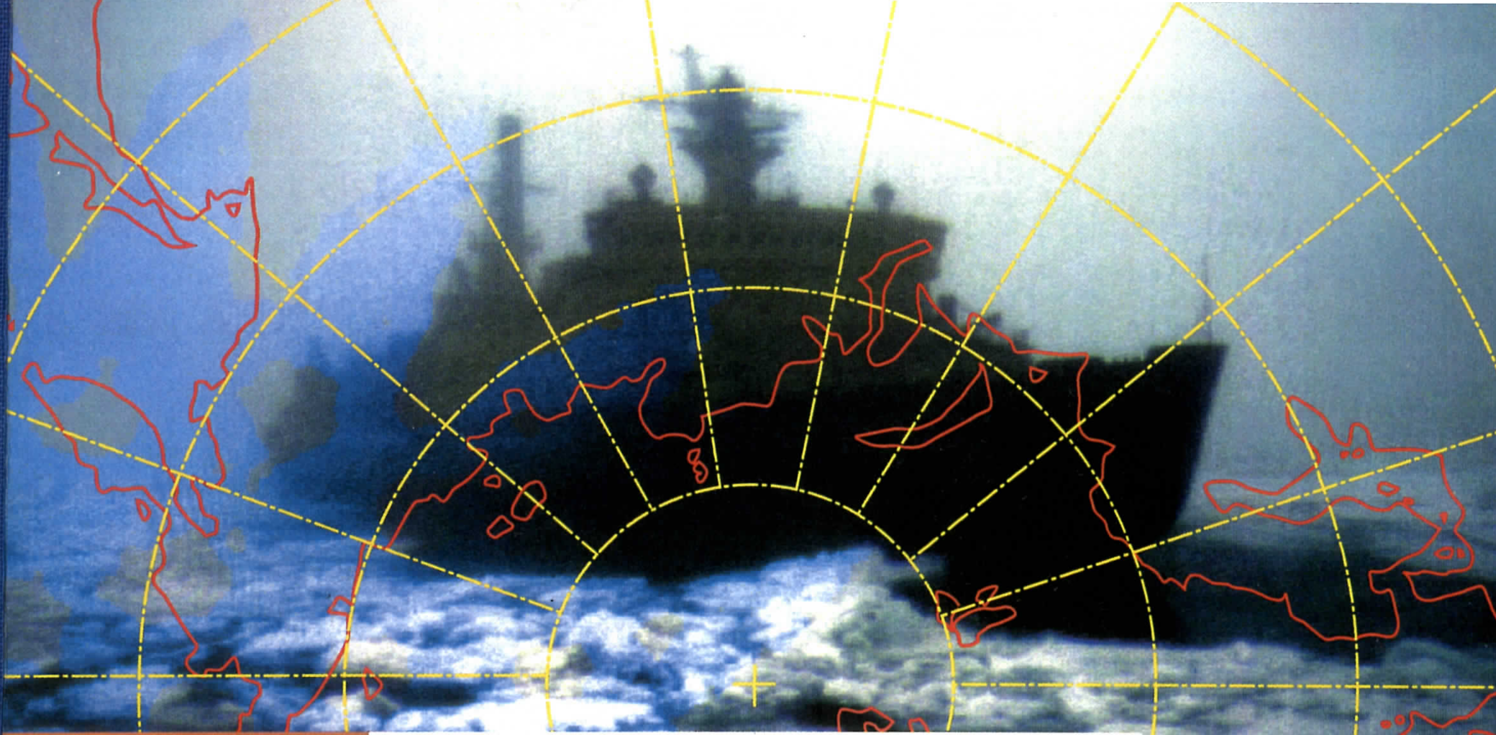
