the coastal waters. For the particle-reactive compounds, the flux is a function of the river outlet pattern. Many of the rivers form deltas and estuaries, where particulate contaminants can be trapped in the sediments. Subsequently resuspension and transport across the shelves can be generated by temporal changes in water turbulence.

In the lower Yenisey River and the Yenisey estuary, high levels of DDT and PCB have been observed in fish and other organisms (Champ et al. 1995). In addition, a large (180 to 200 km) depositional zone of contaminated loose bottom sediments has been found to contain five to ten times the background levels of Cs-137.

in the vicinity of the dumped objects, no sign of dumped nuclear waste has so far been observed in the open waters of the Kara Sea (Salbu et al. *in press*).

Results from large-scale programmes like AMAP and recent reviews of the fate and effects of contaminants in the Arctic reflect the international communitys growing concerns for the Arctic environment. The current understanding of pollution issues, their priority and importance, is however fragmentary and far from complete. In many cases, like for the Russian shelves, the baseline data are simply not adequate for the task of assessing what action is needed.

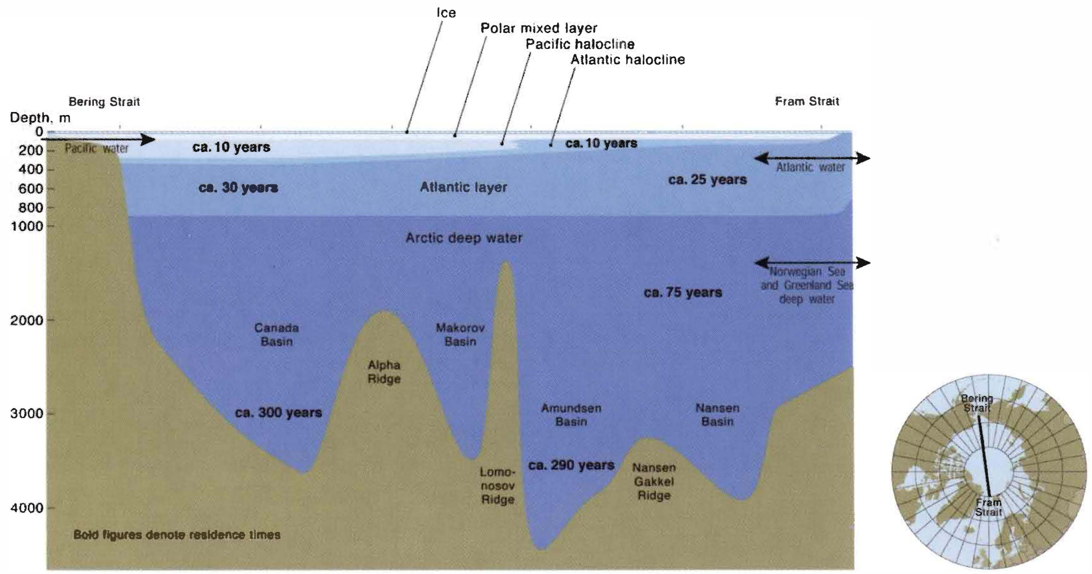


Figure 1.8. *Vertical section of the Arctic Ocean and the different water masses with their approximate residence time. After AMAP (1997).*

The atmospheric pathways into the Arctic are complex, and include pollutants generated locally as well as by far-distant sources. The emissions from the Noril'sk Mining and Metallurgic Combine, which at present (1994-95) are about 2 mill. tons annually (Vilchek et al. 1996), reflect local source pollution, while the input of persistent organic compounds from the heavily industrialised areas of eastern and northern Europe and Asia are examples of long-range atmospheric transport (Barrie 1986; Klungsøyr et al 1995; Chernyak et al. 1996).

Radiocesium, although somewhat particle reactive, discharged by the reprocessing plants of Sellafield and La Hague, are the most clearly documented examples of long-range ocean current transport of contaminants to the Arctic Ocean. Contrary the atmospheric transport time, which are shown to be days or weeks, the transit time of the oceanographic circulation is measured in years.

According to Vilchek et al. (1996), the Russian pollution standard Max. Permissible Concentration (MPC) is exceeded for many

Significantly elevated concentrations of trace elements or hydrocarbons however, have neither been observed in the Petchora River system or in the Lena River estuary (Martin et al. 1993). Such results may be explained by the combined effect of the river volumes (cf. table 1.2), the estuarine circulation pattern (including the seasonal stratification) and relatively strong coastal currents, facilitating a contaminant transport across the shelves.

Direct discharges from land-based sources or from shipping activity are generally more significant in sheltered water with less pronounced circulation. The gulfs of Kola, Teriberskiy and Motovskiy are all reported to be highly polluted by phenols and petroleum products (Vilchek et al. 1996).

In the period of the Former Soviet Union (FSU), nuclear wastes were stored on the frozen ground, or discharged and dumped into the rivers and onto the shelves in the Barents and the Kara Seas (Champ et al. 1995). Studies in the Kara Sea have demonstrated leakages from the wastes. The contamination however, is localised

Sea ice conditions

Authors:
Stig Magnar Løvås, SINTEF Civil and Environmental Engineering.
Sylvi Vefsnmo, SINTEF Civil and Environmental Engineering.

Introduction

Sea ice includes any form of ice found at sea which has originated from the freezing of sea water, and has two main sub-divisions: Pack ice and Fast ice. Sea ice is a complex medium requiring many descripting attributes. Ice concentration is a measure of the mean areal density of ice in an area, while Stage of development classifies the ice in terms of how it is formed and/or age. The main classes are New ice, First-year ice and Old ice, but each of these have sub-classes. The terms used to describe stage of development also indicate the thickness of the ice, but ice thickness may also be given explicitly. Other descriptors for sea ice are Forms of ice (floe size etc.), Arrangement (e.g. Ice massif, ice edge), Pack-ice motion processes (diverging, compacting, shearing), Deformation processes (fracturing, hummocking, ridging), Openings in the ice (Crack, fracture zone, lead, polynya), Ice surface features (level, deformed, rafted, ridge, hummock, bare/snow-covered ice, etc.), and Stages of melting (Puddle, thaw holes, dried/rotten/flooded ice).

Sea ice conditions along the NSR

The ice conditions along the NSR are dynamic, leading to large annual, seasonal and regional variations. In the winter months November to April the whole region is covered by very dense drifting ice and fast ice. Seaward of the fast ice boundary, the ice cover is in constant motion due to currents and winds. The thinnest ice is mainly found in the southern Kara and Laptev Sea. Large ice fields observed in the same regions each summer are called ice massifs and the Taymyr, Ayon and Wrangel massifs are the most important obstacles to ship traffic along the NSR since the massifs contain significant concentrations of multi-year ice and frequently heavily hummocked ice is present. The summer season for the region occurs roughly from June to September, when the ice cover melts significantly, diminishing in both extent and strength. The greatest seasonal fluctuation occurs at the east and west ends of the route. This is due to the influence of ocean currents moving northward from warmer Atlantic Ocean in the west and the Bering Sea in the east, which accelerate the ice decay in the spring and retard the freeze-up in the fall. The coastal zone is occupied by fast ice in the winter period which is non-uniformly developed. Fast ice begins to form in mid-October in the fresher water of the river estuaries and expands to cover most of the continental shelf up to 500 km from the mainland.

Kara Sea

In the *Kara Sea* the ice formation starts in September in the northern sea regions and in October in the southern part. From October to May almost the entire sea is covered with ice of different type and stage of development. In June to September the ice concentration is low in the Kara Sea, especially in the western part where drifting thick ice may be present. In the eastern part, especially the Severnaya Zemlya massif, the ice concentration is higher and the ice consists mainly of thick first-year ice. When the seasonal ice minimum is reached by mid September the entire Kara Sea south of 75°N is normally ice free. In extremely mild summers, the Kara Sea may become ice free as far north as 80°N. The coastal zone is occupied by fast ice which is non-uniformly developed. Seaward of the stranded ice there is a zone of open water or young ice. The region of the flaw polynyas are the Amderma and Yamal polynyas in the south-western sea part and the Ob'-Yenisey polynya in the south. In the spring period the drift in the Kara Sea has a prevailing direction westward and southward while in summer mainly to the south-west and south.

Laptev Sea

The *Laptev Sea* has the largest expance of fast ice in the world from January to June. The fast ice thickness typically reaches 200 cm due to mean midwinter air temperature of -30 °C and can grow up to 250 cm during severe winters. The amount of old ice in the Laptev Sea is limited due to wind directions and ocean currents. The total area of summer melt is particularly extensive due to the reduced amount of old ice. In the western part the ice drift is southwards and large masses of ice are deposited along the coast of Severnaya Zemlya and the Taymyr Peninsula. Along with the eastward ice deposition from the Kara Sea, the Vil'kitskogo Strait and the Taymyr coast present a serious challenge to navigation at all times of the year.

East-Siberian Sea

The *East-Siberian Sea* is the shallowest of the Eurasian seas. The broad continental shelf allows fast ice, averaging from 170-200 cm thick, to extend as far as 500 km outward from the coast. In winter the prevailing wind direction is from the south producing weak ice conditions and potential navigation lanes at the outer edge of the fast ice as they do in the Kara and the Laptev Seas. East-Siberian Sea has the highest fraction of old ice and the Ayon massif has more than 60 % of old ice on average and the average thickness may be 250 cm in the winter months. In summer the winds shift to northerly and the ocean currents favour the influx of ice from the north resulting in the permanence of the Ayon massif. Winter freeze-up begins in the north in September and is usually complete by mid-October.

Chukchi Sea

The *Chukchi Sea* is almost ice covered from early December to mid-May. The seasonal variations in the ice conditions are large resulting in loosing about 80 % of its maximum winter extent in the summer season. Important factors influencing the variability are the bathymetry, wind, currents, air temperature and the presence of Wrangel Island. Ocean currents and wind tend to transport old ice from the Arctic to the Longa Strait under great pressure, which sometimes presents the greatest obstacle on the route.

About the maps

The maps on this page (figure 1.9) show probability of ice in a winter (March) and a summer (September) month. The statistical analysis is based on the digital database of 10-day ice charts prepared by the Arctic and Antarctic Research Institute (AARI), St.Petersburg, Russia. The database covers the years 1967-1990 and was acquired via internet from the National Snow and Ice Data Center (NSIDC), Boulder, Colorado, USA. The statistical analysis was carried out by SINTEF Civil and Environmental Engineering, Trondheim, Norway.

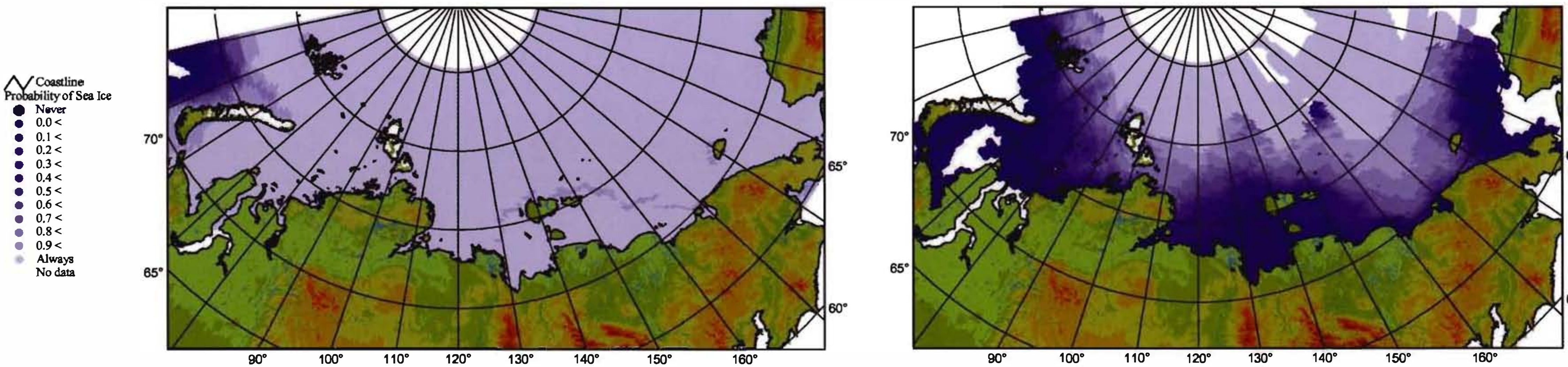


Figure 1.9. *Probability of sea ice in the NSR area in March (left) and September (right).*

Sea ice stage of development

Authors:
Stig Magnar Løvås, SINTEF Civil and Environmental Engineering.
Sylvi Vefsnmo, SINTEF Civil and Environmental Engineering.

Introduction

The waters of NSR are covered by ice in different stages of development. Sea ice which forms and remains fast along the coast are called fast ice. Sea-ward of the fast ice boundary, the pack ice may experience openings (leads) and converging areas where the ice crushes together to form pressure ridges. During the freezing period, new ice is continually being produced in the leads. Ice in the transition stage between new and first-year ice (10-30 cm in thickness) is called young ice. Sea ice which has survived at least one summer melt is called old ice, but may be sub-divided into second-year and multi-year ice.

Old ice

Minor fractions of old ice are found in the western part of the Kara Sea. West of Severnaya Zemlya the fraction of old ice varies between 20-40 % and the thickness may reach 160-180 cm in late winter. The amount of old ice in the Laptev Sea is limited due to wind directions and ocean currents. In the western part of the Laptev Sea the ice drift is southwards and large masses of ice are deposited along the coast of Severnaya Zemlya and the Taymyr Peninsula. The main old ice found in the southern Laptev Sea is in the Taymyr massif. The majority of this old ice persists through the summer and the mean ice thickness may reach 200 cm. The East-Siberian Sea has the highest fraction of old ice and the Ayon massif has more than 60 % of old ice on average, where the thickness may be up to 250 cm in the winter months. Ocean currents and wind tend to transport old ice from the Arctic to the Longa Strait under great pressure, which sometimes presents the greatest ship obstacle on the route. The Wrangel massif consists of low concentrations of old ice and the ice thickness may reach 200 cm in late winter.

The Severnaya Zemlya, Novosibirskiy and Ayon massifs carry large amounts of old ice and are very resistent to summer melt. The concentrations show that during more than half of the year no ice has been present in the southern part of the Kara, Laptev and Chukchi seas. In the mildest years no old ice is observed along the traditional sailing regions. In extreme years high concentrations of old ice are found in the Novaya Zemlya massif. Except for the ice massif, no old ice is present in the Kara Sea.

Fast ice

The coastal zone is occupied by fast ice in the winter period which is non-uniformly developed. The fast ice extent is generally narrow except in the eastern Kara Sea where it may extend up to 150-200 km seaward. The Laptev Sea has the largest expance of fast ice from January to June. Fast ice begins to form in mid-October in the fresher water of the river estuaries and expands to cover most of the continental shelf up to 500 km from the mainland. The thickness of the fast ice commonly reaches 200 cm and may grow up to 250 cm in severe years. The fast ice in the East-Siberian Sea extends 250-500 km from the mainland and may reach a thickness of 150-170 cm in late winter. Only a narrow band of fast ice (about 10-15 km) forms along the mainland coast and around Wrangel Island.

In the summer months the fast ice is only present from Dikson to Severnaya Zemlya. Prevailing southerly winds constantly pushing drift ice northwards from the immobile fast ice. The drift ice is quickly replaced by polynyas of newly formed young and new ice.

About the maps

The maps on this page show probability of fast ice in March (figure 1.10 left) and average concentration of old ice in September (figure 1.10 right). The statistical analysis is based on the digital database of 10-day ice charts prepared by the Arctic and Antarctic Research Institute (AARI), St.Petersburg, Russia. The database covers the years 1967-1990 and was acquired via internet from the National Snow and Ice Data Center (NSIDC), Boulder, Colorado, USA. The statistical analysis was carried out by SINTEF Civil and Environmental Engineering, Trondheim, Norway.

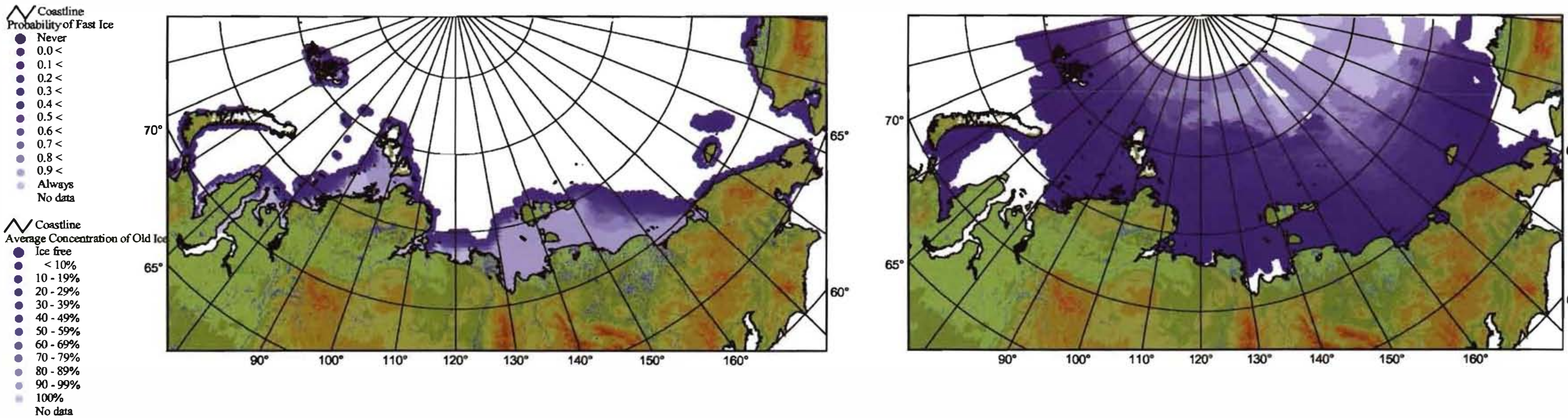


Figure 1.10. *Probability of fast ice in the NSR area in March (left) and average concentration of old ice in September (right).*

References for this chapter

Aagaard, K. & Carmack, E.C. 1989. The role of sea ice and other fresh water in the Arctic circulation. J. Geophys. Res. 94 (C10): 14,485-14,498.

AMAP 1997. Arctic pollution issues: A state of the arctic environment report. Arctic Monitoring and Assessment Programme (AMAP). 186 pp.

Anon. 1993. North Sea Quality Status Report 1993. North Sea Task Force.

Anon. 1994. Report of the UN Mission to the oil spill in the Komi Republic of the Russian Federation. Report, U.N. Dept. of Humanitarian Affairs. UN Environmental Programme, Joint UNEP/DHA Environmental Unit 8-15 December, 1994. 16 pp. + appendices.

Atlas, R.M. 1985. Effects of hydrocarbons on micro-organisms and petroleum biodegradation in Arctic ecosystems. Pp. 63-100 in Engelhardt, F.R. (ed.): "Petroleum effects in the Arctic environment". Elsevier Appl. Sci. Publ., London.

Bakken, V., Brude, O.W., Løvås, S.M., Smith, C. & S. Vefsnmo 1995. Manual on Standards - Implementation of GIS Data base, INSROP Discussion Paper, Projects I.3.1/II.3.2, May 1995, Norwegian Polar Institute, Norway.

Bakken, V., Brude, O.W., Larsen, L.H., Moe, K.A., Wiig, Ø., Sirenko, B., Gavrilo, M., Belikov, S.Y. & Garner, G.W. 1996a. INSROP Dynamic Environmental Atlas. Pp. 213-221 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Bakken, V., Gavrilo, M.V., Isaksen, K. & Strann, K.B. 1996b. Selection of marine bird Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area. INSROP Working Paper No. 60 - 1996. 56 pp.

Bakken, V., Brude, O.W., Hansson, R., Larsen, L.H., Løvås, S.M., Moe, K.A., Thomassen, J. & Wiig, Ø. 1997. INSROP Dynamic Environmental Atlas. Pp. 280-282 in: "Conf. Proc., AMAP Internat. Symp. on Environm. Poll. of the Arctic", Tromsø, Norway June 1-5, 1997.

Backlund, A. 1995. Development of oil and gas exports from Northern Russia. INSROP Working Paper No. 22 – 1996. 24 pp. + appendices.

Barrie, L.A. 1986. Arctic air pollution flow of current knowledge. Atmos. Environm. 20: 643-663.

Barrie, L.A., Gregor, D., Hargrave, B., Lake, R., Muir, D., Shearer, R., Tracey, B. & Bidleman, T. 1992. Arctic contaminant sources, occurrence and pathways. Sci. Tot. Environm. 122: 1-74.

Barry, R.G. 1989. The present climate of the Arctic Ocean and possible past and future states. Pp. 1-46 in Herman, Y. (ed.): "The Arctic Seas. Climatology, oceanography, geology, and biology". Van Nostrand Reinhold Comp., N.Y.

Berge, J.A., Berglind, L., Brevik, E.M., Følsvik, N., Green, N., Knutsen, J., Konieczny, R. & Walday, M. 1997. Concentration and effects of organotin compounds in the marine environment along the Norwegian coast. Pp. 89-90 in: "Conf. Proc., AMAP Internat. Symp. on Environm. Poll. of the Arctic", Tromsø, Norway June 1-5, 1997.

Champ, M.A., Brooks, J.A., Makeyev, V.V., Wade, T.L., Kennicut II, M.C. & Baskaran, M. 1995. Preliminary results of studies of industrial and nuclear contaminants in the Yenisey River and Kara Sea. Pp. 28-65 in Kirk, E.J. (ed.): "Ocean pollution in the arctic north and the Russian Far East." Proc. from the Ocean pollution session of the Conf. Bridges of science between North America and the Russian Far East, Vladivostok, September 1, 1994. Am. Ass. Advancem. Sci.

Chernyak, S. M., Rice, C.P. & McDonnel, L.L. 1996. Evidence of currently-used pesticedes in air, ice, fog, seawater and surface microlayer in the Bering and Chukchi seas. Mar. Poll. Bull. 32(5): 410-419.

EPPR 1997. Review need for future action on transport of oil by ships. Report, Emergency Prevention Prepardness and Re sponse (EPPR), Moscow. 39 pp.

Dallmann, W.K. 1997a. Indigenous peoples of the Northern Russian Federation and their environment. Atlas and historical/ethonographical background information. INSROP Working Paper No. 90 – 1997. 112 pp.

Dallmann, W.K. 1997b. Indigenous peoples of the northernmost Russian Federation: Environmental needs and threats. Pp. 250-251 in: "Conf. Proc., AMAP Internat. Symp. on Environm. Poll. of the Arctic", Tromsø, Norway June 1-5, 1997.

Gavrilo, M.V. & Sirenko, B. 1995. Initial Survey of Russian Data Sources. INSROP Working Paper No. 9 - 1995. 103 pp.

Granberg, A. 1992. The Northern Sea Route and the Policy of New Russia. International Challenges 12(1): 5-15.

GESAMP 1990. The state of the marine environment. GESAMP Report and Studies No 39, UNEP.

Hansen, J.R., Hansson, R. & Norris, S. (eds.) 1996. The state of the European Arctic environment. EEA Environmental Monograph No. 3. European Environmental Agency/ Norwegian Polar Institute.

Hansson, R. & Moe, K.A. 1996. INSROP Sub-programme II: Environmental factors. Conceptual design & current status. Pp. 205-211 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Hibler, W.D. 1989. Arctic ice - Ocean dynamics. Pp. 47-92 in Herman, Y. (ed.): "The Arctic Seas. Climatology, oceanography, geology, and biology". Van Nostrand Reinhold Comp., N.Y.

Ivanov, Y.M., Ushakov, A.P. & Yakovlev, A.N. 1998. Current use of The Northern Sea Route. INSROP Working paper No. 96 - 1998. 30 pp.

Klein, D.R. & Kuzyakin, V. 1982. Distribution and status of wild reindeer in the Soviet Union. J. Wildl. Manage. 46(3): 728-733.

Klungsøyr, J., Sætre, R., Føyn, L. & Loeng, H. 1995. Man's impact on the Barent Sea. Arctic 48: 279-296.

Larsen, L.-H., Evenset, A. & Sirenko, B. 1995. Linkages and Impact hypothesis concerning the Valued Ecosystem Components (VECs) Invertebrates, Fish, the Coastal Zone and Large Rivers Estuaries and Deltas. INSROP Working Paper No. 12 - 1995. 38 pp. + appendices.

Larsen, L.-H, Palerud, R., Goodwin, H. & Sirenko, B. 1996. The marine invertebrates, fish and coastal zone features of the NSR area. INSROP Working Paper No. 53 - 1996. 42 pp. + appendices.

Lenski, L. 1992. Damage statistics of ships sailing the Northern Sea Route. In: "Proc. of internat. symp. of arctic operations and navigations", Tromsø 1992.

Løvås, S.M. & Brude, O.W. 1996. INSROP GIS - User'sguide and system documentation. INSROP Working Paper No. 47 - 1996. 69 pp. + appendices.

Løvås, S.M. & Smith, C. 1996. INSROP GIS - The concept and its role in INSROP. Pp. 93-100 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective." Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Løvås, S.M., Smith, C. & Moe, K.A. 1994. Design and Development of Information System. INSROP Working Paper No. 4 - 1994.211 pp.

Macdonald, R.W. & Brewers, J.M. 1996. Contaminants in the arctic marine environment: Priorities for protection. ICES J. of Mar. Sci. 53: 537-563.

Macdonald, R.W., Carmack, E.C., McLaughlin, F.A., Iseki, K., Macdonald, D.M. & O'Brien, M.C. 1989. Composition and modification of water masses in the Mackenzie Shelf Estuary. J. Geophys. Res. 94: 18,057-18,070.

Mackay, D. & Wania, F. 1995. Transport of contaminants to the Arctic: partitioning, processes and models. Sci. Tot. Environm. 160/161: 25-38.

Martin, J.M., Guan, D.M., Elbaz-Poulichet, F., Thomas, A.J. & Gordeev, V.V. 1993. Preliminary assessment of the distributions of some trace elements (As, Cd, Cu, Fe, Ni, Pb And Zn) in a pristine aquatic environment: the Lena River estuary (Russia). Mar. Chem. 43: 185-199.

Mikhailichenko, V & Ushakov, A. 1993. The Northern Sea Route and the applicable Regulations for Navigation along its course. Pp. 11-29 in Simonsen, H. (ed.): "Proc. from the Northern Sea Route Expert Meeting 13-14 Oct. 1992." Fridtjof Nansen Institute, Oslo, Norway.

Moe, K.A., Thomassen, J., Løvås, S.M. & Hansson, R. 1995. The Northern Sea Route - Environmental Assessments as an Integrated Part of the International Northern Sea Route Programme (INSROP). In: "International Conference organised by the Advisory Committee on Protection of the Sea (ACOPS)", Conf. Proc. Moscow, 19th-22nd September 1994. 18 pp.

Moe, K.A., Hansson, R. & Thomassen, J. 1997. Strategic Environmental Impact Assessment - Northern Sea Route (Russia). Results obtained during phase I of International Northern Sea Route Programme (INSROP) Pp. 201-203 in: "AMAP Internat. Symp. on Environm. Poll. of the Arctic". Tromsø, Norway June 1-5, 1997.

Ottar, B. 1981. The transfer of airborne pollutants to the Arctic region. Atmos. Environm. 15: 1439-1445.

Pearce, F. 1993. The scandal of Siberia. New Scientist, November 1993: 28-33.

Pickard, G.L. 1975. Descriptive physical oceanography. An introduction. Pergamon Press, Oxford. 2nd ed.

Ramsland, T. 1995. Oil product exoport from North West Russia. INSROP Working paper No. 8 – 1995. 34 pp.

Ramsland, T. 1996. The Northern Sea Route and the rivers Ob-Irtysh and Yenisey. INSROP Working Paper No. 44 – 1996. 48 pp.

Ramsland, T. & Hedels, S. 1996. The NSR transit study (Part IV): The economics of the NSR. A feasibility study of the northern Sea Route as an alternative to the international shipping market. INSROP Working paper No. 59 – 1996. 45 pp.

Rudels, B. 1987. On the exchange of water masses between the Polar Ocean and North Atlantic. Univ. Gothenburg, Dept. of Oceanogr.

Rudels, B., Jones, E.P., Anderson, L.G. & Katner, G. 1992. On the intermediate depth waters of the Arctic ocean. In Johannessen, O.M., Muench, R.D. & Overland, J.E. (eds.): "The Polar Oceans and their role in shaping the global environment." Geophys. Monogr. 85: 33-46.

Sagers, M.J. 1994. Oil spill in Russian Arctic. Polar Geography and Geology 19(2): 95-102.

Salbu, B., Nikitin, A.I., Strand, P., Christensen, G.C., Chumichev, V.B., Lind, B., Fjelldal, H., Selnæs, T.D., Rudfjord, A.L., Sickel, M., Valetova, N.K. & Føyn, L. Joint Russian-Norwegian collaboration on radioactive contamination from dumped nuclear waste in the Kara Sea. Results from the 1994 expedition to Abrosimov and Stepovogo fjords. Sci. Tot. Environm. *In press.*

Schlosser, P., Bonisch, G., Kromer, B., Loosli, H.H., Buhler, B., Bayer, R., Bonani, G. & Koltermann, K.P. 1995. Mid 1980s distribution of ^{3}H. ^{3}He, ^{14}C, and ^{39}Ar in the Greenland/Norwegian Seas and the Nansen Basin of the Arctic Ocean. Progr. Oceanogr. 35: 1-28.

Semanov, G.N. 1996. The ecological safety of navigation on the Northern sea Route. Pp 223-227 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Timms, S.J., Lynn, N.M., Mount, M.E. & Sivintsev, Y.V. 1995. Modelling the release to the environment in the Kara Sea from radioactive waste in the dumped reactor compartment of the icebreaker *Lenin*. Pp. 1-27 in Kirk, E.J. (ed.): "Ocean pollution in the arctic north and Russian Far East. Proc. Ocean Poll. Sess., Conf. Bridges of science between North America and the Russian far East", Vladivostoc, 1994. Am. Ass. Advancem. Sci.

Thomassen, J., Løvås, S.M. & Vefsnmo, S. 1996a. The adaptive Environmental Assessment and management AEAM in INSROP - Impact Assessment Design. INSROP Working Paper No. 31 - 1996.

Thomassen, J., Løvås, S.M. & Vefsnmo, S. 1996b. Environmental Impact Assessment in INSROP. Pp. 229-236 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Vilchek, G.E., Krasovskaya, T.M. & Chelyukanov, V.V. 1996. The environment in the Russian Arctic: Status report. Polar Geography 20(1): 20-43.

Wartena, E.M.M. & Evenset, A. 1997. Effects of the Komi oil spill 1994 in the Nenets Okrug, North-west Russia. Akvaplan-niva Report No. APN 514.789.1.

Wergeland, T. 1991. Commercial Shipping and the NSR. Pp. 185-236 in Østreng, W. & Jørgensen-Dahl, A. (eds.): "The Northern Sea Route." Pilot Studies Report R: 013-1991. Fridtjof Nansen Institute, Oslo, Norway.

Wiig, Ø., Belikov, S.E., Boltunov, A.N. & Garner, G.W. 1996. Selection of marine mammal Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area. INSROP Working Paper No. 40 - 1996. 70 pp.

Østreng, W. 1991. The Northern Sea Route: A new era in Soviet Policy? Ocean Developm. Internat. Law 23(3): 259-287.

Østreng, W. 1992. The Geopolitics of the Northern Sea Route. International Challenges 12(1): 21-25.

Østreng, W. 1993. INSROP Startup - Why INSROP?. INSROP Newletter 1(1): 1-2.

Chapter 2

Benthic invertebrates, fish, plants and animals in polynias, and the water-land border zone

Authors:
Lars-Henrik Larsen, Akvaplan-niva, Tromsø, Norway
Boris Sirenko, Zoological Institute, St. Petersburg, Russia
Anita Evenset, Akvaplan-niva, Tromsø, Norway

Introduction

This group of Valued Ecosystem Components (cf. the INSROP VECs, see Chapter 1) intends to reflect the lower trophic levels of the Arctic food web. Virtually, they do not constitute a uniform group. Each of the selected VECs (see table 2.1) actually comprises a number of organisms or groups of organisms, that have certain species-specific attributes of unique ecological significance. However, in addition to provide the nutritional supply for predators like birds, seals and whales (see Chapter 3 and 4), the organisms all spend their entire life-cycle, either as sessile or pelagic, mobile forms, in the sea. This makes up a common base for dose-response relationships in terms of exposure to dispersed and water-soluble fractions of contaminants discharged or released to the sea (cf. the impact factors described by Thomassen et al., this issue). Consequently, the VECs form elements of importance to the overall INSROP Sub-programme II aims; the INSROP EIA (Hansson & Moe 1996).

Selection of VECs

During the screening and focusing Workshop in Oslo 1993 (Hansson et al. 1994), a number of strictly marine resources and the associated flora and fauna were discussed in terms of criteria like representativity (ecological as well as geographical), importance to other species (including human), and possible interactions with the shipping and navigation in the NSR.

Four VECs were selected, each comprising several individuals of the same species (e.g. population level) or groups of species (e.g. community level), as well as their habitats (table 2.1).

Benthic invertebrates

Benthic (bottom living) invertebrates are the most species-rich group of animals of the entire NSR area. Though not very conspicuous for travellers along the NSR, one square meter of seabed with overlaying water column contains several dozens of invertebrate species. This is more or less true along the entire area. Compared to pelagic, intertidal or terrestrial animal communities, the benthic invertebrates thus make up the most diverse faunal assemblages of the Arctic.

The number of known species of benthic invertebrates decreases from west to east: Barents Sea 2,499 species, Kara Sea 1,580 species, Laptev Sea 1,084 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.

The benthic organisms are permanently present in the marine environment both on a temporal and spatial scale, and consequently exposed to any changes in the surrounding seawater and sediment that may be caused by discharges of contaminants to the sea. For research and monitoring of e.g. Arctic biodiversity and pollution issues, the benthic communities should be considered one of the focal points like they are in the other waters, like the North Sea.

Marine, estuarine and anadromous fish

A total of 152 different marine, anadromous, and freshwater species are recorded in the NSR area. Compared to adjacent seas, the number indicates a relative poor fish fauna. The mapping of the fish fauna however has been sporadic, particularly in the open sea, and only a few quantitative studies covering parts of the area, have been carried out.

Commercial fisheries, mainly located in the estuaries and lower parts of the large rivers, have shown a significant drop during the last few years. This picture can be observed in virtually all the rivers and the seas of the Russian Arctic (Vilchek et al. 1996).

However, there is no doubt about the significance of the fish resources; the fauna forms an important component of the food web of the large rivers, estuaries and the marine habitats, as well as an important nutritional basis for local people. Consequently, effects generated by shipping and navigation may be transferred to other levels of the food web as well as to local human populations.

The effects however may be adverse or positive. Operational and accidental discharges (such as oil spills) belong to the first category of impact factors that can adversely affect the number and distribution of the fish. Increased sailing can also physically disrupt the fisheries. On the other hand, NSR may serve as a mean for transportation of fish products to markets outside the area, and also ensure supply of fishing gear, equipment etc., which can facilitate exploitation of fish resources that currently are considered less attractive.

Plant and animal life in polynias

The key to the ecological significance of the polynias lies in the ice-edge itself, rather than in the open water. In general, ice-edges are areas of high biological activity, probably due to periods of wind-driven upwelling as well as ice-melt, giving stable, stratified water-masses (Dunbar 1985). These conditions facilitate the primary production and consequently make the polynias important to higher trophic level organisms such fish, marine birds and marine mammals.

During the ice-covered season, it is realistic that NSR ships will travel through the polynias whenever possible, in order to save energy, reduce the use of ice-breakers, and to minimise the risk of ship damage.

This attraction inevitably increases the risk for exposure of the polynian flora and fauna to regular as well as accidental discharges from the shipping activity. In combination with the ecological significance, the impact in the polynias may be more pronounced than in other, less productive waters.

The water-land border zone

The coastal zone provides the habitat of for a great diversity of marine as well as terrestrial organisms such as benthic invertebrates, birds, and mammals. The shore is also the major entrance to the marine environment for local human populations, and many of the human settlements in the NSR are located close to the sea or rivers.

The accumulation of solid waste like plastic litter on the shore is a well-known and worldwide phenomenon. Much of this waste is generated by and discharged from ships. This is also true for marine oil spills, and the impact on shoreline habitats caused by the stranding of oil have been demonstrated in the accidental events of Torrey Canyon, Amoco Cadiz, Globe Asimi, and Exxon Valdez. Encroachment of the coastal zone caused by pollution, harbour construction, erosion etc., is a matter growing concern (GESAMP 1990).

The NSR is no exception with regard to shoreline contamination; observations confirm the use of the shore as dumping site for shipwrecks as well as solid waste like plastic, glass and metals. The extent of these dumpsites may reach 5-10 m along a shoreline having an extent of more than 4,000 km (Vilchek et al. 1996).

Also the large rivers of the NSR are subjected to pollution. According to estimates by Vilchek et al. (1996) the amount of oil spilled onto the ground and into the rivers ranges from 3 to 10 million tons per year only in the Tyumen' North-Komi Republic. Several large oil spills are known from this area, including the pipeline ruptures in 1990 and 1993, resulting in the release of up to 500,000 and 420,000 tons of oil, respectively.

These and other relevant pollution issues are addressed in the INSROP EIA by Larsen et al. (1995). To each impact factor corresponding impact hypotheses have been developed for subsequently to be assessed and analysed in line with the overall INSROP Sub-programme II aims (Hansson & Moe 1996) and methodology (see Thomassen et al., this issue).

Table 2.1. *Lower trophic level VECs and their characterisations.*

VEC	Characterisation
Benthic invertebrates	Small bottom living species of worms, molluscs, arthropods etc. The faunal assemblages are characterised by high individual- as well as species-richness. The benthic invertebrates form the link between primary producer (plankton algae) and higher trophic levels (such as fish), and species like molluscs are also eaten directly by some marine mammals (such as walrus).
Marine, estuarine and anadromous fish	The fish resources are important components of the arctic food web both as predator (to plankton) and prey (to birds and mammals), as well as of importance to local human consumption in the remote areas. The major fishing is located in the estuaries and lower parts of the large rivers.
Plant and animal life in polynias	Polynias are areas of regularly open water surrounded by ice, and consequently preferred for navigation. In terms of the ice-edge, the polynias are characterised by high biological diversity and productivity; the associated plants and animals life include all trophic groups and all levels of the arctic marine food chain, from algae to polar bear.
Water-land border zone	The coastal zone forms the interface between the terrestrial and the marine environment, and is characterised by sharp gradients and zonations. The shore is habitated by lower trophic level organisms like benthic invertebrates as well as birds (such as goose and waders) and marine mammals (like the walrus). The shore is exposed to surface pollution like oil and accumulation of solid waste is a worldwide problem.

Benthic invertebrates

Authors:
Lars-Henrik Larsen, Akvaplan-niva, Tromsø, Norway
Boris Sirenko, Zoological Institute, St. Petersburg, Russia
Anita Evenset, Akvaplan-niva, Tromsø, Norway

Figure 2.1. *A medusa head, (Sea star) from the Kara Sea.*

The ecological significance of benthic invertebrates

The continental shelf off the Siberian north coast, including the Chukchi, East Siberian, Laptev and Kara shelves, is many kilometres wide, and generally less than 50 meters deep (Weber 1989). The Chukchi Shelf covers an area of 9,000 km^2 and is characterised by nearshore sandbars, ice gouges, and large sediment dunes. The continental shelf of the East Siberian Sea, up to 800 km wide, is a flat, shallow plain. Thus, 350 km offshore from the Kolyma Valley, the water depth is still not more than 30 meters. Only the Indigirka and Kolyma submarine valleys, which are submerged river channels, provide relief. West of the Indigirka Valley, the water depths 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 sedimentary discharges from the rivers. The Laptev Sea is cut by numerous transverse submarine valleys of erosional and tectonic origin that can also be traced on land (Holmes & Craeger 1989). The depth and bottom relief conditions are, together with the organic input, the most important factors determining which benthic invertebrates occur.

It is thought that in the shallow Arctic seas of the NSR, the influence of physical, ice-related disturbance significantly affects the structure and stability of the benthic communities. Physical disturbance from ice results in low biomass levels in shallow water communities (Golikov & Scarlato 1989). Thus, sediment gouging by inshore ice flows and frazil (suspension ice) formation are powerful disruptive forces for both infaunal and epifaunal communities. Another influential factor for species composition and biomass of benthic communities of the NSR area is the strong salinity gradient, resulting from the huge riverine input of freshwater.

As a consequence of these factors, it is thought that the benthic fauna in shallow areas may be dominated by relatively small, mobile and short-lived forms. Some benthic taxa may become incorporated onto the underside of the ice, and thus be transported over large distances. 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.

The number of known species of benthic invertebrates decreases from west to east: Barents Sea 2,499 species, Kara Sea 1,580 species, Laptev Sea 1,084 species, East Siberian Sea 962 species, and Chukchi Sea 946 species. There are 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, but also because the benthic fauna of the central and eastern parts of the NSR are some of the least studied animal communities in the world.

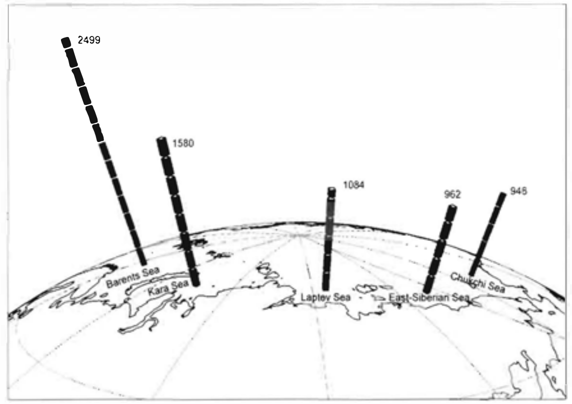


Figure 2.2. *Number of benthic invertebrate species known from the Arctic seas of the NSR (Sirenko 1994).*

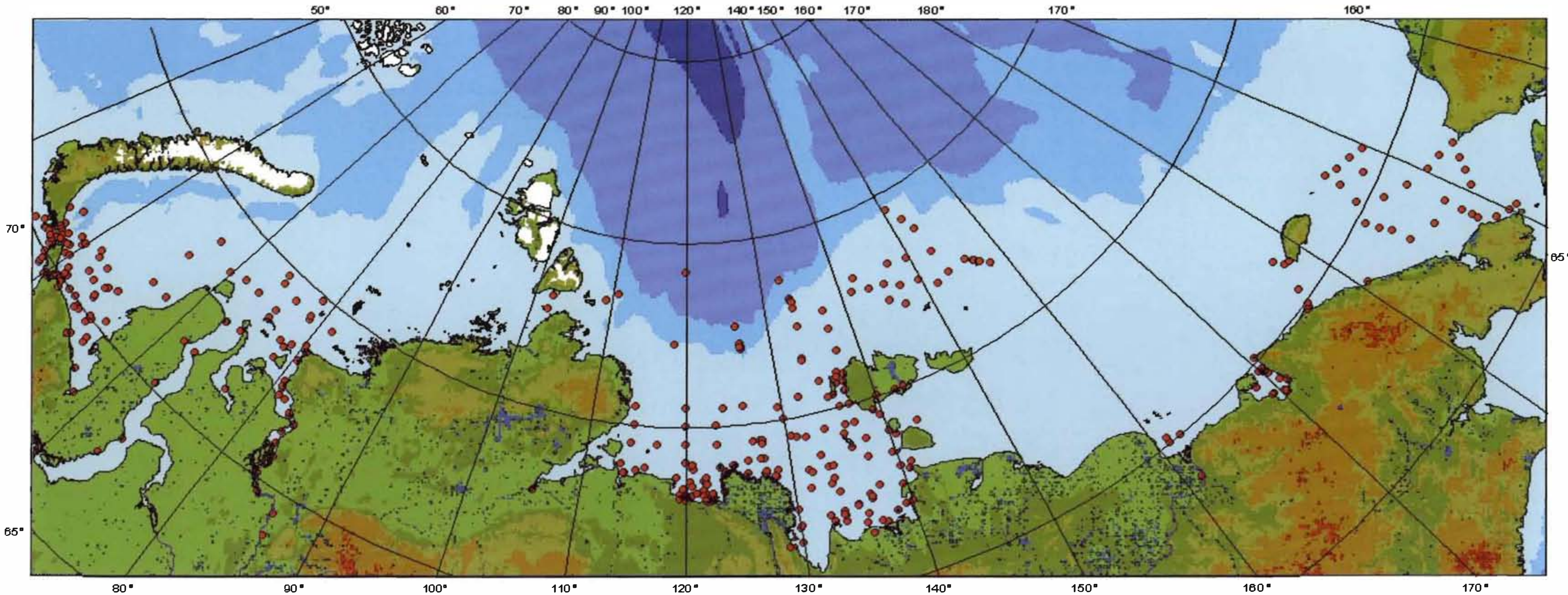


Figure 2.3. *Sampling stations for benthic invertebrates of the NSR area.*

The invertebrate fauna along the NSR provides the nutritional base for higher organisms, and forms an important link between plankton algae (primary producers) and higher trophic levels, such as fish, which in turn is preyed upon by birds and seals. Invertebrates are also eaten directly by some mammals. The main dietary component of the walrus (*Odobenus rosmarus*) is bivalve molluscs, and the grey whale (*Eschrichtius robustus*) relies on the amphipod (Crustacea) assemblages in the northern Bering Sea and Chukchi Sea for most of its food.

In the NSR area, the benthic invertebrate fauna is more or less constantly exposed to sub-zero temperatures, and permafrost below the sea-bed is common (Keck & Wassmann 1993). Relatively few species are adapted to these living conditions and marine Arctic benthic communities are reputed to be relatively low in diversity compared to more southern areas, but are still amongst the most diverse communities in the Arctic. As a result, disturbances affecting a dominant population of one species will have major impacts along the entire food web. It may therefore be difficult for predators to switch to alternate prey species, should their favourite be wiped out. This hypothesis is, among others, presented by Larsen *et al.* (1995), and will be evaluated further through the INSROP-EIA process.

Baseline data

Information has been gathered on the distribution of benthic invertebrates at some 400 stations throughout the NSR (figure 2.3). This information has been collected during a period of nearly 100 years, and the stations are spread over an area of several thousands of square kilometres. This means that the data coverage is relatively good in limited areas, while large areas never have been sampled. Most of the samples have been collected by the Zoological Institute (ZISP), St. Petersburg, which is the institution responsible for invertebrate research in the Arctic seas of Russia. The collections of ZISP contain material from more than one hundred expeditions to the NSR area, starting with the 1895 expedition to the Kara Sea onboard the "Lieutenant Ovtsin". This information is included in the database of the INSROP Dynamic Environmental Atlas (DEA).

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, has been identified at the Zoological Institute in St. Petersburg.

For many species only qualitative data are available, while quantitative/biomass data do not exist. However, biomass data and composition of faunal associations (biocoenoses) do exist for

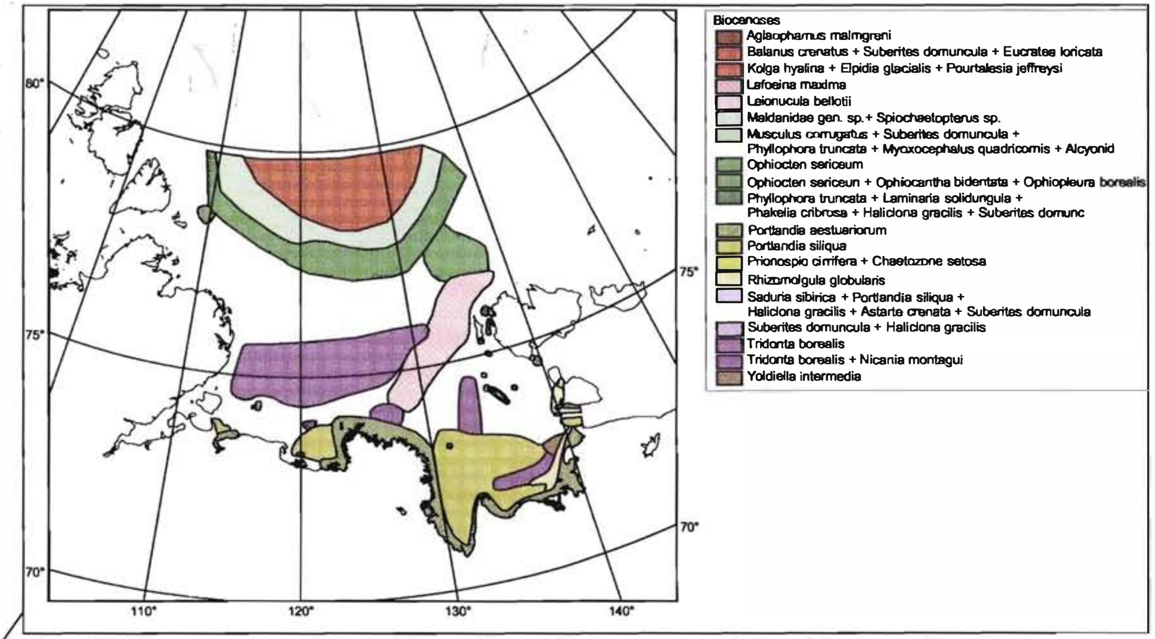


Figure 2.4. *Biocenoses are associations of flora and fauna with discret characteristics and dominance of specific groups or species.*

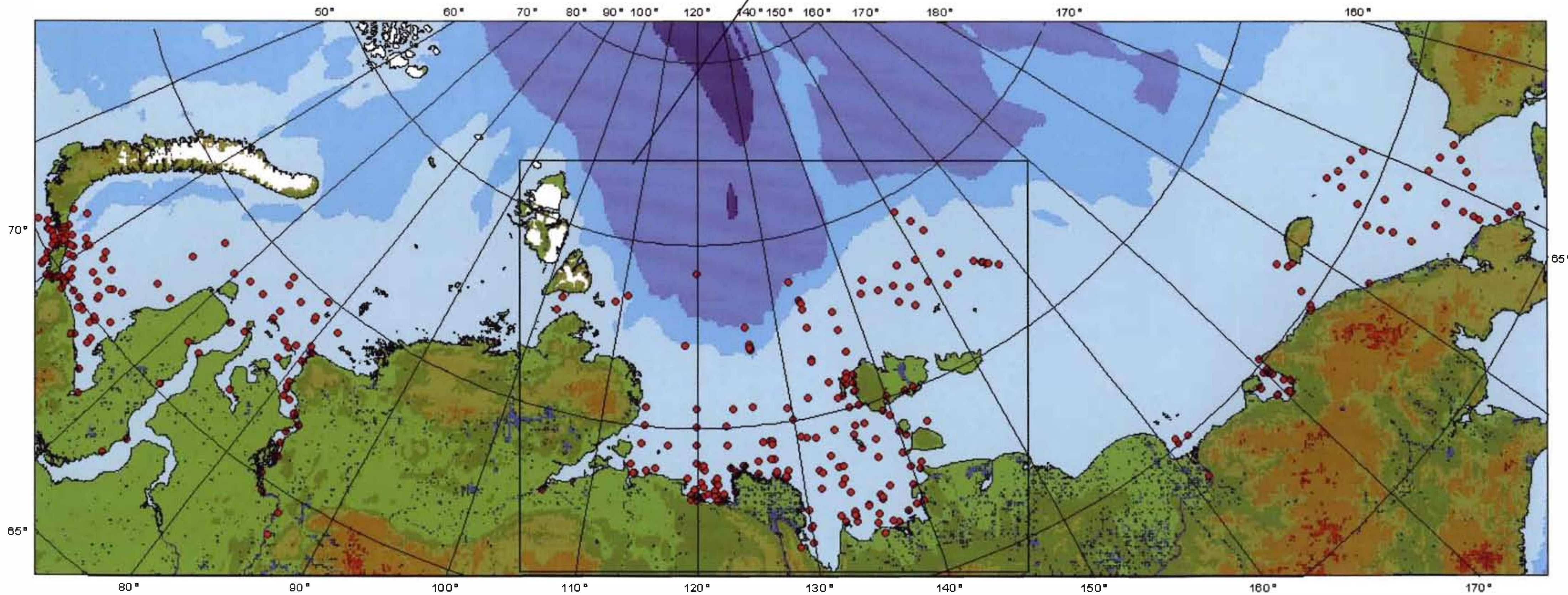


Figure 2.5. *Sampling stations for benthic invertebrates of the NSR area.*

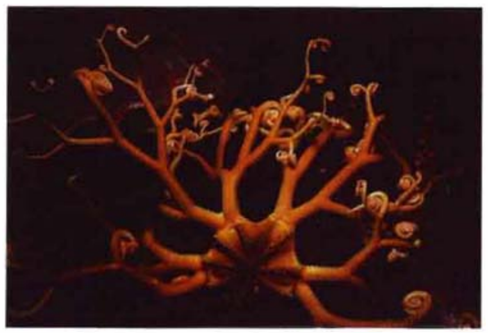
some areas; an example from the Laptev Sea is presented in figure 2.4. A biocoenose is an association of plants and animals, occurring on a specific type of sediment and often also at a specific water depth. Within a biocoenose, the distribution of numbers and biomass of the dominant species are relatively uniform.

The distribution of benthic invertebrates/biocoenoses in the NSR area is significantly influenced by the environmental conditions. Knowledge of the abiotic factors can be used to deduce an expected invertebrate distribution in areas without actual recordings of animals, on the basis of the known habitats and tolerance limits of the invertebrate fauna of neighbouring areas. For the intertidal zone of the NSR, information on sediment composition has been collected (cf. the Water-land border zone).

In the large NSR area, an east-west distribution gradient of invertebrates has been shown to exist, where Atlantic species dominate in the western part, and the share of Pacific species gradually increases 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. 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).

Different types of littoral/shallow water sediments have varying vulnerability towards pollution. Hard substrate mostly occurs in areas with moderate to strong currents or wave action. Particle bound pollutants will pass such areas and settle in areas with less current and wave action. If pollutants are released, most of the contaminants will end up in soft bottom sediments. Invertebrates living in and on soft bottom are therefore expected to be more exposed than hard bottom organisms, even though the latter may filter out contaminated particles from the water. Accumulation of contaminants in invertebrates is a well-known phenomenon, and benthic invertebrates are therefore often used for monitoring purposes.

Due to the large extent of the NSR area, and the relatively low level of human activity, even the most serious accidental event is unlikely to cause more than local damage to the invertebrate VEC itself. Long term, chronic discharges from shipping traffic may however have overall negative effects of far more serious nature than any single accidental event.



Marine, estuarine and anadromous fish

Authors:
Lars-Henrik Larsen, Akvaplan-niva, Tromsø, Norway
Boris Sirenko, Zoological Institute, St. Petersburg, Russia
Rune Palerud, Akvaplan-niva, Tromsø, Norway
Anita Evenset, Akvaplan-niva, Tromsø, Norway

Photo: B. Gulliksen

Figure 2.6. *A key species of the ice covered Arctic waters, the Polar cod (Boreogadus saida) lives in crevises and channels in the ice.*

The ecological significance of marine, estuarine and anadromous fish

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

The most dominant group of anadromous fish of the NSR area is the whitefish, which include the species omul (*C. autumnalis*) and muksun (*C. muksun*). The fish belonging to this group are the most important for human consumption along the NSR. 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 *C. 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).

Accidental oil spills occurring from NSR activities may reduce recruitment and survival in affected fish species (for discussion and evaluation of impact hypotheses on fish, see Larsen et al. 1995). The early life stages of fish are more vulnerable to pollution than the adult stages. Adult fish are capable of swimming away from pollution floating on the surface, like oil, while the youngest stages are to a large degree drifting with currents. Exposure to oil may affect fish egg and larval development (Falk-Petersen & Kjørsvik 1989).

The Siberian fishermen might 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 has been 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.

Baseline data

The fish fauna of the NSR has been only sporadically mapped. Ice-conditions have made expeditions difficult, and almost no commercial fishing takes place in these waters. Thus, the knowledge of migration routes, feeding grounds and spawning areas for strictly marine fish species has not been obtained.

During phase 1 of INSROP, a check-list of fish recorded in each of the four seas and the major tributaries has been developed from existing literature and data. The first published monograph on fishes of the northern seas of the USSR was issued 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 fresh water species of fish have been recorded in the four seas of the NSR. Compared to the adjacent Barents Sea, housing about 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 which are influenced by water currents entering from southern latitudes.

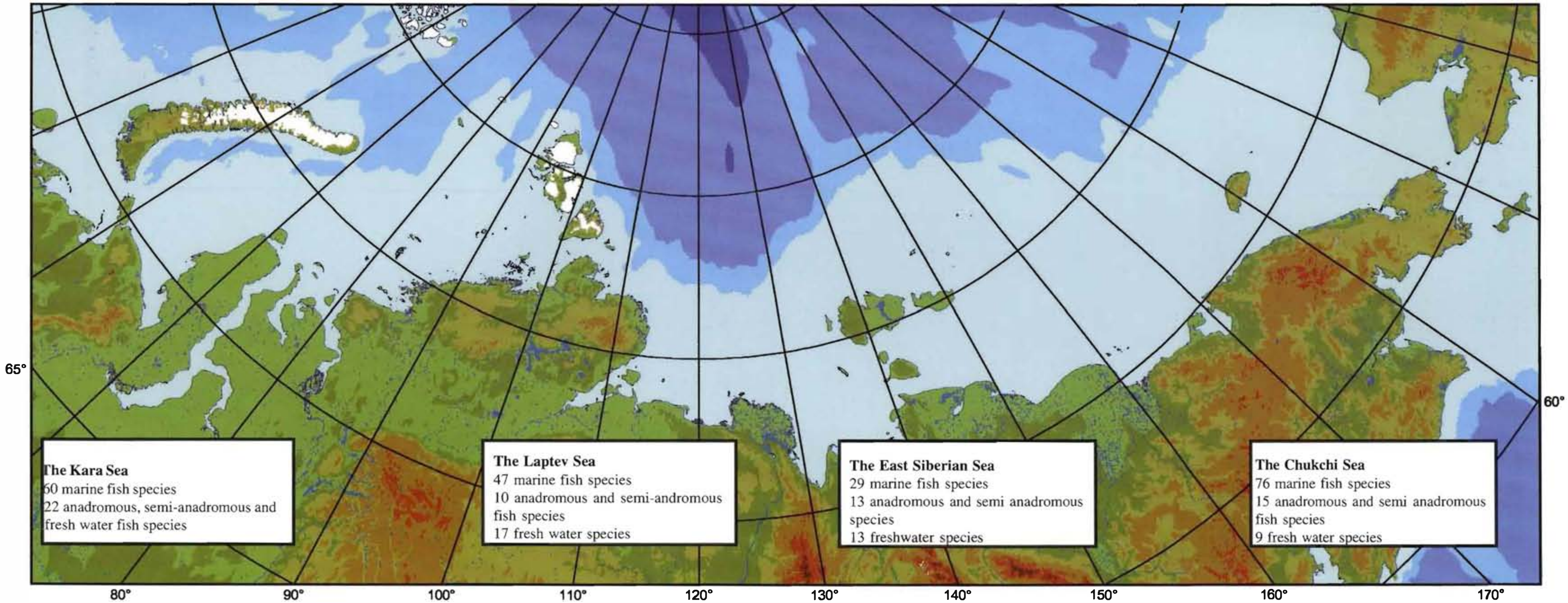


Figure 2.7. *The fish fauna of the NSR.*

Fisheries

The fish resources of the NSR play an important role for local human consumption in these remote areas which have only difficult communication with the rest of the world. However, on a global scale, landings from these Arctic areas are insignificant.

The marine fish fauna is so sparse and so difficult to access that no commercial fishing takes place in the open parts of the seas, except in the westernmost area of the Kara Sea, and occasionally in the Western Chukchi Sea. The fishery of the NSR 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. The catch is consumed either locally or in the nearest village or industrial center. In previous years (until 1991) a small amount of valuable fish species, like Siberian sturgeon (*Acipenser baeri*) and muksun (*C. muksun*) were exported to other parts of the country. Due to high transportation costs this export was unprofitable and has now stopped (Kudersky pers. comm.).

Fishing takes place both summer and winter. In the Gulf of Ob and lower Ob 60 - 65% of the annual catch is taken during the summer, while 35 - 40% are taken during the winter season. The corresponding figures for Yenisey and the rivers of Yakutia (Lena, Yana, Indigirka and Kolyma) are 70% summer, 30% winter and 50% summer, 50% winter. The equipment used varies somewhat from river to river, but the most important are fixed and drifting gill nets, drag seines, trap nets and under ice nets (Kudersky pers. comm.).

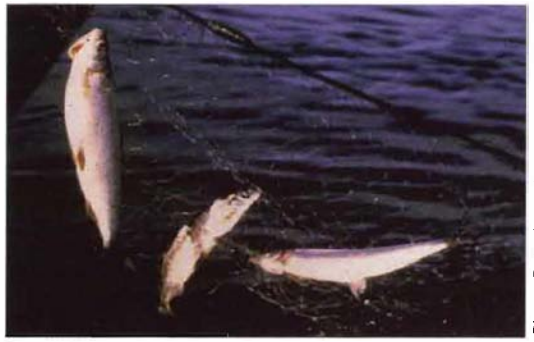


Photo: P.-A. Amundsen.

Figure 2.8. *The whitefish (Coregonids) is a very important group of anadromous fish for local fisheries along the Northern Sea Route.*

An 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 relatively thin and easy to penetrate. 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 Yenisey 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 the Ob Bay, the recorded catch of smelt has varied from 516 tons in 1989 to 28 tons in 1991.

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 catches. 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. Data on whitefish landings are presented to illustrate the extent of the fishing activities in different areas. Note that the scales of the figures are different for the different catch-areas.

The data presented indicate a significant decline in landings of whitefish in all four tributaries to the Kara Sea. For example, the landings of whitefish from the Ob Bay has suffered a 42 % reduction during the period 1990-1994. In the lower Yenisey river, the decline was 35 % during the same period (from 160 tons in 1991 to 68 tons in 1994). Compared to the average landings of the period 1981-85, the recorded landings of whitefish from Ob Bay in 1994 (816 tons) made up only 46 % of the landings recorded ten years earlier.

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

As in the Kara Sea, no off-shore fishery takes place in the Laptev Sea. Fishery is restricted to the river estuaries and deltas, 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 tendency towards decreasing yields is less pronounced in the Laptev Sea area than in the Kara Sea. However, the available data only cover the period up to 1990 (1991), during which period the yields were relatively stable, as they were in the Kara Sea. The largest drop in landings in areas from which data are available is for the period 1991-94. It is therefore possible that the landings in the Laptev Sea may also have declined during the 1990s.

The GOSNIORKH does not possess data on landings from areas east of the Kolyma river.

The decline in landings in the fisheries of the NSR area, reflects to a certain extent the emigration of people from the Siberian country-side, which has been triggered by the recent economic stress in the Russian community. Most people leaving Siberia are of non-indigenous origin, and they 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 from the area for political reasons.


Photo: S.P. Åsheim.

Figure 2.9. *The spring fishing for smolt on the ice covered Yenisei river.*

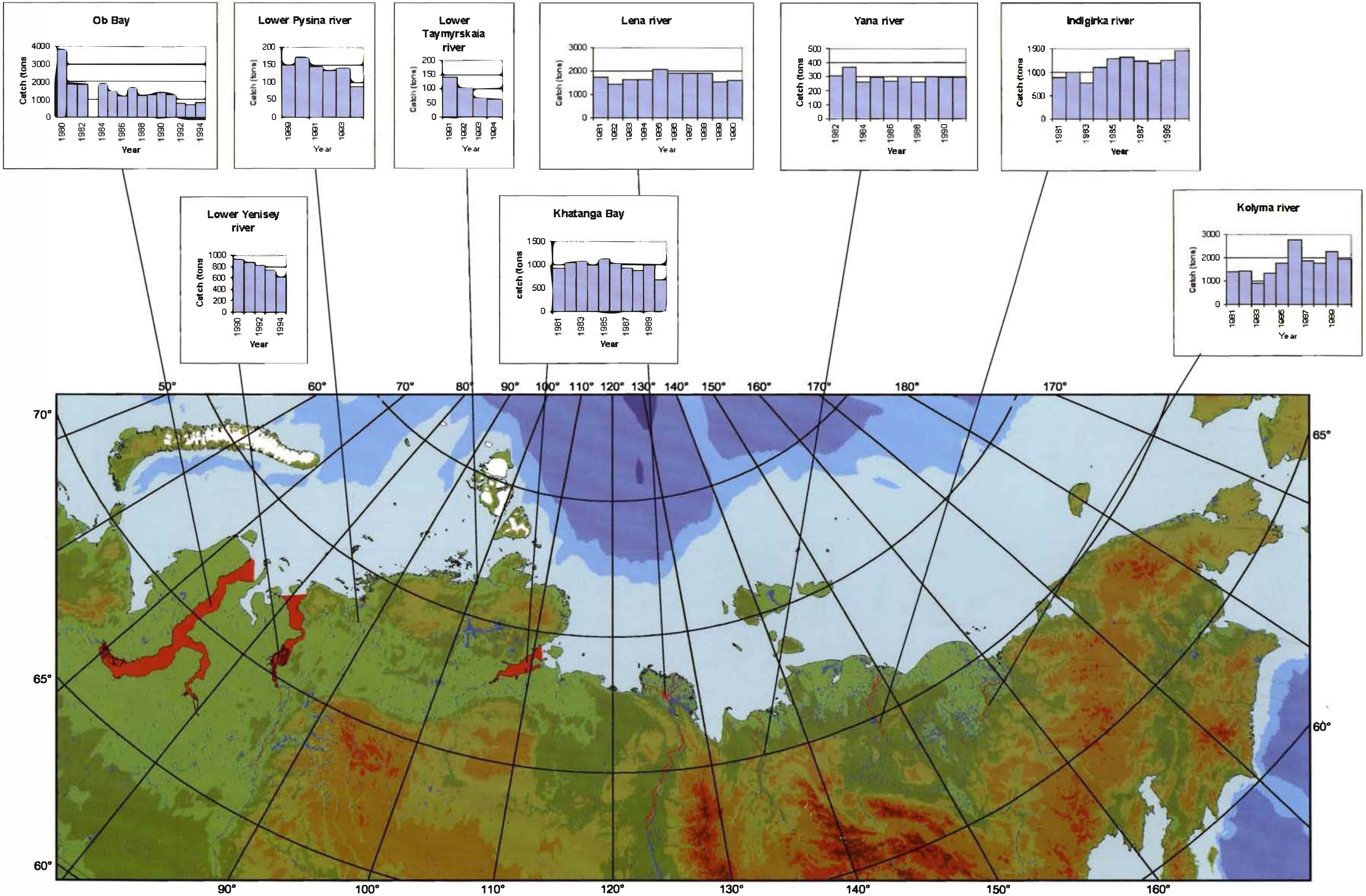


Figure 2.10. *Data on landings from some main rivers in the NSR area.*

Plant and animal life in polynyas

Authors:
Lars-Henrik Larsen, Akvaplan-niva, Tromsø, Norway
Boris Sirenko, Zoological Institute, St. Petersburg, Russia
Rune Palerud, Akvaplan-niva, Tromsø, Norway

The ecological significance of polynyas

When the sun returns in spring, the first light and sun heat induces melting of the ice along the edges of polynyas. The release of freshwater causes stratification of the water masses, and together with the release of trapped nutrients from the ice, trigger a diatom dominated, early spring phytoplankton bloom (Quillfelt 1996). Upwelling will also bring water rich in nutrients to the surface, thus enhancing the primary production. Surveys have indicated that the primary production in polynyas may be as high as 65 g carbon/m^2/year (Keck & Wassmann 1993), which is several times the average primary production in ice-covered Arctic areas. This rich phytoplankton bloom forms the basis for an extensive production in the higher levels of the food chain. 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.

This bloom in polynyas parallels 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).

In many respects, the surface under the ice resembles the sea bed as substrate for invertebrates. Work on Arctic shelf areas in Canada, Greenland and Alaska has suggested that colonisation of ice by the benthos generally occurs in shallow water areas (Carey 1985; Quillfelt 1996) as in 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 the water column and residing on the sea floor to the ice. Recent 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.

Some polynyas occur at the same place every year. Some are open throughout the winter, while others may be ice covered through the coldest months. The areas with highest frequency of polynyas have partly been mapped by INSROP Sub-programme I. An outline of the polynyas in the Laptev Sea in 1992 is presented in figure 2.12.

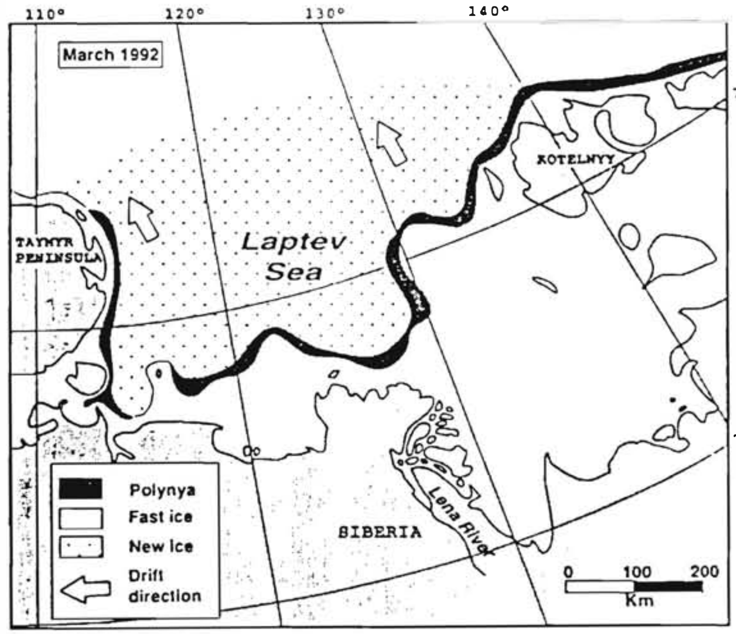


Figure 2.12. *The ice conditions of the Laptev Sea during March 20-24 1992, mapped by AARI, St. Petersburg. After Reimnitz (1995).*

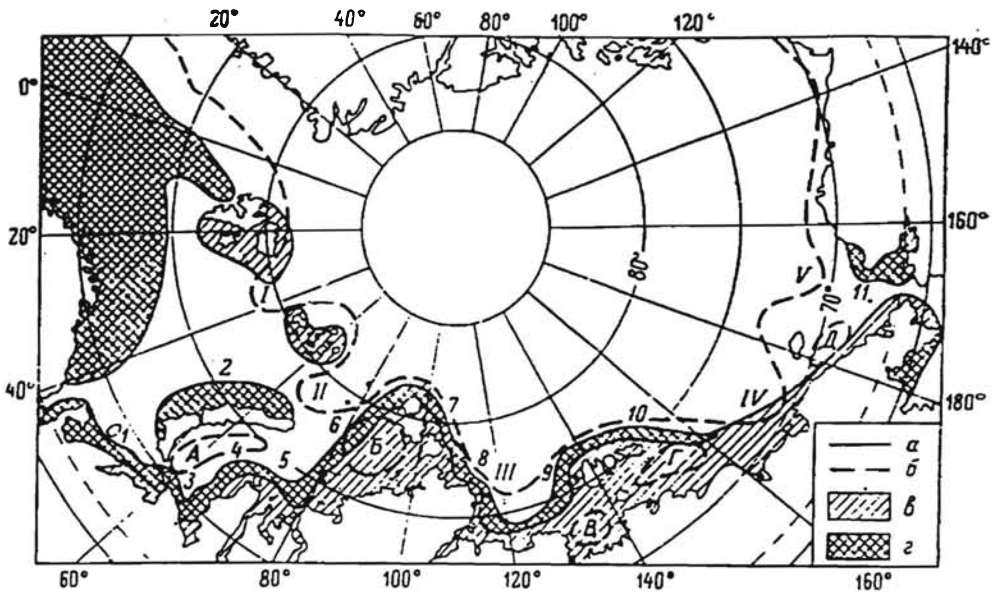


Figure 2.11. *Ice cover of the Arctic Ocean. Areas of regularly occuring winter polynyas (open water) are indicated by hatching (Soviet Arctic 1970). a: Ice egde in winter, b: ice edge in summer, v: fast ice, g: polynya.*

Water - land border zone (sensitive areas)

Authors:
Lars-Henrik Larsen, Akvaplan-niva, Tromsø, Norway
Boris Sirenko, Zoological Institute, St. Petersburg, Russia
Rune Palerud, Akvaplan-niva, Tromsø, Norway

The ecological significance of the water-land border zone.

The coastal zone comprises the littoral zone, which regularly dries out during the tidal cycle, the supralittoral zone which is irregularly flooded during storms and the layda-zone, where permafrost makes vertical water movement impossible while horizontal tidal influence is pronounced. Despite this being a harsh habitat due to large fluctuations in salinity, temperature and ice-scouring, the coastal zone plays host to important and vulnerable biological resources. The different sedimentation regimes along the coast are reflected in the large variation in sediment composition, and in areas of fine sediment accumulation, shores are considered to be most vulnerable in the event of an accidental spill of oil or other noxious substances.

The water land border zone is frequently used by humans. Many of the human settlements in these northern areas are located along the coast or along the rivers. Man-made installations, such as harbours, water intake for the fishing industry and processing plants, fishing boats and equipment, are therefore at risk in the event of an accidental spill of oil or other materials.

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 of several tens of thousands of other inhabitants concentrated around harbours, factories or mineral resources. The population along the NSR therefore consists of a mixture of indigenous people and inhabitants originating from other parts of Russia or the former Soviet Union. Even though more than 1,100 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 climatically harsh region. Reindeer herding, fur hunting and fishing are most common among the indigenous populations, but these activities are also important trades for people of non-indigenous heritage. Although these people have a very different historical, cultural and linguistic background, the rough Arctic conditions require similar lifestyle adjustments for all inhabitants. In some of the sparsely populated areas shipping traffic is very sporadic, and in some areas there are connections to other parts of the country only once or twice a year. In such areas the inhabitants have to be self-sustaining in order to survive.

Baseline data

Information on sediment composition and shore morphology in the coastal zone is used for deducing distribution of expected biological resources, based on knowledge of the organism`s demands for specific substrates. The sediment composition is also an important indicator of the accumulation/abrasion conditions of beaches, which in turn is decisive for the fate of e.g. an oil slick reaching the coastal zone. Substrate composition is thus a measure of vulnerability towards pollution.

During INSROP phase 1, the sediment composition of the entire shoreline of the NSR has been mapped. The shoreline in the Kara Sea, from Dikson to the Boris Vilkitsky Strait is relatively straight and consists of steep cliffs with some angular projections, gulfs and bays. Some parts are characterised by numerous, widely spread islands separated by shallow straits. The shore is composed of rocks and coarse sediments (gravel, pebbles and boulders).

Usually, low temperatures lead to slower degradation of any foreign/pollution compounds. Due to the low temperatures in the NSR area, a contaminant reaching the area will have a longer lasting effect on the ecosystem than the same compound is expected to have in areas with higher temperatures. An exception is radioactive isotopes that will decay at known rates independent of temperature. The water - land border zone is most vulnerable to pollution floating on the sea, such as an oil slick, as any contaminant washed ashore may damage both plant and animal life.

However, different parts of the water - land border zone have a varying vulnerability towards pollutants. The vulnerability is dependent on how exposed the coast is to wind and wave movements. In the exposed parts, wind and wave movements will rapidly wash away any contaminant that reaches land, and only a short time exposure of the intertidal communities will occur. Examples from the whole world have shown that the exposed littoral zone is highly "self-cleaning." An oil spill will for instance mostly be washed

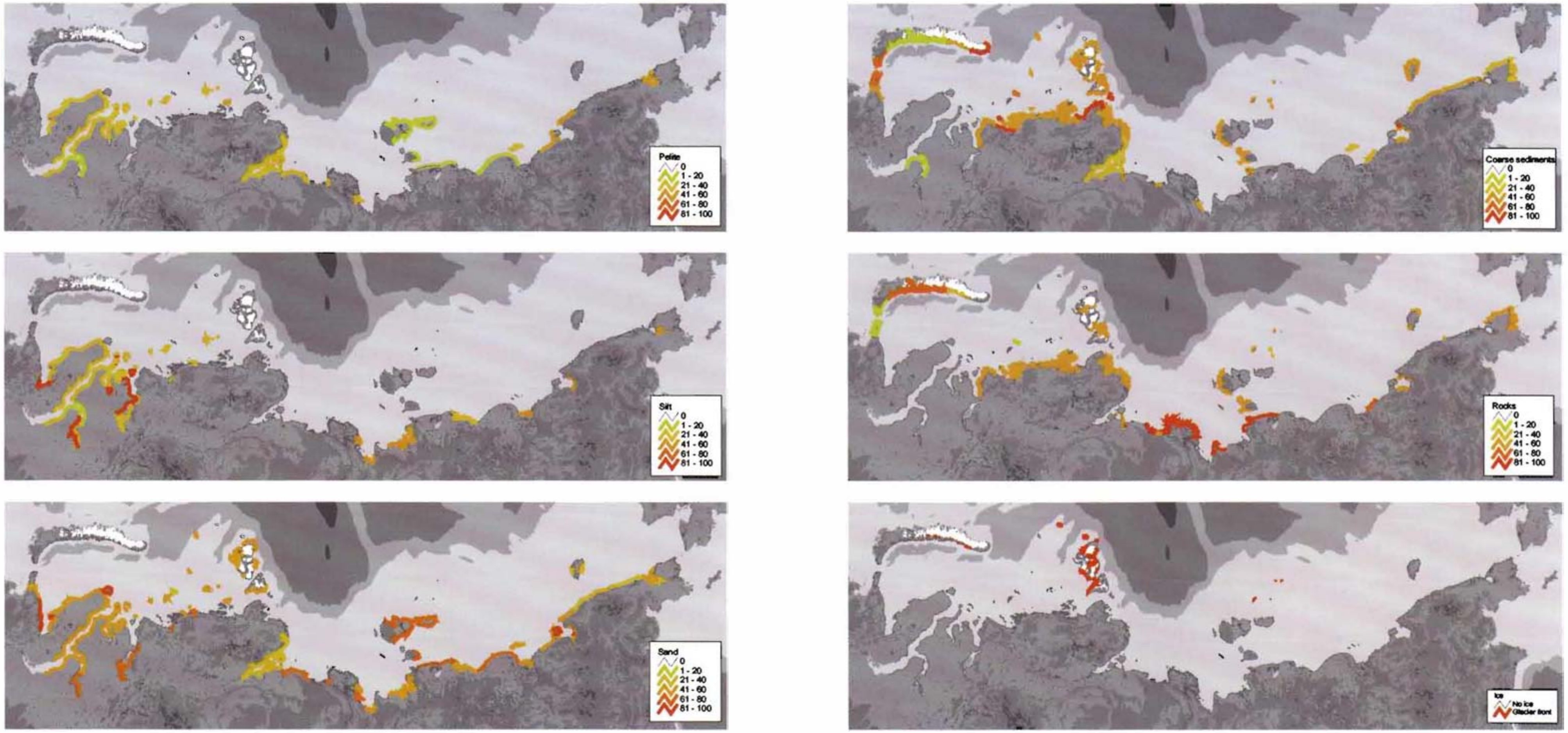


Figure 2.13. *Sediment composition and shore morphology in the coastal zone along the NSR. Maps show percentage Pelite, Silt, Sand, Coarse sediments, Rocks and Ice.*

away within months. A Norwegian exposed shore has shown to recover from an oil spill within 3 years (Lein et al. 1992), except for long-lived plants and animals, which will only occur as juvenile plants after that period.

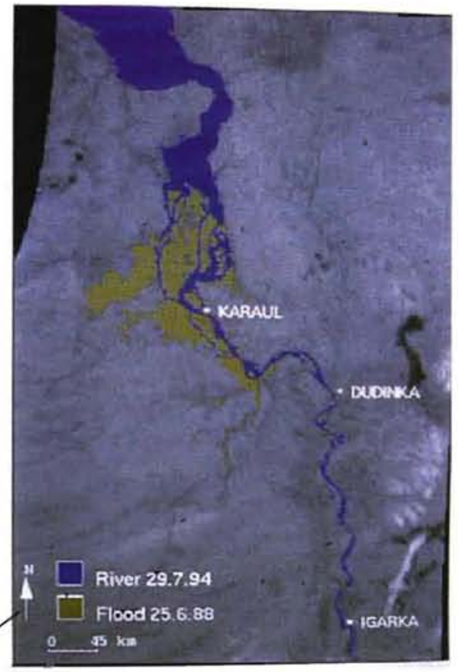
In sheltered areas, and especially in estuarine areas, accumulation of fine sediments occurs. Such areas are important foraging areas for wading birds. These sheltered areas are very vulnerable to pollution, as contaminants like oil will associate with the fine grained sediment, and persist for years. Due to low temperatures and often poor oxygen conditions the breakdown of any contaminants will proceed very slowly. Thus, all the animals living on contaminated soft bottom beaches will be exposed to potential toxic compounds for a long time. During periods of extreme weather conditions, wind and surf may spread oil and other pollutants up into the supralittoral zone, thus affecting areas that may be used as pasture land. This phenomenon was observed on the Shetland Islands after the "Braer" incident in January 1993.

A special part of the coastal zone is the inland areas, which become flooded during the spring rise in the rivers. The large Siberian Rivers, from Ob in the west to Kolyma in the east, are responsible for more than 85 % of the total fresh- water transport to the Arctic. At the same time these rivers are important traffic-corridors, providing ship transportation possibilities to the inland parts of Siberia. In spring and early summer, when snow melting begins in central and southern Siberia, the water level of the rivers gradually rises. As the melting of snow and ice proceed northwards, an extreme increase in water flow occurs, and the rivers flood large areas along the banks of the lower reaches and the delta.

The spring flood normally lasts for three to five weeks from early June onwards. During summer, the rivers fall to "normal" water level. These areas, which are water covered for only a few weeks each year are vulnerable to water- borne pollution. An example of the extent and location of inundated riverine areas, mapped by use of satellite remote sensing, is presented in figure 2.14.

The extent and location of inundated river areas in the lower Yenisei valley were mapped by use of two NOAA-9 and NOAA-11 "Advanced Very High Resolution Radiometer" satellite images, covering the same river area, one from the spring flow period and one from summer were superimposed on each other. Due to frequent cloud cover in the area it was not possible to obtain two images from the same year. An image from the 25th June 1988 was therefore used to cover a spring-flood period, and another from the 29th July 1994, was used to cover a "normal" situation (figure 2.14). The total inundated area was then calculated to 11.600 km^2.

Figure 2.14 (right). *Inundated river areas of the lower Yenisey valley mapped and calculated by remote sensing technique. The yellow area was inundated during high water flow of 25th June 1988, while the blue area is the river at normal water level on 29th July 1994.*



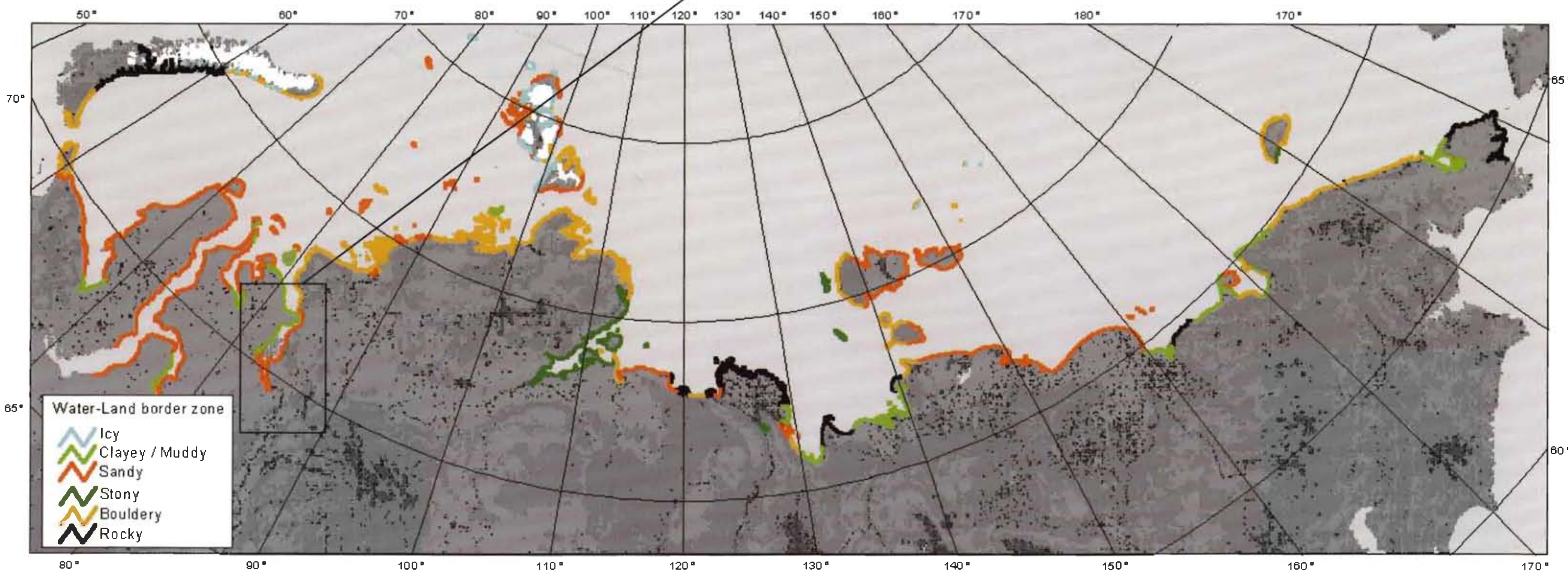


Figure 2.15. *Sediment composition in the coastal zone of the NSR area.*

References for this chapter

Andriyashev, A.P. & Chernova, N.V. 1994. Annotated list of fish in the Arctic Seas and contiguous waters. Questions of ichtyology 34: 435-456. (In Russian.)

Carey, A.G. Jr. 1985. Marine ice fauna: Arctic. Pp. 173-190 in Horner, R (ed.): Sea Ice Biota. CRC Press, Boca Raton.