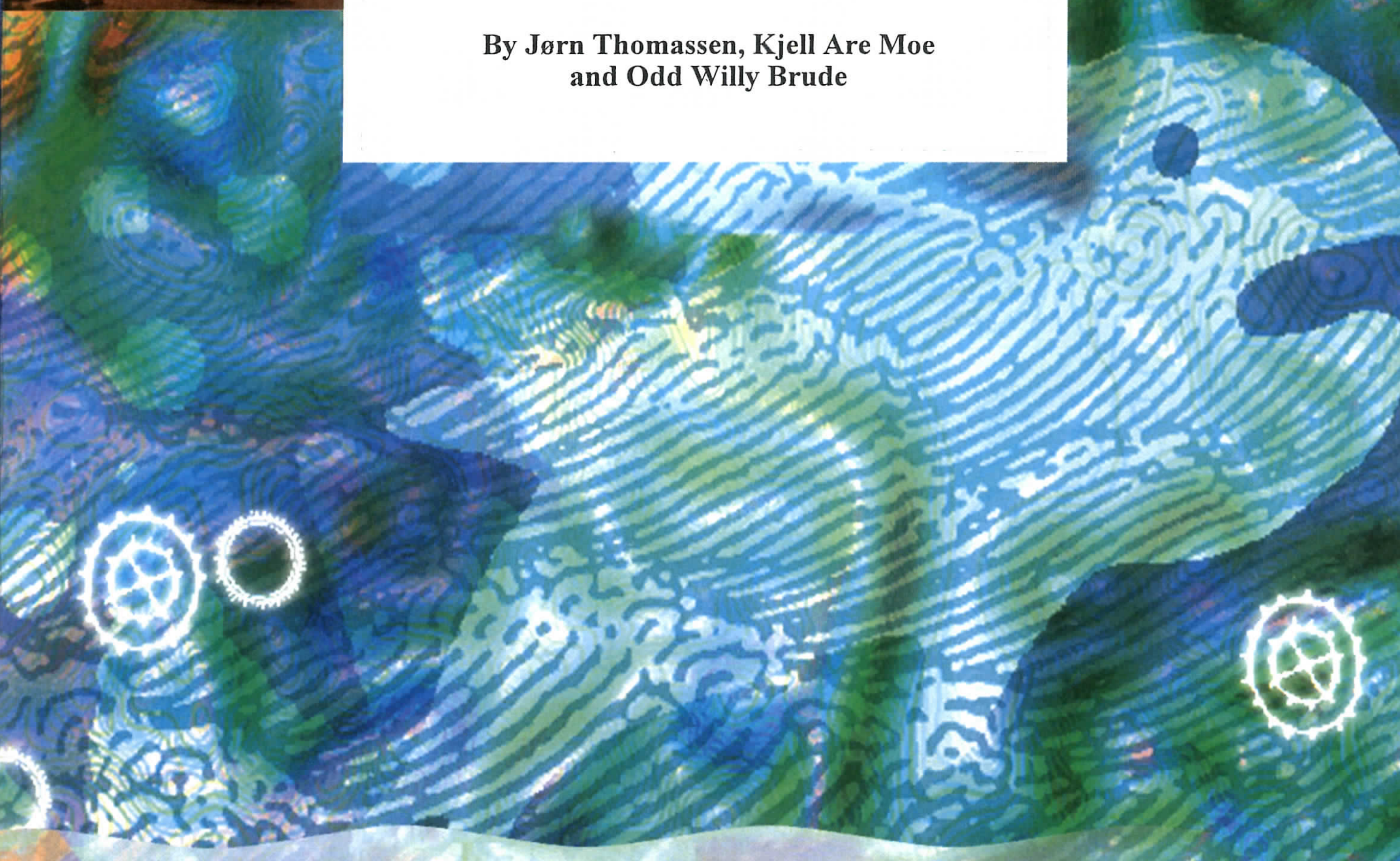