Dunbar, M.J. 1981. Physical causes and biological significance of polynyas and other open water in sea ice. In Stirling, I. & H. Cleator H. (eds.): Polynyas in the Canadian Arctic. Occasional paper 45. Canadian Wildlife Service.

Dunbar, M.J. 1985. The Arctic marine ecosystem. Pp. 1-35 in Engelhardt, F.R. (ed.): Petroleum effects in the Arctic environment. Elsevier Appl. Sci. Publ. 281 pp.

Falk-Petersen, I.-B. & Kjørsvik, E. 1989. Histological and ultrastructural effects due to hydrocarbon exposure in larval cod (*Gadus morhua* l.) Rapp. p. -V. Réun. Cons. Int. Explor. Mer. 191: 493.

GESAMP 1990. The state of the marine environment. GESAMP Report and Studies No. 39, UNEP.

Gjøsæter, H., Godø, O.R. & Ulltang, Ø. 1992. De viktigste fiskeslagene i Barentshavet. Chapter 12 in Sakshaug, E. (main ed.): Økosystem Barentshavet (Ecosystem Barents Sea). PROMARE research programme, Norway. 304 pp. (In Norwegian.)

Golikov, A.N. & Scarlato, A.O. 1989. The evolution of Arctic ecosystems during the neogene period. Pp. 257-279 in: Y. Herman (ed.): The Arctic Seas, Climatology, Oceanography, Geology and Biology. Van Nostrand Reinhold, New York.

Hansson, R. & Moe, K.A. 1996. INSROP Sub-programme II: Environmental factors. Conceptual design & current status. Pp. 205-211 in Kitagawa, H. (ed.): Northern Sea Route; Future and Perspective. Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Hansson, R., Moe, K.A. & Løset, S. 1994. Screening and focusing Workshop - Environmental factors. INSROP Discussion Paper. Oslo. February 1994.

Holmes, M.L. & Craeger, J.S. 1989. Holocene history of the Laptev Sea continental shelf. Pp. 211-230 in Herman, Y. (ed.): The Arctic Seas, Climatology, Oceanopgraphy, Geology and Biology. Van Nostrand Reinhold, New York.

Horner, R.A. 1989. Arctic sea ice biota. Pp. 123-146 in Herman Y. (ed.): The Arctic Seas, Climatology, Oceanography, Geology and Biology. Van Nostrand Reinhold, New York.

Keck, A. & Wassmann, P. 1993. Den Sibirske Kontinentalsokkel og Polhavet. Klima, elver, is og havstrøm. Naturen 5: 227-234. (In Norwegian.)

Larsen, L-H., Evenset, A. & Sirenko, B. 1995. Linkages and impact hypotheses concerning the Valued Ecosystem Components (VEC's) Invertebrates, Fish, the Coastal Zone and Large River Estuaries and Deltas. INSROP Working Paper No. 12 - 1995. 38 pp + appendices.

Lein, T.E., Hjohlman, S., Berge, J.A., Jacobsen, T. & Moe, K.A. 1992. Oljeforurensning i hardbunnsfjæra - effekter av olje og forslag til sårbarhetsindekser for norskekysten. (Oil-pollution in hardbottom shores - Effects of oil and suggestions for vulnerability indices for the Norwegian coast.) Report no. 23 - 1992, Institute of Fisheries and Marine Biology, University of Bergen. 44 pp. (In Norwegian.)

Lønne, O.J. & Gulliksen, B. 1989. Size, age and diet of polar cod, *Boreogadus saida* (Lepechin, 1773), in ice covered waters. Polar Biology 9: 187-191.

Lønne, O.J. & Gabrielsen, G.W. 1992. Summer diet of seabirds feeding in sea-ice covered waters near Svalbard. Polar Biology 12: 685-692.

Quillfelt, C.H.v. 1996. Ice algae and phytoplankton in north Norwegian and Arctic waters: Species composition, succession and distribution. Dr. Sci. Thesis, University of Tromsø.

Raymond, J.A. 1988. Fish Resources. Chapter 7 in Hameedi, M.J. & Naidu, A.S. (eds.): The Environment and Resources of the Southeastern Chukchi Sea - A Review of Scientific Literature. NOAA Report 86-ABH-0013; OCSEP Research Unit 690. 103 pp.

Sirenko, B.I. 1994. Biological diversity of invertebrates in the far eastern seas of Russia. Symposium on Far Eastern Seas Biology, Vladivostok, September 1994.

Sirenko, B.I. & Piepenburg, D. 1994. Current knowledge on biodiversity and benthic zonation patterns of Eurasian Arctic shelf seas, with special reference to the Laptev Sea. Ber. Polarforsch. 144: 69-77.

Vilchek, G.E., Krasovskaya, T.M. & Chelyukanov, V.V. 1996. The environment in the Russian Arctic: Status report. Polar Geography 20(1): 20-43.

Weber, J.R. 1989. Physiography and bathymetry of the Arctic Ocean Sea floor. Pp. 797-828 in Herman, Y. (ed.): The Arctic Seas, Climatology, Oceanography, Geology and Biology. Van Nostrand Reinhold, New York.

Chapter 3

Marine Birds

Authors:
Vidar Bakken, Norwegian Polar Institute, Oslo, Norway
Maria V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Introduction

The Northern Sea Route (NSR) area comprises many important marine bird species. Some species are also endemic breeders. The NSR area borders three oceans: the Atlantic Ocean to the west, the Pacific Ocean to the east, and the Arctic Ocean to the north (see Chapter 1, this issue). The composition and type of bird species are quite different in the respective oceans, and along the NSR route the distribution of the species from these oceans is overlapping or distinct.

In addition to the east-vest gradient, there is a north-south gradient of significant importance for the distribution of birds. Most of the NSR lies within the Arctic and the northern areas belong to the high Arctic where sea ice and low temperatures set distribution limits for many species. In winter, almost all marine bird species migrate out of the NSR area. However, during favourable weather conditions some species may winter in the marginal zones of the NSR area.Sea ice is an important physical factor for the marine birds, which limits the distribution of many species. Auk species are dependent on open water, and dense ice may entirely exclude these species. However, in ice-covered areas there is a system of recurring polynyas, leads and fractures which can be exploited by seabirds for feeding and resting. There is also a special ice fauna in the sea ice, which some seabirds may use as food (see Chapter 2, this issue).

Table 3.1. *Marinebirds; selected VECs of the INSROP EIA process.*

Main components	Species	
Seabirds	Red-throated Diver	*Gavia stellata*
	White-billed Diver	*G. adamsii*
	Pelagic Cormorant	*Phalacrocorax pelagicus*
	Black-legged Kittiwake	*Rissa tridactyla*
	Ivory Gull	*Pagophila eburnea*
	Brünnich's Guillemot	*Uria lomvia*
	Black Guillemot	*Cepphus grylle*
	Little Auk	*Alle alle*
	Horned Puffin	*Fratercula corniculata*
Marine Wildfowl	Emperor Goose	*Anser canagicus*
	Barnacle Goose	*Branta leucopsis*
	Greater Scaup	*Aythya marila*
	Common Eider	*Somateria mollissima*
	King Eider	*S. spectabilis*
	Spectacled Eider	*S. fischeri*
	Steller's Eider	*Polysticta stelleri*
	Long-tailed Duck	*Clangula hyemalis*
	Common Scoter	*Melanitta nigra*
	Velvet Scoter	*M. fusca*
	Goosander	*Mergus merganser*
Waders in resting and feeding areas		

In general, the knowledge about the birds in the NSR area is poor. In this issue of the INSROP Dynamic Environmental Atlas (DEA) the most relevant information concerning the biology of the species and potentially threats of the NSR activity to the populations is summarised. In addition, a more comprehensive description of potentially influenced species is about to be published (Gavrilo et al. *in prep.*).

The INSROP Marine Bird Project is headed by Vidar Bakken, Norwegian Polar Institute, Oslo, Norway, while Maria Gavrilo, Arctic and Antarctic Research Institute, St.Petersburg, is the national co-ordinator in Russia.

Figure 3.1. *Kittiwakes and Pomarine Skua are common species in the ice covered areas along the NSR route.*

Selection of VECs

In the INSROP EIA process, three Valuable Ecosystem Components (VECs) of marine birds have been selected (cf. Chapter 1, this issue): Seabirds, Marine Wildfowl, and Waders in Resting and Feeding Areas. These groups comprise about all species that utilise the marine habitat all or parts of the year. Both Seabirds and Marine Wildfowl are separated into many species which are presented in the database of the INSROP DEA, see table 3.1.

So far, the presence of the bird species spending at least part of the year in the marine habitat has been the main criteria for selection. Special emphasis has been placed on oil spill vulnerability (Gavrilo et al. 1998). A farther selection of species within each group will be done when evaluating other potential impact factors (cf. Thomassen et al., this issue).

The VEC *Seabirds* consists of species in the orders Gaviiformes, Procellariiformes and Pelecaniformes, and in the suborders Lari and Alcae in the order Charadriiformes. The species found to be vulnerable to oil spills by Gavrilo et al. (1998) were Red-throated Diver, White-billed Diver, Pelagic Cormorant, Black-legged Kittiwake, Ivory Gull, Brünnich's Guillemot, Black Guillemot, Little Auk, and Horned Puffin. All the species in this VEC are real marine birds living in connection with the sea all year round, and their main feeding habitat is in the marine environment.

The VEC *Marine wildfowl* consists of species in the order Anseriformes and includes both real marine species and species living close to the sea only parts of the year. The species found to be vulnerable to oil spills by Gavrilo *et al.* (1998) were Emperor Goose, Barnacle Goose, Greater Scaup, Common Eider, King Eider, Spectacled Eider, Steller's Eider, Long-tailed Duck, Common Scoter, Velvet Scoter, and Goosander. This group is especially connected to the coast and to areas with brackish waters.

The last VEC selected was *Waders in resting and feeding areas.* This includes species in the suborder Charadrii in the order Charadriiformes. The NSR area is inhabited by many wader species that often have special feeding and resting areas along the NSR, which they use in connection with migration. Damage to such areas may have strong negative effects on the waders. The same areas may also be important to geese.

In the following sections, selected information obtained during INSROP Phase 1 on the VECs at species level is outlined. Much of the data are for the first time presented for the western audience.

Black-legged Kittiwake

(Rissa tridactyla L.)

Photo: Vidar Bakken

Authors:
L.V. Firsova, Zoologic Institute (ZIN RAS), St.Petersburg, Russia
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St.Petersburg, Russia

Status. The Kittiwake is a widespread breeding species within the NSR area.

Distribution and population size: The breeding range is circumpolar in the Arctic-Boreal climatic zone. The world population is estimated to 6,000,000-8,000,000 pairs (Lloyd et al. 1991).

Within the NSR area, the breeding range is from the northernmost island to the coast of the Eurasian Mainland. Nonbreeding Kittiwakes occur far beyond the breeding range limits, reaching the latitudes of the Central Arctic Basin. There are about 50 colonies within the NSR area, numbering from several to two tens of thousands pairs. Colonies with more than 1,000 pairs are known from north-east Novaya Zemlya, Severnaya Zemlya, Preobrazheniya Island, New Siberian Islands, Vrangel Island and several places from Chukotka (Antipin 1938; Rutilevskiy 1963; Kondratiev 1986; Stishov et al. 1991; Korte et al. 1995). Colonies with more than 15,000 pairs are registered on Kolyuchin, Henrietta and Vrangel Islands (Leonov 1945; Kondratiev 1986; Stishov et al, 1991). Smaller colonies with less than 1,000 pairs occur many places in the NSR area (Syroechkovskiy & Lappo 1994; Kondratiev 1986; Bogoslovskaya et al. unpubl.). The minimum number of Kittiwakes within the NSR area may be roughly estimated to 100,000-150.000 pairs, which is about 1.5 - 2 % of the world population.

Only a few data exist on population trends in the NSR area. An increase was recorded for two small colonies at Chukotka only (Kondratiev 1986). The overall number of Kittiwakes on the Vrangel Island and Gerald Island are fluctuating a lot from year to year (Stishov et al. 1991).

Habitats and breeding. The colonies are located in rocky cliffs mainly along the sea coast and in the fjords, sometimes in rivers, canyons and even in lakes more than 50 km away from the sea. Non-breeding Kittiwakes prefer more pelagic marine habitats compared to other species of gulls (Shuntov 1972).

The egg laying period starts in June and ends in July (Demme 1934; Stishov et al. 1991; Korte et al. 1995). The full clutch contains 1-3 eggs (Yudin & Firsova 1988 a), but on the Vrangel Island it does not exceed two eggs (Stishov et al. 1991). Both parents incubate the eggs for 24 - 28 days (Modestov 1967; Firsova 1978). Hatching occurs in late July - early August (Laktionov 1946; Uspenskiy 1963; Stishov et al. 1991). At the age of 40 days, the chicks are able to fly.

In the low Arctic, food availability in the vicinity of the breeding colonies is of great importance for the breeding success (Krasnov 1989). For high Arctic regions, abiotic factors become more important. Among natural predators of eggs and chicks, larger gulls and skuas are the most important. Predation efficiency is inversely proportional to the nesting density (Krasnov et al. 1995). Predation by Glaucous Gulls may sometimes affect the breeding success (Kondratiev et al. 1987)

Seasonal migrations. Kittiwakes arrive at their breeding grounds as soon as open water appear nearby the colonies. Already in April in the northeast Novaya Zemlya; in mid-May on polynyas around Severnaya Zemlya and on the Vrangel Island (Gorbunov 1929; Antipin 1938; Ushakov 1951; Uspenskiy 1969; Pridatko 1986). They leave the colonies during September and abandon the areas around the colonies in late September and October (Gorbunov 1929; Antipin 1938; Laktionov 1946; Stishov et al. 1991). In warm years, birds can delay the departure until late October (Uspenskiy 1969; Stishov et al. 1991).

The main wintering areas are situated between 40 and 60° N both in the Atlantic and in the Pacific oceans. Kittiwakes nesting west from Taimyr Peninsula are suggested to migrate westward to the Atlantic Ocean, while those gulls breeding east of Taimyr migrate to the Pacific Ocean.

Food habits. The main feeding biotope is at the sea surface, but coastal shallows and even the tidal zone can be used as well. In the north of the range, freshwater flows near the edges of glaciers, small river mouths and ice edges where strong vertical currents occur as the result of temperature and salinity gradient are among favourite foraging habitats (Salomonsen & Gitz-Johansen 1944; Løvenskiold 1964; Mehlum 1984). Food is mostly taken from the sea surface or depths less than 0.5 m. Kleptoparasitism and commensalism are known for this species (Krasnov et al. 1982; Løvenskiold 1964; Salomonsen & Gitz-Johansen 1944; Nelson 1887). As many other gull species, Kittiwakes are known as ship followers.

The foraging distance from the colony can sometimes reach 100 km, but Kittiwakes from the Vrangel Island are never observed more than 20-30 km from the colonies when breeding (Stishov et al. 1991). Small fishes are the main food, but different plankton invertebrates are also taken (Salomonsen & Gitz-Johansen 1944; Løvenskiold 1964; Belopolskiy 1957, Krasnov 1989). Some data on the diet composition from the Siberian seas, indicate that Polar Cod is the main prey item (Uspenskiy 1963; Rutilevskiy 1963; Stishov et al. 1991).

Human use. No economical significance.

Interaction with NSR activities. In contrast to many other colonial gulls, Kittiwakes may suffer more from food depletion caused by overfishing. As there is no extensive fishing along the NSR area, the greatest impact on the Kittiwakes populations may be caused by accidental or chronic oil pollution. Cases of mass death from oil spill are documented (Underwood & Stowe 1983). As a long-lived top predators, Kittiwakes may actively accumulate pollutants, though their concentrations are 3-5 times lower than in larger gulls (Savinova 1990). Regular disturbance in colonies as a result of human visits or low aircraft flights may have negative effect by means of increased predation. Creation of leads, crevices and turning of ice-floes by the ships, may result in increased food availability and may have positive effects on the population. However, the birds attracted by the ships are also more likely to be exposed to discharges and emmisions.

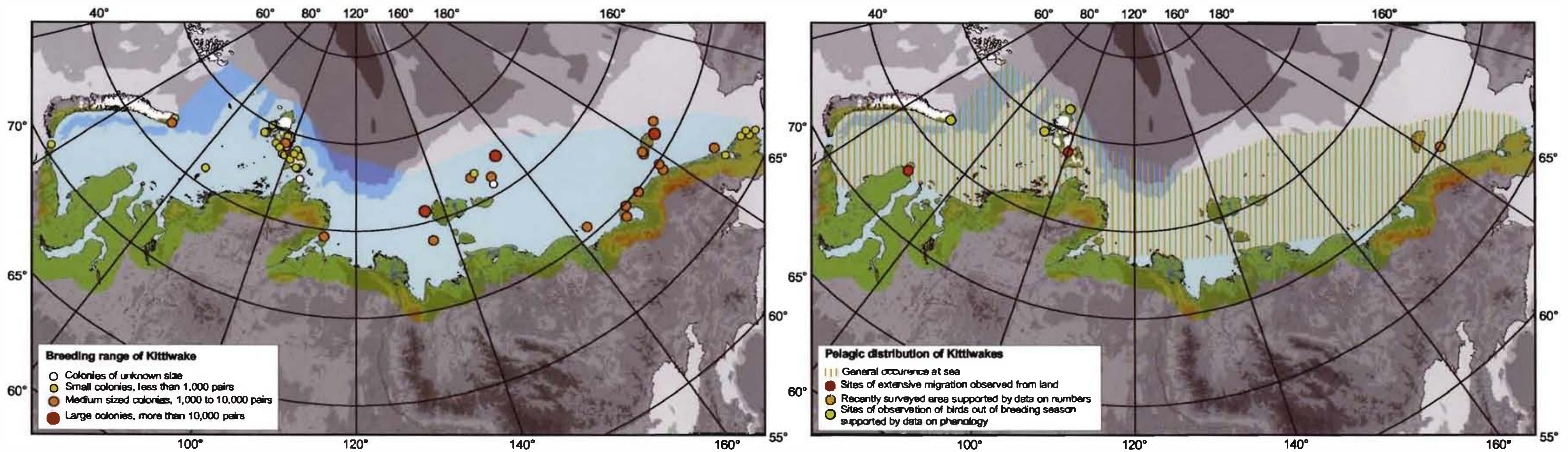


Figure 3.2. Distribution of Black-legged Kittiwake in the NSR area. (Non investegated areas in gray shade).

Ivory Gull

(Phagophila eburnea)

Photo: Vidar Bakken

Authors:
A.E. Volkov, Zoologic Institute (ZIN RAS), St. Petersburg, Russia
V. Bakken, Norwegian Polar Institute, Oslo, Norway

Status. The Ivory Gull is breeding and partly wintering in the NSR area. It is included in the Red Book of the Russian Federation. In the Russian Arctic, the breeding sites of the Ivory Gull have been protected since 1993 with the establishment of the Great Arctic Reserve including the Kara Sea islands and of the Federal Complex Reserve "Franz Josef Land".

Ivory Gull lives most of the year in the ice-covered waters. It has an flight appearance and a sound much like a tern. The adults are pure white with black legs. Juveniles have brown-black speckles and spots scattered from nape over whole of back to upper tail-coverts. In general, the biology of the Ivory Gull is poorly known.

Distribution and population size. Ivory Gull breeds in the northern part of Canada, northern and eastern coasts of Greenland, Spitsbergen, Victoria Island, Franz Josef Land, Novaja Zemlja, Severnaya Zemlya (Antipin 1938; Evans 1984; Yudin & Firsova 1988), and at the Kara Sea islands (Syroechkovsky Jr & Lappo 1994). The world population is estimated at about 14,000 pairs (Volkov & de Korte 1996).

In the NSR region, the majority of the Ivory Gulls breed at Severnaya Zemlya and at the Kara Sea islands. At the Severnaya Zemlya Archipelago, the number of breeding Ivory Gulls fluctuates between 1,000 and 2,000 pairs (Volkov & de Korte 1996). In the Kara Sea islands, the number of breeding Ivory Gulls appear to be several thousand pairs (Syroechkovsky Jr & Lappo 1994).

Habitats and breeding. The distribution of the Ivory Gull is closely related to the ice covered waters in the Arctic. At the Kara Sea islands and Franz Josef Land, breeding has been observed on flat ground (Uspenskiy & Tomkovich 1986; Syroyechkovskiy & Lappo in press). Both cliff and flat ground colonies have been observed at Severnaya Zemlya and Spitsbergen (Volkov & de Korte 1996; Løvenskiold 1963).

The nest is made by seaweed, debris or moss (del Hoyo et al. 1996). The clutch size is normally two eggs (1-3) which are incubated for 24-26 days. The chicks stay in the nest for 4-5 weeks.

Seasonal migrations. During spring and autumn migration, the Ivory Gull is encountered all over the Arctic Basin including the coast of the mainland. During the breeding season, migrating birds are also common over the whole Arctic Basin, but on the mainland coast it is only observed at the Taimyr Peninsula.

Food habits. During the breeding season the diet of Ivory Gull is mainly based upon fish (primarily Polar Cod *Boreogadus saida*) and marine invertebrates (*Amphipodae*, *Clione*) (Yudin & Firsova 1988). In the non-breeding season, they take a lot of different food items as carcasses, fish, crustaceans, and garbage/sewage near human settlements.

Human use. Ivory Gulls have no economical value, but personnel from the polar stations have collected eggs in the colonies.

Interaction with NSR activities. Oil spills may have a negative influence on the Ivory Gull population. Currently there are no data showing that noise from helicopters or single visits by humans in the colonies may have adverse effects. However, Ivory Gulls may leave the breeeding area by regular disturbance by the activity on polar stations as registrered at the Sredniy and Golomyany islands (Sedov Archipelago).

The creation of leads, crevices and turning of ice floes as a result of the shipping activity, may increase the food availability and have a positive effect on the Ivory Gull population.

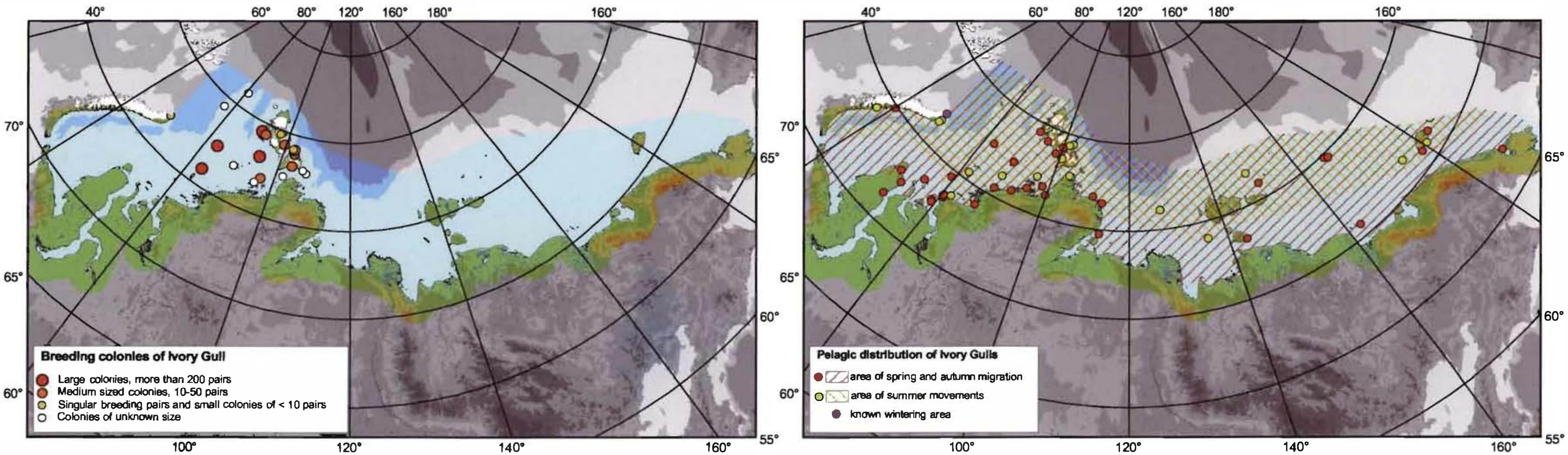


Figure 3.3. Distribution of Ivory Gull in the NSR area. (Non investegated areas in gray shade).

Brunnich's Guillemot

(Uria lomvia L.)

Author:
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Status. The Brünnich's Guillemot is a nesting and migratory species in the NSR area. According to the most recent reviews (Stepanya 1975; Golovkin 1990) four subspecies are identified: *U. l. lomvia, U. l. eleonorae, U. l. heckery* and *U. l. arra*. A revision of the systematics however, should be considered. Based on the recent reviews, two endemic subspecies *U. l. eleonorae* and *U. l. heckery* occur within the NSR area. They are partly protected in the Vrangel Island and the Lena-Delta State Reserves.

Distribution and population size. The breeding range is circumpolar within the Arctic and Sub-Arctic. The Brünnich's Guillemot is considered to be one of the most numerous seabird in the world and the breeding population is estimated at 14,000,000 birds. (CSWG 1996). There are more than 20 colonies distributed irregularly over the NSR area with a break in the Kara Sea. The largest, with more than 10,000 birds, is in northeast Novaya Zemlya, east Taimyr, New-Siberian Islands, Kolyuchin, Vrangel, and Herlad Islands (Antipin 1938; Uspenskiy 1957, 1959; Rutilevskiy 1963; Stishov et al. 1991; Kondratyev et al. 1987). It is estimated that the total number of breeding Brünnich's Guillemot within the NSR area is not less than 350,000-400,000 birds, which is about 3 % of the world breeding population.

Brünnich's Guillemots show different population trends over their range. From the NSR area, reliable data on population dynamics are available for the Vrangel Island only where the population for the last decade has been estimated to 109,000-143,000 individuals (Pridatko 1986). As the population decline is recorded in regions with extensive fishing only, it could be suggested that in the Siberian seas the overall number seems to be stable.

Habitats and breeding. Brünnich's Guillemot is an colonial cliff nesting species. Within the NSR area, Brünnich's Guillemots often breed in mixed colonies with Kittiwakes, Black Guillemots and Glaucous Gulls.

The ice conditions are of great importance for the Brünnich's Guillemots. Outside the breeding season, the birds generally occur in continental shelf waters with drifting ice and surface temperatures between 0-10 °C. They are known to aggregate near the ice edge zone. The northern boundary of the breeding range is tied up with an average multiyear position of the drifting ice edge in late August-early September, as the chicks leave colonies in ice free waters. Hence, the Brünnich's Guillemot does not breed in Severnaya Zemlya because of the heavy ice conditions in this area. Another important factor effecting colony position is presence of recurring polynyas and leads. For Brünnich's Guillemot this is even more important than for the other seabirds nesting in the Arctic. The foraging range is also affected by the ice conditions. Dense sea ice near the colony may force the birds to fly significant distances to reach suitable feeding habitats (e.g. open water, ice edge zones) (Gaston & Nettleship 1981). In the northern parts of the breeding area, heavy ice conditions can cause delayed breeding. If the fast ice or dense drift ice surrounds the colony in autumn, it may result in a complete loss of the fledged chicks (Pridatko 1986).

Brünnich's Guillemot lay one egg only directly on the ledge. Incubation period lasts for 28-35 days. After hatching, the chicks remain on the ledge from 18 to 30 days. The duration of the stay on the ledges depend to a great extent on the environmental factors, such as the physical condition of the chicks which is dependent on the amount and quality of the food brought by the parents, in addition to weather and ice conditions during fledging. Fledging dates within the NSR area vary from early August to early September. The duration of the presence of Brünnich's Guillemots in the breeding colonies vary from 100 days in the colonies located far away from wintering grounds to 180 days close to the wintering grounds.

Seasonal migrations. Brünnich's Guillemots usually winter not far from the breeding grounds near the ice edge zone. There are known cases of wintering of small number of guillemots in the polynya off the Zhelaniya Cape (Antipin 1938; Butyev 1959). Wintering in other polynyas of the Siberian Seas is assumed (Kozlova 1957; Uspenskiy 1969). Seasonal movements of Brünnich's Guillemots do not have a well-pronounced migrating character, being rather nomadic. In the autumn the birds usually move gradually away from the nesting region in small groups as the water is freezing. In spring the migration is more pronounced. Numerous flocks of birds migrate over areas covered by dense sea ice can be observed. The main winter quarters for the Atlantic populations in North Atlantic are in the sea off Newfoundland and southwest of Greenland. Pacific populations winter in the Bering Sea, Sea of Okhotsk, and the northern Pacific.

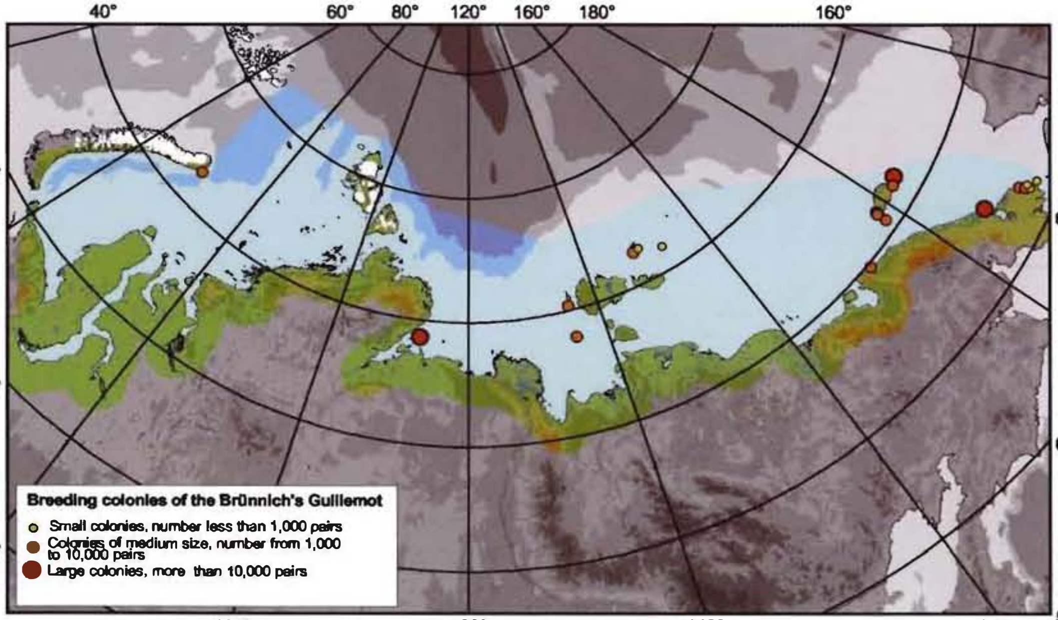
Food habits. Brünnich's Guillemots forage while diving. Normally food is taken in the water column with depth less than 50 m. Diet may vary significantly by seasons, years and in different geographical regions. Brünnich's Guillemot is a typical generalist and take a lot of different prey items. In some food samples from the Siberian Seas during the nesting period, Polar Cods and Crustaceans were observed (Uspenskiy, 1956 Rutilevskiy, 1963; Golovkin & Flint 1975; Stishov et al. 1991). Normally, Brünnich's Guillemots feed quite close to the colonies in the breeding period. Some observations from the NSR area indicate the foraging range of about 20 km (Golovkin & Flint 1975; Pridatko 1986).

Human use. Up to the 1950s, harvesting on eggs and adults was wide-spread in the USSR, resulting in a depletion of the population in some colonies. At present, the colonies of guillemots provide only an additional food source for the local people in the NSR area.

Interaction with NSR activities. The development of shipping along the NSR is mainly a threat for the Brünnich's Guillemots because of possible oil spills. The most vulnerable period is just after the chicks have fledged from the colonies in late August until October, as the chicks are unable to fly. The adults are also unable to fly during this period of moulting. There are reasons to believe that the routes of the autumn migrations in the Siberian Seas are significantly influenced by suitable ice conditions. Combined with the corresponding ship traffic, there is a risk for adverse impact by accidental events such as oil spills. In addition to accidental pollution, the guillemots as long-lived top predators are exposed to chronic pollution.

The disturbance caused by low flying aircraft can result in panic in the colony. Loss of eggs and chicks from the ledges and increased gull predation can be the result.

One of the potentially positive factors connected with the NSR shipping includes the creation of leads by the vessels facilitating the food availability for the guillemots. However, the input of this factor is unknown.



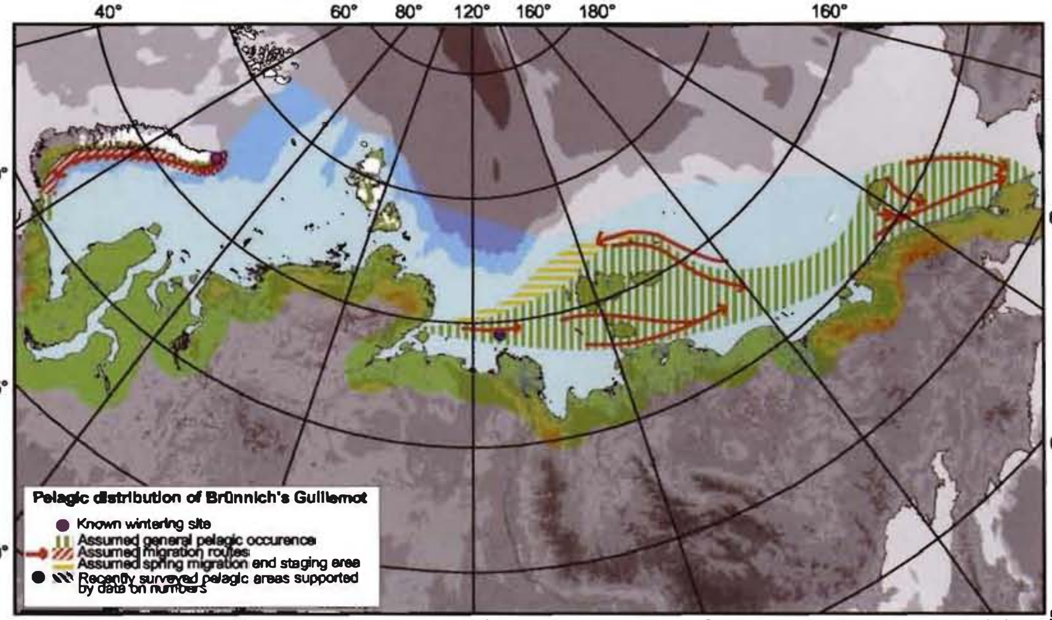


Figure 3.4. Distribution of Brünnich's Guillemot in the NSR area. (Non investegated areas in gray shade).

Seabird Colonies

Photo: Georg Bangjord

Author:
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

The colonial seabirds breeding within the NSR area are mainly represented by 12 species, 11 of the order *Charadriiformes* and one of the order *Pelicaniiformes.*

Depending on the species composition, the colonies can be subdivided into several types (Uspenskiy 1959). Under the severe climatic conditions of the Siberian shelf seas, the Arctic and high-Arctic seabird colonies are charcterised by relative few breeding species.

The colonies of Severnaya Zemlya are characterised by the absence of Brünnich's Guillemots and the dominance of Little Auks. The Ivory Gull is also widespread in the archipelago and over the Kara Sea islands. Mainly, the breeding colonial seabirds in this area are represented by four species: Little Auk, Kittiwake, Black Guillemot and Glaucous Gull. In addition, Ivory Gulls breed normally separately in flat ground colonies. The breeding colonies on the islands in the northeast Kara Sea and the northwest Laptev Sea belong to the high-Arctic type.

Table 3.2. *Breeding fauna of the colonial seabirds within the NSR area.*

	Sea			
Species	**Kara**	**Laptev**	**East-S**	**Chukchi**
Phalacracorax pelagicus	-	-	B	B
Larus hyperboreus	B	B	B	B
L. argentatus	(B)	(B)	B	B
Rissa tridactyla	B	B	B	B
Pagophila eburnea	B	B	-	-
Alle alle	B	B	-	-
Uria lomvia	B	B	B	B
U. aalge	-	-	-	B
Fratercula corniculata	-	-	-	B
Lunda cirrhata	-	-	-	B
Cepphus grylle	B	B	B	B
C. columba	-	-	-	B

***B** - breeding; **(B)** - breeding, but in separate colonies not considering in this study*

The breeding species in other colonies of the NSR area also mainly belong to the Arctic type, and are dominated by Kittiwake and Brünnich's Guillemot. The breeding colonies of the extreme northeast Novaya Zemlya, east Taimyr and New-Siberian Islands are characterised by only four breeding species: Brünnich's Guillemot, Kittiwake, Black Guillemot and Glaucous Gull.

Moving eastwards, Brünnich's Guillemot and Kittiwake still dominate the colonies, but some Pacific species are added: Pelagic Cormorant, Horned Puffin and Tufted Puffin. In the easternmost region, Black Guillemot is replaced by Pigeon Guillemot and also the Common Guillemot appears. High abundance of Black Guillemot is typical in the colonies of Herald Island and in the De-Long archipelago. The colonies of Vrangel and Herald Islands, as well as many of those situated along the Arctic coast of Chukotka, belong to the Arctic type with supplementary species from the boreal part of the Pacific Ocean. The maximum number of species (8) are found in the easternmost region of Chukchi Peninsula. Here, the boreal species become dominant and the colonies belong to the northern boreal-Pacific type.

The distribution of seabird colonies is governed by the combination of suitable breeding habitats, protection and good feeding conditions. It is well documented that the seabird colonies are mainly localised in the regions of high biological productivity. High vertical water circulation in the Arctic seas mainly occurs in polar front areas which are found in the Barents, Bering and Chukchi seas. Among these, only the western Chukchi Sea belongs strickly to the NSR area. Here, the highest number of species breed compared to the other seas of the Siberian shelf are found.

The sea ice is an important oceanographic factor affecting the life of the Arctic marine organisms. The presence of sea ice restricts the food access for the seabirds, and for guillemot fledglings dense sea ice may significantly increase the mortality when they leave the colonies. On the other hand, it is shown that the ecosystems of recurring polynyas and the ice edge are characterised by enhanced biological productivity. The regions of the shelf break are also a zone of increased water circulation and enhanced productivity. The high Arctic colonies of seabirds are confined to recurring polynyas (Kupetskiy 1959; Brown & Nettleship 1981; Gavrilo et al. 1995 and others). Within the NSR area, the only large colony of the Kara Sea is situated at the northern tip of Novozemelskaya polynya; the colonies of Severnaya Zemlya are tied up with the Eastern Severozemelskaya polynya which is located along the boundary of the continental slope; the colonies of Preobrazheniya Island and the New-Siberian Islands correspond to the system of the Laptev polynyas which is known as the Great Siberian polynya. The Zavrangelevskaya polynya adjoins Vrangel Island.

The structure of the shores, although it is not a decisive factor for the existence of colonies, can restrict their distribution to a certain

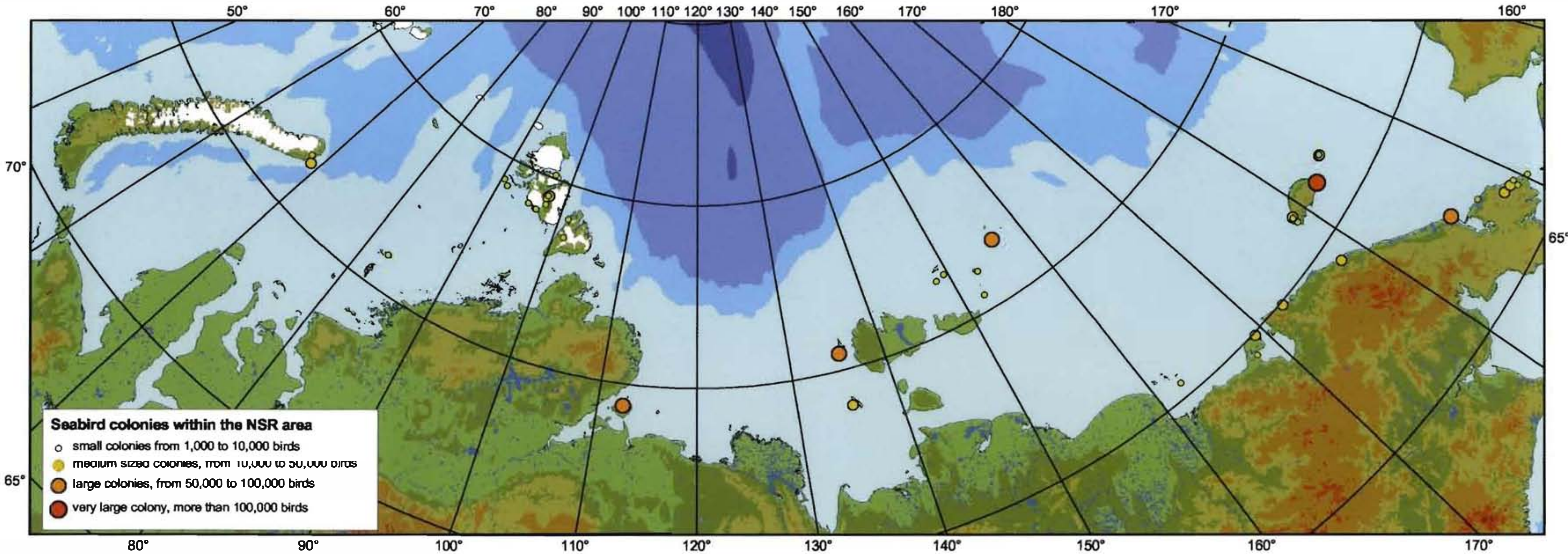


Figure 3.5. Distribution of seabirdcolonies in the NSR area. (Non investi

extent. The majority of seabirds in the NSR area nest on the rocky part of the coast, which give them protection from terrestrial predators. Suitable breeding habitats within the NSR area are limited, and are mainly confined to the Arctic islands. At the mainland, suitable breeding habitats are only found in the eastern Chukotka.

In general, the number of seabirds in the colonies of the Siberian shelf seas are relatively few. Among the 46 colonies considered in this study, there is only one colony with more than 100,000 individuals, four colonies with 50-100,000 individuals and 11 colonies with 10-50,000 individuals. The lowest number of seabirds in colonies is in the Kara Sea. The largest colony in this area situated at northeast Novaja Zemlja, has about 20-25,000 individuals. The colonies in the Laptev and the East-Siberian Seas occupy an intermediate position. The largest colonies are tied up with the Great Siberian polynya. Large breeding colonies are also situated in west Vrangel Island and at the eastern coast of Severnaya Zemlya. The colonies in the Chukchi Sea are characterised not only by the highest species diversity, but also by the highest number of breeding seabirds. The largest colonies known for the NSR area are located at Uering Cape and on Kolyuchin Island with 200,000 and 60,000 individuals, respectively. According to available data, the total number of seabirds in the colonies within the NSR area are estimated at 600,000 to 700,000 pairs, excluding terns, Glaucous Gulls, Ivory and Herring Gulls breeding in separate colonies.

Seabirds inhabiting the Siberian shelf seas are migratory birds. Few winter areas are recorded in the polynyas off Zhelaniya Cape and in Matochkin Shar Strait (Antipin 1938; Dubrovskiy 1944; Butyev 1959). It is also assumed that seabirds are wintering in the other polynyas (Uspenskiy 1969).

The arrival time to the nesting areas depends on the ice conditions in the adjacent water areas. The birds migrate towards the breeding colonies along a system of polynyas. In spring, the migration frequently approaches to the colonies from the north, following the recurring polynyas (Antipin 1938; Uspenskiy 1957). The first occupied colonies are those situated close to the ice egde. Thus, the colony in extreme northeast Novaya Zemlya is occupied already in the beginning of April. Some later, by the end of April, the colonies at Vrangel Island are occupied. Black Guillemot, Brünnich's Guillemot and Glaucous Gull, wintering near the drifting ice edge, are the first species to return to the colonies. A little later, Kittiwakes and Pelagic Cormorants return. Horned and Tufted Puffins migrate from temporal latitudes and arrive as the last species. In autumn, Black Guillemoth is among the last species to leave the breeding colonies. Glaucous Gulls can be observed around the colonies as late as November.

The time the seabirds stay in the colony during the breeding season varies a lot. The longest period lasts for about 7 months at the northeast Novaya Zemlya. The shortest period is known from the Henrietta Island. In spite of the Great Siberian polynya situated close to the colony, severe climatic conditions prevent birds to attend the colony due to snow and ice in the cliffs. The time from the first colony attendance at the beginning of the May to the birds have left colony by 20 September, is only 100 days (Leonov 1946).

As described by Bakken et al. (1996) and Gavrilo et al. (1998), oil spills in connection with the increased shipping along the NSR can be a major threat to the populations of seabirds breeding in colonies. The most vulnerable period is the time during the breeding period from early April until September. However, one should take into account that the distribution of the seabirds in spring is highly dependent of the ice situation. Important foraging areas can be tens of kilometres from the colony as in colonies situated at eastern Severnaya Zemlya. In periods with little ice during the breeding season, some data indicate that the foraging range is less than 30 kilometres from the colony (Golovkin & Flint 1975; Pridatko 1986).

Barnacle Goose

(Branta leucopsis Bechst.)

Authors:
I. Pokrovskaya, VNIIPriroda.
G.M. Tertitskiy, Institute of Geography, RAS.
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Status. The Barnacle Goose has increased in numbers and expanded the breeding range. Therefore it has been excluded from the last version of the Red Data Book of Russia (in press). A significant part of Eastern European population is protected in the "Vaigachskiy" federal refuge.

Distribution and population size. The Barnacle Goose is a monotypical species in the Northern Atlantic separated spatially in three populations: Eastern Greenland, Spitsbergen, and Eastern European. Recently all populations have increased in numbers and expanded the breeding range. Only Southern Island of Novaya Zemlya and Vaigach Island used to be main breeding areas for the Eastern European population. Since 1970's, many new breeding localities have been established along the migration route including Yugor and Kanin Peninsulas, Malozemelskaya and Bolshezemelskaya tundra, and Kolguev Island (Kalyakin 1986; Leito et al. 1990; Gavrilo 1991; Ponomareva 1991; Filchagov & Leonovich 1992; Mineev 1994; Syroechkovskiy-jr. 1995a; Volkov & Chupin 1995). The Barnacle Goose inhabits only the western-most part of the NSR area including Yugor Peninsula, Vaigach Island, and Southern Island of Novaya Zemlya (Kalyakin 1993; Morozov 1995). Besides, the species has been recorded in sum-meron Yamal and Gydan Peninsulas (Linkov 1983; Kalyakin 1993; Zhukov 1995).

Recently the total winter population in the world was estimated to 110,000-175,000 individuals (Owen 1984; Kalyakin 1993; Madsen 1994). The Eastern European population has increased from 50,000 birds in the 70's to 120,000-130,000 in the early 90's (Madsen 1994; Rose & Scott 1994).

There are no exact data on the number of Barnacle Geese breeding in the NSR area. The Vaigach Island is one of key areas for the Barnacles and the population is estimated to 10,000-25,000 individuals (Kalyakin 1984, 1993; Ponomareva 1994). The Yugor population is estimated to 550-800 individuals (Kalyakin 1993; Morozov 1995). The population of Barnacle Geese at the eastern coast of Novaja Zemlja is highly underestimated as the area is not yet surveyed. During the survey in 1992 at Novaya Zemlya the highest density of Barnacle Goose was recorded in the area at Menshikova Cape (34 and 14 birds/km² at sea and on tundra, respectively) (Pokrovskaya & Tertitskiy 1993). At the present state of knowledge, the NSR area population can be estimated at about 5-10 % of the world population and minimun 8-20 % of the Eastern European population. In addition, there is an unknown number of birds on the eastern coast of Novaya Zemlya.

Habitats and breeding. The Barnacle Geese are mostly tied up to the coastal zone during the breeding season. Within the coastal habitats they are flexible in choosing breeding sites, but inaccessibility for terrestrial predators is essential. Rocky coastal precipices, ridges, river canyons, and small off-shore islets are the main nesting sites in the NSR area (Kalyakin 1986; Morozov 1995).

The Barnacle Goose becomes mature in the third year in life. They breed in colonies up to 20-30 pairs and in single pairs (Kalyakin 1986; Morozov 1995). Often they breed in mixed colonies with eiders, Glaucous Gulls, or close to raptors to get protection.

The breeding period begins in the second half of June (Mineev 1994). In Vaigach, the clutch size is found to be 3.9-4.4 eggs, and the mean brood size - 2.4 goslings (Kalyakin 1986; Syroechkovskiy et al. 1995). The incubation period lasts for 24-25 days and hatching occurs during mid-July (Kalyakin 1986). After 40-45 days the goslings are able to fly.

The ratio between breeders and non-breeders varies highly and depends on weather, time of the melting of snow, number of rodents and on the ratio between age and sex in the population. Between years it is found to vary from 4:1 to 1:2 in Vaigach and Yugor areas (Kalyakin 1986; Romanov 1989; Morozov 1995). It should be taken into account that non-breeders seem to be highly underestimated because they mainly stay at sea.

Seasonal migrations. The Barnacle Goose is a typical short-distance migrant. From the breeding sites they fly about 4,000 km to reach the wintering grounds in Scotland, Ireland and the Netherlands (Leito 1990; Leito et al. 1994). The flyway of the Eastern European population follows the southeast coast of the Barents Sea, then they go southwards across the White and Baltic seas to the wintering sites. The spring migration goes along the Western Yugor Peninsula and Yugor Shar Strait, with peak in early June (Kalyakin 1984; Mineev 1994).

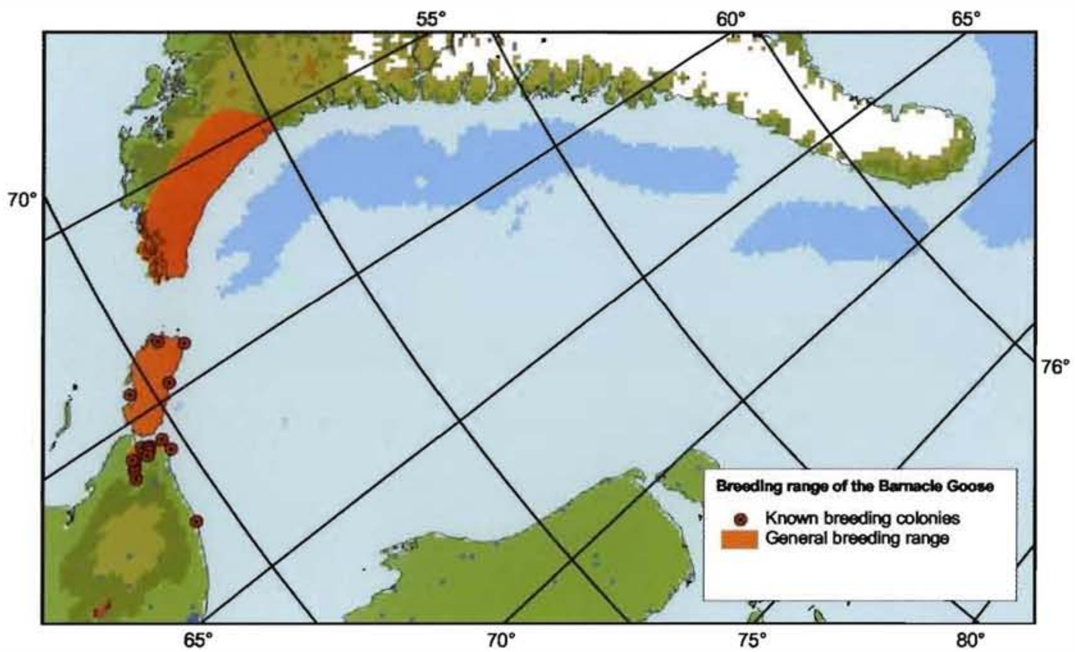
Food habits. Vegetation is the main part of the diet. Molluscs and crustaceans are sometimes consumed (Isakov & Ptushenko 1952). The diet in summer of the Eastern European population is not studied, but different species of dwarf willows, horsetails and saxifragas are in their main diet in Spitsbergen (Prop et al. 1984).

Human use. The economic value is small. Barnacle Geese comprised about 6% of the geese hunted in spring in the Yugor-Vaigach area (Kalyakin 1986). In some places, egg collection by local people may decrease the clutch size in colonies next to settlements (Ponomareva 1992, Filchagov & Leonovich 1992).

Interaction with NSR activities. Even if the population are stable, the Barnacle Goose still remains vulnerable to human impacts due to their aggregation in certain marine habitats.

Development of shipping along the NSR may affect the Barnacle Goose population in several ways. The birds are vulnerable to oil spills during moulting when brood rearing flocks are tied up to narrow coastal zones and they escape by swimming. Geese that nest on small off-shore islets have to overcome straits with flightless goslings by swimming, to reach the brooding areas on the mainland. This factor becomes most important in years with small numbers of lemmings, when only goslings from such habitats have the best chances to survive. Hence, the most vulnerable time is mid-July until late August. Strict regulation of human activity on these areas should be considered in oil spills emergency plans.

Other impacts, such as direct disturbance and noise or increasing of edible waste deposits are of less importance, but may significantly decrease nesting success in some cases by the increase of predator abundance and theirs hunting success.



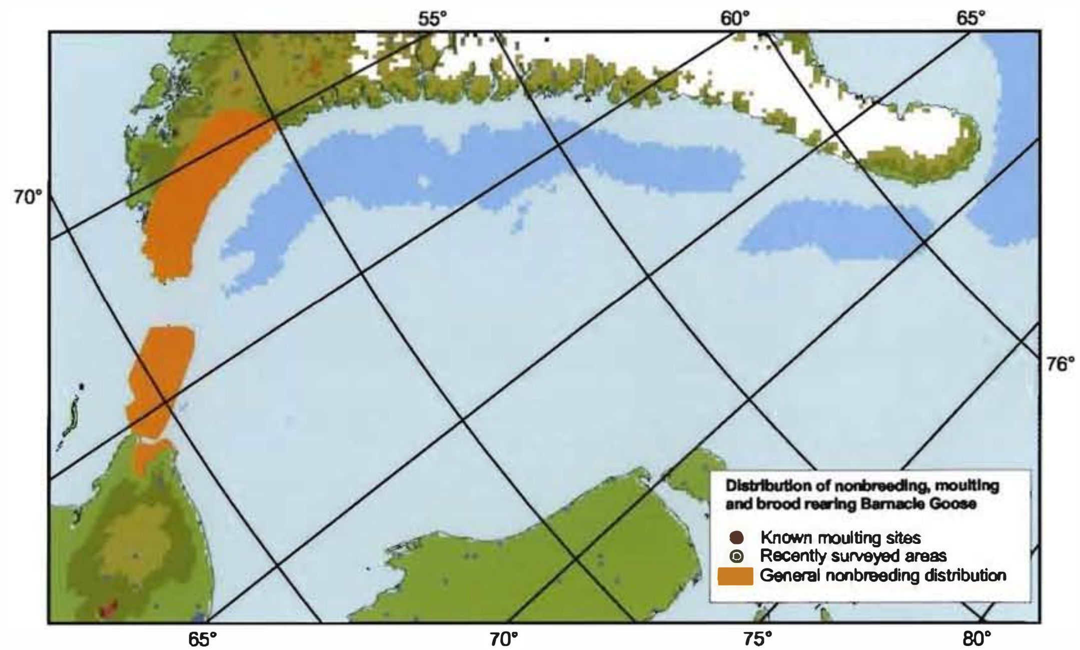


Figure 3.6. Distribution of Barnacle Goose in the NSR area.

Brent Goose

(Branta bernicla L.)

o: Vidar Ba

Author:
E.E. Syroechkovskiy-jr., IPEE

Status. Two subspecies of Brent Goose are breeding in the NSR area; Dark-bellied Brent Goose (*B.b. bernicla*) and Black Brent Goose (*B.b. nigricans*), which in this paper includes *B. b. orientalis*. The Black Brent Goose is included in the Russian Red Data Book. The most threatened Asian population of the Dark-bellied Brent Goose is protected in the Lena-Delta Reserve. The key areas for the Dark-bellied Brent Goose, which is a endemic breeder in Russia, are protected in the Great Arctic Reserve.

Distribution and population size. Brent Goose breeds across high-Arctic tundra. The Dark-bellied Brent Goose breeds on the Arctic coast of Yamal, Gydan and Taimyr, in Severnaya Zemlya archipelago and at the Kara Sea Islands. During the last decades, new nesting areas have been established along the migration route from the Western Europe (Filchagov & Leonovich 1992). The Black Brent Goose breeds in isolated populations from the lower reaches of the Olenek River eastward up to the Anadyr River mouth (Isakov & Petushenko 1952; Cramp 1977).

The Brent Goose population inhabiting the northern coasts of Russia in summer is estimated to 300,000-370,000 individuals, i.e. 60-70% of the world population (Rose & Scott 1994). The number of the Dark-bellied Brent Goose have been steadily increasing for the last 30 years, while the Black Brant demonstrates the opposite trend. Particularly noticeable decline is observed in the Asian population, and this population is only estimated at some thousand of birds (Syroechkovskiy-jr. 1995b).

Seasonal migrations. Dark-bellied Brent Geese fly in spring from the Western Europe along the White Sea-Baltic flyway, across the Kanin Peninsula in early June. They appear in Taimyr on June 10, and depart during August. On the Yugor Peninsula coasts the birds are recorded up to early October (Mineev 1994).

Black Brent Geese appear on the breeding grounds in very late May and early June (Degtyarev et al. 1995). Departure takes place in late August and September. The seasonal migrations of the American population are mainly in the latitudinal direction connecting Yakutian breeding grounds and American winter grounds (Kistchinski & Vronskiy 1979). The Asian population winters in Japan, Korea and China. In spring, the geese migrate along Lena and Yana River valleys, while in autumn they round the mainland along the coast, but the migration patterns are not entire clear.

Habitats and breeding. Together with the Emperor Goose, the Brent Goose is one of the most marine geese species. Much of the life cycle is spent near the sea. They do not penetrate inland more than some tens of kilometres. While breeding, the Dark-bellied Brent Goose are not much assosiated to the sea, because most of the coastline is covered by ice until July and August. They nest on plain tundra and on minor islands near the mainland. Geese that breed on the mainland, moult over extensive deltas and along the seashore. Birds nesting on remote islands moult on tundra. In Yakutia and at Chukotka, the Black Brent Goose occur within the coastal zone, inhabiting deltas, estuaries and lagoon areas both for breeding and moulting. Both races make extensive use of the coastal habitats and the sea while migrating.

Annually, not more than 25% of birds in the population breed. They breed both in individual pairs and in colonies up to hundreds of nests. The colonies are often mixed with gulls and other waterbirds (Demme 1934; Degtyarev et al. 1995; Pozdnyakov et al. 1995; Syroechkovskiy-jr. 1995c in press).

The Brent Goose starts nesting immediately after arrival, i.e. in late May and early June. The clutch size is 3-5 eggs. The incubation period lasts for 23-26 days and the goslings hatch in early July. The pairs with broods join in flocks, single pairs are rare on the tundra or along the river and lake banks. The goslings are able to fly 30-35 days after hatching and soon after they leave the breeding area.

Food habits. The Brent Goose grazes on tundra, preferring wet areas with rich herbaceous vegetation, particularly when moulting. Grass and sedge are the principal food, but all vascular plants can be consumed when food is in shortage, especially in the north of the barren-grounds tundra.

Human use. The Black Brent Goose is not important as a game bird as it is included in the Red Data Book. The hunting of the nominate race is also prohibited almost everywhere. The Brent Goose is the most trusting one with regard to humans among Arctic geese, and that is why it suffers most due to illegal hunting. Brent Geese are easy to catch and shoot during the moulting period.

Interaction with NSR activities. The development of land-based infrastructure and an increase in the number of people on the nesting and moulting grounds, can adversely affect the geese. However, the disturbance appears to make smaller impact on Brent Goose as compared with other geese. Moulting birds are more vulnerable of aircrafts than other Arctic geese. Moulting flocks interrupt feeding and enter water, hence, frequent low flights of aircraft can significantly affect time and energy budget in moulting Brent Geese.

As the Brent Goose is closely connected with the marine habitat, it is more vulnerable to oil pollution at sea than many other geese. While breeding, the geese are at higher risk of oil spills at Yamal and Gydan coasts, partly in the Yenisey and Khatanga Bays, and also those breeding in deltas of north Yakutia. Chronic pollution in the coastal zone can adversely affect populations inhabiting western segments of the range including west Yamal and north Gydan, and also the coasts of the northeast Asia, as the geese here make extensive use of littoral vegetation, especially before departure.

Thus, increased shipping along the NSR, development of land-based infrastructure, oil pollution both chronic and accidental, illegal hunting and to lesser extent disturbance, are considered harmful to the Brent Goose.

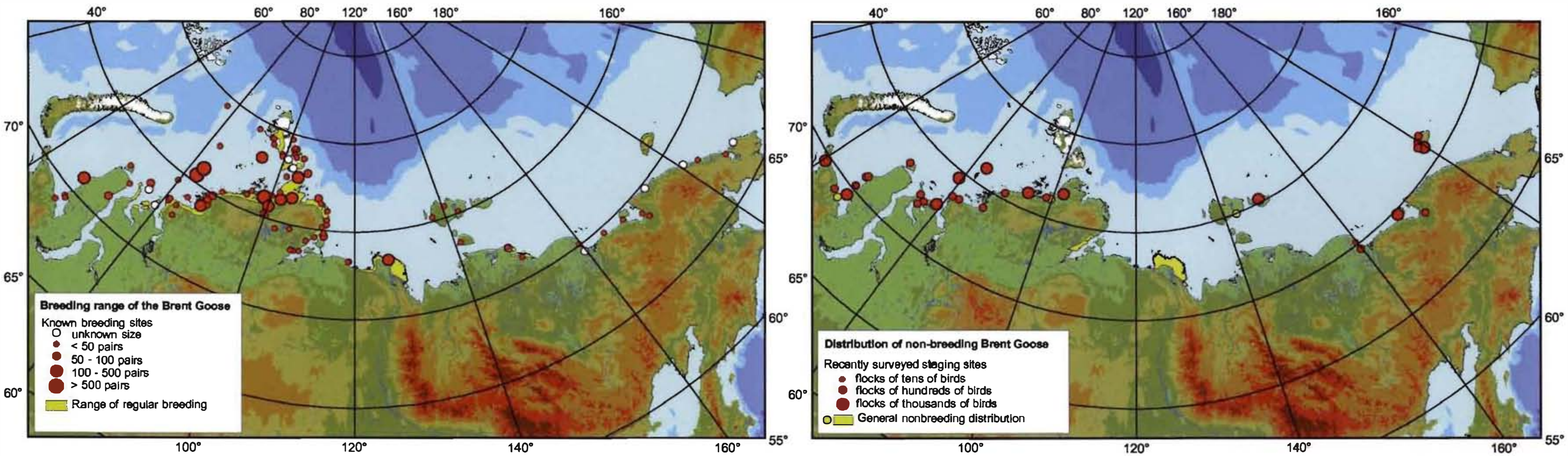


Figure 3.7. Distribution of Brent Goose in the NSR area.

White-fronted Goose

(Anser albifrons Scop.)

Photo: Bjørn Frantzen (bird in captivity)

Author:
E.A. Kretchmar, IBPN RAS

Status: The White-fronted Goose is a widespread nesting and migratory species within the NSR area.

The White-fronted Goose is polytypical with a circumpolar breeding range. Following the systematics by Portenko (1972) and Kolbe (1981), four subspecies are recognised: Eurasian *A. albifrons albifrons* and three north American subspecies including *A. a. flavirostris, A. a. gambelli*, and *A. a. frontalis*.

Eurasian White-fronted Goose is an endemic breeding species in Russia. Along the NSR, they are protected in the Vaigachskiy, Purinskiy and Chaigurino State Refuges and the Great Arctic, Taimyrskiy and Lena-Delta State Reserves.

Distribution. The breeding range along NSR includes the zone of the continental tundra and forest tundra from the western coast of Kanin Peninsula in the west to the Chukchi Peninsula in the east. The distribution pattern of breeding grounds are non-uniform depending on the presence of wetlands. In the north it penetrates into a number of the Arctic islands, including Vaigach Island, the Southern Island of Novaya Zemlya and New-Siberian Islands.

Seasonal migrations. White-fronted Goose breeding in northern Eurasia is a typical long-distant migrant whose wintering grounds are located within the same continent. The winter areas are in wetlands of west Europe, Asia Minor, in the coastal regions of the Black Sea, the Sea of Azov, and the Caspian Sea. The White-fronted Geese breeding east of the Lena-Delta, winter in the southeast China, on the Korean Peninsula, and on Japanese Islands.

White-fronted Geese arrive to the breeding grounds in the second half of May and early June. In late June and first half of July, there are local movements of non-breeding geese to the moulting grounds. The autumn migration lasts from late August to early October all over the NSR area.

Calculations from available data (Andreev in press; Kistchinski 1988; Krivenko 1984, 1991; Martynov 1983; Labutin et al. 1986; Mineev 1995) indicate a total population number of White-fronts inhabiting the territory directly adjacent to the NSR to 500,000-1,000,000 birds. It is assumed that the population size is closer to the lower range.

The population trend of the White-fronted Goose is different along the NSR. In the western part, the population is stable or slowly increasing, but east of Taimyr Peninsula a gradual decrease in numbers is observed. This situation seems to be related to a spatial separation of the winter areas. The eastern populations of geese are under a strong hunting pressure because of food shortage among the human population in Asia.

Habitats and breeding. In spring, geese are tied up with thaw patches that are formed in the well-exposed hummocked zones. Dry, slightly elevated places are preferred for nesting. The nests are often attached to the water bodies. Different classes of tundra are used as principal nesting habitats.

Broods and brood groups gather on the shores of the water bodies. They make local movements along river channels with productive shores. Non-breeding birds usually gather for moult at isolated lakes. Sometimes moulting geese mix with brood groups.

The White-fronted Goose becomes mature after the third year. It breeds usually in solitary pairs, but loose colonies are known from the western part of the range (Mineev 1995).

The birds start breeding 5-15 days after arrival. The lengh of the incubation is 24-25 days. The clutch contains on average 4-5 eggs. Hatching occurs from the end of June to late July. After leaving the nest, the broods shift to the feeding biotopes. Sometimes the broods join into small aggregations including up to 10 and more families (Krechmar et al. 1991). Goslings are able to fly 6-7 weeks after hatching; i.e. in late August - early September.

Food habits. After arrival and prior to the growth season, the diet of the White-fronted Goose mainly consists of the underground starch-abundant parts of different sedges and last year berries. Sedges, graminoids and berries are the main diet during summer.

Human use. The White-fronted Goose is one of the most popular hunting species. In the eastern part of the NSR area it plays an important role in the life of the indigenous people.

Interaction with NSR activities. NSR-related activities can be harmful to the White-fronted goose populations because of increased disturbance, hunting pressure and to some extent pollution of coastal areas.

During the last thirty years, economic activities have increased the pressure upon the breeding habiatas. The development of infrastructure and the use of light aircraft, vehicles, and shallow-draft boats makes man able to freely penetrate remote regions which formely have served as reliable refuges both for breeding and non-breeding moulting birds. The use of helicopters during the period of moult and brood rearing (the second half of July-early August) provides a serious potential impact factor to the birds.

Contamination of the coastal zone by oil products can affect moulting birds and broods assosiated to the shore in late July-early August. However, the fraction of White-fronts using these biotopes is small.

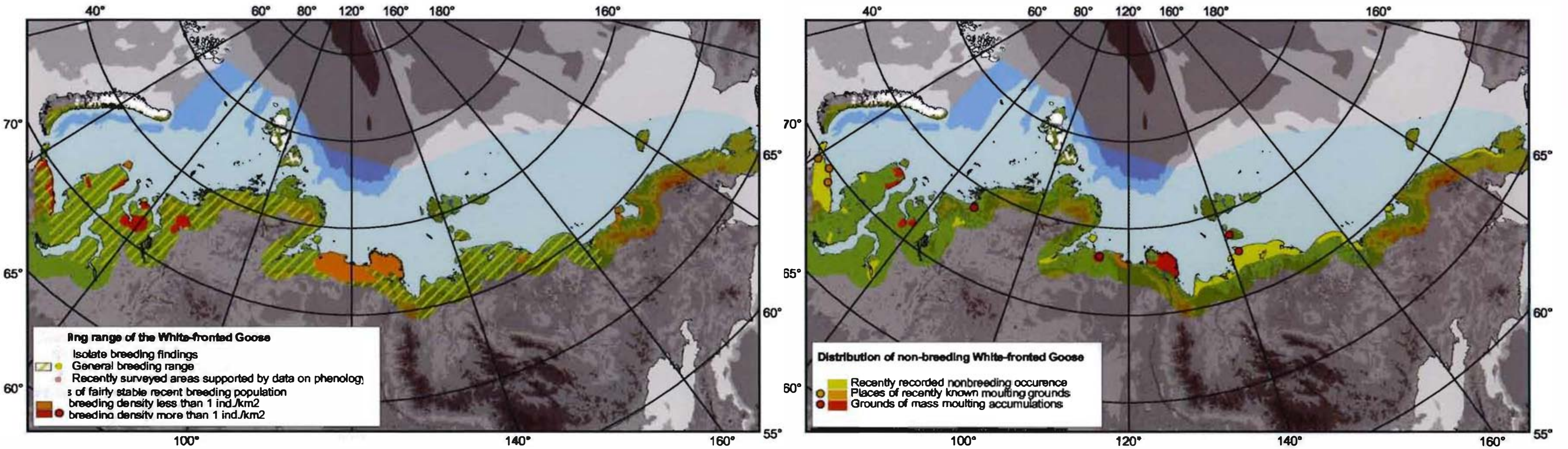


Figure 3.8. Distribution of White-fronted Goose in the NSR area. (Non investegated areas in gray shade).

Bean Goose

(Anser fabalis Lath.)

Photo: Georg Bangjord

Authors:
G.M. Tertitskiy, Institute of Geography, RAS
A.V. Kondratiev, IBPN, RAS
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Status. The Bean Goose is a widespread nesting and migratory species within the NSR area.

Bean Goose is a polytypical species, but the systematics concerning the subspecies are not yet confirmed. Four or five subspecies are recognised by different authors (Stepanyan 1975; Cramp 1977). This paper is based on the point of view of the latter author, and mainly two Russian tundra subspecies *(A.f. rossicus* and *A.f. serrirostris)* are considered.

The species is protected in the Great Arctic and Lena-Delta State Reserves, in Vaigachskiy, and Purinskiy Federal Refuges.

Distribution and population size. The Bean Goose is widely distributed over north Eurasia. The two tundra subspecies breeding within the NSR area are separated by the border between Khatanga and Lena river. *A.f. rossicus* breeds west and *A.f. serrirostris* east of this border.

The total number for the Bean Goose population breeding in the NSR area is uncertain. The data on population density from different regions can be used to describe the general distribution of the species. The highest abundance is recorded on west Yugor Peninsula and Vaigach Island (4.2 and 1.2 ind/km², Romanov 1988; Mineev 1994). Further to the east the density never exceeds 1 ind/km², except for the Kolyma Lowland (0.7-1.3 ind/km², Krechmar et al. 1991). In other regions, it varies between 0.08-0.4 ind/km² (Ryabitsev 1995; Labutin et al. 1986; Blokhin 1988; Degtyarev 1990).

A population density trend can be recognised almost all over the range. In almost all parts of the NSR the number of the Bean Goose have decreased dramatically during the last decades except for Vaigach Island and Yugor Peninsula (and probably Novaya Zemlya). Extensive human activity on Yamal is responsible for the population decrease of Bean Goose in this area, and probably for a change in the moulting sites to Gydan (Molochaev pers. comm.). During the last 15-20 years, the number of breeding birds in Taimyr have declined by tens fold (Krechmar 1966; Kokorev 1983; 1985 cited after Rogacheva 1988). All across the Asian tundra a significant population decline of both breeding and moulting geese has been registered since the middle of this century.

Seasonal migrations. The flyway of *A.f. rossicus* passes across the European part of Russia and along the northern coast. The flyway of *A.f. serrirostris* goes across east Siberia and follows the larger river valleys. The departure to the wintering grounds is from the second half of August to October. The autumn migration can start as early as in mid-August (Yugor Peninsula), while the local breeders still not have completed their moult (Mineev 1994).

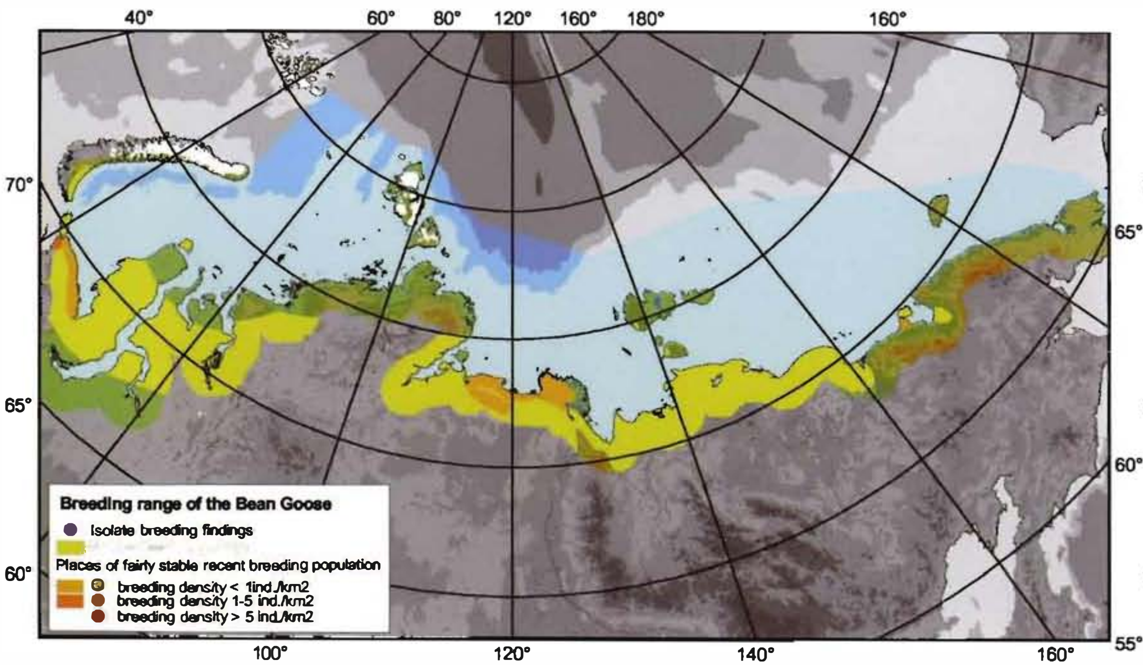
Habitats and breeding. Just after arrival, the first thawed patches on tundra covered by cottongrass are of great importance to the Bean Geese. The availability of food may have significant influence on the breeding success (Sdobnikov 1959; Krechmar et al. 1991). While nesting the geese prefer slopes, bluffs, elevated banks of lakes, and rivers which early become free of snow, and with various types of grass and bush tundra, mostly nearby water bodies. Broods are reared on lakes or river channels and graze on adjacent meadows. On the southern tundra, most of the Bean Geese moult on lakes, but further north they moult mostly on river arms and in deltas. Along the Arctic coast, Bean Goose often moult at sea (Rutilevskiy 1967; Uspenskiy & Kistchinski 1972; Kalyakin pers. comm.).

The breeding part of the population fluctuates highly from year to year. The Bean Goose breeds in isolated pairs. The breeding starts immidiately after arrival, sometimes almost during winter condition. Within the NSR area, the average size of clutch may vary from 2.6 to 5.8 eggs (Krechmar 1966; Pozdnyakov & Sofronov 1995). A decrease of the clutch size is recognised toward the north (Krechmar et al. 1991; Syroechkovskiy et al. 1995). Incubation lasts about 27 days (25 - 30 days). Brood size is also highly variable. The average size is 3.4-3.7 goslings, but 4.2-5 chicks may be reached in favourable years (Danilov et al. 1984; Blokhin 1988; Mineev 1994; Pozdnyakov & Sofronov 1995). The chicks become adult-sized at an age of 6-7 weeks and are able to fly in the end of August.

Food habits. The favorite food in spring is blooming heads and underground stems of cottongrasses *Eriophorum spp.*, green shoots of *Arctophila fulva* and water sedge *Carex aquatilis* (Isakov 1952; Krechmar et al. 1991). In summer, the geese feed intensively on different species of grasses, sedges, cottongrasses and horsetails, preferring different species depending on certain habitat. When moulting, not only these species, but all vegetation is grazed on including mosses and dycotyledons.

Human use. The Bean Goose is one of the favorite hunting species in all seasons. The intensive harvest of the wintering grounds in China is the main reason for the dramatic decrease in the eastern tundra goose populations (see Andreev in press.). On the breeding sites, direct harvest seems to have a small impact on the population, while indirect impact during the hunting season is rather high (Blokhin 1988; Degtyarev 1990).

Interaction with NSR activities. Bean Goose is not highly associated with the coast in the NSR area. Only in the northernmost parts (Novaya Zemlya, New-Siberian Islands), the geese may moult at sea. Birds using delta channels as moulting and rearing habitats are at risk of being hit by oil pollution. Thus, development of shipping along the NSR may be a threat to the Bean Geese inhabiting the northern areas. Increased hunting and disturbance caused by the development of land-based infrastructure will be the main threats to the Bean Goose population in the southern part of the NSR area.



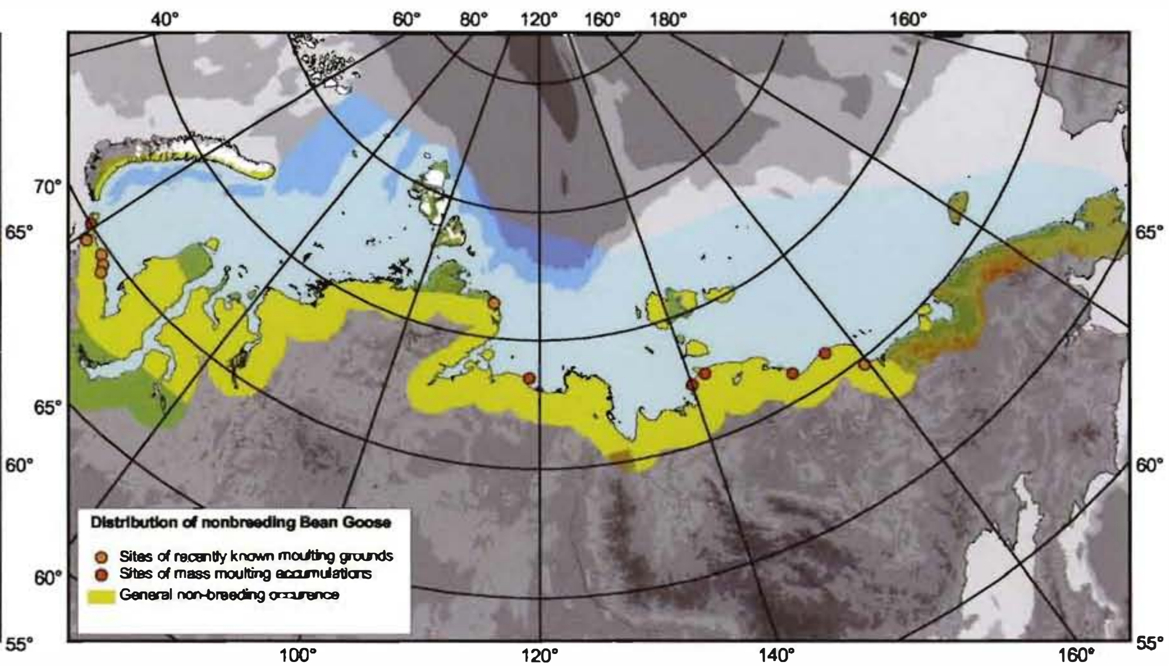


Figure 3.9. Distribution of Bean Goose in the NSR area. (Non investegated areas in gray shade).

Emperor Goose

(Philacte canagica Sewast.).

Photo: Bjørn Frantzen (bird in captivity)

Author:
A. V. Kondratyev, IBPN RAS

Status: The Emperor Goose breeds in a restricted area in the easternmost part of the NSR. It is included in the Red Data Book of the Russian Federation.

Distribution and population size: The breeding range is restricted to Alaska and Chukotka. The estimated world population is about 60,000 individuals (King & Dau 1991; Petersen et al. 1994).

Within the NSR area, the Emperor Goose inhabits the area from the Amguema River mouth eastward to the Dezhnev Cape, with the highest density (3 pairs per 10 km^2) found in Vankarem Lowland and coastal tundra along the Kolyuchin Bay (Kistchinskiy 1972; Kistchinskiy 1988; Krechmar & Kondratyev 1982; Krechmar et al. 1978). The population at the Arctic Ocean coast is in the range of 2,000 to 5,500 individuals (estimated from summer aerial survey, Eldridge et al. 1993; Hodges & Eldridge 1995 unpubl. report). That is about 3-6% of the world population. The Ukouge lagoon used to be the principal moulting ground, where the majority of the flocks numbered 2000 birds (Kistchinskiy 1972).

The American population decreased gradually from 1964 to 1986, but has partly recovered. Recently it is considered to be stable. The Russian population also demonstrated a general decline during the last decades, but the most recent trend is unknown.

Habitats and breeding. The Emperor Goose is a typical marine goose. While moulting, migrating and wintering, the birds are mainly associated with the tidal zone and lagoons. The narrow coastal strip covered by flooded maritime sedge and grass meadows is prefered as nesting biotope (Petersen 1991; Krechmar & Kondratyev 1982; Krechmar et al. 1991; Kondratyev 1993). Emperor Goose rarely nests on tundra more than 60 km from the sea (Portenko 1972; Kistchinskiy 1988).

Emperor Goose becomes mature in the third year of life. The maximum known age is 9 years. The breeding part of the population does probably not exceed 20% of the total numbers of birds that arrive to the nesting grounds (Kistchinskiy 1988). The spring numbers of the Emperor Goose are influenced by two main factors: breeding success of the previous year (53% variation) and winter mortality, which is relatively higher compared to other goose species (Petersen et al. 1994).

Usually nesting starts in late June. A full clutch contains 2-7 (4 on average) eggs. The incubation period lasts for 23-26 days (24 on average). Hatching occurs on 12-19 July. Goslings take on wing at 50-60 days, i.e. in the second half of August (Krechmar et al. 1978; Krechmar & Kondratyev 1982; Kistchinskiy 1988).

The incubation is performed by the female only, while the male guards the nest during the first half of incubation. Then the males stay away until the brood-rearing period when they spend most of time protecting the goslings in open habitats. Broods can join in aggregations up to 45 birds (Tomkovich & Sorokin 1983).

The breeding success show significant temporal and spatial variations, reaching in favorable years 60-90% (Petersen 1992). The main reason for low breeding success is the predation pressure of the Arctic Foxes, specially in the last period of the incubation period when the male is absent from the nesting area.

Non-breeders stay in the nesting area until late June when they gather in flocks from 15 to 50 birds, for moulting at sea coast and in lagoons. When disturbed, Emperors escape by running to the nearest water. Non-breeding moulting geese are able to fly by mid-August and brood-rearing parents some later.

Seasonal migrations. The spring arrival to the breeding grounds occurs in late May and early June, depending on weather conditions. Autumn migration starts as early as in mid-August. The vast majority of the world population winters in the Aleutian Islands. Spring staging in the lagoons of the Alaska Peninsula is a period of great importance to the life cycle of the Emperors.

Food habits: The principal food in marine and estuarine habitats is benthic intertidal invertebrates and vegetation, and vegetation in terrestrial habitats (Kistchinskiy 1972; Petersen et al. 1994).

Human use. Even if the species is protected all over the area, the Emperor Goose are hunted, mainly in spring, by local people of Alaska and partly Chukotka.

Interaction with NSR activities. Because the habitats of Emperors are tied up with intertidal landscapes during the entire annual cycle, they are more vulnerable to oil spills than other goose species.

During brood-rearing and moulting the Emperors are extremely sensitive to disturbance and avoid human settlements. Increase of disturbance, visits to feeding and moulting areas by humans in the second half of summer, may result in the birds leaving the area.

The main reason for the high mortality of the Emperors in the wintering grounds is the contamination of coastal ecosystems at the Aleutian Islands (Petersen et al. 1994).

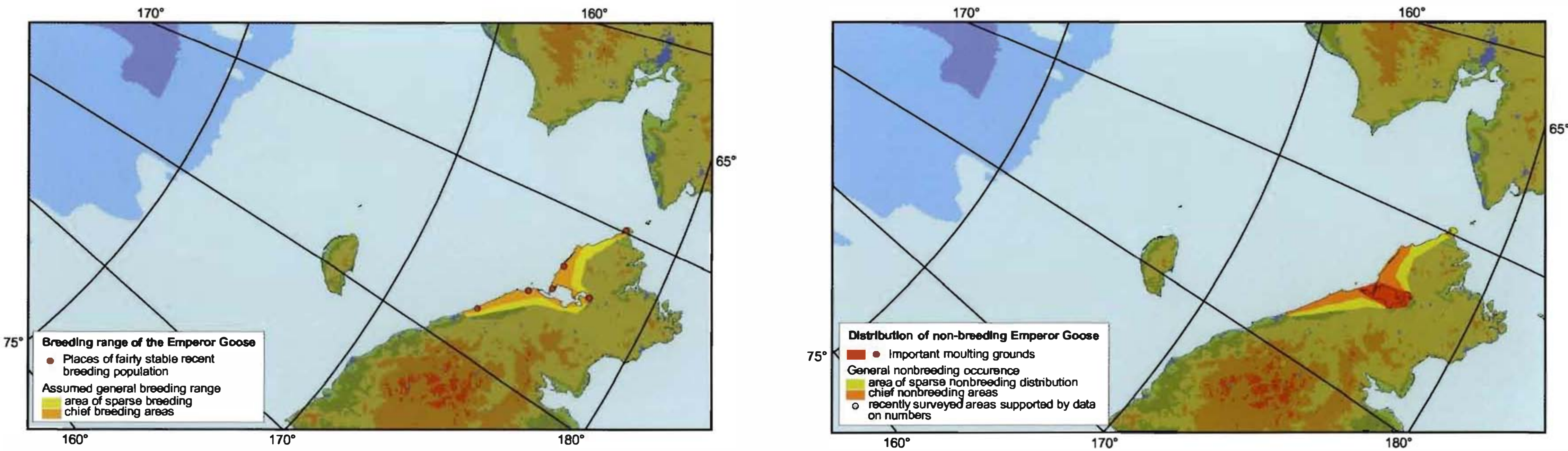


Figure 3.10. Distribution of Emperor Goose in the NSR area.