INSROP WORKING PAPER NO. 163 - 1999, II.5.10

INSROP – Environmental Impact Statement

By Jørn Thomassen, Kjell Are Moe and Odd Willy Brude



INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship & Ocean Foundation, Japan

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Sub-Programme II: Environmental Factors

Project II.5.10: Environmental Impact Assessment

Supervisor: Jørn Thomassen

Title: **INSROP – Environmental Impact Statement**

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

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

FOREWORD - INSROP WORKING PAPER

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

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

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

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

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Preface

An Environmental Impact Statement (EIS) is the most common term of the formal document coming out from an Environmental Impact Assessment (EIA). The objective of an EIS is normally to communicate the main significant results from the EIA to the decision makers. The approach and the content of an EIS document vary according to different legislation, norm and practice, but in general the main elements are a description of purpose and needs, of the alternatives, of the affected environment and of the environmental consequences.

The INSROP EIS will, however, be somewhat different than traditionally written EIS documents. *First*, there are no concrete development plans for how and when an extended use of the Northern Sea Route will occur. Several possibilities exist, from transportation of crude oil to dry cargo, as a plain transition route from east to west or vice versa, or as a transportation ore to and from harbours. Another decision to be made is when to operate along the NSR. In late autumn, winter and spring the NSR is characterised by severe ice conditions, and sailing implies huge challenges concerning navigation and avoidance of accidents. Further on, the NSR area covers a zone extending from latitude 60E to latitude 170W, from the Kara port to the Bering strait, and cannot be regarded traditionally as a specific single geographical location where concrete development plans exist. *Second*, a dramatic change of the budget situation for the environmental factors in INSROP phase II, made it impossible to carry out a full scale EIA.

Thus the objectives of INSROP EIA have been:

1. To build up a dynamic EIA - system that can handle different types of information and is flexible in use when new information is available or when plans or scenarios are altered.
2. By using this system, make a limited EIA for selected environmental components (Valued Ecosystem Components) for coarse scenarios in NSR, all based on present available information.

Consequently, the INSROP EIS is a concluding synthesis of these two objectives, with the main emphasis put on a limited EIA for selected environmental components. Social (except to some extent indigenous people), economical and related issues normally treated in an EIA have been defined as beyond the scope of INSROP EIA.

Several documents have already been prepared within INSROP Environmental factors, documents and work which form the fundament for this EIS. The synthesis of the vulnerability assessments with Potential Impact Levels and corresponding impact maps are especially prepared for the EIS, and are presented in section 4 in this document.

Trondheim 10. March 1999

Jørn Thomassen
supervisor

Table of contents

1. Executive summary

The INSROP Sub-programme II: Environmental Factors (1993-1998), has been aimed at the development of the foundation of environmental assessments with regard to NSR activity from the very beginning. Faced to the transitional state of Russian environmental management strategies during the 90's, a call for a flexible approach was early recognised. One-off solutions should be avoided – re-use of the findings should be emphasised. Consequently, the effort has been placed on two main components:

- A systemised base of information that characterises the environment in the which the activity occur, e.g. the baseline data in the Dynamic Environmental Atlas.
- Tailored methods and routines for damage analyses and a systematic process for implementation, e.g. a stepwise approach to selection of focal natural resources, identification of relevant Impact Factors of the activity, and indication of likely interactions by simple and robust assessments and analyses.

The integration of these two, in terms of the NSR *Environmental Assessment & Planning System* makes the INSROP Environmental Assessment complementary to basic elements in Strategic Environmental Assessment. The results of the study, the baseline of the temporal and spatial distribution of vulnerable natural resources, an integrated information system, and tailored methods for impact analyses, e.g. provide a basis for environmental considerations relevant to NSR activities in the short term and for strategic long-term assessments of future developments. The tool-kit are easily implemented for given case studies like assessments of sailing routes, oil spill risk and contingency planning etc., and reflect the call for transparency and stringency that is required to this kind of processes. If new findings deviate significantly from the initial assessment basis, either in terms of changes in baseline, vulnerability or environmental threats, the flexibility of the IT-system opens for on-line adjustment of any individual parameter. The adjusted data sets can subsequently form up-dated input to damage estimation, mitigating measures or monitoring strategies. The concept has been accepted among scientific communities in Russia and Norway and has proven to be in line with Russian regulations on Preliminary EIA.

The main components of the system were selected as cost-effective solutions to implement state-of-the-art computing technology. INSROP GIS is developed as an ArcView application for use on PCs running Microsoft Windows, while ArcInfo, running on UNIX workstation, is used to prepare some of the data sets for use by ArcView and to run analyses beyond the capabilities of ArcView on a PC. These products are widely used by the GIS community and provide the necessary IT-tools required to handle large volumes of environmental data and to develop sophisticated applications for a wide variety of analytical purposes. The selected software also provides a standardised system for linking textual, tabular and graphic information to digital maps, which facilitates export and import of georeferenced data in formats compatible with the major GIS on the commercial market.

The plans for offshore oil development reflect the introduction of new Impact Factors in the NSR, activities that provide chronic discharges to the sea and emissions to the air. In the North Sea, regular discharges from the offshore petroleum production has proven to affect the benthic communities as well as fish resources in the vicinity of the installations. In addition, this petroleum activities make significant contribution to an increasing risk of accidental oil spills.

The Arctic environment is currently exposed to contaminants and stress in a number of modes. In essence, it is the *cumulative effect*, e.g. the sum of the stress from every individual source that provides the overall impact and significance to the environment. This also include impact factors and loads not assessed in details in the INSROP EIA (cf. POPs, which are focal items of AMAP). The Arctic pollution is definitely of growing concern among authority bodies and the scientific community. Correspondingly, a trend of more frequent low level environmental deviations gradually reduces the common perception of the Arctic as a pristine environment. In this context increased development of the NSR forms additional factors that inevitably will contribute to the current load in some way or another:

- Physical disturbance are generated by shipping operations, dredging of harbours and land-based developments such as oil and gas production. The latter, in terms of pipeline construction and constructions, is known to cause habitat fragmentation and physical barriers, which indirectly affect the herd of reindeer by indigenous peoples.
- Releases of contaminants like radionuclides from nuclear waste, petroleum hydrocarbons from extraction and transportation of oil and gas, and persistent organic pollutants from power stations, mining industry and landfills, are considered among the most pronounced threats to the NSR environment. The marine, limnic and terrestrial environment are experienced to suffer significantly from such releases.
- Accidental oil spills may virtually provide the most serious impact. If this happens at the «wrong» place at the «wrong» time in the marine environment, at the ice edge, in polynyas etc. during the high production period,

the impact can be significant. The shallow waters are considered most sensitive to such pollution. These areas are important to organisms of all levels of the Arctic food web, and adverse effects may easily pass from one level to another and ultimately affect the entire ecosystem on a regional basis. The limnic and terrestrial environment has proven to be equally sensitive. The freshwater systems of the Arctic are poorly buffered and sensitive to pollution. If significantly affected, the impact may last for decades because of the slow recovery of this environment.

- Chronic, long term-low level pollution may affect all ecosystem levels within a given area. However, it is the low-dose – long term exposure that is the most serious threat to the environment. Arctic is no exception to this. In the marine environment the shallow waters of the harbours, ports and loading facilities is experienced to suffer the greatest impact. The relevance of offshore water organisms maintaining a state of chronic stress generated by regular, low-level oil discharges from shipping operations in the NSR, seems not likely. The limnic and terrestrial environment have shown to be subjected to many smaller spills and leakages of oil from land-based petroleum developments. Significant impact is currently widespread in western Siberia, and if the current development strategies are not changed dramatically, similar patterns can be foreseen in new development regions.
- Interaction between man-made noise and the environment may be temporal or chronical. Temporal noise is considered of less importance, unless it occurs on the «wrong» place at the «wrong» time (cf. bird cliffs, haul-out sites etc.. The exposure to chronic noise may result in habitat abandonment of higher trophic level organisms like birds and mammals, but habituation will occur. If habitats or home-ranges of vital importance are permanently lost, damage on population level is not unlikely.
- Accumulation of contaminants is facilitated by the many Arctic organisms' ability to withstand food shortage by storing energy in the form of body-fat when food is available. Consequently, the adverse effects of contaminants may be more severe in cold climate than in temperate regions. Ultimately, the bioaccumulation may reach the indigenous and local peoples if the natural resources within their main residence area and subsistence branches are affected. These, as well as other activities that may be harmful to the linkage between the environment and ethnicity should be assessed in details prior to project implementation. In this regard the information systemised in the Dynamic Environmental Atlas should be considered a reference source.