Common Eider

(Somateria mollissima L.)

Photo: Fridtjof Mehlum

Author:
G.M. Tertitskiy, Institute of Geography, RAS
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Status. The Common Eider is a widespread polytypic, nesting and migratory species within the NSR area. The population trends vary between regions. The Pacific Eider is considered to decline and is protected in Vrangel Island State Reserve and included in the Red Data Book of Yakut ASSR.

Distribution and population size. The Common Eider is a circumpolar species, widespread throughout Arctic and sub-Arctic coasts, although apparently absent from west and central Siberia and north Canadian Archipelago. The nominate race penetrates the westernmost zones of the NSR (Gorbunov 1929; Demme 1946b; Estafyev et al. 1995). Isolated breeding sites are found on the Kara Sea islands and in Severnaya Zemlya (Syroechkovskiy & Lappo 1994; Volkov & de Korte pers. comm.). The NSR area is inhabited by Pacific Eiders (Rutilevskiy 1957; Portenko 1972). Nonbreeding Eiders penetrate west as far as southeast Taimyr, and can be found at sea from Khatanga Bay to the Bering Strait.

The Common Eider is quite numerous and the nominate race population is estimated to 3,000,000 birds, while the Pacific race population size to 150,000 birds only (Rose & Scott 1994). In spite of unreliable data on abundance for the western NSR area, the number of Eiders here hardly exceeds 1% of nominate race population (Kalyakin 1984; Mineev 1994; Ponomareva 1994). Pacific Eider used to be a common breeder along the coasts of Anjou Isles four decades ago, with highest density along the southern coast of Zemlya Bunge (Rutilevskiy 1957). At the Vrangel Island, the overall number is estimated to 20,000 individuals (Stishov 1984). Goudie et al. (1994), assume that the population of Pacific Eider has shown a 3-4 fold decrease since 1970s. The number of Common Eiders inhabiting the NSR area comprise about 40% of the total number of the Pacific race.

Seasonal migrations. Eastern European Eiders winter in ice free waters of the Barents Sea and partly in the White Sea. In the Pacific, the main wintering areas are located along the ice edge in the central Bering Sea and in the Bering Strait as well (Isakov & Ptushenko 1952; Shklyarevich 1979; Johnson & Heartier 1989). Extensive migration occurs along the Arctic coast of east Chukotka. Common Eiders are assumed to occur at sea in the vicinities of the breeding areas as soon as leads and polynyas appear in the middle of April and early May, some places as late as June (Antipin 1938; Rutilevskiy 1957; Uspenskiy 1967, Portenko 1972; Krechmar et al. 1977; Tomkovich & Sorokin 1988). As soon as the egg laying is finished, males, failed females and nonbreeding birds start the migration to the moulting areas. Extensive migration occurs in Chukotka during late June and July. Successful breeding Eiders leave the tundra by late August, and during September-November they leave the waters close to the breeding areas. The only large flocks in the pre-migration period are found on the south coast of the Vrangel Island (Stishov et al. 1991). Autumn migration in the western Kara Sea occurs in mid-September (Demme 1946b).

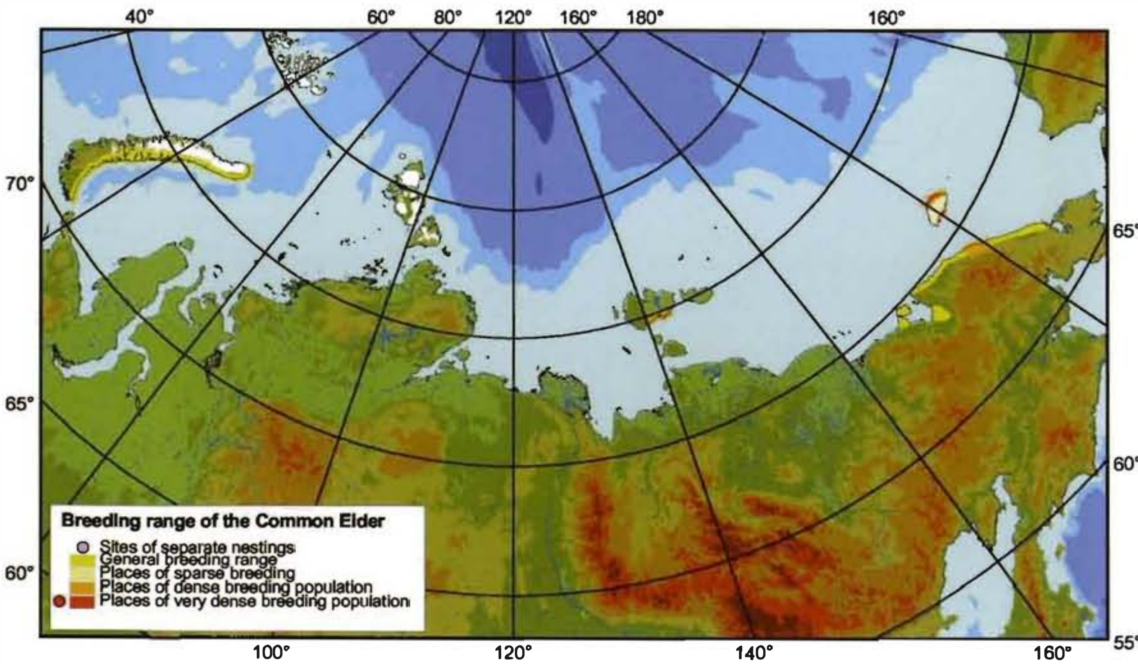
Habitats and breeding. Among the marine ducks, the Common Eider is the species most connected to the marine habitats, although prevailing biotope preferences differs among the races. *Somateria m. mollissima* is strongly tied up with sea coast, and the overwhelming majority breeds on small inshore islands inaccessible for predators. One to two days after hatching, the female brings the brood to the sea. Unlike birds of the nominate race, the Pacific Eider breeds on the tundra as far as 50-100 km from the sea (Kistchinski 1976; Stishov pers. comm.). They often breed in mixed colonies with Barnacle Geese, Black Brants, Arctic Terns, Glaucous and Herring Gulls, and can use the benefit of protection from Snowy Owls, Peregrine Falcons, and human settlements (Demme 1946b; Portenko 1972; Krechmar et al. 1978; Stishov et al. 1991). After hatching, the female can stay with the brood on the lakes.

Common Eiders of the nominate race breed mostly in colonies. Pacific Eiders usually nest solitary, but they can also form colonies in optimal habitats (Rutilevskiy 1957; Krechmar et al. 1978; Stishov et al. 1991). The breeding starts in June. A full clutch contains 3-5 eggs, incubation period is 24-27 days and hatching occurs mid-July and early August. Unlike other eiders, the Common Eider usually forms mixed and joint broods (Koryakin 1983; Stishov et al. 1991). The juveniles reach the size of the adults two months after hatching. Non-breeding birds stay at sea in sheltered coastal waters, lagoons and downstream of plain rivers.

Food habits. The Common Eider preys at sea by diving on different benthic invertebrates. Shallow waters less than 10 m is the main feeding habitat in summer. The diet includes mostly molluscs, but echinoderms and crustaceans are also consumed. The diet depends on the type of benthos available in the foraging area (Tatarinkova et al. 1979; Shklyarevich & Shklyarevich 1982). In winter, they often feed on fish.

Human use. Fifty years ago, eider was an important resource which was exploited in Novaya Zemlya. Nowadays, hunting and egging of Common Eider is only important in the vicinities of settlements. In spite of that all eiders are protected in Russia, the Pacific Eider is hunted in the eastern Russia.

Interaction with NSR activities. As a marine diving duck, the Common Eider is vulnerable to sea surface contamination, primarily to oil spills in the intertidal zone and in polynyas. The period when the birds are flightless in the spring staging and moulting period and gather in large flocks, is the most vulnerable period. In general, birds of nominate race, being more closely connected with sea, are of greater risk to oil pollution. Local development of land-based infrastructure provide degradation of breeding habitats and increased hunting and harvesting pressure. This will probably be most important for the Common Eiders as they are more colonial than the other eider species. Thus, development of shipping along the NSR may be harmful to the Common Eider, primary in terms of oil pollution, and to a lesser extent, in terms of increased illegal hunting and egging, and disturbance in the breeding colonies due to development of land-based infrastructure



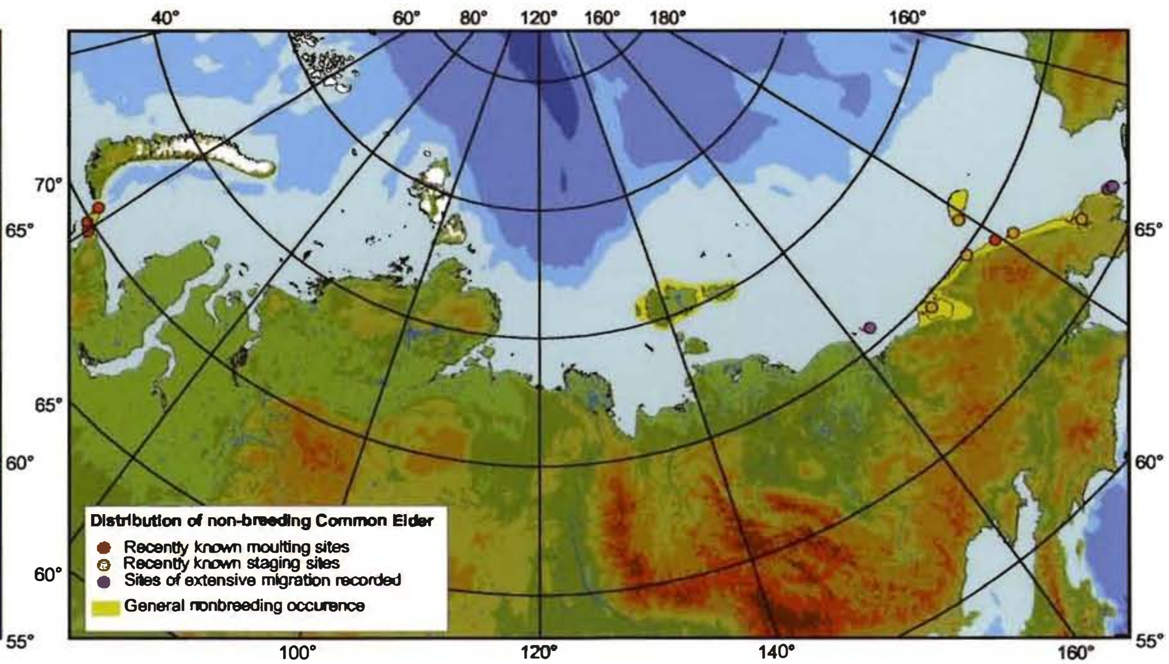


Figure 3.11. Distribution of Comon Eider in the NSR area.

King Eider

(Somateria spectabilis L.)

Photo: Karl-Birger Strann

Author:
D. V. Solovieva, Lena Delta State Reserve

Status. The King Eider is a widespread nesting and migratory species in the NSR area. It is protected in the Great Arctic, Taimyrskiy, Lena-Delta and Vrangel Island Reserves, and the Vaigachskiy and the Chaigurino Federal Refuges.

Distribution and population. The breeding range is almost circumpolar. It is absent at the east Chukchi Peninsula, in Europe west of Kolguev Island (except Spitsbergen) and on some islands in the Canadian archipelago. Within the NSR area, King Eiders breed on islands and on the mainland all along the coast.

The estimated size of the spring population of King Eider within the NSR area is about 840,000 individuals, including 600,000 breeding adults and 240,000 nonbreeding females. The nesting populations with highest density are known from Novaya Zemlya, northeast Taimyr and Yamal. The present population size seems to be stable, but a slight decrease is assumed in the western part of the breeding range.

Seasonal migrations. King Eider is a typical long-distant migrant with prevailing latitudinal migration. Eiders nesting in western Siberia and Europe, winter in the European seas. Birds, nesting in East Siberia, on Alaska and in western Canada, winter in the Bering Sea. The birds nesting elsewhere winter in the North Atlantic.

Pacific King Eiders begin the spring migration in early April, and by mid-April they appear in the polynya near the New Siberian Islands. The Atlantic population appears in polynyas near Novaya Zemlya as early as in March. The flight from the sea to the tundra starts in late May at almost the same time all along the breeding range.

The summer migration of males starts in early July. The departure of nonbreeding females extends from July to early August. Females with broods leave the breeding grounds in September. Autumn migration goes both along the Arctic coast, through lagoons and over the mainland.

The Atlantic population migrates from the breeding grounds much later than the birds from the Pacific. A south-westward migration over the sea has been observed in the first half of November. Timing and selection of migration routes depend strongly on the ice conditions.

Habitats and breeding. Most of the year, King Eiders stay at sea: males - 11 months a year, breeding females - about 9 months, while immatures come ashore from time to time. At sea, King Eiders occur in open water and in polynyas and leads as well. Before the migration, King Eiders concentrate in the estuaries and shallow marine areas.

While breeding, King Eiders move to the freshwater bodies. Various biotopes are used, but lakes are obligatory. River deltas are preferable habitats. In watershed, nesting density decreases and they never breed in the high areas of the tundra.

Usually the King Eider breeds solitary, but they tend to concentrate in colonies under protection of larger gulls. King Eiders spend not more than 100 days at the breeding sites, including 80 days of the breeding cycle. Eiders start nesting within 10-15 days after arrival. A full clutch consists of 5-6 eggs (3-8). When laying, the male guards the nest, and departs to the sea after the permanent incubation begins. The incubation lasts for 26-28 days. Hatching in early clutches occurs by early July. In the beginning, ducklings are reared on freshwater bodies. Then, in mid-August they move downstream to the sea. The King Eider often forms joint and mixed broods. The main predators on tundra are Arctic Fox, Glaucous and Herring Gulls and Arctic and Pomarine Skuas.

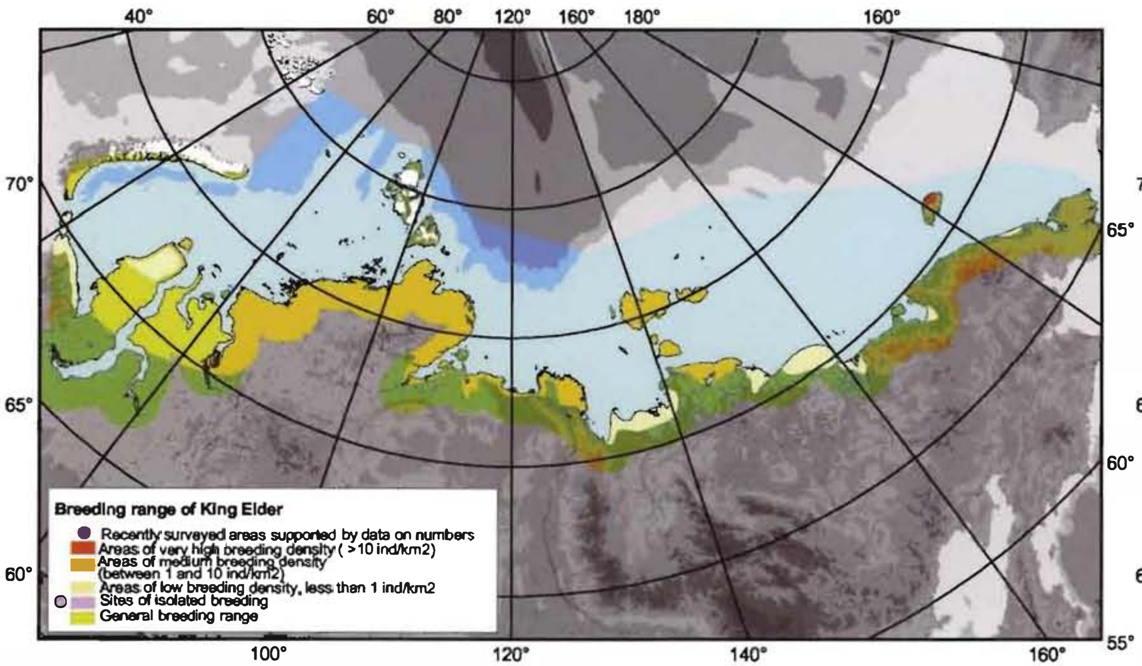
Food habits. At sea, King Eiders feed on different benthic invertebrates by diving at depths of 12-15m. The diet varies within the range: molluscs dominate in the Bering Sea, while echinoderms dominates in the Atlantic waters. In spring, King Eiders feed mostly on seeds of the water plants and hironomids larva. Hatching coincide with the peak of the biological production of the benthic invertebrates, mainly crustaceans.

Human use. King Eiders are hunted during spring migration all along the migration routes. Hunting in autumn takes place on the Chukchi Peninsula only.

Interaction with NSR activities. As a marine diving duck the King Eider is strongly exposed to contamination, primarily oil spills at sea, in the estuaries and polynyas. The most vulnerable periods are during spring and moulting when flightless birds accumulate in large flocks.

While staging in polynyas during spring, King Eiders can be directly disturbed by vessels as reported from the SW Kara Sea (Borisov pers. comm.).

Local development of land-based infrastructure can result in degradation of nesting habitats, increased disturbance and hunting pressure.



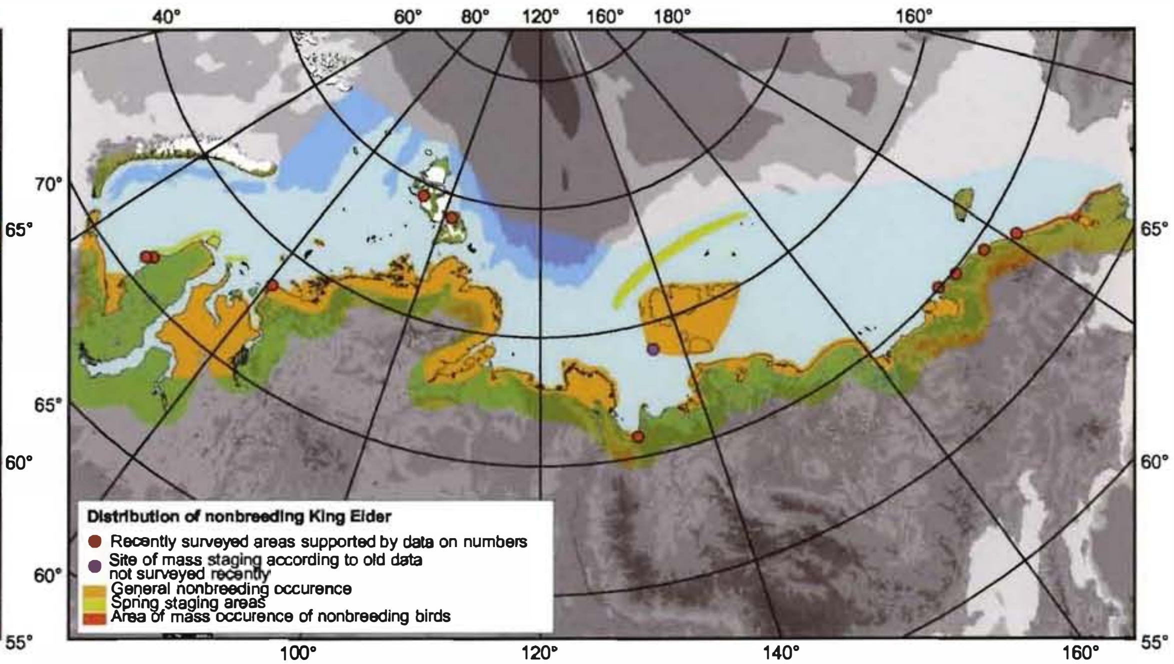


Figure 3.12. Distribution of King Eider in the NSR area. (Non investegated areas in gray shade).

Spectacled Eider

Somateria fischeri (Brandt)

Photo: Svein-Håkon Lorentsen (bird in captivity)

Author:
A. V. Kondratyev, IBPN RAS
D. V. Solovieva, Lena Delta State Reserve

Status: The Spectacled Eider is a nesting and migratory species in the NSR area. The breeding range is limited to the northern coast of Yakutia. The population is sharply declining and it is recommended to include it in the second edition of the Red Data Book of the Russian Federation. Spectacled Eider is protected in the territories of Lena-Delta State Reserve and Chaigurino State Refuge in Yakutia. No specific protection exist in marine biotopes, which are of great importance and seems to be responsible for the population decline.

Distribution and population size. In Siberia the Spectacled Eider breeds from Lena-Delta eastward to the mouth of Amguema river. In Alaska it breeds along the coast between Kuskokwim river mouth northward to Collwill River (Dau & Kistchinski 1977). The Spectacled Eider moults mostly in the Bering Strait area, but many birds remain in the Arctic waters nearby the breeding grounds. The winter quarters are situated far from the coasts in polynyas of the Bering Sea (Balogh 1996).

Within the NSR area, Specacled Eider can be found along the coast and in the seas eastward of the Lena-Delta to the Bering Strait. The species is most abundant at the Indigirka-Delta, in Kolyma Alazeya area and at the mouth of Chaun River (Dau & Kistchinski 1977). Moulting partly occurs in this area. Many birds moult in dense flocks far from the shores in the Bering Strait.

Tweny years ago, the total world population was estimated to 200,000 breeding birds (Madge & Burn 1988). The Alaskan population declined by 50,000 pairs in the 70s (Dau & Kistchinski, 1977), to 1,700 pairs (i.e. 3,400 individuals) in 1992. The modern state of the North Slope population is estimated to 9,300 birds (Larned 1994). Near 150,000 individuals have been surveyed in the winter quarters in polynyas of the Bering Sea between St.-Lawrence and St.-Mathews Islands (Balogh 1996).

In 1971 in the Indigirka-Delta, the number of birds was estimated to 17,000-18,000 pairs (i.e. 34,000 - 36.000 birds) by Kistchinski and Flint (1979). In 1993, the total number of Spectacled Eiders at Indigirka-Delta was estimated at 19,000 birds (Pearce et al. unpubl.), while the number in 1994 was 46,000 birds (Hodges & Eldridge 1994).

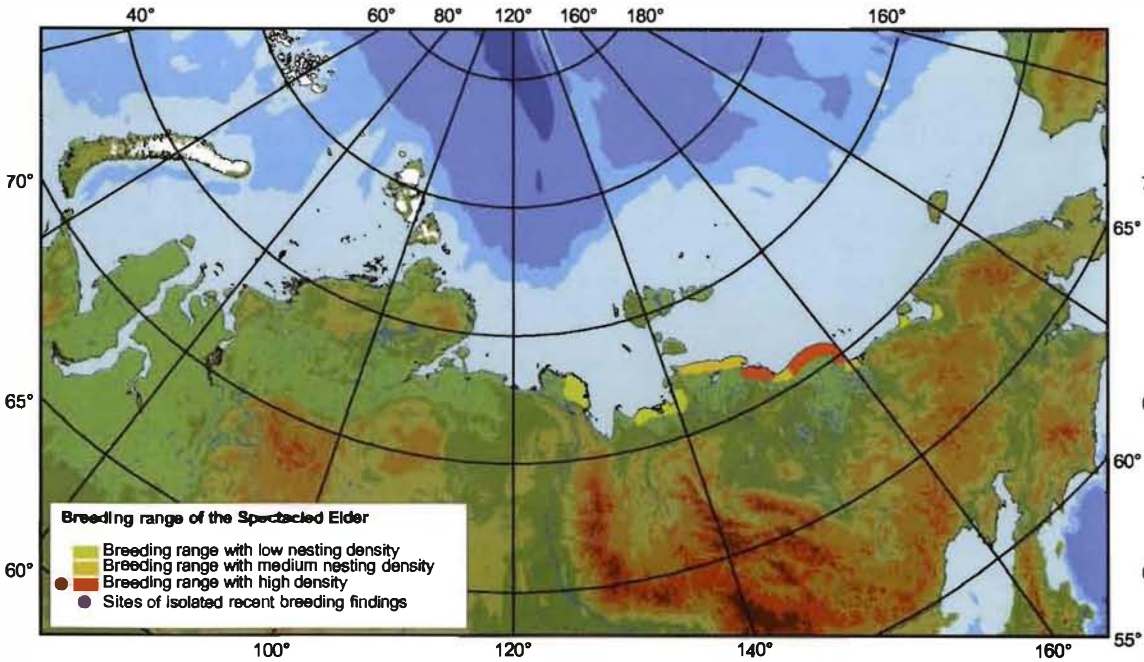
In Kolyma, Alazeya area, the maximum number has been guestimated to about 10-15,000 to 25,000 individuals with overall density of 2 pairs/km^2 (Andreev unpubl.; Hodges & Eldridge 1995). At Chaun Lowland, the number is estimated to 1,000 birds (Krechmar et al. 1991; Kondratyev 1990), and later to 2,000 birds (Hodges & Eldridge 1995).

Habitats and breeding. The Specacled Eider arrives early June. The pre-nesting period is no longer than 5 - 10 days. Some pairs nest solitary, while others gather in colonies up to 100 pairs, attached to gull colonies, mainly Sabine's Gull and Herring Gulls (Kistchinski & Flint 1979; Kondratyev & Zadorina 1992). Only 10-20% of the total spring population breed. Complete clutch contains 2-6 eggs, 4.6 on average (Kistchinski & Flint 1979; Krechmar et al. 1991; Kondratyev & Zadorina 1992). The incubation period lasts for 23-25 days. Nonbreeding females, including subadults and failed-breeders, gather into flocks (5-30 birds) and stay within the nesting areas. Hatching occurs in mid-July at Chaun Bay (Kondratyev & Zadorina 1992). After 1-2 days broods start to migrate along the lakes.

Food habits. In pre-nesting and first part of the nesting period, the Steller's Eiders feed mostly in shallow waters, taking chironomids and trichoptera larvae from bottom of shallow lakes, and taking tipulid larvae and other moss invertebrates washed out from flooded by spring melted waters adjacent moss areas. Later, various plankton and benthic crustaceans become their main food (Kondratyev & Zadorina 1992). In winter, it feeds on molluscs and crustaceans among pack ice (Cochrane 1992).

Human use. Only subsistence hunting is allowed for native people in Chukotka.

Interaction with NSR activities. The limited distribution and the habit of concentrating during moulting and wintering periods, make the Spectatled Eider very vulnerable. Oil pollution is considered to be the main threat to the populations. Additional impact provided by the NSR activity may be critical for the Spectacled Eider.



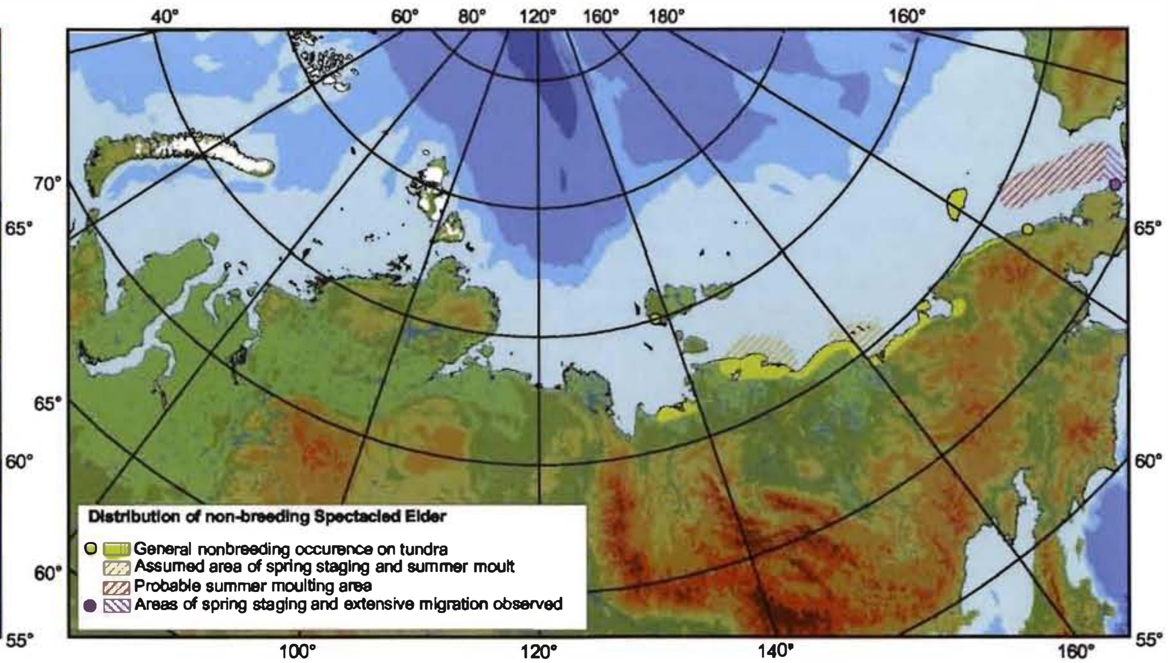


Figure 3.13. Distribution of Spectacled Eider in the NSR area.

Steller's Eider

Polysticta ste).

Photo: Bjørn Frantzen

Author:
D. V. Solovieva, LenaDelta State Reserve

Status: The Steller's Eider is a nesting and migratory species in the NSR area. It is included in the Red Book of the Yakut ASSR as a declining species showing a reduced distribution (Solomonov 1987). The main known breeding places of the species are protected by the Ust'-Lenskiy Reserve. The Great Arctic Reserve and Taimyrskiy Reserve also cover parts of the breeding range. It is proposed to include the Steller's Eider in the Red Book of Russia (Solovieva in press).

Distribution and population size. Two separate geographical populations are recognised. The Atlantic population breeds at the tundra from the middle of Taimyr Peninsula to the Varanger Fjord; winters in the seas of the North Atlantic with the most important area extending along the Kola Peninsula. The Pacific population inhabits the tundra near the sea of the Northeast Asia and sporadically breeds on the western coast of Alaska. The deltas of the rivers Olenek, Lena and Indigirka, as well as the New-Siberian Islands, are optimal for breeding. This population winters in the eastern Bering Sea.

According to winter counts, the total number of the Steller's Eider declined tenfold from about 1 million at the beginning of this century to 100.000-150,000 individuals in the 1990s (Tugarinov 1941; Nygard et al. 1995). Recently, the Pacific population demonstrates a decrease in numbers, while the Atlantic population has shown an increase (Kertell 1991; Nygard et al. 1995). The vast majority of the world population breeds within the NSR area.

Seasonal migrations. Steller's Eider is a typical long-distant migrant. Pacific Steller's eiders begin spring migration in April (Podkovyrkin 1951; Petersen 1980). According to ring recoveries, migration seems to go as a wide front from the Bering Sea through the inland parts of Chukotka, Magadan Region and Yakutia. The birds pass over the Bering Strait in mid-May until 20 June depending on the conditions from year to year. Mass migration takes no more than 5-7 days (Tomkovich & Sorokin 1983; Konyukhov unpubl.). The flyway of the spring migration for the Atlantic population has not yet been described.

The birds arrive at the tundra by mid-June. In the spring migration to the breeding grounds, both adults and immature birds are involved (Rutilevskiy 1957). The first birds usually appear 2-7 days before mass migration occurs, which takes 1-2 days. The summer migration of the nonbreeding group begins already in mid-June. There is no well-defined geographical direction, but the birds are always observed flying from the mainland to the sea. Males that have finished breeding, fly to the sea during the first half of July. On the moulting grounds near the Chukchi Sea coast, males appear already in mid-July. Brooding females leave the breeding grounds by late August and the last birds can stay as late as mid-September. The autumn migration passes over the sea.

Habitats and breeding. The Steller's Eider nests at the Arctic and sub-Arctic tundra along the sea. Sometimes the nests can be situated as far as 130 km from the coast. The stay of the Steller's Eider at the breeding places is limited to a 70 days period. Outside the breeding season it stays at sea in shallow waters with depth less than 10 m. During the spring migration, the eiders stay on melt water bodies in tundra and forest-tundra zones.

Steller's Eider is known to nest solitary (Rutilevskiy 1957; Cramp & Simmons 1982). However, in optimal conditions (the Lena-Delta) it is found to nest in colonies of medium density. The Steller's Eiders occupy the nest sites during 1-5 days after arrival. Egg laying begins on 18-23 June. The eggs of the Steller's Eider are smaller in size as compared to other eiders. Mean clutch size is 6 eggs (5 - 8). The incubation period begins after laying of 4-5 eggs and continues for 26-27 days. The first broods appear during the first two 10-days periods of July (Rutilevskiy 1957; Dorogoy 1984; Solovieva unpubl.). Unlike eiders of the Somateria genus, the Steller's Eider does not form joint broods.

Predators in tundra include Arctic Foxes, Glaucous Gull, Herring Gull, Arctic and Pomarine Skuas. During the egg-laying period, as much as 15% of eggs are taken by predators. The predation pressure from the Arctic foxes and skuas depends in general on the food availability. The Steller's Eider can have complete breeding failure in seasons of high predation pressure.

Food habits. At sea, the littoral zone is the main food biotope where eiders feed either by diving or by dabbling. The diet at sea is mainly based on molluscs, crustaceans and polychaetes (Portenko 1972; Petersen 1981). In the tundra fresh water bodies, eiders prey on larvae of chironomidae and plecoptera (Chernov 1967) and later in July, on crustaceans (mainly Isopoda).

Human use. The Steller's Eider has no significant economic importance. In some of the settlements along the Siberian coast, hunting takes place during the spring migration. The harvest of eiders continually exceeds a maximum permissible level.

Interaction with NSR activities. As other marine diving ducks spending a lot of time at sea, the Steller's Eider can be exposed to surface contamination, primarily oil spills. The increase in larger gull populations attracted by the anthropogenic food sources, such as municipal and edible waste, may lead to increased predation pressure on eiders. Scaring of females from the nests during human visits of the nesting sites, may cause egg loss due to increased predation.

Thus, the development of shipping along the NSR can be harmful to the Steller's Eider primarily in terms of oil pollution and, to a lesser extent, to the increased illegal hunting and disturbance at the nesting places due to the development of land-based infrastructure.

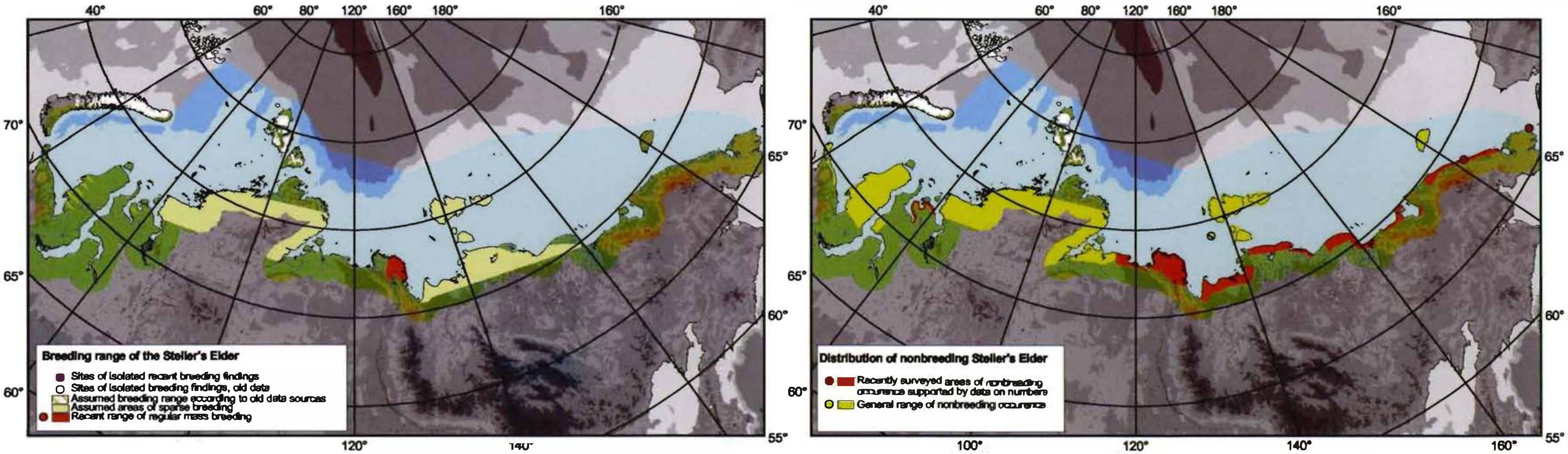


Figure 3.14. Distribution of Steller's Eider in the NSR area. (Non investegated areas in gray shade).

Long-tailed Duck

(Clangula hyemalis L.)

Photo: Karl-Birger Strann

Authors:
I. V. Pokrovskaya, VNIIPriroda
G.M. Tertitskiy, Institute of Geography, RAS
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia

Status. The Long-tailed Duck is common and widespread all over the NSR area. It is a numerous species and the population is apparently stable and the need of any special conservation and management measures is not considered.

Distribution and population size. The breeding range is circumpolar within the Arctic-boreal climatic zone. Within the NSR area, the breeding range covers the entire mainland coast except for the north Taimyr. Areas with fairly stable populations and high breeding density are: east Yugor Peninsula (breeding density up to 3 ind/km², Mineev 1984); central and south Yamal (up to 7.5 ind/km² at Kamenny Cape, Ryabitsev 1995); Chaun Lowland (up to 30 ind/km², Krechmar et al. 1991); Vankarem Lowland and coast by Kolyuchin Bay (up to 1.8 and 4.5 ind/km² respectively, Kondratyev this study), and for the Lena, Yana, Kolyma and Indigirka deltas, Ayon Isle and Kyttyk Peninsula as well (Kistchinski & Flint 1972; Kistchinski 1988; Krechmar et al. 1991). On the Northern Island of Novaya Zemlya, New-Siberian Isles, Vrangel Island it breeds sporadically, but occurs in great numbers while moulting (Rutilevskiy 1973, Stishov et al. 1991; de Korte et al. 1995). Other recently known moulting aggregations are recorded in the Vaigach area, in river mouths of Yugor Peninsula and north Yamal, Yenisey Bay, deltas of Pyasina, Lena and Indigirka, around Ayon Island and Kyttyk Peninsula, in the area of Svyatoy Nos Cape and Lopatka Peninsula, at sea next to the Rauchua-Delta, in Kolyuchin Bay (Kondratyev this study; Lappo this study; Mineev this study; Morozov 1984; Labutin et al. 1986; Romanov 1989; Krechmar et al. 1991).

Spontaneous patchy distribution patterns and considerable inter-annual population fluctuations are peculiar for this duck (Kistchinskiy 1983; Vronskiy 1986; Mineev 1994), which makes it difficult to give a total estimate of the population. Summarising all available data, the estimate of the Long-tailed Duck population for the Russian North Pacific Rim (east of the Lena-Delta) is 500,000 individuals (Goudie et al. 1994), which is about 5% of the world population (Hoyo et al. 1991).

Recent population trends are also difficult to determine for different areas, but the number is considered to be generally stable for the entire Russia over the last decade (Krivenko 1991; Goudie et al. 1994).

Seasonal migrations. Four main winter quarters are known for the Long-tailed Ducks, including two in north Atlantic and two in the north Pacific. Migration routes pass over the sea and crosses mainland along the river valleys as well (Kistchinski 1988; Bianki 1989). In the westernmost part of the NSR area, Long-tailed Ducks migrate in spring mainly over the sea, while in Taimyr, north Yakutia and Chukotka they use the continental flyway (Krechmar 1966; Estafyev et al. 1995). The Long-tailed Duck arrives on the nesting grounds early compared to other diving ducks; as soon as open water appears. Within the NSR area, this occurs in the end of May and beginning of June (Kistchinski 1988; Krechmar et al. 1991; Mineev 1994). Unusual early arrivals are known for areas artificially warmed by industrial discharge (Krechmar et al. 1991).

Moult migration is well pronounced in males of Long-tailed Ducks. It starts after the egg-laying is completed, i.e. in late June, and continues until mid-July (Portenko 1972; Rutilevskiy 1973; Danilov et al. 1984; Kistchinski 1988). From their breeding areas the ducks move generally northward to the polar coast and Arctic isles. Mass migration to the north over polynyas alongside the shores of Yamal used to be common in the 1970s (Danilov et al. 1984).

After completed moult, the males start the autumn migration in late August, however the ducks may occur at sea until late September and early October until the area is freezing (Naumov 1931; Tyulin 1938; Isakov & Ptushenko 1952). Adult males fly mostly along the sea coast, while successful females with youngs cross mainland keeping to river valleys and lake systems (Portenko 1972; Rutilevskiy 1973; Tomkovich & Sorokin 1988).

Habitats and breeding. As a typical seaduck, the Long-tailed Duck spend most of the year at sea. In winter they stay at sea, generally far offshore, along ice edge, but also inland in large deep lakes or brackish lagoons. During spring migration, the ducks occur either in polynyas or inland rivers in thawed patches. When moulting, males stay mostly at sea in shallow waters, sheltered bays, lagoons and estuaries, and even big lakes are used. Females stay in the tundra in remote densely fringed lakes, rivers and river branches (Gorbunov 1929; Isakov & Ptushenko 1952; Portenko 1972; Rutilevskiy 1973; Kistchinski 1988; Stishov et al. 1991).

The Long-tailed Duck breeds in many types of biotops at the tundra. It nests relatively open on tundra close to small water bodies, on bogs and coastal sites including deltas and estuaries. Broods are reared in small shallow lakes and ponds with well developed vegetation along shores, in some places in lagoons. The species breeds mainly solitary, but colonies are formed under good protective conditions. The Long-tailed Ducks starts breeding relatively late, usually in the end of June on the mainland coast, and even in late June on the Vrangel Island (Portenko 1972; Danilov et al. 1984; Krechmar et al. 1991; Stishov et al. 1991; Mineev 1994).

A full clutch contains 5-11 eggs. Incubation lasts for 26 (24-29) days (Krechmar & Artyukhov 1979; Cramp 1977). The peak of hatching is in the second half of July. Most of the juveniles are able to fly in late August and early September.

Food habits. At sea the Long-tailed Duck feeds by diving on different benthic invertebrates. The marine diet includes molluscs, mainly bivalves, crustaceans, and other invertebrates. Fish is also consumed (Isakov & Ptushenko 1952). The ducks moulting in the southwest Kara Sea were found to prey mainly on gastropods (Mikhel 1937). Being very active and proficient diver, the Long-tailed Ducks are reported to dive down to 50 m. On the tundra the diet is based on insect larvae, but other fresh-water invertebrates, fish and plants are included as well (Krechmar et al. 1991; Mineev 1994). In unfavorable years, the Long-tailed Duck can switch to non-typical food - water plants and detritus (Danilov et al. 1984; Mineev 1984).

Human use. The Long-tailed Duck is an important game bird.

Interaction with NSR activities. Close relations to the sea, behavioral patterns and habit of concentrating in large numbers, particularly during flightless moult periods, make the Long-tailed Ducks vulnerable to surface contamination. Mass death caused by oil spills is well documented. Feeding on benthic invertebrates at sea make them vulnerable to chronic pollution as well. Development of land-based activity and disturbance will hardly affect the Long-tailed Ducks when nesting. As they prefer to breed nearby settlements, this makes them vulnerable to illegal hunting and dog predation.