In general, environmental damage in the Arctic may last for longer periods than in temperate regions. The transfer of damage in the food web is facilitated. In any ways however, the damage is a function of the fate of the impact factor, resources at risk and their ecological attributes. Consequently, the vulnerability of the Arctic organisms varies from species to species and between time periods and geographical regions.

The current environmental status of the NSR environment is a function of the load from NSR activities in the past as well as other factors that in some way or another have had or still have a significant influence on the NSR environment. Some of these factors are located within Arctic, some are outside the Arctic. The basis for such comparisons however is vague. The resolution of the baseline data is in most cases inappropriate for identification of temporal and spatial trends in key biochemical parameters (e.g. contaminant levels, population trends etc.). The corresponding comparison of sources and their importance, in terms of weighting the load from NSR activities vs. other loads within as well as outside the Arctic, can not be measured quantitatively by scientific means.

With the exception of local terrestrial, river, harbour and port pollution, the dumping of nuclear waste from the icebreaker fleet, waste and wreck accumulation on shores etc., there is no scientific evidence that the pure civil shipping operations have proven significant stress to the NSR environment[1].

To address some vital questions raised by Østreng (1999), whether it is environmentally safe to increase the sailing dose for NSR, and if there are any temporal and spatial trends in vulnerability vs. activities, it is important to understand the inherent attributes of the environment and the NSR activities, in terms of the knowledge on the temporal and spatial distribution of the selected VECs, their ecological dynamics and vulnerability to the given species specific Impact Factors. From this, the following overall conclusions can be made (see Moe & Semanov (1999) for further details):

- Except for ports, harbours, ship yards etc., there is no historical evidence that navigation itself has proven significant impact on the marine environment. The same can be applied to NSR. Sailing on the NSR has been carried on for decades. Even if significant local contamination of ports and harbours, accumulation of waste and garbage on the shore etc., are documented, there is no evidence that the large scale trends of some declining ecosystem component populations have been caused directly by this sailing.
- Increased sailing frequency however, will inevitably increase the risk for ship accidents, and correspondingly increase the risk of accidental release of oil. Large scale oil spills can have deleterious impact on the marine

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[1] Military activities, both naval and land-based, can be considered a separate issue of environmental concern. It is said in independent reports (Nilsen & Bøhmer 1994) that the Soviet/Russian Northern Fleet has broken the country's own set of regulations for dumping radio-active waste and that correct information about the dumping has been blocked or interfered.

environment. The most vulnerable period is assumed to be during the most productive season, e.g. the late spring-summer, which also correspond to the most frequent sailing period. In this period vulnerable natural resources are spread all over the NSR area. On a spatial scale, particular attention should be placed on the protected areas[2]. The Lena reserve, recently expanded to include the New Siberian Island, is one such focal areas. to oil spill in the NSR (see Figure 5.8 for further information on protected areas).

However, from an environmental point of view, there is also an obvious link between the commercial shipping on the NSR, via the port, harbour and loading facilities, to land-based development of industry and infrastructure. These activities have shown to cause deleterious impact in regions of the limnic and the terrestrial environment of the Russian north, as in Arctic environment elsewhere. The plans for offshore oil development reflect the introduction of new Impact Factors in the NSR, activities that provide chronic discharges to the sea, emissions to the air as well as increase the risk for large scale oil spills.

The Arctic pollution is definitely of growing concern among authority bodies and the scientific community. Correspondingly, a trend of more frequent low level environmental deviations gradually reduces the common perception of the Arctic as a pristine environment. In this context increased development of the NSR forms additional factors that inevitably will contribute to the current load in some way or another.

[2] Please note that EPPR currently is implementing a project which aims to identify and rank areas of significant vulnerability to oil spill in the Arctic, also including the NSR area. The INSROP DEA will be a major source to this work and the results are planned published within 1999. When identified, the georeferenced areas and key attributes can be entered into the DEA as a basis for further analyses.

2. Purpose and needs

INSROP is multidisciplinary and multinational research programme organised by three co-operating partners: The Central Marine Research and Design Institute (CNIIMF) in St. Petersburg, The Ship and Ocean Foundation (SOF) in Tokyo and The Fridtjof Nansen Institute in Oslo. According to Østreng (1996) the purpose of INSROP is solely *«to build up a scientifically based knowledge foundation encompassing all relevant aspects concerning the Northern Sea Route problem complex, to enable public authorities and private interests to make rational decisions based upon scientific insight rather than upon mythology and insufficient knowledge».*

2.1 An EIS for the Northern Sea Route

The purpose of this INSROP Environmental Impact Statement (EIS) is to present the main overall potentially significant environmental impacts from ship traffic along the Northern Sea Route (NSR). Based on coarse scenario descriptions several impact factors are identified, ranging from main to detailed level. Several so-called Valued Ecosystem Components (VECs) have been identified, components to be in focus when assessing the potential impacts. Impact hypotheses have been formulated as a consequence of the impact factors on the VECs. Assessment systems have been developed to calculate Potential Impact Levels (PIL indices) which can be area and time specific.

2.2 Present use of the Northern Sea Route

Sailing along the NSR is not a new event or scenario. Most famous in historical time is perhaps the journey through the Northeast Passage with the vessel Vega in 1878-79, under the leadership of the Finnish-Swedish explorer and scientist A.E.Nordenskiöld, and the Fram expedition in 1893-96. The latter one, leaded by Fridtjof Nansen, sailed along the NSR, until the vessel was captured by the ice and started on a three year of ice drift journey across the north pole basin.

Today, Russian vessels carry out all general cargo transportation on the NSR (Ivanov *et al.* 1998b). 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. 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 improved. The increasing transportation of oil and lubricants probably represents the most significant threat to the environment (Moe & Semanov 1999).

2.3 An extended use of NSR

A pilot study was carried out prior to the initiating of INSROP (Wergeland 1993) with the aim of making an analysis of whether it would be profitable for independent shipowners to invest in ice-classed vessels for transit route through the NSR. When INSROP was established in 1993, the main scenario was transit sailing along NSR from east to west or vice versa. Later on also traffic to and from coastal harbours and to some extent on the rivers were included in the possible INSROP scenarios.

In default of concrete development plans for an extended use of NSR, the INSROP EIA identified main as well as specific activity parameters, which include sailing activities, harbour facilities and infrastructure on an operational and accidental level (see Thomassen *et al.* 1998, Moe & Semanov 1999). This identification was made to have a set of impact factors on different operational levels ready for use in concrete assessments. The impact factors identified are also the basis for the general and more specific assessments made in this EIS.

2.4 *Approach and methods*

In November 1993 Russian and Norwegian environmental experts first met on a screening and focusing workshop in Oslo. The most important agreements concerning the EIA process was to focus on a selected number of important issues and to use an adjusted form of the Adaptive Environmental Assessment and Management (AEAM) - concept (derived from Holling 1978) as the leading methodological approach in the EIA work. Another important decision was to use a Geographical Information System (GIS) in the storage and processing of the collected information. This enables us to have a dynamic system which easily can be updated and also have the flexibility for a multipurpose use. See Hansson *et al.* (1990) and Thomassen *et al.* (1996, 1998) respectively for an overview of the AEAM concept and the use of the method in INSROP.