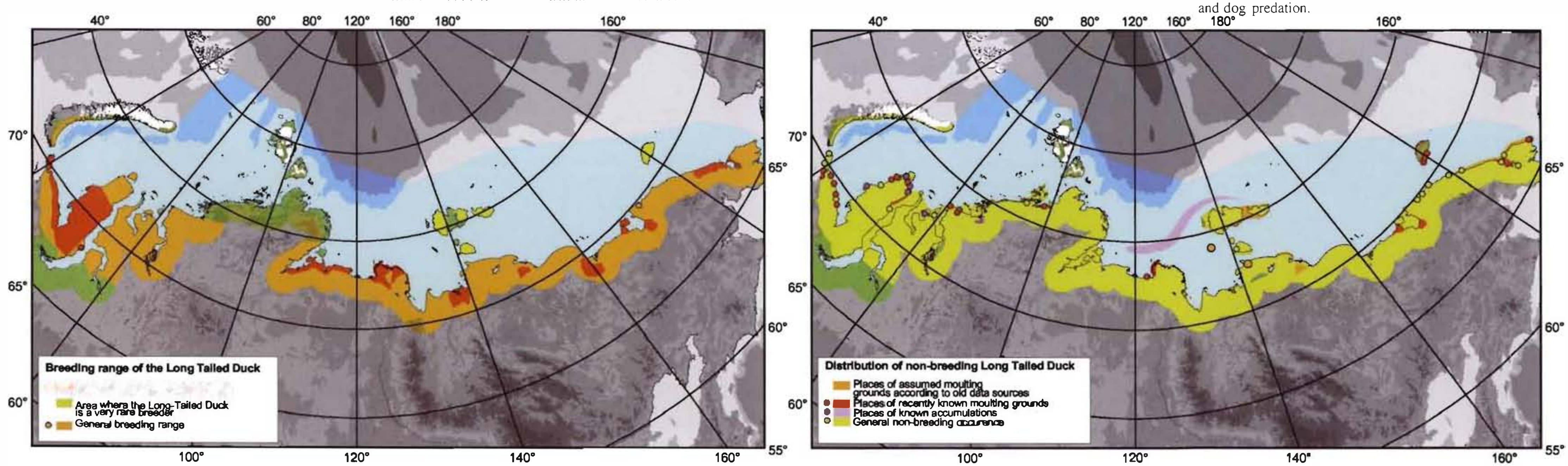


Figure 3.15. Distribution of Long-tailed Duck in the NSR area. (Non investegated areas in gray shade).

Waders at feeding and resting areas

Authors:
M.V. Gavrilo, Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia
A.A. Estafyev, IBPN RAS
A.Ya. Kondratyev, IBPN RAS
E.V. Lappo, Lena Delta State Reserve
D.V. Solovieva, Lena Delta State Reserve
I.V. Pokrovskaya, Lena Delta State Reserve

The vast territory along the NSR area is inhabited by more than 30 wader species, not taking into account the vagrants. The waders are the most diverse group in terms of the number of species. During the nesting period, the waders are scattered within the breeding range and, in general, they are not directly connected to the coast. Only a few species, such as the Ringed Plover and to a smaller extent the Temminck's Stint and the Turnstone, use the coastal habitats (beaches and spits) while breeding. An insignificant part of the populations of species like Purple Sandpiper and Little Stint which breed close to the coast, use the littoral zone for feeding.

However, during the non-breeding period and during summer and autumn migrations, most of the waders make extensive use of the coastal areas. Spring migration of waders at the Arctic coast is less pronounced than other seasonal movements and is not connected with the sea coast, as the birds keep to the snow-free tundra zones at once after they have returned. The factors influencing the dates of the spring arrival are the mean daily temperature and the status of the snow melting in the tundra. However, quite stable arrival dates are observed which indicates that other factors can be more important. The stable arrival time is characteristic for the transequatorial migrants which include waders (Gavrilo 1990). On average, at the coast along the NSR the mass arrival of waders occurs during June. In the first part of the month to the sub-Arctic tundra, in the second week to the northern barren grounds tundra and by mid-June to the extreme northern regions. The highly specialised feeders like phalaropes, snipes and the Long-billed Dowitcher arrive some later than the other species.

As among geese, ducks and gulls, summer migrations are also common among the northern waders. They start soon after the spring arrival to the nesting grounds, i.e. in some regions already in the first half of June. The nonbreeding segment is the first to move. Probably, this segment mainly consists of one year old birds, but this is not yet confirmed (Estafyev 1991). The next group to move is the failure breeders and individuals of the sex which do not take care of the offspring. For species with sex differentiated care of offspring, summer migrations are usually better pronounced. Some species begin intensive moulting quite soon after breeding. The moult of the flight feathers near the nesting grounds is considered to be more typical of the species adapted to temperate habitat conditions (Gavrilo 1987). Some individuals of phalaropes only changes the biotopes within the nesting grounds from ponds to large lakes. Other waders, like Bar-tailed Godwit, Ruff, Pectoral Sandpiper, Long-tailed Dowitcher and partly Red-necked Phalarope, make distinctive summer migrations northward of the nesting grounds . Like the wildfowl, the Grey Phalarope performs an extreme adaptation to the Arctic conditions and migrates to the sea.

Autumn migrations begin in the second half of July with the migration of adult waders leaving the grown broods. Soon after fledging, the young birds of many species shift from tundra to coast. Even the young birds of some species, like Ruff and Grey Phalarope, migrate first northwards. Most waders disappear from the coasts by mid-August and early September in the northernmost regions of the NSR area. The synchronism of the seasonal migrations depends in many respects on the conditions of the season, and in unfavourable years the synchronity is higher and the migration starts earlier.

The open littoral zone of the Siberian Arctic seas is quite narrow and with low biological production due to the scouring effect of ice. The most suitable feeding areas for waders are the protected coastal habitats like silty shoals, lagoons, shoals in the estuaries and deltas, laidas or coastal shallows (for Phalaropes).

In contrast to the breeding biology, it should be mentioned that the biology and distribution of waders during the nonbreeding period are poorly studied. In particular, there are few data on the numbers, habitat use and distribution of staging areas while migrating. An obvious lack of data on the key territories during the non-breeding period of the wader life is reflected in the new Russian list of Ramsar Sites adopted in 1994. Among 35 new sites, none is located at the Arctic coast of Siberia (Lebedeva & Tomkovich 1995). Taking into account evident shortage of the data concerning the nonbreeding period, the characteristics of the breeding population and the biology of wader species are included in the present study to get an impression of the problem under consideration.

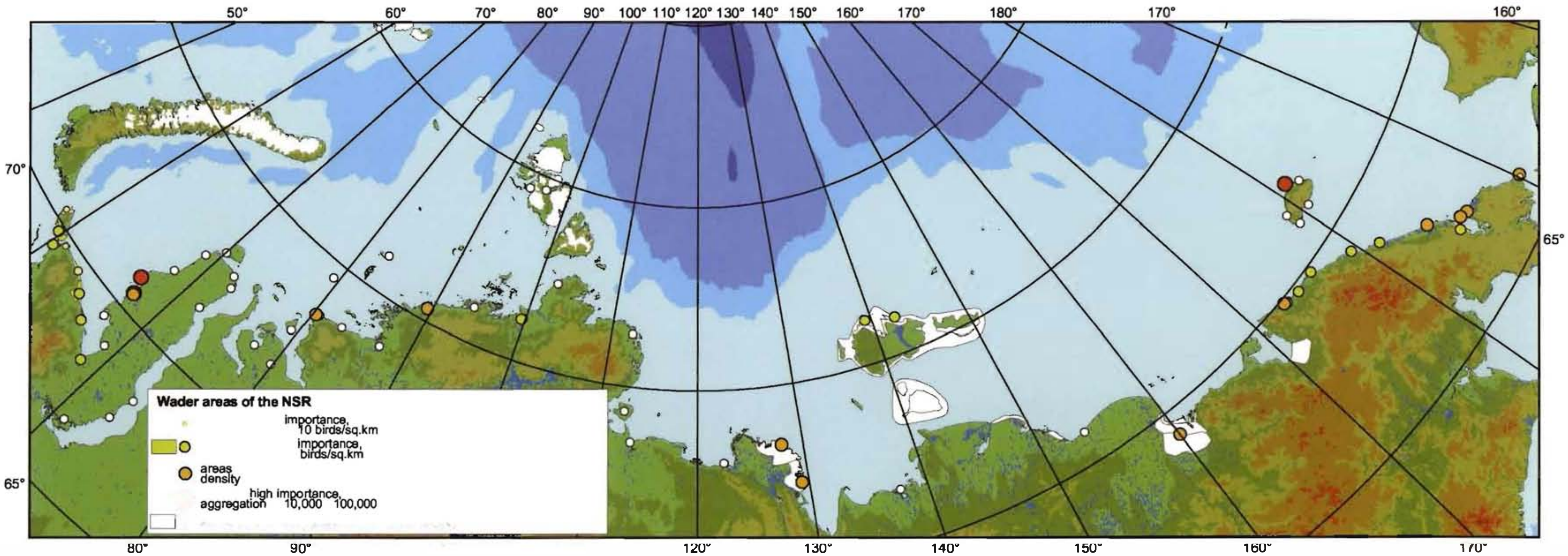


Figure 3.16. Distribution of Waders in the NSR area.

References for this chapter

Antipin, V.M. 1938. Fauna of vertebrate animals of north-east of the Novaya Zemlya. Problemy Arktiki. No. 2: 153-171. (In Russian.)

Bakken, V., Gavrilo, M.V., Isaksen, K. & Strann, K.-B. 1996. Project 11.4.2. Marine Birds. Selection of Valued Ecosystem Components and descriptions of impact hypothesis in the Northern Sea Route Area. INSROP Working Paper. No. 60 - 1996. 56 pp.

Balogh, G. 1996. Secret Spectacled Eider wintering grounds found. WWF Arctic Bulletin. No. 1: 14-15.

Belopolskiy, L.O. 1957. Ecology of colonial seabirds of the Barents Sea. Moscow-Leningrad. 460 pp. (In Russian.)

Bianki, V.V. 1989. Long-tailed Duck. Migratsii ptits Vostochnoy Evropy i Severnoy Azii. Plastinchatoklyuvye. Moscow. Pp. 181-185. (In Russian.)

Blokhin, Y.Y. 1988. About status of geese shooting in Lena-Delta. Okhrana ugodiy i ispolzovaniye okhotnichikhptits. TsNIL Glavokhoty RSFSR. Moscow. Pp. 51-60. (In Russian.)

Brown, R.G.B. & Nettleship, D.N. 1981. The biological significance of polynyas to arctic colonial birds. Polynyas in Canadian Arctic. Occasional Paper. Canad. Wild. Surv. No. 45: 59-66.

Butyev, V.G. 1959. The wintering of birds at the north of Novaya Zemlya. Ornitologiya. Moscow. Iss. 2: 99-101. (In Russian.)

Chernov, Y.I. 1967. Trophical relations between birds and insects in tundra zone. Ornitologiya. Moscow. MGU. Iss. 8: 133-149. (In Russian.)

Cochrane, J.F. 1992. Endangered and Threatened Wildlife and Plants: Proposed Rule to list Spectacled Eider as Threatened and notice 12-Month finding for a petition to list two Alaskan Eiders as endangered. Federal Register, Fish and Wildlife Service. Anchorage. Vol. 57, Iss. 90: 19852-19856.

Cramp, S. (ed.) 1977. The birds of the Western Palearctic. Oxford Univers. Press. Vol. 1. 724 pp.

Cramp, S. & Simmons, K.E.L. (eds.) 1983. The birds of the Western Palearctic. Oxford Univers. Press. Vol. 3. 913 pp.

CSWG 1996. International Murre Conservation Strategy and Action Plan. Conservation of Arctic Flora and Fauna. 16 pp.

Danilov, H.H., Ryzhanovskiy, V.H. & Ryabicev, V.K. 1984. Birds of the Yamal Peninsula. Nauka. Moscow. 333 pp. (In Russian.)

Dau, C.P. & Kistchinski, A.A. 1977. Seasonal movements and distribution of the Spectacled Eider. Wildfowl. No. 28: 65 - 75.

Degtyarev, A.G. 1990. Distribution and number of geese in North Yakutia. Resursy zhivotnogo mira Sibiri, zveri i ptitsy. Nauka. Novosibirsk. Pp. 73-74. (In Russian.)

Degtyarev, A.G., Sleptsov, S.M., Troev, S.N. & Pears, J. 1995. Brant (*Branta bernicla nigricans*) in the north-eastern Yakutia. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 81-85. (In Russian.)

Demme, N.P. 1934. The hunting fauna of Severnaya Zemlya. Unpubl. report. Stored in Central Archive of Scientific technical Information. Leningrad. 120 pp. (In Russian.)

Dubrovskiy, A.N. 1944. Birds as indicators of ice regime of the Arctic seas. Priroda. Vol. 33, No. 2: 67-68. (In Russian).

Estafyev, A.A. 1991. Fauna and ecology of waders of Bolshezemelskaya tundra and Yugor Peninsula. Nauka. Leningrad. 144 pp.

Estafyev, A.A., Voronin, R.N., Mineyev, Y.N., Kochanov, S.K. & Beshkarev, A.B. 1995. Birds. Nonpasserines. Fauna of European North-east Russia. Birds. Nauka. St. Petersburg: Vol. 1. Part 1. 325 pp. (In Russian.)

Evans, P.G.H. 1984. Status and conservation of seabirds in Alaska. Status and conservation of the worlds seabirds. ICBP Technical Publication. No. 2: 49-84.

Filchagov, A.V. & Leonovich, V.V. 1992. Breeding range expansion of Barnacle and Brent Geese in the Russian European North. Polar Research 11: 41-46.

Gavrilo, M., Bakken, V., Firsova, L., Kalyakin, V., Morozov, V., Pokrovskaya, I. & Isaksen, K. 1998. Oil vulnerability Assessment for Marine Birds occurring along the Northern Sea Route Area. INSROP Working Paper no. 97 – 1998. 53 pp.

del Hoyo, J., Elliott, A. & Sargatal, J. (eds.) 1996. Handbook of the Birds of the World. Vol. 3. Lynx Editions. Barcelona. 821 pp.

Isakov, Y. A., Ptushenko, E.S. 1952. Order *Anseriformes*. Ptitsy Sovetskogo Soyuza. Sov. Nauka. Moscow. Vol. 4: 250-640. (In Russian.)

Kalyakin, V.N. 1984. Nesting waterfowl of the Yugor Peninsula. Sovremennoe sostoyanie resursov vodoplavayushchikhptits. Moscow. Pp. 14-16. (In Russian.)

Kalyakin, V.N. 1986. About distribution and ecology of Barnacle Goose *Branta leucopsis* on Vaigach Island and Yugor Peninsula. Aktualnye problemy ornitologii. Nauka. Moscow. Pp. 93-104. (In Russian.)

Kalyakin, V.N. 1993. Fauna of birds and mammals of the Novaya Zemlya region and an assessment of their condition. Tr. Morskoy arkticheskoy kompleksnoy ekspeditsii. Novaya Zemlya. Moscow. Vol. 2, Iss. 3: 23-90. (In Russian.)

Kertell, K. 1991. Disapearrance of the Steller's Eider from Yukon Kuskokwim Delta, Alaska. Arctic 44: 177-187.

King, R.Y. & Dau, C.P. 1991. Spring population survey of Emperor Geese (*Chen canagica*) in southwestern Alaska 2-7 May. Fairbanks.

Kistchinski, A.A. 1972. On the biology of the Emperor Goose. Gusi v SSSR. Tr. mezhved. soveshchaniya. Pp. 159-169. (In Russian.)

Kistchinski, A.A. 1983. On the structure and dynamics of breeding range in birds of the North. Tr. ZIN AN SSSR. Vol. 116: 47-57. (In Russian.)

Kistchinski, A.A. 1988. Avifauna of North-East Asia: History and Modern State. Nauka. Moscow. 288 pp. (In Russian.)

Kistchinski, A.A. & Flint, V.E. 1972. Waterfowl birds of Indigirka tundra. Resursy vodoplavayushchikh ptits SSSR, ikh vosproizvodstvo i ispolzovanie. MGU. Moscow. Iss. 2: 62-66. (In Russian.)

Kistchinskiy, A.A. & Flint, V.E. 1979. On the biology of the Spectacled Eider *Somateria fischeri*. Ekologia i morfologia v SSSR. Pp. 194 - 207. (In Russian.)

Kistchinski, A.A. & Vronskiy, N.V. 1979. Migration of Brent Goose - *Branta bernicla (L.)*. Migratsii ptits Vostochnoy Evropy i Severnoy Azii. Aistoobraznye Plastinchatoklyuvye. Moscow. Pp. 188-203. (In Russian.)

Kolbe, N. 1981. Die Entenvogel der Welt. Neumann Verlag. Leipzig. 477 pp. (In German.)

Kokorev, Y.I. 1983. Ornithofauna of Pura River Basin, West Taimyr Ptitsy Taimyra (Ekologia, okhrana i khozyaystvennoe ispolzovanie). Pp. 15-19. (In Russian.)

Kokorev, Y.I. 1985. Abundance and population dynamics of game birds in typical tundra of Taimyr. Zveri i ptitsy Severa Sibiri: ekologiya, okhrana i khozyaistvennoe ispolzovanie. Novosibirs. Pp. 36-45. (In Russian.)

Kondratyev, A.Y. 1986. Colonies of the sea birds on the north coast of Chukotka. Tez. dokladov I s'ezda Vsesoyuznogo ornitologicheskogo obshchestva i IX Vsesoyuznoy ornitol. Konferentsii. Nauka. Leningrad. Vol. 2: 309-311. (In Russian.)

Kondratyev, A.V. 1993. Breeding biology, habitat selection, and population number of four geese species in the south-west coast of the Anadyr Bay. Russian Journal of ornithology. Vol. 2, Iss. 3: 287-302. (In Russian.)

Kondratyev, A.V. & Zadorina, L.V. 1992. Comparative ecology of King and Spectacled Eiders on Chaun tundra. Zool. zhurnal. Vol.71, No. 1: 99-108.

Kondratyev A.Y., Korovin, M.M. & Bodyak, N.D. 1987. The number and structure of seabirds colonies at the Koluchin Island (Chukchi Sea). Raprostranenie i biologiya morskikh ptits Dalnego Vostoka. Vladivostok. Pp. 22-35. (In Russian.)

de Korte, Y., Volkov, A.E. & Gavrilo, M.V. 1995. Bird observations in Severnaya Zemlya, Siberia. Arctic. Vol. 48, No. 3: 222-234.

Kozlova, E.V. 1957. Charadriiformes: suborder *Alcae*. AN SSSR. Zool. in-t. Fauna SSSR. Nov. ser. AN USSR. Moscow-Leningrad. Vol. 2, No. 65, Iss. 3. 144 pp. (In Russian.)

Krasnov, Y.V. 1989 Diet composition and behavioural peculiarities of gulls under conditions of multi-years shortage of fish food. Ekologiya ptits morskikh ostrovov i poberezhiy Kolskogo Severa. Murmansk. kn. izd-vo. Murmansk. Pp. 55-62. (In Russian.)

Krasnov, Y.V., Nikolaeva, H.G. & Chernyshova, H.M. 1982. Foraging behaviour peculiarities of Arctic Skuas in the seabirds colonies of the Eastern Murman. Tez. Dokladov Pribaltiyskoy konferentsii molodykh ornitologov. Pp. 119-121. (In Russian.)

Krasnov, Y.V. & Barrett, R.T. 1995. Large-scale interactions among seabirds, their prey and humans in the southern Barents Sea. In Skjoldal, H.R., Hopkins, C., Erikstad, K.E. & Leinaas, H.P. (eds.): Ecology of fjords and coastal waters. Elsevier Sci. B.V. Amsterdam. Pp. 443-456.

Krechmar, A.V. 1966. The birds of the western parts of the Taimyr Peninsula. Tr. Zoologicheskogo in-ta AN SSSR. Leningrad: Nauka. Vol. 34: 185-312. (In Russian.)

Krechmar, A.V. 1986. White-fronted Goose (*Anser albifrons*) in middle reaches of Anadyr. Zool. Zhurn. Vol. LXV, No. 4: 560-570. (In Russian)

Krechmar, A.V., Andreev, A.V. & Kondratyev, A.Y. 1978. Ecology and distribution of birds on the North-east of the USSR. Nauka. Moscow. Part 2. 194 pp. (In Russian.)

Krechmar, A.V. & Artyukhov, A.I. 1979. The Long-tailed Duck in the middle reaches of Anadyr River. The birds of North-Eastern Asia. Academy of Science of USSR. Vladivostok. Pp. 3-28. (In Russian.)

Krechmar, A.V. & Kondratyev, A.Y. 1982. Nesting ecology of the Emperor Goose. Zool. zhurnal. Vol. 61, No. 2: 254 - 264. (In Russian.)

Krechmar, A.V., Andreev, A.V. & Kondratyev, A.Y. 1991. The birds of northern plains. (In Russian.)

Krivenko, V.G. 1984. Present numbers of waterfowl in the middle region of the USSR. Sovremennoye sostoyaniye resursov vodoplavayushchikh ptits (Tez. vsesoyuzn. seminara 20-23 okt. 1984 g.). Moscow. Pp. 156-159. (In Russian)

Krivenko, V.G. 1991. Waterfowl birds and its conservation. Agropromizdat. Moscow. 271 pp. (In Russian.)

Kupetskiy, V.N. 1959. The permanent polynyas in freezing seas. Abstract. Ph.D. Thesis. Leningrad. 356 pp. (In Russian.)

Labutin, Y.V., Degtyarev, A.G., Blokhin, Y.Y. & Larionov, V.P. 1986. Resources of the waterfowl birds of the tundras of Western Yakutia. Voprosy okhotnichey ornitologii. Moscow. Pp. 37-54. (In Russian.)

Laktionov. A.F. 1946. The Severnaya Zemlya Archipelago. Moscow-Leningrad: Glavsevmorputi. Pp. 3-151. (In Russian.)

Larned, W. 1994. Eider population in Alaska. Unpubl. USFWS report. USFWS Anchorage.

Lebedeva, E.A. & Tomkovich, P.S. 1995. An important step in conservation of wetlands in Russia. Informational materials of the working group on waders. Moscow. No. 8: 16-18. (In Russian.)

Leito, A., Renno, O. & Lillelekht, V. 1990. Numbers, distribution and conservation of Barnacle Goose in Estonia. Soobshcheniya Pribaltiyskoy komissii po izucheniyu migraciy ptits. Tartu. No. 23: 78-85. (In Russian.)

Leonov, L.I. 1945. Bird fauna of Henrietta Island. Problemy Arktiki. No. 5/6: 73-88. (In Russian.)

Linkov, A.B. 1983. Some peculiarities of distribution and ecology of geese and brants in North-East Gydan Peninsula. Ekologiya i ratsionalnoe ispolzovanie okhotnichyikh ptits v RSFSR. Moscow. Pp. 62-69. (In Russian.)

Lloyd, C., Tasker, M.L. & Partridge, K. 1991. The status of seabirds in Britain and Irland. Poyser. London.

Løvenskiold, H.L. 1964. Aviafauna Svalbardensis. Oslo. 460 pp.

Madge, S. & Burn, N. 1988. Wildfowl: an identification guide to the ducks, geese and swans of the world. C. Nelm. London. 298 pp.

Madsen, Y. 1994. Barnacle Goose. Birds in Europe. Their Conservation Status. Cambridge. Pp. 112-113.

Martynov, A.S. 1983. Some data on the Geese of the Krasnoyarsk Territory. Sovremenoye sostoyaniye resursov vodoplavayushchikh ptits: Tez. Vsesoyuznogo seminara. Moscow. Pp. 154-155. (In Russian.)

Mehlum, F. 1984. Konsentrasioner av sjøfugl langs kanten av isbreer og utenforbreelver pa Svalbard. Fauna. Vol. 37, No. 4: 156-160. (In Norwegian.)

Mikhel, N.M. 1937. Observations on birds and mammals of the Karskaya Bay area. Izvestiya Gos. geograf. obshchestva. Vol. 69, Iss. 3: 443-447. (In Russian.)

Mineev, Y.N. 1994. Waterfowl birds of the Yugor Peninsula. Komi Sci. Centre Ural Branch RAS. Syktyvkar. 104 pp. (In Russian.)

Mineev, Y.N. 1995. White-fronted Goose Anser albifrons in the tundra of Nenetzky Autonomous district of Archangelskaya Region. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No 1: 121-128. (In Russian.)

Modestov, V.M. 1967. Colonial seabirds ecology (according to the observations carried out in the Eastern Murman and Volga River delta). Tr. Kandalakshskogo gos. zapovednika. Iss. 5: 49-154. (In Russian.)

Morozov, V.V. 1984. Waterfowl of Cape Kharasavey environment (Northern Yamal). Sovremennoe sostoyanie resursov vodoplavayutchikh ptits. Moscow. Pp. 147-148. (In Russian.)

Morozov, V.V. 1995. Recent distribution and number of the Barnacle Goose (*Branta leucopsis*) on Yugor Peninsula. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 39-44. (In Russian.)

Naumov, S.P. 1931. The Mammals and birds of the Gydan Peninsula (the North-western parts of Siberia). Tr. polyarnoy komissii

AN SSSR. Leningrad. Iss. 4: 1-106. (In Russian.)
Nelson. E.W. 1887. Report upon Natural History Collection made in Alaska. Chief Signal Officer. Arctic Series Publication. Signal Service US. Army. N III. Washington DC. Pp. 19-226.
Nygaard, T., Jordhøy, P., Kondakov. A. & Krasnov, Y. 1995. A survey of waterfowl and seal on the coast of the southern Barents Sea in March 1994. NINA Oppdragsmelding 362: 1-24.
Owen, M. 1984. Dynamics and age structure of an increasing goose population - the Svalbard Barnacle Goose *Branta leucopsis*. Norsk Polarinstitutt. Skr. 181: 37-47.
Petersen, M.R. 1980. Observation of wing-feather molt and summer feeding ecology of Steller's Eiders at Nelson Lagoon, Alaska. Wildfowl. Vol. 31: 99-106.
Petersen, M.R. 1981. Populations, feeding ecology and molt of Steller's Eiders. Condor. Vol. 83: 256-262.
Petersen, M.R. 1983. Observation of Emperor Goose feeding at Nelsson Lagoon, Alaska. Condor. Vol. 85: 367 - 368.
Petersen. M.R. 1991. Reproductive ecology of EmperorGeese. Ph.D. Thesis, Univers. Calif., Davis.
Petersen, M.R. 1992. Reproductive ecology of Emperor Geese: Annual and individual variation in nesting. Condor. Vol. 94: 383 - 397.
Petersen, M.R., Schmutz, Y.A. & Rockwell, R.F. 1994. Emperor Goose. In Poole, A. & Gill, F. (eds.): The birds of North America. The Academy of Natural Sciences. Washington DC. No. 97: 1-20.
Podkovyrkin, B.A. 1951. Winter grounds of some seaducks near Northern Kuril Islands. Okhrana prirody. Iss. 13: 128-132. (In Russian.)
Pokrovskaya, I.V. & Tertitskiy, G.M. 1993. Present status of hunting avifauna at Novaya Zemlya. Tr. Morskoy arkticheskoy kompleksnoy ekspeditsii. Novaya Zemlya. Moscow. Vol. 2, Iss. 3: 91-97. (In Russian.)
Ponomareva, T.S. 1991. Barnacle Goose in the vicinity of the Kolguev Island. Materialy 10 Vses. Ornitolog. Konferentsii. Navuka i tekhnika. Vitebsk. Vol. 2, Part 2: 157-158. (In Russian.)
Ponomareva, T.S. 1992. Nesting of Barnacle Goose in the Kolguev Island region. Byulleten MOIP, otd. biologii. Vol. 97, Iss. 2: 39-44. (In Russian.)
Ponomareva, T.S. 1994. Nesting of some waterfowl species in northern Vaigach and adjacent islands. Byulleten MOIP. otd. biologii. Vol. 99, Iss. 6: 66-71. (In Russian.)
Portenko, L.A. 1972. Transcontinental Connections Migratory Birds in the Extreme North-East Asia. Transkontinentalnye svyazi pereletnykh ptits i ikh rol v rasprostranenii arbovirusov. Nauka. Novosibirsk. Pp. 79-81. (In Russian.)
Portenko, L.A. 1972, 1973. The Birds of the Chukchi Peninsula and Vrangel Island. Nauka. Leningrad. Parts I & 2. (In Russian.)
Pozdnyakov, V.I. & Sofronov, Y.N. 1995. Status of Bean Geese population (*Anser fabalis*) in Lena-Delta in 1994. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 147-149. (In Russian.)
Pridatko, V.I. 1986. Colonial seabirds of the Vrangel and Herald Islands (ecology, protection). Abstract. Ph.D. Thesis. Kiev. Pp. 21 (In Russian.)
Prop, J., von Earden, M.R. & Drent R.H. 1984. Reproductive success of Barnacle Goose (*Branta leucopsis*) in relation to food exploration on the breeding grounds, Western Spitsbergen. Norsk Polarinstitutt Skr. 181: 87-117.
Rogacheva, E.V. 1988. Birds of the Central Siberia. Nauka. Moscow. 309 pp. (In Russian.)
Romanov, A.A. 1989. To the distribution and number of some species of Anseriformes in the Vaigach Island. Rastitelnyy i zhivotnyy mir zapovednykh ostrovov. Moscow. Pp. 78-82. (In Russian.)
Rose, P.V. & Scott D.A. 1994. Waterfowl Population Estimates. IWRB Publications. Iss. 29: 1-102.
Rutilevskiy, G.L. 1957. Eiders of the New-Siberian Islands. Tr. Arkticheskogo i antarkticheskogo nauchno-issled. in-ta. Morskoy transport. Leningrad. Vol. 205: 33-62. (In Russian.)
Rutilevskiy, G.L. 1963. Birds of Stolbovoy Island. Tr. Arkticheskogo i Antarkticheskogo nauchno-issled. inta. Morskoy transport. Leningrad. Vol. 224: 93-117. (In Russian.)
Rutilevskiy, G.L. 1967. The animal world. Novosibirskie ostrova. Fiziko-geograficheskaya kharakteristika arkhipelaga. Gidrometeoizdat. Leningrad. Pp. 179-207. (In Russian.)
Rutilevskiy, G.L. 1973. New materials on the ecology and distribution of Long-tailed Duck. Tr. Arkticheskogo nauchno-issled. in-ta. Vol. 318: 167-182. (In Russian.)
Ryabitsev, V.K. 1995. Short review of Geese at Yamal Peninsula. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No 1: 164-166. (In Russian.)
Salomonsen, F. & Gitz-Yohansen, 1944. Grønlands Fugle. Eynar Munsgaard Vorlag. København. Part. 1-3: 1-607. (In Danish.)
Savinova, T.N. 1990. Chemical pollution of the northern seas. Academy of Science of USSR. Apatity. 146 pp. (In Russian.)
Sdobnikov, V.M. 1959. Ducks and geese of northern Taimyr. Tr. NII Selskogokhozyaistva Kraynego Severa. Leningrad. Vol. 9: 154-183. (in Russian).
Shuntov, V.P. 1972. Seabirds and biological structure of the ocean. Dalnevostochn. kn. izd-vo. Vladivostok. 376 pp. (In Russian.)
Solomonov, N.G. 1987. Red Book of Yakutskaya ASSR. Novosibirsk. 175 pp. (In Russian.)
Stepanyan, L.S. 1975. Composition and distribution in birds of USSRs fauna: Non-Passerofomes. Nauka. Moscow. Pp. 1-369 (In Russian.)
Stishov, M.S., Pridatko, V.I. & Baranyuk, V.V. 1991. Birds of the Vrangel Island. Nauka. Novosibirsk. 254 pp. (In Russian.)
Syroechkovskiy, E.E.jr. 1995a. News in the distribution of the Barnacle Goose in Russia. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No 1: 39-46. (In Russian.)
Syroechkovskiy, E.E.jr. 1995b. Current status of Asian population of Pacific Black Brant *Branta bernicla nigricans*. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 57-67. (In Russian.)
Syroechkovskiy, E.E.jr. 1995c. Distribution, numbers and some ecological peculiarities of Brent Goose in Taimyr. Moscow. In press. (In Russian.)
Syroechkovskiy, E.E.jr. & Lappo, E.G. 1994. Birds of Izvestiy TsIK Islands and Sverdrup Island (Kara Sea). Pp. 111-151 in: Arkticheskie tundry Taimyra i ostrovov Karskogo morya: priroda, zhivotnyy mir i problemy ikh okhrany. RAS. Moscow. Vol. 1. (In Russian.)
Syroechkovskiy, E.V., Litvin, K.E., Kalyakin, V.N. & Morozov, V.V. 1995. Investigation of the ecology of Geese and swans in Novaya Zemlya and Vaigach Islands. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 158-163. (In Russian.)
Tomkovich, P.S. & Sorokin, A.G. 1983. Bird fauna of the Eastern Chukotka. Rasprostraneniye i sistematika ptits. Moscow. MGU. Pp. 77-159.
Tugarinov, A.Y. 1941. Anseriformes. Fauna SSSR. Nov.ser. Ptitsy. ZIN AN SSSR. Moscow-Leningrad. Vol. 1, No. 30, Iss. 4. 383 pp. (In Russian.)
Tyulin, A.N. 1938. The game fauna of the Bely Island. Tr. Nauchnoissled. in-ta polyarnogo zemledeliya, zhivotnovodstva i promyslovogo khozyaystva (Ser. Promyslovoe khozyaystvo). Glavsevmorputi. Leningrad. Iss. 1: 5-39. (In Russian.)
Underwood, L.A. & Stowe, T.Y. 1984. Massive wrecke of seabirds in eastern Britain, 1983. Bird Study. Vol. 31, No. 2: 79-88.
Ushakov, G.A. 1951. On untouched land. Glavsevmorputi. Moscow-Leningrad. 393 pp. (In Russian.)
Uspenskiy, S.M. 1956. The seabird colonies of Novaya Zemlya. Nauka. Moscow. 179 pp. (In Russian.)
Uspenskiy, S.M. 1957. The colonial sea birds of Anjou Islands. Tr. Arkticheskogo instituta. Morskoy transport. Leningrad. Vol. 205: 97-108. (In Russian.).
Uspenskiy, S.M. 1959. Seabirds nesting in colonies of the northern and Far-eastern seas of the USSR, their distribution, number and role as a plancton and benthos consumers. Byull. MOIP. Otdel. biol. Vol. 64, No. 2: 39-52. (In Russian.)
Uspenskiy, S.M. 1963. The birds and mammals of Benneta Islands. Tr. Arkticheskogo instituta. Morskoy transport. Leningrad. Vol. 224: 180-206. (In Russian.)
Uspenskiy, S.M. 1969. Life in High Latitudes. Demonstrated mainly on Birds. Mysl. Moscow. 463 pp. (In Russian.)
Uspenskiy, S.M. & Kistchinski, A.A. 1972. The experience of goose counts from airplane on the north of Western Siberia. Gusi v SSSR. AN Estonskoy SSR. Tartu. Pp. 106-116. (In Russian.)
Uspenskiy, S.M. & Tomkovich, P.S. 1986. Fauna and conservation of birds in Franz Jozef Land. Prirodnye kompleksy Arktikii voprosy ikh okhrany. Gidrometeoizdat. Leningrad. Pp. 63-76. (In Russian.)
Volkov, A.E. & Chupin, I.I. 1995. New data on breeding of Barnacle Goose, *Branta leucopsis*, on Kolguev Island. Geese Study Group Bulletin of Eastern Europe and Northern Asia. Moscow. No. 1: 47-50. (In Russian.)
Volkov, A.E. & de Korte, J. 1996. Distribution and numbers of Ivory Gull (*Pagophila eburnea*) on Severnaya Zemlya, Russian Arctic. Polar Research 15: 11-21.
Vronskiy, V.G. 1986. Birds in the sub-zone of barren-grounds tundra of western Taimyr. Abstract. Ph.D. Thesis. 18 pp. (In Russian.)
Yudin, K.A. & Firsova, L.V. 1988a. The Kittiwake. Ptitsy SSSR. Chaykovye. Nauka. Moscow. Pp. 215-226. (In Russian.)
Yudin, K.A. & Firsova, A.V. 1988b. The Ivory Gull. Ptitsy SSSR. Chaykovye. Nauka. Moscow. Pp. 51-57. (In Russian.)
Zhukov, V.S. 1995. Rare, vagrant and less studied species of Taz River lower reaches and Gydan Peninsula. Materialyk rasprostraneniyu ptits na Urale, v Priuralye i Zapadnoy Sibiri: informatsionnye materialy. Ural Branch of RAS. Ekaterinburg. Pp. 24-26. (In Russian.)

Chapter 4

Marine mammals

Authors:
Øystein Wiig, Zoological Museum, University of Oslo, Oslo, Norway
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Anchorage, Alaska, USA

Introduction

The main objectives of the marine mammal project in INSROP are to establish a database containing information on distribution, abundance, migrations, and breeding and feeding areas for marine mammals in the Northern Sea Route (NSR) area, and to present a discussion of possible impacts of the NSR activities on these species. This information will be used as baseline for the INSROP Environmental Impact Assessment (EIA). In the INSROP EIA, the assessments and analyses are carried out in terms of identification and avaluation of the relevant impact factors and their interaction with the environment represented by the so-called Valued Ecosystem Components (VECs) (Thomassen et al. 1995).

Wiig et al. (1996) presented how the marine mammal VECs were selected, and discussed the validity of a number of Impact Hypotheses (IHs) with relevance to NSR activity and the selected VECs. Based on this discussion further studies and management actions were recommended. A more detailed description of the biology of the marine mammal VECs are given in Belikov et al. (1997). The data presented in this issue of the Dynamic Environmental Atlas (DEA) are based mainly on these papers.

The Marine Mammal Project is headed by Professor Øystein Wiig, Zoological Museum, University of Oslo, Oslo, Norway, while national coordinators are Professor Yasuhiko Naito, National Institute of Polar Research, Tokyo, Japan, Dr. Stanislav Belikov, All-Russian Research Institute for Nature Conservation, Moscow, Russia, and Dr. Gerald W. Garner, National Biological Service, Anchorage, Alaska, USA.

Evaluation of VECs

During a screening and focusing workshop which was held in Oslo, November 1993, most of the mammalian species occurring in the NSR area were evaluated (Hansson et al. 1994). It was noted that in the selection of VECs it must be focused on species that may potentially be affected by NSR activity, and where detectable changes in the populations may occur as a result of such impacts. It was also agreed that for the species given priority, it should be pointed out what is the vulnerable attributes, period, area and type of behavior. On that basis four VECs were selected: polar bear, walrus, ringed seal, and white whale. The selection of VECs was later re-evaluated, and additional species of marine mammals were considered for inclusion as VECs (table 4.1). An evaluation of each possible VEC was done with respect to:

1. Ecology - the importance of the species for the total ecology in the NSR area.
2. Economy - Factors of direct economic importance (mainly hunting).
3. Other human affairs - Factors like conservation, cultural value, special needs for indigenous people, other social or society effects.
4. Environmental effects of NSR - Factors like pollution and physical disturbance.
5. Data availability - How much data are available and what are the costs of new data.

The relative importance of each possible VEC was scored on a scale 0 - 3, where 0 = lowest importance and 3 = highest importance (table 4.1).

Selection of VECs

Table 4.1 summarizes the evaluation of each of the possible VECs selected. Polar bear and walrus were the possible VECs that seem to be most important based on the evaluation. Bearded seal, ringed seal, white whale, Gray whale and bowhead whale were the second most important group, while harp seal, spotted seal, and narwhal were regarded as less important as VECs in the NSR area.

Based on this evaluation the following seven VECs were selected: Polar bear, Walrus, Bearded seal, Ringed seal, White whale, Gray whale and Bowhead whale.

Table 4.1. *Evaluation of the relative importance (0 = low - 3 = high) of possible VECs in the Northern Sea Route area.*

VEC	Ecology	Economic	Human affairs	Effect of NSR	Data costs	Sum	Relative importance
1. Polar bear	2	2	3	3	2	12	3
2. Walrus	2	3	3	3	2	13	3
3. Bearded seal	2	2	1	2	2	9	2
4. Ringed seal	3	3	1	2	2	11	2
5. Harp seal	1	0	1	0	2	4	0
6. Spotted seal	1	1	1	1	2	6	1
7. Narwhal	1	0	2	1	2	6	1
8. White whale	2	1	1	3	2	10	2
9. Gray whale	1	1	3	3	2	10	2
10. Bowhead whale	1	1	3	3	2	10	2

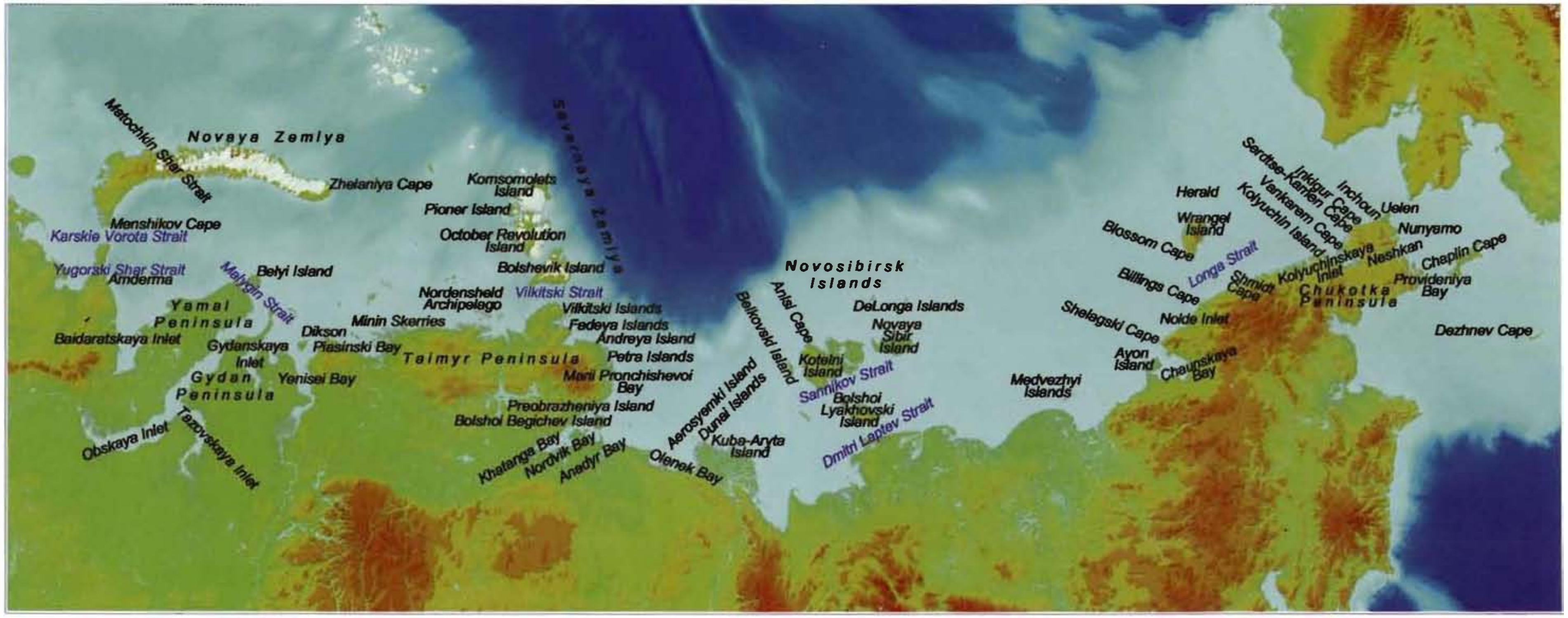


Figure 4.1. Places mentioned in this chapter.