In AEAM the impact predictions are derived from a procedure which includes the selection of VECs (Valued Ecosystem Components) that can be affected by the NSR activities. The methodology also identifies major linkages between different components in the system by preparing Schematic Flow Charts including impact factors, which again form the basis for the Impact Hypotheses (IHs). Key statements in every scientific work are the documentation of the process and the choices made. In the EIA process, it is important that the reasons for decisions are visible and transparent, particularly when it involves the rejection of proposed impact scenarios. More detailed information about this process can be found in recent INSROP publications (Bakken *et al.*1996, Larsen *et al.* 1995, 1996, Thomassen *et al.* 1996, Wiig *et al.* 1996).

2.4.1 INSROP preliminary scenarios

To be able to describe impact factors on the components given priority to, proposed and probable NSR activities were discussed (Thomassen *et al.* 1996). In the spatial dimension, transit routes between the Kara Port and the Bering Strait, sailing to and from harbours, and to some extent sailing up the large rivers Ob, Yenisei and Lena, were included in these scenarios. The most probable sailing season is in summer time (July - October), but sailing in the remaining months were also included. Due to the lack of concrete development plans for an extended use of NSR, combined with an uncertain political environment in Russia, the scenarios had to be of a coarse and general nature.

2.4.2 Impact factors

Five major impact factors were identified from the INSROP preliminary scenarios: *pollution, noise, waste, physical disturbance* and *change of development patterns* (initially named social and cultural factors) (see chapter 6 for further information). Notice that these impact factors have later in INSROP Phase II been partly changed and also given a higher resolution (Thomassen *et al.* 1998, Moe & Semanov 1999).

2.4.3 Valued Ecosystem Components (VECs)

A *Valued Ecosystem Component* is defined as *a resource or environmental feature that: is important (not only economically) to a local human population, or has a national or international profile, or if altered from its existing status, will be important for the evaluation of environmental impacts of industrial developments, and the focusing of administrative efforts* (Hansson *et al.* 1990).

The selection of VECs is probably the most important and at the same time the most difficult step in the process. The critical point is to focus upon decision making, and the VEC concept therefore should include social, political and economic qualities. Moreover, only a limited number of VECs can be used, which in turn calls for critical evaluation in the selection process. Table 2.1 lists the VECs given priority in INSROP.

Table 2.1. Valued Ecosystem Components identified in INSROP.

No	Valued Ecosystem Components	No	Valued Ecosystem Components	No	Valued Ecosystem Components
A1	VEC Benthic invertebrates	C1	VEC Polar bear	D1	VEC Human settlement
A2	VEC Marine estuaries and anadromous fish	C2	VEC Walrus	D2	VEC Water/land border zone
A3	VEC Plant and animal life in polynyas	C3	VEC Bearded seal	E1	VEC Protected areas
B1	VEC Seabirds	C4	VEC Ringed seal	F1	VEC Indigenous people
B2	VEC Marine wildfowl	C5	VEC White whale	G1	VEC Domestic reindeer
B3	VEC Waders in resting and feeding areas	C6	VEC Gray whale	G2	VEC Wild reindeer
C	Marine mammals	C7	VEC Bowhead whale		

2.4.4 Schematic Flow Charts

A *Schematic Flow Chart* is a diagram of boxes and arrows indicating in which context each of the VECs appears. It illustrates how a proposed activity may affect the VEC and how the impact may occur. Each linkage is explained in a brief text following the chart. Hansson *et al.* (1990) described the content of the flow chart to include the main categories of the physical, biological and possibly also social and political factors influencing the VEC, so-called *system components*, and impacts from the NSR activities, called *developments*. Figure 2.1 shows an example of a schematic flow chart for the VEC Domestic reindeer and VEC Wild reindeer.