Polar Bear
(Ursus maritimus)

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska, USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. The polar bear is protected in Russian areas. The Chukchi population is hunted in Alaskan area. The polar bear is included in the list of rare species in the Red Book of the Russian Federation (Anon. 1983). The species is listed as Conservation Dependent by IUCN (IUCN 1996).

Distribution and population size. The polar bear has a circumpolar distribution, and is confined to Arctic and sub-Arctic ice covered sea areas. The bears are not evenly distributed, but are found in several more or less isolated populations (DeMaster & Stirling 1981). Eleven populations of polar bears in the Arctic were recognized at the latest meeting of the IUCN Polar Bear Specialist Group (Wiig et al. 1995) and the total population size was estimated to be between about 20,000 and 30,000. Three populations are found along the Siberian coast. These are the Franz Josef Land/ Novaya Zemlya population, the Laptev population, and the Chukchi population, which together consists of about 5,300-9,700 bears. The Franz Josef Land/Novaya Zemlya population includes eastern portions of the Barents Sea, the Franz Josef Land archipelago, and the Kara Sea, including Novaya Zemlya. The information for the Kara and Barents Seas in the vicinity of Franz Josef Land and Novaya Zemlya is mainly based on aerial surveys and den counts. Studies of movements, using telemetry, have been done throughout the area but data analyses to define the boundaries are incomplete. The Laptev population area includes the western half of the eastern Siberian Sea, the entire Laptev Sea, including the Novosibirsk and Severnaya Zemlya Islands. Telemetry data from the East Siberian and the Chukchi Seas support the eastern boundary. Recent telemetry data from the Kara and Laptev Seas indicate that the western boundary is probably Severnaya Zemlya, but data analyses are incomplete. The use of telemetry to study movements, has confirmed that the Chukchi population is widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portion of the East Siberian Seas.

Habitat. The polar bear usually prefer ice edges, active ice with re-freezing leads, often solid fjord-ice in late winter and drift ice in summer (Stirling et al. 1993). During ice free periods they are sometimes found on land along beaches.

Food habits. The polar bear lives mainly on ringed seals and partly on bearded seals (Stirling & Archibald 1977). They also feed on other seals, walruses, white whales, carcasses and whatever they find of birds, eggs etc.

Breeding. Polar bears can reach the age of about 30 years. Females are sexually mature at an age of four to five years and males several years later. The breeding time is in April-May (Ramsay & Stirling 1986). In late fall the pregnant female digs a snow den, in which she normally give birth to two (one-three) cubs in end of December. The female and cubs emerge from the den in March-April. The cubs normally accompany their mother until their third spring when the female again comes into heat.

Human use. Polar bears are protected in the NSR area (Belikov et al. 1997). The economical importance of polar bears is therefor small. Illegal hunting is however, an increasing problem. In addition, there are reasons to believe that the hunting in some parts of the area soon will be legalized. The Chukchi population is hunted for subsistence purposes by Alaskan Inuits. The polar bear is a symbol for the Arctic and has high international conservation value. The cultural value for indigenous people in the NSR area is relatively high in spite of the fact that hunting is forbidden. In Alaska the population is important also in this respect. The bears are important in relation to increased tourism in the area.

Interaction with NSR activities. Research has shown that polar bears will become acutely affected and usually die when exposed to oil spills. Oil spills in the drift ice - the polar bear's most important habitat - involve the greatest potential risk. Low temperatures will preserve the oil for a long time, it will be concentrated in leads and seep up through the ice (Stirling 1990).

Traffic and industrial activity can result in production of edible waste that, if made accessible, may increase the area's carrying capacity for polar bears (Lunn & Stirling 1985). Disturbances/ activity in traditional denning areas in the fall may prevent females from denning in optimal areas and at optimal periods of time. Disturbances in the denning area before delivery may cause the females to abort and may also imply an increase in energy expenditure. Disturbances/activity in the denning area after the female has broken out of the den can cause increased energy expenditure and increased cub mortality. Many bears find active installations and human activity frightening and will keep at a distance from them. Such installations/activities located in traditional migration routes may cause polar bears to take longer/ more energy intensive and risky routes. Stirling (1988) found, however, that many bears were attracted to human installations in the ice because of their curious nature and because open water made by installations in the ice make seals more abundant and/or more accessible.

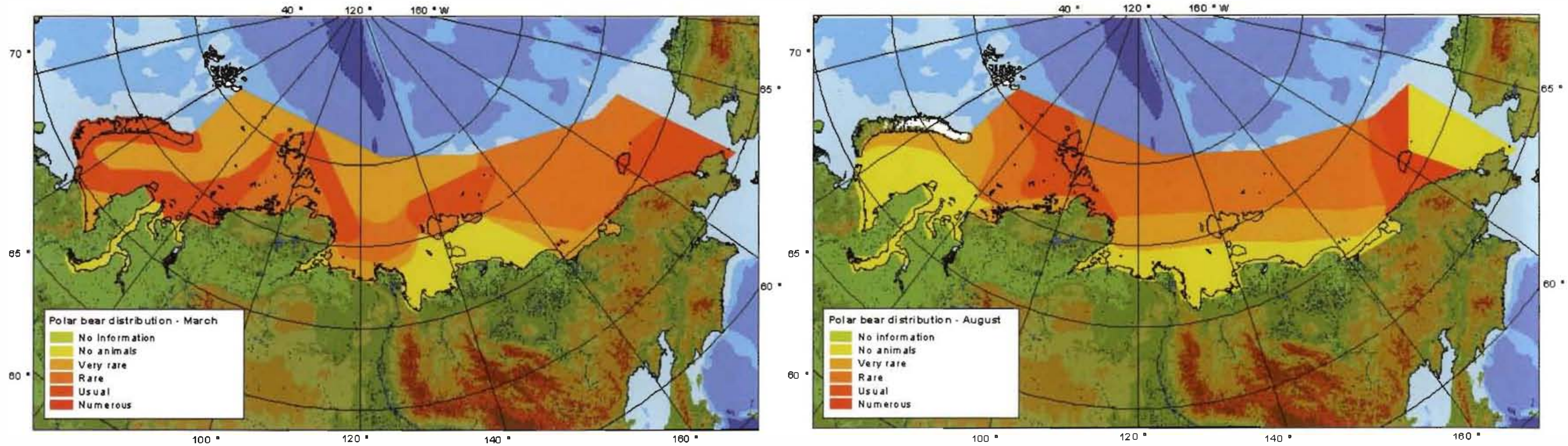


Figure 4.2. *Spring (March) and summer (August) distribution of Polar bear in the NSR area.*

Walrus

Odobenus rosmarus

Photo: Øystein Wiig

Authors:

Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Russia

Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia

Gerald W. Garner, National Geological Survey, Alaska, USA

Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. Pacific walruses are harvested by Chukchan and Alaskan Natives. Atlantic and Laptev walruses are included in the Red Book of the Russian Federation (Anon. 1983). Laptev walrus is listed as Data Deficient by IUCN (IUCN 1996).

Distribution and population size. The walrus has a nearly circumpolar distribution. Fay (1991) recognized six populations: four of Atlantic walruses, the Laptev walrus, and the Pacific walrus. Born et al. (1995) described eight populations of Atlantic walruses. No consistent data exists on the distribution of walruses in the Kara Sea in winter. They appear in the western part of the Kara Sea in spring, and when the ice retreat they apparently migrate from the Barents Sea. They return again to the Barents Sea in autumn.

In the Laptev Sea walruses are observed beyond the fast ice zone in winter. Mostly they inhabit the southern and central parts of the sea and the areas north of the Novosibirsk Islands. They are rarely observed in the northern Laptev Sea (north of 100 m depth). Small groups of subadult animals winter in permanent cracks in the fast ice of Vilkitski Strait (Gorbunov & Belikov 1990). In the beginning of summer, most walruses are distributed along the ice edge. The biggest haul out of Laptev walruses in the second half of summer is at Spit Morzhovaya in Marii Pronchishevoi Bay (up to 600 animals). In October walruses leave haul outs completely.

The Pacific population of walruses is distributed in the eastern East-Siberian Sea, the Chukchi Sea and the northern portion of the Bering Sea. The western limit of the area is situated in the region of Chaunskaya Bay in the East-Siberian Sea. Near the northern coast of Alaska walruses occur up to Cape Barrow.

The world population is about 250.000. Most of these are found in the Chukchi/Bering Sea area. About 5,000 are found in the Laptev Sea and less than 1,000 in the Kara Sea (Belikov et al. 1997).

Habitat. Walruses are found in shallow waters (< 100m) and show preferences for moving pack ice where they haul out to rest. In summer and autumn they also use specific terrestrial haul outs.

Food habits. The walrus lives mostly of benthic organisms like bivalves and snails, but small crustaceans, worms, fish, star fish and even other marine mammals are also eaten (Fay 1991). Adult male walruses reduce their feeding during the breeding season in late winter.

Breeding. Female walruses usually mature at an age of about five to six years while males are sexually mature at about nine to ten. It takes several more years before the males are large enough to compete socially during mating (Fay 1991). Mating occurs from January to March. The whelping is usually in spring. The single calf suckles for about two years. After weaning females stay with groups of adult females, while males usually wander away to join herds of younger and older males.

Human use. The walrus traditionally has been very important for subsistence of coastal settlements in the Russian Arctic. Walruses provide people with food (meat and fat) and material for making boats, ropes (skin) and clothes. Walrus tusks are the most valuable item people can get from walruses. It is used for making a variety of traditional domestic things, hunting equipment and arts. Since 1956, when the harvest of walruses became prohibited, only indigenous inhabiting the eastern Arctic coast are allowed to hunt some thousand walruses annually for subsistence. The reported catch in 1992 was totally about 3,000 (Russian and American). Illegal hunting probably occurs. The walrus is important for indigenous people, and has a high conservation value.

Interaction with NSR activities. Noise, smell and visual impressions from aircraft and ship traffic may cause the walrus to avoid their traditional habitats, calves may be crushed or separated from their mothers by panic reactions, or energy expenditure may increase because of repeated disturbances and calf survival may accordingly be reduced (Fay et al. 1984). Oil spills in haul-out sites and in open waters may cause the walrus to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Inhalation of vapor and ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction and survival.

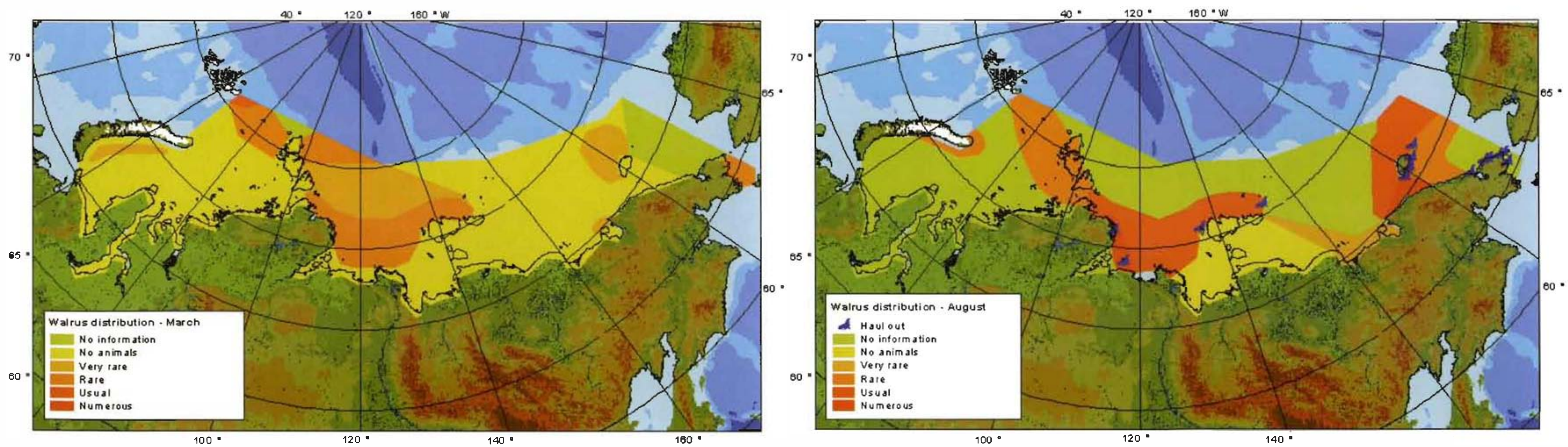


Figure 4.3. *Spring (March) and summer (August) distribution of Walrus in the NSR area.*

Bearded Seal

Erignathus barbatus

Photo: Ian Gjertz

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska, USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. The Bearded seal is harvested in the whole NSR area.

Distribution and population size. Bearded seals have a circumpolar distribution and are found all along the European, Asiatic and North-American coasts of the Arctic Ocean (King 1983). Two subspecies are generally recognized; one from the Laptev Sea in the Siberian Russia and westwards across the Atlantic into the Hudson Bay, and the other from the Laptev Sea and eastwards through the Canadian Arctic. The population size in different areas is poorly known. The world population is suggested to be in excess of 500,000 individuals (Stirling & Archibald 1977).

In the Russian Arctic, Atlantic bearded seals inhabit the shallow zone of the White, Barents, Kara and Laptev seas and the western portion of the East-Siberian Sea. They occur everywhere in the Kara Sea. However, they mostly inhabit the region of Yugorski Shar, the shallow waters between Vaigach Island and Yamal Peninsula, Baidaratskaya Inlet, the marine area north of Belyi Island and along the eastern coast of Novaya Zemlya. In the eastern Kara Sea bearded seals occur north of Dikson Island, north of Piasinski Bay, in the region of Minin Skerries, east of Arctic Archipelago Islands, in the region of Nordensheld Archipelago and west of Severnaya Zemlya (west of Shokalski Strait and near Pioner Island) (Belikov et al. 1997).

Data about bearded seals in the Laptev Sea are very poor. Usually seals occur only in Vilkitski Strait, especially in spring and summer time. Bearded seals are to a less degree observed along eastern Taimyr Peninsula, near Begichev Island and near Preobrazheniya Island.

In the east-Siberian Sea bearded seals are observed but nothing is known about their distribution. According to Geptner et al. (1976) bearded seals occur everywhere in the Chukchi Sea, but mostly they occupy one-year drift ice and areas along the mainland coast. According to Fedoseev (1984) bearded seals migrate to the Chukchi Sea in summer.

Habitat. The general benthic food habits of bearded seals restrict their range to relatively shallow waters (Burns 1981). They are often found in the drifting pack ice. In winter seals make and maintain breathing holes in areas of thinner ice. Bearded seals are solitary animals and are often seen hauled out at the edge of small floes and along leads. Bearded seals are thought to move great distances during the year mainly to maintain contact with the ice, but in areas where the ice melts like in the White Sea, they may haul-out on shore (Heptner 1976). In addition some animals, mainly subadults may summer in the open seas (Burns 1981).

Food habits. The principal prey are bottom living invertebrates, mainly crustaceans and molluscs, and some fish.

Breeding. Males and females mature at five to seven years old. Breeding occurs from March to May. The peak pupping period is in the end of April and beginning of May (Chapskii 1938). The pups are born on ice floes and are able to enter the water and swim if necessary.

Human use. The bearded seal is hunted by Inuits and has been hunted commercially by the Russians. The bearded seal is important for Inuits not only as food but also as source of skin, ropes, dog harness etc. Subsistent hunting of bearded seals take place in many local villages throughout its distribution area, and a small-scale commercial hunt takes place in Russia (Jefferson et al. 1993).

Interaction with NSR activities. Increased shipping and navigation will lead to increased disturbance which can cause a reduction in local bearded seal populations. Disturbances can cause increased activity and energy expenditure in seals. The breaking of ice in breeding areas can cause an increase in pup mortality and reduced mating success (Kelly et al. 1988). Physical contact with oil can cause increased heat loss and accordingly increased energy expenditure and food requirements. Inhalation and ingestion of oil can cause poisoning. Mortality may accordingly increase and reproduction may be reduced in populations exposed to oil spills (Loughlin 1994).

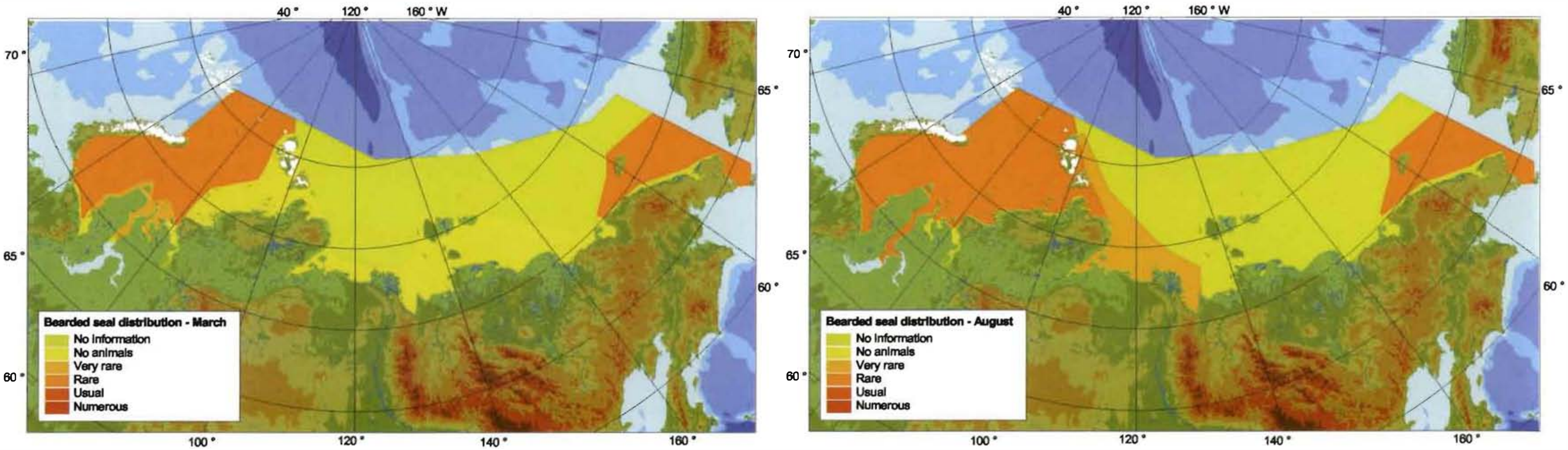


Figure 4.4. *Spring (March) and summer (August) distribution of Bearded seal in the NSR area.*

Ringed Seal

Phoca hispida

Photo: Ian Gjertz

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska, USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. The ringed seal is the most harvested marine mammal in the NSR area.

Distribution and population size. The circumpolar ringed seal is the smallest and most abundant Arctic seal. The total world population is unknown (Frost & Lowry 1981), but estimates have ranged between 2.3 and 7 million individuals. Ringed seals are found from 35°N to the North Pole in all seas of the Arctic Oceans, and in several of the large fresh water lakes of the World.

The density of the ringed seal varies in different regions of the Kara Sea. Mostly it inhabits areas not far from the coastline from Novaya Zemlya to Vilkitski Strait and Severnaya Zemlya including almost all bays and inlets (Geptner et al. 1976).

The Laptev Sea is not considered an area where the ringed seal is abundant. Ringed seals inhabit the area along eastern Taimyr and east along the mainland coast. They are common in eastern parts of the Laptev Sea especially in the Novosibirsk Island region, and near the entrances to Dmitri Laptev Strait and Sannikov Strait (Geptner et al. 1976).

In the East-Siberian Sea ringed seals inhabit the marine area along the mainland coast including all bays and inlets and the zone of drift ice reaching Novosibirsk and DeLonga Islands. Ringed seals in the East-Siberian Sea are much more abundant east of Medvezhyi Islands than west of them. The highest density is registered in Chaunskaya Bay and along the coast (Geptner et al. 1976).

The distribution pattern of ringed seals in the Chukchi Sea is mainly determined by hydrological conditions. Inlets, bays and lagoons of the sea with the exception of Kolyuchinskaya Inlet are shallow and in winter they are frozen to a degree which is unfavorable for the ringed seal. Because of this, ringed seals in the Chukchi Sea mostly occur in marine areas along shore avoiding bays, inlets and lagoons. The highest density is registered in the region of Serdtse-Kamen Cape, the entrance to Kolyuchinskaya Inlet and north-west of Kolyuchin Island (Geptner et al. 1976; Fedoseev 1966).

Habitat. Ringed seals are inhabitants of the permanent pack-ice but congregate on landfast ice for breeding. Some populations also breed in stable drifting pack-ice (Finley et al. 1983). Fedoseev (1975) recognized a ringed seal "ecotype" living in the drift ice in east Siberian waters. Wiig et al. (in press) documented that ringed seals breed in the drifting pack ice of the Barents Sea. In the breeding season the adults are found in the stable fast ice, while non-breeders frequent more peripheral ice and moving pack (Frost & Lowry 1981). Subadult ringed seals primarily inhabit the shear zones between the land fast ice and drift ice, shore lead systems, polynias and unconsolidated offshore pack ice (Geptner et al. 1976; Starikov 1990). Early in summer the seal molts, still in the same areas. In late summer all ages and both sexes move out to the permanent pack-ice or to the remnants of ice near the shore where they remain into early spring.

Food habits. The food of ringed seals varies markedly with season and geographical area. Fish, pelagic amphipods, euphausiids, shrimps and other crustaceans make up the bulk of the diet (Frost & Lowry 1981).

Breeding. The ringed seal matures at an age of four to seven years. Mating occurs in late April-early May. Pups are born in March/April usually in a specially constructed subnivean birth lair in the lee of ice irregularities on shorefast ice.

Human use. The ringed seal is very important as food source for Inuits and other local people. The ringed seal has no special conservation or cultural value, apart from its importance for Inuits.

Interaction with NSR activities. Increased ship traffic will lead to increased disturbance which can cause a reduction in local ringed seal populations. Disturbances can cause increased activity and energy expenditure in seals. Icebreaking navigation in breeding areas can cause an increase in pup mortality by the destruction of birth lairs and reduced mating success (Kelly et al. 1988). Physical contact with oil can cause increased heat loss and accordingly increased energy expenditure and food requirements. Inhalation and ingestion of oil can cause poisoning. Mortality may accordingly increase and reproduction may be reduced in populations exposed to oil spills. Polar bears, and to some extent arctic foxes, are ringed seal predators. An increase in these populations, e.g. as a result of increased dumping of (edible) waste from industrial activity can cause increased mortality and reduce ringed seal reproduction.

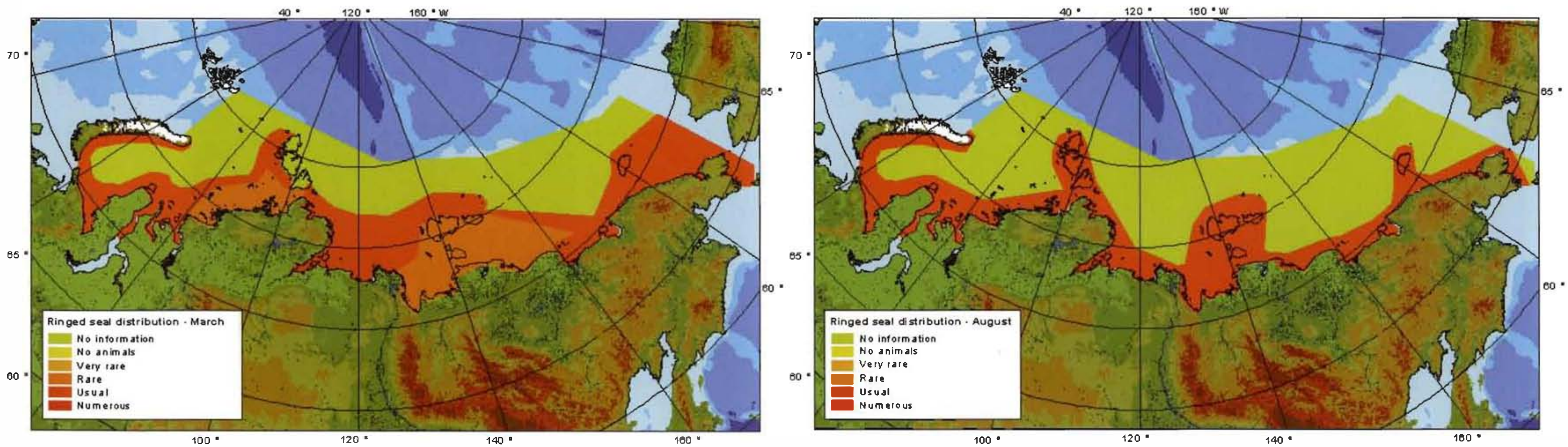


Figure 4.5. *Spring (March) and summer (August) distribution of Ringed seal in the NSR area.*

White Whale

Delphinapterus leucas

Photo: Øystein Wiig

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska, USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. The White whale is harvested in the entire NSR area. It is listed as Vulnerable by IUCN (1996).

Distribution and population size. The white whale has a circumpolar Arctic and partly Sub-Arctic distribution. The world population have been suggested to be close to 60,000 individuals (Brody 1989). About half of these are believed to be in the Bering/Chukchi Sea area. Based on morphological, genetic and distributional differences 15 stocks of white whales have so far been recognized (Jefferson et al. 1993). White whales are highly gregarious and are normally found in pods consisting of a mix of different age and sex groups or in all male groups. There is a general seasonal movement of herds coming into coastal waters and river estuaries during summer and to winter off-shore in the pack-ice or in polynyas (Brodie 1989). During the summer-stay in shallow waters, white whales undergo an annual apparently unique process in whales, where they shed their epidermis in a molt-like manner (St. Aubin et al. 1990).

Most of the white whale population seasonally occupying the Barents and the Kara seas winter in the south-eastern part of the Barents Sea (Ognetov & Potelov 1984; Geptner et al. 1976; Kleinenberg et al. 1964). A number of researchers propose that a few white whales can winter in the Kara Sea. It is particularly pointed out by Kleinenberg et al. (1964) that the lighter the ice conditions in the Kara Sea in winter are the more white whales stay there for the winter. It is commonly accepted that spring migration of white whales from the Barents to the Kara seas begin in April-May (Kleinenberg et al. 1964; Geptner et al. 1976; Ognetov & Potelov 1984). In May and June white whales, migrating east by the northern point of Novaya Zemlya, enter the northern and north-eastern Kara Sea, following leads and channels in ice. In some years they reach Severnaya Zemlya and waters of the Laptev Sea east of the archipelago as early as May. In October-November white whales migrate to the Barents Sea.

Available data on the white whales of the Laptev Sea are few and do not allow characterization of seasonal distribution and number of animals. Some investigators believe that white whales can winter in a polynia north of the Novosibirsk Islands (Kleinenberg et al. 1964; Geptner et al. 1976). According to the same authors animals occur east of Severnaya Zemlya Archipelago, in Velkitski Strait and in south-western part of the sea, including Khatanga Bay, and estuaries of such rivers as Anabar, Olenek and Lena in summer. Apparently many white whales come to the Laptev Sea from the Kara Sea.

The area occupied by the Bering population of white whales includes the Bering and the Chukchi seas and partly the East-Siberian Sea. According to Fedoseev (1986) the spring migration begins in the second half of May and continues to June. From June white whales are common and numerous in the Chukchi Sea and in the eastern portion of the East-Siberian Sea. The autumn migration from the feeding grounds to the Bering Sea continue from the second half of October to the end of November. There is no evidence of white whales wintering in the Chukchi and East-Siberian seas.

Habitat. White whales are found in fjords and nearshore waters. They swim along ice-edges or among drift ice in smaller or larger flocks. In summer they are usually seen close to land, often at the mouth of larger rivers or estuaries.

Food habits. The white whale feeds on squid, benthic crustaceans and fish, and in particular polar cod.

Breeding. Female white whales are sexually mature at the age of 6 years and stay fertile until the age of 21 (Brodie 1989). Males mature at about nine years. The calves are born in spring and summer. There is a 14 months gestation period followed by a lactation period of up to 2 years. Consequently the white whale females gives birth to a new calf only every third year.

Human use. The white whale is to some degree hunted in the NSR area and has some economic importance. It has some importance for the Inuit culture.

Interaction with NSR activities. Oil spills in open water may cause white whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction capacity. Increased traffic will lead to increased disturbance which can cause a reduction in local white whale populations. Disturbances can cause increased activity and energy expenditure (Seaman et al. 1985). Icebreaking traffic in breeding and summering areas can cause an increased mortality.

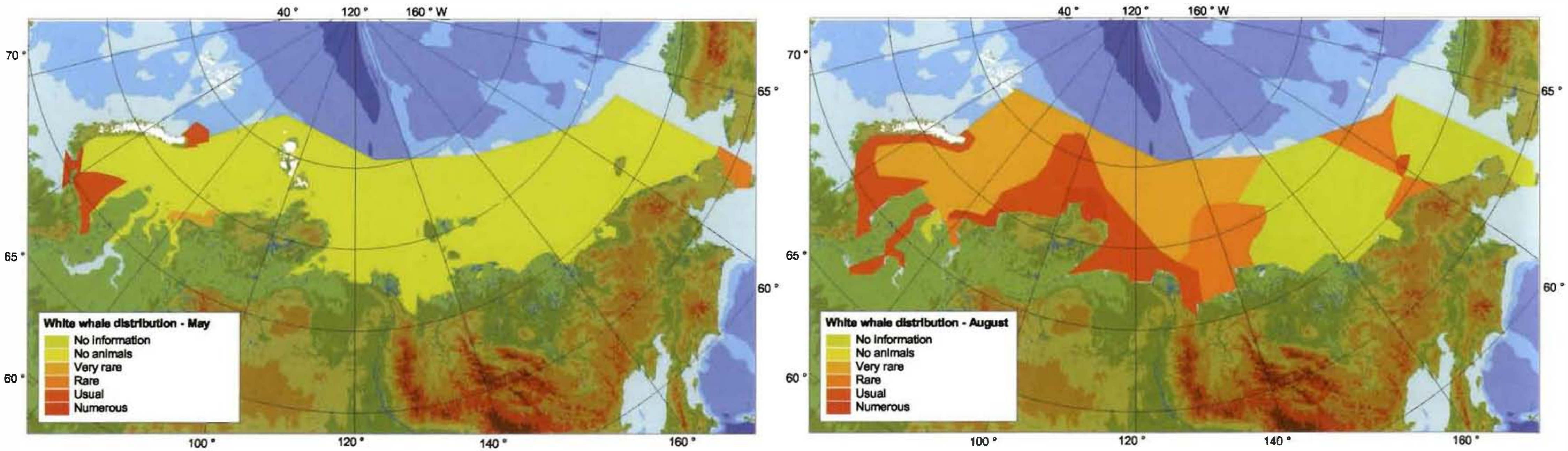


Figure 4.6. *Spring (May) and summer (August) distribution of White whale in the NSR area.*

Gray Whale

Eschrichtius robustus

Photo: Steve leatherwood

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska, USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. The gray whale is harvested to some degree by aboriginals in Chukotka. The population is included in the Red Book of Russian Federation (Anon. 1983). It is listed as Conservation Dependent by IUCN (1996).

Distribution and population size. The gray whale occurs in coastal waters of the North Pacific Ocean, Bering and Chukchi seas. The total population size is about 15,000 (Reeves & Mitchell 1988). Most of them are found in the East Pacific stock which extends from Baja California and into the Chukchi Sea.

The gray whales of the Chukchi-Californian population spend the winter and give birth in waters off California. In February they begin migrating north along the western coast of America. Whales move to the Beaufort, Chukchi and Bering seas which are their primary feeding grounds (Blokhin 1984; Wynne 1992).

Migrating gray whales appear first near the eastern coast of the Chukotka Peninsula (in the region of Cape Chaplin) in the last part of May. Most of them move north along the south-eastern coast of Chukotka in June (Blokhin 1986; 1995). The whales inhabit the Chukchi Sea from the end of May until the beginning of November (Blokhin 1984; Popov 1990). The largest number of whales occupy the Chukchi Sea in August–September (Tomilin 1962). The northern and western limits of the population habitat in summer are determined by the edge of the drift ice. Whales have been observed in the eastern portion of the East-Siberian Sea, in Longa Strait, and as far north as Wrangel Island. From June through the summer, gray whales occupy the whole Chukchi Sea, but concentrate in sites with high density of their main prey; benthic crustaceans. Considerable aggregations of gray whales appear near the northern coast of Chukchi Peninsula in autumn.

Habitat. The gray whale is found primarily in coastal waters and probably remains closer to shore than any other large cetacean. From late May to early October the eastern population congregates in the shallow waters of the northern and western Bering Sea, Chukchi Sea and the Beaufort Sea. In October to January they move about 18,000 km to the southern part of their distribution area. In the spring they move north again.

Food habits. The gray whale tends to fast in winter and feast in summer. Their main food is benthic crustaceans mainly amphipods. They often plow through the mud or sand with their head sideways and stir up prey. Water and organisms are sucked into the mouth, and then the water is forced out, leaving the food within the baleen.

Breeding. The gray whale becomes physically mature when nearly 20 years old. They have a two-year reproductive cycle with mating in November/December and birth about 13 months later.

Human use. The gray whale has little economic significance in the NSR area. Some are taken as subsistence harvest by Inuits. Whale watching is of economic importance in the southern range of the population. The species has a high conservation value and some importance for Inuits.

Interaction with NSR activities. Oil spills in open water may cause gray whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances, like oil-exposed food organisms, may reduce reproduction capacity. Increased ship traffic will lead to increased disturbance which can cause a reduction in local gray whale populations. Disturbances can cause increased activity and energy expenditure. Icebreaking traffic in breeding and summering areas can cause increased mortality.

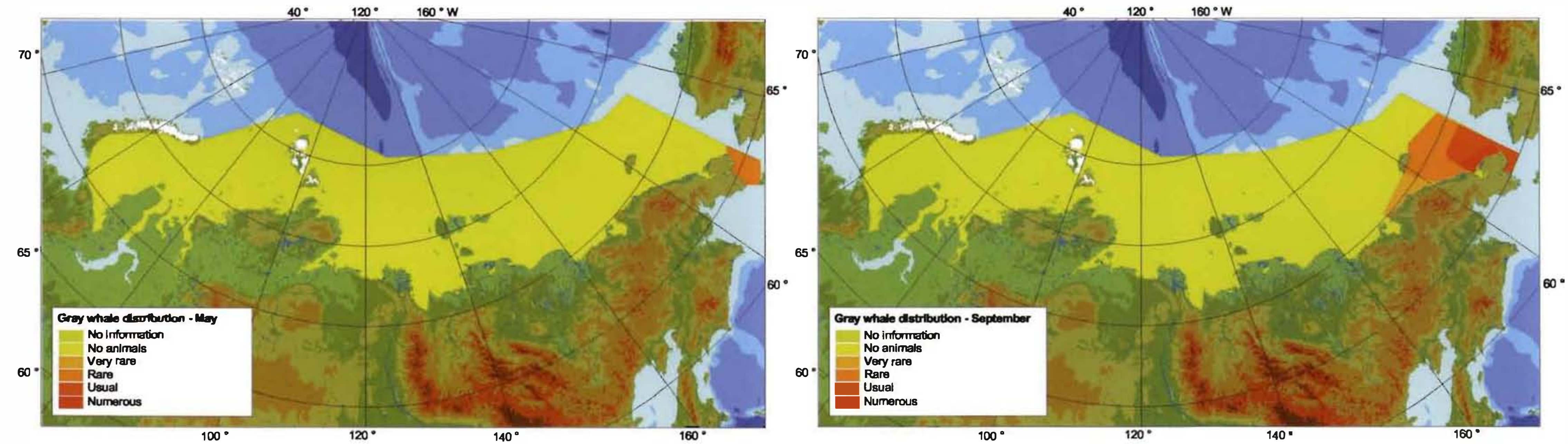


Figure 4.7. *Spring (May) and summer (September) distribution of Gray whale in the NSR area.*

Bowhead Whale

Balaena mysticetus

Photo: Mads Peter Heide-Jørgensen

Authors:
Stanislav E. Belikov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Andrei N. Boltunov, All Russian Research Institute for Nature Conservation, Moscow, Russia
Gerald W. Garner, National Geological Survey, Alaska,USA
Øystein Wiig, Zoological Museum, University of Oslo, Norway

Status. Some Bowhead whales are taken for subsistence use. The population is included in the Red Book of Russian Federation (Anon. 1983). It is listed as Conservation Dependent by IUCN (IUCN 1996).

Distribution and population size. The bowhead whale is distributed in the northwest Atlantic, the Barents Sea, and the Bering, Beaufort, Chukchi and the Okhotsk seas. The total population size is about 8,000 individuals, and most of them are found in the Bering Sea stock (Burns et al. 1993). The other stocks are nearly extinct. Some few individuals from the Spitsbergen population seems to be found in the Franz Josef Land area (Wiig 1991). The Bering-Chukchan population of bowhead whales occupies the Chukchi Sea in summer (Tomilin 1962). The population spends the winter in the Bering Sea. A part of the population (more than 200 animals) stays in the Sirenikovskaya polynya and in the polynya situated south-south-west of St. Lawrence Island. Because juveniles appear there in March–April, it is possible that whales give birth there (Bogoslovskaya et al. 1984).

Tomilin (1957) designated the eastern East-Siberian Sea as the western limit of the population. Materials from last centuries whaling allow us to conclude that bowhead whales begin to move from the northern coast of Alaska and the Beaufort Sea to the western portion of the Chukchi Sea in the end of July (Berzin & Rovnin 1984). According to Popov (1990) they appear near the northern coast of Chukotka Peninsula in the beginning of September.

Before autumn migration bowhead whales aggregate along the northern coast of Chukotka Peninsula. East of Cape Vankarem whales are usual in autumn. Along the coastline between Cape Serdtse-Kamen and the settlement Uelen bowhead whales are usual from the middle of October to the middle of November (Bogoslovskaya et al. 1984).

Habitat. Bowheads are usually found in association with sea ice and appear to move seasonally with the melting and freezing of the ice. The Bering Sea stock migrates into the Chukchi and Beaufort seas in early summer and then returns south in the autumn.

Food habits. The diet consists mainly of zooplankton like copepods, amphipods and euphausiids. They feed in the summer and live mostly of stored fat in the winter. Bowhead whales are slow swimming whales and are able to dive deeper than 1,000 m and stay submerged for more than 1 hour. They are skim feeders and mainly swim at or near the surface with open mouth feeding on small to medium sized zooplankton (Lowry & Burns 1980). Findings of stones and benthic amphipods in some stomachs indicate that some feeding also takes place near the bottom.

Breeding. The reproductive biology is poorly known. Females presumably mature at an age of about 15 years. Most calving appears in the spring. The length of the gestation period is unknown, but is probably between 12-14 months. New-borns are 4 - 4.5 m long (Nerini et al. 1984). The length of the lactation period is unknown. Bowhead whales reach sexual maturity at body lengths of 11.5 m for males and 14 -14.5 m for females. A major problem in life history of bowhead whales, and in general for most baleen whales, is that adequate methods for age determination are not available. Calving interval seems to be about 3-4 years. Breeding probably occur during the summer feeding migration to the north.

Human use. The bowhead is totally protected but Inuits in Alaska and Siberia are allowed to take some for subsistence. The species is very important for these people. The bowhead whale is nearly extinct in most of its distribution range and has a high conservation value. It also has high cultural value for Inuits.

Interaction with NSR activities. Oil spills in open water may cause bowhead whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances, like oil-exposed food organisms, may reduce reproduction capacity. Increased ship traffic will lead to increased disturbance which can cause a reduction in local bowhead whale populations. Disturbances can cause increased activity and energy expenditure. Icebreaking traffic in breeding and summering areas can cause an increased mortality (Richardson et al. 1993).

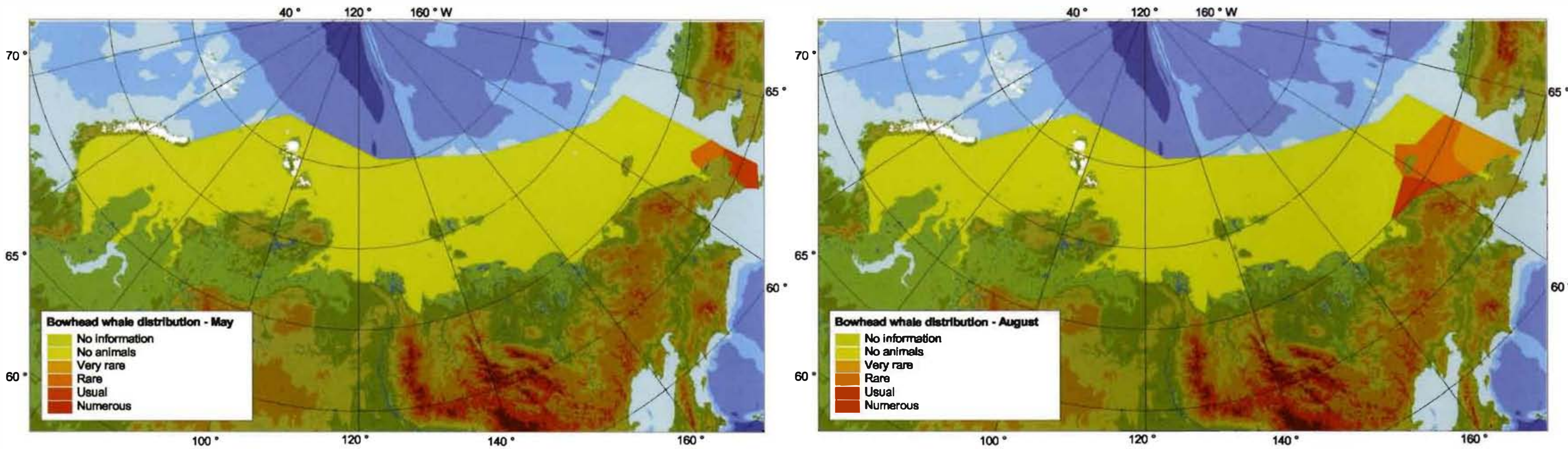


Figure 4.8. *Spring (May) and summer (August) distribution of Bowhead whale in the NSR area.*

References for this chapter

Anon. 1983. Red Book of the Russian Federation. Animals. Rosselkhoz. Moscow. 453 pp. (In Russian.)

Belikov, S.E., Boltunov, A.N., Belikova, T.P., Belevich, T.A., Gorbunov, Y.A. 1997. The distribution of marine mammal Valued Ecosystem Components in the Northern Sea Route area. INSROP Working Paper *in press*.

Berzin, A.A. & Rovnin, A.A. 1984. Distribution and number of Balaenidae in the Pacific Ocean. Pp. 147-162 in: Marine mammals. Nauka. Moscow. (In Russian.)

Blokhin, S.A. 1984. Status of population of gray whales (*Eschrichtius robustus*). Pp. 223-232 in: Marine mammals. Nauka. Moscow. (In Russian.)

Blökhin, S.A. 1986. Data on gray whales observation from the observation points situated on the coastline of Chukchi peninsula. Pp. 28-35 in: Research on marine mammals of the North Pacific in 1984/85. Moscow. (In Russian.)

Blokhin, S.A. 1995. Distribution, number and behaviour of gray whales of the Chukchi-Californian population near south-eastern Chukotka Peninsula. Pp. 15-16 in: Thesis of reports of International Conference on Study and Protection of Marine Mammals. 11-12 October, 1995. Galitsino, Moscow oblast. Moscow. (In Russian.)

Bogoslovskaya, L.S., Vostrogov, L.M. & Krupnik, I.I. 1984. The bowhead whale in the waters of Chukotka. History and present state. Pp. 191–212 in: Marine Mammals. Nauka. Moscow. (In Russian.)

Born, E.W., Gjertz, I. & Reeves, R.R. 1995. Population assessment of Atlantic walruses. Norsk Polarinst. Medd. 138.

Brody, P.F. 1989. The white whale - *Delphinapterus leucas* (Pallas, 1776). Pp. 119-144 in Ridgway, S.H. & Harrison, R. (eds.): Handbook of marine mammals. Vol. 4. River dolphins and the larger toothed whales. Academic Press. New York.

Burns, J.J. 1981. Bearded seal *Erignathus barbatus* (Erxleben, 1777). Pp. 145-170 in Ridgway, S.H. & Harrison, R.J. (eds.): Handbook of marine mammals. Vol. 2. Seals. Academic Press. New York.

Burns, J.J., Montague, J.J. & Cowles, C.J. 1993. The bowhead whale. Spec. Publ. No. 2. The Society of Marine Mammalogy. Lawrence.

Chapskii, K.K. 1938. The bearded seal (*Erignathus barbatus*, Fabr.) of the Kara and Barents Seas. Trans. Arctic Inst. Leningrad 123: 7-70.

DeMaster, D.P. & Stirling, I. 1981. *Ursus maritimus*. Mammalian Species 145: 1-7.

Fay, F. 1991. Walrus - *Odobenus rosmarus* (Linnaeus, 1758). Pp. 1-23 in Ridgway, S.H. & Harrison, R. (eds.): Handbook of marine mammals. Vol. 1. Seals. Academic Press. New York.

Fay, F.H., Kelly, B.P., Gehnrich, P.H., Sease, J.L. & Hoover, A. 1984. Modern populations, migrations, demography, trophics, and historical status of the Pacific walrus. Institute of Marine Science, University of Alaska. Fairbanks. Alaska. 142 pp.

Fedoseev, G.A. 1966. Aerial observations of marine mammals in the Bering and Chukchi seas. Pp. 173-177 in: Izvestiya TINRO 58. Vladivostok. (In Russian.)

Fedoseev, G.A. 1975. Ecotypes of ringed seal (*Phoca hispida*, Schreber, 1777) and their reproductive capabilities. Rapp. P.-v. Reun. Cons. Int. Explor. Mer 169: 156-160.

Fedoseev, G.A. 1984. Population structure, recent state and perspectives of use of ice forms of pinnipeds in the northern Pacific Ocean. Pp. 130--146 in: Marine mammals. Nauka. Moscow. (In Russian.)

Fedoseev, G.A. 1986. Seasonal changes in distribution, and ecological differentiation of the white whale in the northern Pacific Ocean and eastern Arctic. Pp. 406-408 in: Study, conservation and sustainable use of marine mammals. Theses of reports of the 9th All-Union Conference on study, conservation and sustainable use of marine mammals (Arkhangelsk, 9-11 September, 1986). Arkhangelsk. (In Russian.)

Finley, K.J., Green, C.R. & Davis, R.A. 1983. A study of ambient noise, ship noise and the reactions of narwhals and belugas to the MW Arctic breaking ice in Admiralty Inlet, N.W.T. 1982. Report prepared for Can. Dep. Indian Affairs and Northern Development. Ottawa. LGL Ltd. King City.

Frost, K.J. & Lowry, L.F. 1981. Ringed, Baikal and Caspian seals - *Phoca hispida*, *Phoca sibirica* and *Phoca caspica*. Pp. 29-54 in Ridgway, S.H. & Harrison, R. (eds.): Handbook of marine mammals. Vol. 2. Seals. Academic Press, New York.

Geptner, V.G., Chapski, K.K., Arsenyev, V.A. & Sokolov, V.E. (eds.) 1976. Mammals of Soviet Union. Vol. 2. Part 3. Vysshaya shkola. Moscow. 717 pp. (In Russian.)

Gorbunov, Y.A. & Belikov, S.E. 1990. Results of long-term observations on the Laptev stock of walruses. Pp. 79-80 in: Theses of reports of X All-Union meeting on research, protection and sustainable use of marine mammals. Svetlogorsk. (In Russian.)

Hansson, R., Moe, K.A. & Løset, S. 1994. Sub-programme II: Environmental Factors. Project II.2: Screening and focusing workshop. INSROP Discussion Paper.

Heptner, V.G. 1976. Mammals of the Soviet Union. Vol. 2. Pinnipeds and toothed whales. Publishing House for Higher Schools. Moscow. 718 pp. (In Russian.)

IUCN 1996. 1996 IUCN red list of threatened animals. IUCN, Gland, Switzerland and Cambridge. U.K.

Jefferson, T.A., Leatherwood, S. & Webber, M.A. 1993. FAO species identification guide. Marine mammals of the world. FAO. Rome. 320 pp.

Kelly, B.P., Burns, J.J. & Quakenbush, L.T. 1988. The significance of noise disturbance to ringed seals. Manus to POAC-87. Ninth international conference on port and ocean engineering under arctic conditions. 16-21 August 1987, University of Alaska. Fairbanks. Alaska.

King, J.E. 1983. Seals of the world. Oxford Univ. Press. Oxford. 240 pp.

Kleinenberg, S.E., Yablokov, A. V., Belkovich, V.M. & Tarasevich, M.N. 1964. Belukha. Nauka. Moscow. 454 pp. (In Russian.)

Loughlin, T.R. 1994. Marine mammals and the Exxon Valdez. Academic Press. San Diego.

Lowry, L. & Burns, J. J. 1980. Food utilized by bowhead whales near Barter Island, Alaska, autumn 1979. Mar. Fish. Rev. 42: 88-91.

Lunn, N.J. & Stirling, I. 1985. The ecological significance of supplemental food to polar bears during the ice-free period of western Hudson Bay. Can. J. Zool. 63: 2291-2297.

Nerini, M.K., Braham, H.W., Marquette, W.M. & Rugh, D.J. 1984. Life history of the bowhead whale, *Balaena mysticetus*. J. Zool., Lond. 204: 443-468.

Ognetov, G.V. & Potelov, V.A. 1984. The distribution and migrations of the white whales (*Delphinapterus leucas*) in the Kara Sea. Rep. Int. Whal. Comm. 34: 549-553.

Popov, L. A. 1990. Soviet-American research on marine mammals in the North Pacific. Pp. 4-23 in: Marine Mammals. Moscow. (In Russian.)

Ramsay, M.A. & Stirling, I. 1986. On the mating system of polar bears. Can. J. Zool. 64: 2142-2151.

Reeves, R.R. & Mitchell, E. 1988. Current status of Gray whale, *Eschrichtius robustus*. Can. Field-Nat. 102: 369-390.

Richardson, W.J., Greene, C.R., Malme, C.I. & Thomson, D.H. 1995. Marine mammals and noise. Academic Press. London.

Seaman, G.A., Frost, K.J. & Lowry, L.F. 1985. Distribution, abundance, and movements of belukha whales in western and Northern Alaska. Draft final rep. prepared for U.S. Dep. Commerce.

Starikov, G.V. 1990. About resource and structure of stock of the ringed seal in Gydanski bay of the Kara Sea. Pp. 285–286 in: Theses of reports on the X All-Union meeting on study, conservation and sustainable use of marine mammals. Moscow. (In Russian.)

St. Aubin, D.J., Smith, T.G. & Geraci, J.R. 1990. Seasonal epidermal molt in beluga whales (*Delphinapterus leucas*). Can. J. Zool. 68: 359-367.

Stirling, I. 1988. Attraction of polar bears *Ursus maritimus* to off-shore drilling sites in the eastern Beaufort Sea. Polar Rec. 24: 1-8.

Stirling, I. 1990. Polar bears and oil: Ecological perspectives. Pp. 223-234 in Geraci, J.R. & St. Aubin, J. (eds.): Sea mammals and oil: Confronting the risks. Academic Press. New York.

Stirling, I., Andriashek, D. & Calvert, W. 1993. Habitat preferences of polar bears in the western Canadian Arctic in late winter and spring. Polar Rec. 29: 13-24.

Stirling, I. & Archibald, W.R. 1977. Aspects of predation of seals by polar bears. J. Fish. Res. Bd. Can. 34: 1126-1129.

Thomassen, J., Løvås, S.M. & Vefsnmo, S. 1995. The adaptive environmental assessment and management AEAM in INSROP - Impact assessment design. INSROP Working Paper 31 - 1995.

Tomilin, A.G. 1957. Cetaceans. Pp. 714–756 in: Animals of USSR and adjacent countries. Vol. 9. (In Russian.)

Tomilin, M.M. 1962. Cetaceans of marine fauna of USSR. Pp. 1-212. AN USSR. Moscow. (In Russian.)

Wiig, Ø. 1991. Seven Bowhead whales (*Balaena mysticetus* L.) observed at Franz Josef Land in 1990. Mar. Mamm. Sci. 7: 316-319.

Wiig, Ø., Belikov, S.E., Boltunov, A.N. & Garner, G.W. 1996. Selection of marine mammal Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area. INSROP Working Paper 40 - 1996. 70 pp. + appendices.

Wiig, Ø., Born, E.W. & Garner, G. 1995. Polar Bears. Proceedings of the eleventh working meeting of the IUCN/SSC Polar Bear Specialist Group. Occ. Pap. IUCN SSC No. 10.

Wiig, Ø., Derocher, A.D. & Belikov, S.E. Ringed seal (*Phoca hispida*) breeding in the drifting pack-ice of the Barents Sea. *In press* Mar. Mamm. Sci.

Wynne, K. 1992. Guide to the Marine Mammals of Alaska. 76 pp.

Chapter 5

Indigenous population

Photo: Stein P. Asheim

Author:
Winnfried K. Dallmann, Norwegian Polar Institute, Oslo, Norway

The map below shows present residence and subsistence areas of officially recognized indigenous peoples northern Siberia. Of a total number of 26 northern indigenous minorities, 16 live within the area shown. Two additional, major ethnic groups are indicated, the Komi and Yakuts, which reside in Autonomous Republics, where they form a significant percentage of the population (1989: Komi 23.3%; Yakutiya 33.4%).

For the 26 indigenous minorities, the average portion of the total population of the North is 1.5%. Their portion of the rural population, especially in sparsely populated areas, is much higher, and reaches locally 100%. Some of these peoples are severely threatened by extinction, due to their extremely low population number, within the present map limits especially the Entsy.

In the map area, main carried-on traditional trade branches are reindeer breeding, fishery in freshwater and estuaries, trapping, hunting of game and sea mammals, gathering, fur-farming (initiated through colonial Russian tax collection), traditional arts and crafts. Within many indigenous groups, distinctly different subsistence cultures developed dependent on the natural conditions. Most of the groups live across two or several vegetation zones and have developed a twofold culture; either a tundra and a taiga culture, or a coastal and an inland culture.

Reindeer breeding in both tundra and taiga is the most characteristic and distinguished occupation of the northern minorities among those still having economical significance. It is by them not only considered as an economic branch, but as a way of life closely connected with their ethnic identity. The trade is very sensible to environmental changes and depends on vast, free mugration areas, the availability of summer and winter pastures and suitable calving sites. Modern environmental and social changes create a severe threat towards reindeer breeding and all its related cultures. Other inland occupations are game hunting and fishing in rivers and estuaries.

Coastal cultures are dependent on areas with significant sea mammal resources, like walrus, whale and various seals. They have developed within ethnic groups, whose territories reach to the Far Eastern shores. The Siberian north coast from the Kolyma mouth to the eastern Barents Sea does not provide a subsistence basis for distinct coastal cultures.

Modern trade branches (e.g. forestry, mining, industry, service, teaching, science, modern arts) have gained importance for the urban population, while agriculture, cattle, horse and fur farming have spread northward into the Subarctic areas and gained importance for parts of the rural population.

Main references for map and table data:

Itogi vsesoyuzoy perepisi naseleniya 1959goda. Gosstatizdat, Moskva 1962.

Narody Rossii. Entsiklopediya. Moskva 1994.

Narody Rossii i sopredelnykh stran. PKO "Kartografiya", Moskva 1995.

Table 5.1. *Indigenous groups trade braches, population and language.*

Indigenous groups (residing in areas not far from coasts):	Important rural trade branches:	Total population according to census of:		Having national language as mother tongue:	
		1959	1989	1959	1989
Nenets	RFH(PCAT)	23007	34665	85%	78%
Entsy	HFR	*n.a.*	209	*n.a.*	47%
Nganasans	HF(R)	748	1278	93%	83%
Dolgans	RHF(T)	3934	6932	94%	84%
Khanty	HFR(AC)	19410	22521	77%	61%
Evenks	RHF(ACS)	24710	30163	56%	30%
Evens	RH(FT)	9121	17199	81%	44%
Yukagirs	PFRA(HC)	442	1142	53%	32%
Chukchi	RSTP(FH)	11727	15184	94%	70%
Chuvans	RHF	*n.a.*	1511	*n.a.*	19%
Koryaks	RSFT(AC)	6287	9242	91%	52%
Itelmens	F(H)	1109	2481	36%	20%
Asiatic Inuit	S(HT)	1118	1719	84%	52%
Aleuts	S(H)	421	702	22%	25%

Abbreviations for traditional trade branches: **R**: reindeer breeding, **F**: inland fishery, **H**: game hunting and trapping, **S**: sea mammal hunting and marine fishery, **P**: fur-farming, **A**: agriculture, **C**: stock and horse farming, **T**: traditional arts and crafts. Note that gathering has an additional, secondary importance for most of the listed peoples. Branches added in brackets have little or only traditional significance.

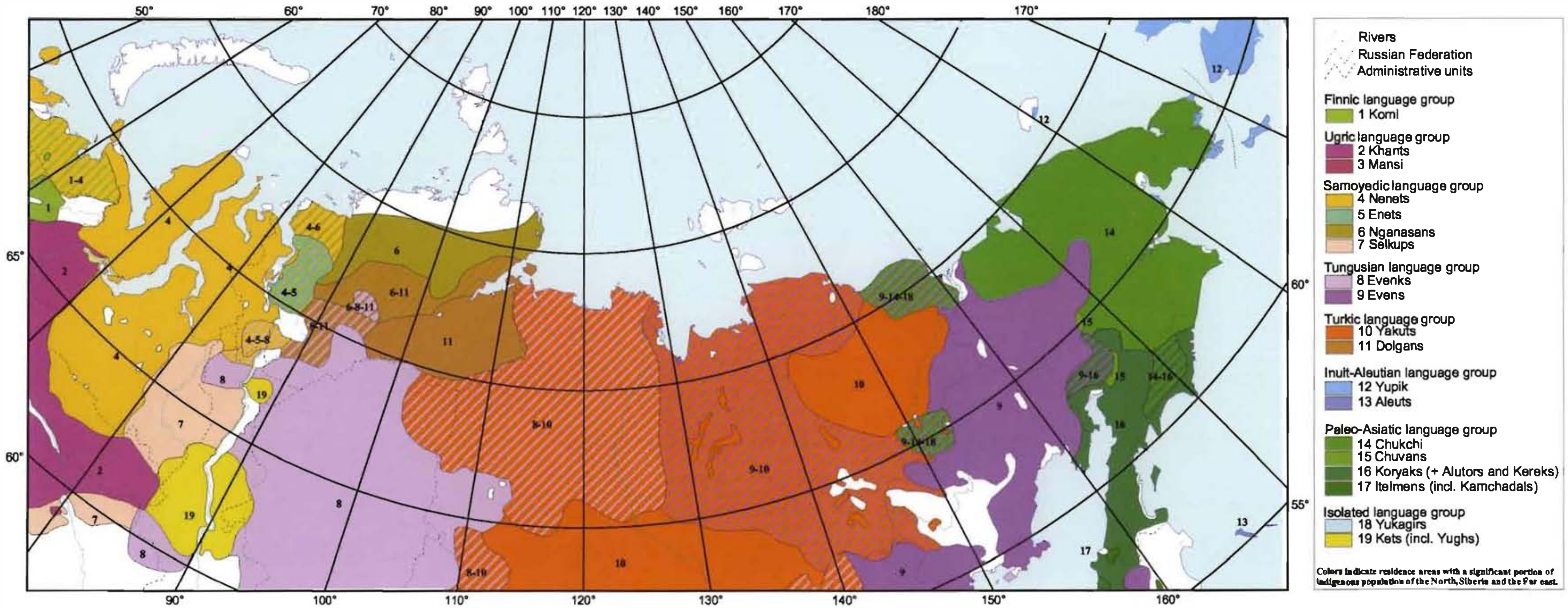


Figure 5.1. Residence and subsistence areas of indigenous peoples in northern Siberia.

Environmental Impact Assessment (EIA) in INSROP

Authors:
Jørn Thomassen, Norwegian Institute for Nature Research (NINA), Trondheim, Norway
Kjell A. Moe, Alpha Environmental Consultants, Oslo, Norway
Odd Willy Brude, Alpha Environmental Consultants, Oslo, Norway

Challenges in the Northern Sea Route area

The exploitation of various biological and mineral resources in the northern areas has a long, profitable and often dramatic history, but unfortunately with little effort put on the sustainability of the exploitation. Most of the resources have been transported southwards for use in more central and populated parts of the world. The historical harvesting and drainage of resources have had severe consequences on several vulnerable species such as polar bears, walrus and whales. Only ecological insight and international political agreements signed in the last few decades have made it possible to save the most vulnerable and threatened species from extinction.

Even more severe are probably the long-term threats on the habitats from various human activities and encroachments, leaving back pollutants and a disturbed or destroyed environment. The historical exploitation of resources in the Northern Sea Route (NSR) area seems not to be an exception from this picture, a picture which has been strengthened in recent decades with the increasing exploitation of oil and gas resources in the northern and north western part of Russia.

The NSR has the potential to be an important transport nerve for resources located in the area, and for the transit of cargo from eastern Asia to Europe and *vice versa*. On the Yamal peninsula oil and gas drilling and production have been important for Russia for several years already. These resources have so far been transported through pipelines south- and eastwards. Rich oil and gas fields are in addition located in the Timan-Pechora basin west of the defined NSR area, and increasing exploitation of these resources in the Nenets Okrug is likely to start in the immediate future. Marine transportation of oil from Timan-Pechora and from inland Russian oil fields is assumed to be important in the future (Ramsland 1995; EPPR 1997). The export of crude oil from the northwest Russian fields, with focus on Timan-Pechora will affect the NSR with an easterly sailing route. The hinterland perspectives of crude oil transport from the Novoportovskoye field and the fields on the Ob and Yenisey rivers will directly affect the NSR, as well as transport of condensates and oil products from the latter two.
Other industrial activities, based on different mineral resources, have also been of major importance in the area, unfortunately with severe environmental impacts mainly from pollution as a consequence. Further utilisation of minerals and rich timber resources, as well as other living resources will probably increase, and must obviously also be included in the future developments in the NSR area.

Important developmental challenges in the NSR area include economy, technology, society and ecology. Sustainability should be the leading guide for all these disciplines in the future exploitation of the NSR-resources, as well as in the transportation and utilisation of the resources. This overriding aim calls for inter-disciplinarity when working out the Environmental Impact Assessment (EIA) for future use of the NSR, which also includes defining and describing the different NSR activities or scenarios.

Photo: Vidar Bakken

Figure 5.2. A view from the NSR area.

INSROP - EIA basic steps

The INSROP Sub-programme II: Environmental Factors, aims to work out an EIA for the various NSR activities (Hansson & Moe 1996; Moe et al. 1997). The methodological concept for the INSROP EIA is described in details by Thomassen et al. (1996), and a simplified scheme of this process is shown in figure 5.3.

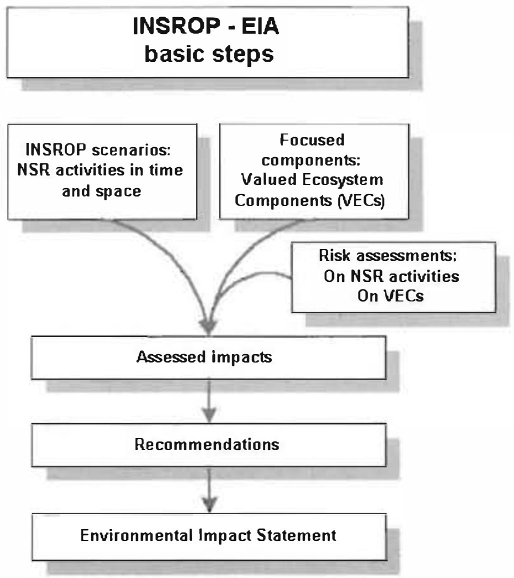


Figure 5.3. *A simplified scheme of the basic steps in the INSROP EIA process.*

The importance of the INSROP-EIA

Shipping and navigation include a number of activities that in one way or another interact with the environment as well as the human society. The interactions can be positive or negative, but in any ways the interactions are entirely activity specific.

The goal of an EIA is to form a basis for decision-makers; the EIA is perhaps the most important predictive tool, which can prevent today's decisions resulting in unacceptable environmental impact tomorrow. Obviously the decisions concerning the NSR are numerous, ranging from local to international level in various disciplines as for example environment, anthropology, ship safety, economy, insurance and politics.

The nature of an EIA therefore calls for an inter-disciplinary approach and co-operation between various interests and specialists, which in turn stress the importance of communication. One important tool for the inter-disciplinarity in INSROP is the use of the Geographical Information System (INSROP GIS, see Chapter 1, this issue), which also will be important in the challenge of communicating the EIA to the recipients.

Photo: Vidar Bakken

Figure 5.4. A view from the NSR area.

Decisions are human oriented processes, and selections and priorities call for an "intelligent simplification". Normally this process occurs through a scoping phase, which can be described as identifying, from a broad range of potential problems, a number of priority issues to be addressed by the EIA (Beanlands 1988). In INSROP a simplified Adaptive Environmental Assessment and Management (AEAM)-concept (Holling 1978), used in several EIAs in Norway as well as in Canada (see Indian and Northern Affairs Canada 1992a, 1992b, 1993), is chosen as the leading method in the EIA process. According to the AEAM, the issues given priority are called Valued Ecosystem Components (VECs). In the INSROP Sub-programme II significant ecological knowledge is collected through the baseline studies and subsequently entered into the Dynamic Environmental Atlas (DEA) (see Bakken et al. 1996a; 1997, and previous sections in this issue). One of the strengths of the AEAM-concept is that it facilitates an inter-disciplinary evaluation of multi-disciplinary information, which is necessary in an EIA.

As the ultimate objective of an EIA is to give indications of the most likely consequences of the NSR-activities, the great challenge will be to give an objective view into the future. Environmental impacts must therefore be addressed through the difference between the environment with and without the proposed NSR-activity, which in turn stress the importance of well defined and detailed described scenarios. This also means that one ideally should make scenarios of the development in the NSR area without the NSR activity (see Figure 5.5).

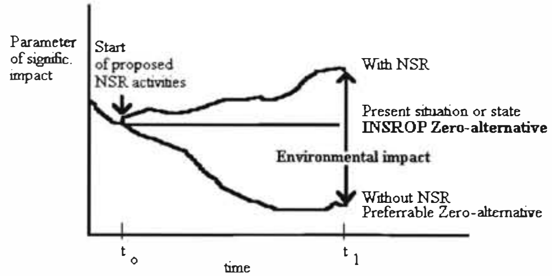


Figure 5.5. *Hypothetical impact based on scenarios with and without the proposed NSR activities. Redrawn after Wathern (1988). It should be clear that the construction of the zero-alternative requires a multi- or even interdisciplinary co-operation.*

The NSR scenarios

The initial EIA-procedure includes the definition and the description of various NSR-scenarios, and the identification of the geographical and temporal characteristics of each type of NSR activity. Moreover it is important to identify the main factors of the activity that can interact with the environment. Principally, these impact factors are tiled to either (Thomassen et al. 1994):

- normal operations, or
- accidental events.

The environmental impacts of the operational scenarios are generally characterised by low intensity, but depending on shipping regularity the duration of the impact may be more or less continuous. The environmental impacts of the accidental scenarios are characterised by high intensity in a short period and with long uneventful periods in between. The accidental scenarios are closely related to the operational scenarios because the sailing routes and the physical environment conditions are the same. However, the accidental scenarios involve the parameter "probability to occur", which form the basis for combining the probability of an event and the possible impact of this event in an Environmental Risk Assessment (ERA). The results of such exercises can be used to identify high risk areas and seasons (see below).

Harmonised to the INSROP EIA concept, the NSR activities have a reference to one or more of the following main components:

- The individual ship, including ice-breaker support
- Harbour facilities for cargo handling
- Infrastructure for cargo and crew support

Activities whitin the first component is considered entirely seabound, the infrastructure is considered land-based, while the harbour facilities are the intermediate link between the other two.

To each type of activity, both regarding the operational aspects as well as the accidental events, a corresponding set of impact factors can be identified. Based on the inherent mechanisms of interaction with the environment, the impact factors are grouped in five main categories:

- Physical disturbance
- Emissions to air
- Discharges / releases to sea, ice, and (or) land
- Noise
- Changes of development pattern

For both the operational and the accidental scenarios, limitations in time and space are necessary. The temporal and spatial characteristics will for example depend on the type of ship and convoys. The ultimate goal of the description of the spatial and temporal scenarios is to specify the temporal variation in sailing frequency along various sections of the NSR. If possible, the sailing frequency will be specified for a set of cargo types.

The oil transportation scenario will evaluate three modes, pipeline transport, river tankers and river barges as input to a terminal solution for the region. In addition, the sea-borne export solution to the production of gas on Yamal and in the Kara Sea is included in this scenario.

Commercial transport with dry cargos originating in Europe with destination Northern Far East is a realistic scenario for the NSR. Another is the sea-borne logistic solution to material supplies to the West Siberian oil fields. The potential dry cargo marked which exist along the rivers Yenisey and Ob is currently evaluated in INSROP Sub-programme III, together with the return cargo for both barges and deep-sea bulk carriers. Transport of timber and mineral resources will, in addition to the hydrocarbon transport activity, be of major importance in the definition of scenarios for the NSR.

An increased use of the NSR can also lead to a change of development patterns of NSR regions. This can be considered to be as a secondary consequence, but nevertheless important for existing societies and indigenous peoples of the north.

Baseline studies

Through the scoping process of the INSROP-EIA, a selected number of VECs was given priority (see Hansson et al. 1994). The systemised information on the temporal and spatial distribution of the VECs collected and stored in the DEA database during Phase 1 of INSROP, forms the baseline information of the EIA. Both historical Russian and western data, as well as data obtained in recent and ongoing studies and monitoring programmes, are included in the database (see Chapter 1, this issue for details).

The NSR area is wide and the existing information is for large areas sparse and often difficult to access. It is therefore important to emphasise that the baseline information is considered "best available". Selected parts of the baseline information are presented in this issue of the DEA and in INSROP Working Papers such as Bakken et al. 1996b); Larsen et al. (1995, 1996); Wiig et al. (1996); Dallmann (1997).

As is the case in INSROP, predicted impacts from a development project should always be the basis for the selection of baseline studies. Thus, the collection of baseline information would be directed towards establishing statistically valid descriptions of selected environmental components prior to the project under consideration (Beanlands 1988). Since the ultimate goal of an EIA however, is to provide decision makers with a description of the most likely consequences of the project, the collection of baseline information also must be directed towards critical decision points. This strengthen the importance of well-defined and detailed descriptions of the NSR activities.
From the proposed and roughly described NSR activities, VECs were selected, and a set of significant impact factors identified. The prediction of the likely impacts on each VEC has been verified by testing impact hypotheses. What the "real" or *in situ* impacts from the NSR will be in future can only be measured over time, preferably through a well-defined and tailored environmental monitoring programme.

Areas of special importance

The program for Conservation of Arctic Flora and Fauna (CAFF) is part of the Arctic Environmental Protection Strategy (AEPS) which was adopted by several Arctic countries in 1991. A review of the state of protected areas in the circumpolar Arctic, which also include the NSR area, was published in CAFF (1994). The information collected in the CAFF work will be used in a further

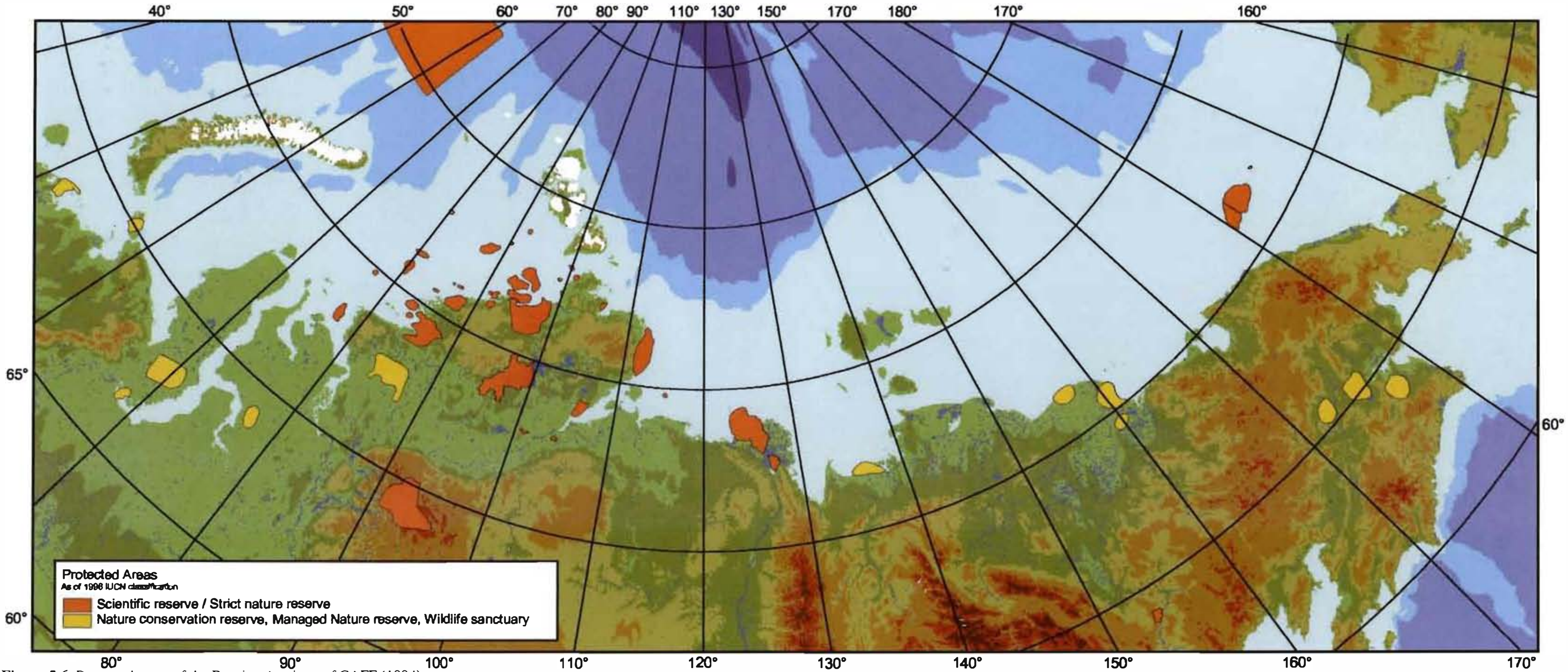


Figure 5.6. Protected areas of the Russian Arctic as of CAFF (1994).

context in the INSROP EIA work.

Through the establishment of protected areas such as nature reserves, national parks, sanctuaries etc., an evaluation of areas of special importance in the NSR area has already been done. In INSROP special attention is given to these areas as well as other areas of significance, such as feeding areas of special importance to seabirds, migration routes for domestic reindeer, and important fishing and harvesting areas for indigenous people.

The AEPS work also include three other programmes which are important to the INSROP EIA work: Arctic Monitoring and Assessment Program (AMAP), Protection of the Arctic Marine Environment (PAME), and Emergency, Prevention, Preparedness and Response (EPPR). Baseline data and monitoring results are currently exchanged between AMAP and INSROP, and the proposed design of the PAME collection and sharing system is tailored for integration and analyses of data in the DEA and *vice versa* (Moe et al. 1996).

Ship accidents

In the summer season, when the ice conditions are most favourable, there are several ships with low ice classification navigating the NSR without icebreaker assistance. This operational practice may increase the occurrence of ship damage. At the end of the summer season (September-October) deteriorated hummocks and old ice may be present under the water surface. Sailing single in such conditions may be dangerous, especially during poor visibility. The frequency of ship accidents is evidently dependent on ship type, navigation with and without icebreaker and the ice conditions. In regions with severe ice conditions, for instance the Vilkitskiy Strait and the Sannikov Strait, the probability for ice damage increases. The high intensity of navigation in the Kara Sea represents a potential for increased frequency of ship accidents.

In order to point out areas or seasons of significance to ship accidents, historical or experience data on frequencies for ship accidents should be analysed. With high spatial resolution the navigation routes can be divided into segments, and the areas and periods with higher frequencies for ship accidents can be identified. The critical question is if the necessary input data for this kind of analyses can be accessed.

Since the human error factor related to accidents is generally unpredictable, this element should be considered independently of the probability estimations.

Environmental Risk Assessment (ERA); the use of INSROP GIS – DEA as an analytical tool

One of the aims of the ERA is to identify VECs in particular areas or seasons with the potential of being significantly affected by a specific NSR activity. Given the causal connection between the activity, the ability to be exposed by the corresponding impact factor(s), and the species-specific susceptibility to injury, e.g. vulnerability, the potential environmental risk can be indicated by combining:

- the temporal and spatial distribution of VECs
- time- and georeferenced measures for the NSR activity (such as sailing routes and frequency, type of ship, cargo types and volumes etc.)
- the corresponding activity-specific impact factors (such as oil drift statistics etc.).

In the INSROP GIS – DEA tailored routines are developed for quantitative assessments and semi-quantitative analyses of possible impact and environmental risk. The concept, including selected results presented on a series of maps (figure 5.7 to 5.11), is briefly outlined step by step in the following sections.

a) In the beginning was the natural environment. .... The level of interactions between the environment and human activity is characterised by the current development or activity status (cf. figure 5.3).

b) Some natural resources are common in the area at certain periods of the year. The relevant type of data are stored in the DEA database and standard routines are developed for presentation of key information on maps and tables. The resource occurrence is indicated in Figure 5.7 in terms of the spatial distribution of Ivory gull colonies.

Figure 5.7. *Example on the spatial distribution of a VEC (Ivory Gull colonies).*

c) Ships of the NSR fleet also navigate the selected waters. The spatial navigation pattern is applied to the environment in terms of historical sailing routes (figure 5.8).

Figure 5.8. *Historical sailings routes in the Kara Sea.*

d) The navigation however forms disturbance, e.g. an impact factor to the environment. The spatial range of the impact factor, in terms of the area that may be influenced, can be calculated by tailored buffer-routines (figure 5.9).

Figure 5.9. *Spatial range of a given impact factor represented by a influence zone along the sailing segments.*

e) By joining the influence area affected and the Ivory gull distribution, the intersections between the impact factor and number of colonies can be identified and the fraction of colonies affected can be calculated (figure 5.10).

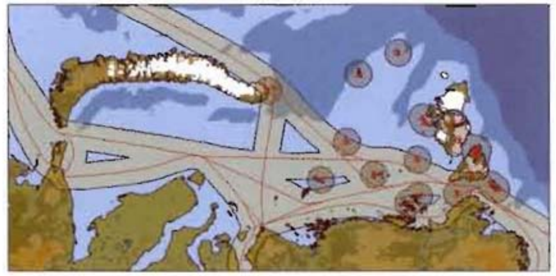


Figure 5.10. *Potential conflict area given as overlap between the VEC distribution and the influence zone for the impact factor.*

f) Based on the information on the individual resources (b), the navigation pattern (c) and the corresponding range of the impact factor (d) and the vulnerability to the impact factor, algorithms have been developed to aggregate this information on a grid level, i.e. counting the fractions affected within each cell. The results, given for the Ivory gull case as example in figure 5.11, are non-dimensional indices (e.g. none, low, moderate, high), indicating the probability of environmental impact within each individual grid cell.

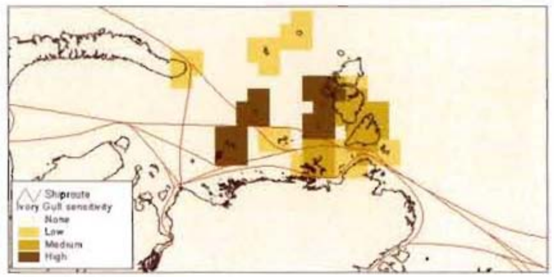


Figure 5.11. *Indication of sensitive/high risk areas.*

The values calculated above give a relative representation of the environmental risk within a certain influence area. Grid cells with high risk values will be focused with regard to assessments of mitigating measures and contingency planning. In addition to risk maps, maps indicating species sensitivity and vulnerability to given impact factors are easily generated. Oil drift statistics will be entered into the system providing data for calculating the environmental risk in the oil transport scenario.

In the INSROP GIS – DEA, all routines are made flexible for easy access to the information and adjustments of the factors involved. In a subsequent maintenance or upgrading phase of the system, any changes in resource distribution or navigation patterns can be harmonised towards the *in situ* status.

It is important to notice that the GIS is an important tool when handling large volumes of georeferenced data in non-biased analyses and for communication of the results on maps and tables. In EIA work however, the GIS can never fully replace the professional assessments made by dedicated experts and scientist.

References for this chapter

Bakken, V., Brude, O.W., Larsen, L.H., Moe, K.A., Wiig, Ø., Sirenko, B., Gavrilo, M., Belikov, S.Y. & Garner, G.W. 1996a. INSROP Dynamic Environmental Atlas. Pp. 213-221 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Bakken, V., Gavrilo, M.V., Isaksen, I. & Strann, K-B. 1996b. Selection of marine bird Valued Ecosystem Components and descriptions of impact hypotheses in the Northern Sea Route Area. INSROP Working Paper No. 60. 56 pp.

Bakken, V., Brude, O.W., Hansson, R., Larsen, L.H., Løvås, S.M., Moe, K.A., Thomassen, J. & Wiig, Ø. 1997. INSROP Dynamic Environmental Atlas. Pp. 280-282 in Conf. Proc., AMAP Internat. Symp. on Environm. Poll. of the Arctic, Tromsø, Norway June 1-5, 1997.

Beanlands, G. 1988. Scoping methods and baseline studies in EIA. - In Wathern, P (ed.). Environmental Impact Assess-ment: theory and practice. Unwin Hyman Ltd.

Conservation of Arctic Flora and Fauna (CAFF) 1994. The State of Protected Areas in the Circumpolar Arctic 1994. CAFF Habitat Conservation Report No. 1. Directorate for Nature Management,Trondheim, Norway. 163 pp.

Dallmann, W.K. 1997. Indigenous peoples of the northern part of the Russian Federation and their environment. INSROP Working Paper No. 90. 101 pp + appendices.

EPPR 1997. Review need for future action on transport of oil by ships. Report, Emergency Prevention Prepardness and Response (EPPR), Moscow. 39 pp.

Hansson, R. & Moe, K.A. 1996. INSROP Sub-programme II: Environmental factors. Conceptual design & current status. Pp. 205-211 in Kitagawa, H. (ed.): "Northern Sea Route; Future and Perspective", Conf. Proc., INSROP Symposium Tokyo '95 (IST'95), Tokyo, 1-6 October 1995.

Hansson, R, Moe, K.A. & Løset, S. 1994. Screening and focusing Workshop - Environmental factors. INSROP Discussion Paper. Oslo, February 1994.

Holling, C.S. 1978. Adaptive environmental assessment and management. John Wiley & Sons: Chichester- New York - Brisbane - Toronto. 1986.

Indian and Northern Affairs Canada 1992a. Beaufort Region Environmental Assessment and Monitoring Program (BREAM). Final Report for 1990/1991. Environmental Studies No. 67. 416 pp.

Indian and Northern Affairs Canada 1992b. Beaufort Region Environmental Assessment and Monitoring Program (BREAM). Final Report for 1991/1992. Environmental Studies No. 69. 359 pp.

Indian and Northern Affairs Canada (1993). Beaufort Region Environmental Assessment and Monitoring Program (BREAM). Final Report for 1992/1993. Environmental Studies No. 71. 298 pp.

Larsen, L.H., Evenset, A. & Sirenko, B. 1995. Linkages and impact hypotheses concerning Valued Ecosystem Components (VECs) Invertebrates, Fish, the Coastal Zone and Large River Estuaries and Deltas. INSROP Working Paper No. 12. 38 pp.

Larsen, L.H., Palerud, R., Goodwin, H. & Sirenko, B. 1996. The Marine Invertebrates, Fish and Coastal Zone Features of the NSR Area. INSROP Working PaperNo. 53. 41 pp.

Moe, K.A., Skeie, G.M., Behrens, H.L., Førsund, H.M., Melbye, A.G. & Nesse, S. 1996. PAME data collection and sharing system. Proposals on conceptual design. DNV-Report 96-3719. 78 pp.

Moe, K.A., Hansson, R. & Thomassen, J. 1997. Strategic Environmental Impact Assessment - Northern Sea Route (Russia). Results obtained during phase I of International Northern Sea Route Programme (INSROP) Pp. 201-203 in Conf. Proc., AMAP Internat. Symp. on Environm. Poll. of the Arctic, Tromsø, Norway June 1-5, 1997.

Ramsland, T. 1995. Oil product exoport from North West Russia. INSROP Working paper No. 8. 34 pp.

Thomassen, J., Løvås, S.M. & Løset, S. 1994. Environmental Impact Assessment - Preliminary Assessment Design. INSROP Discussion Paper, Trondheim, June. 31 pp.

Thomassen, J., Løvås, S.M. & Vefsnmo, S. 1996. The Adaptive Environmental Assessment and Management AEAM in INSROP - Impact Assessment Design. INSROP Working Paper No. 31. 45 pp.

Wathern, P. (ed.) 1988. Environmental Impact Assessment. Theory and practice. Academic Div. of Unwin Hyman Ltd. London. 332 pp.

Wiig, Ø., Belikov, S.E., Boltunov, A.N. & Garner, G.W. 1996. Selection of marine mammal Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area. INSROP Working Paper No. 40 - 1996. 70pp.