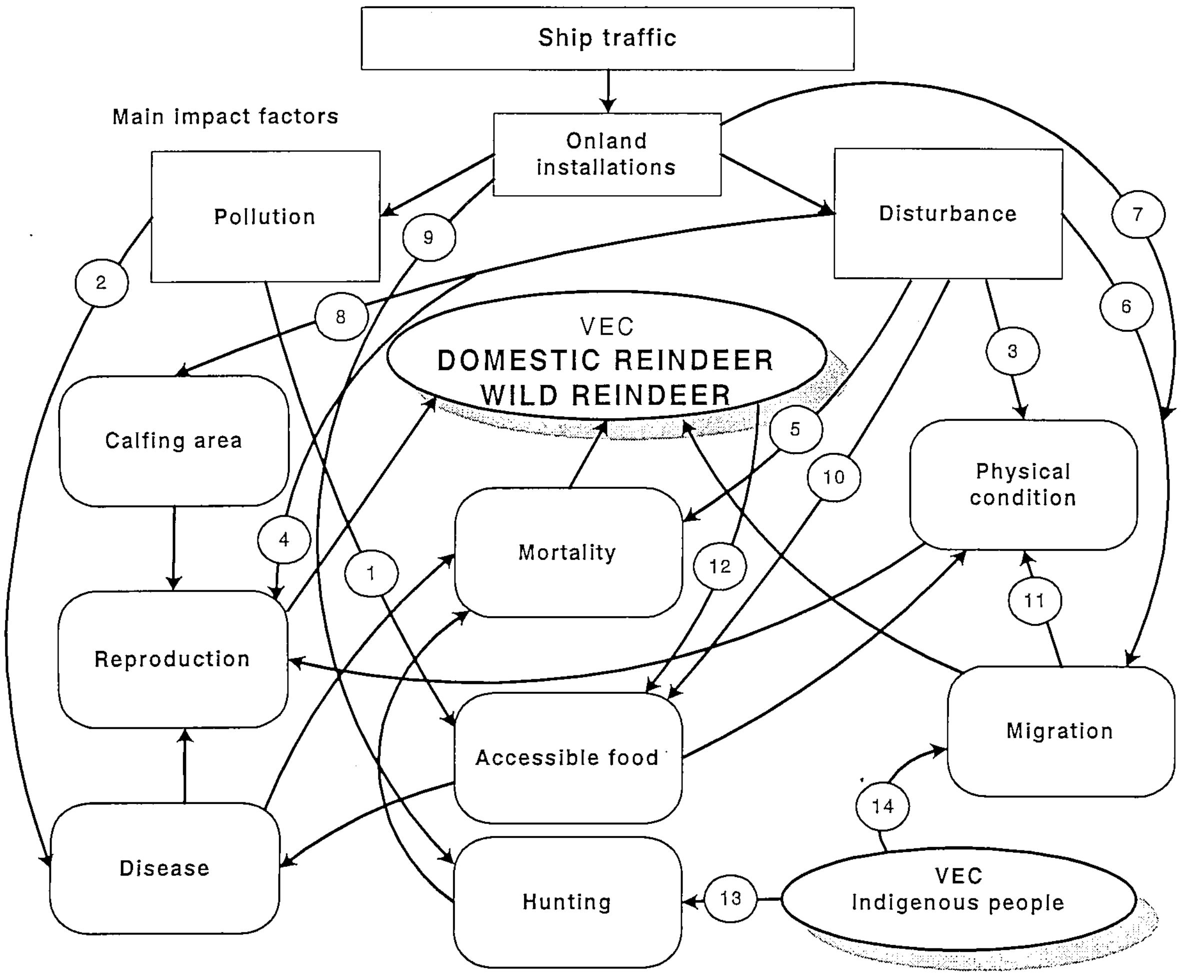

Figure 2.1. Schematic flow chart for VEC Domestic reindeer and VEC Wild reindeer (after Thomassen et al. 1999).

Linkages (self explanatory linkages are not described)

1. Pollution can affect the quality of grazing ranges
2. Direct uptake of toxic pollutants can cause diseases.
3. Disturbance will cause an increase in flight induced energy expenditures and accordingly impaired condition.
4. Disturbance can cause reduced reproduction because of abortions and resorptions.
5. Disturbance can directly cause increased mortality.
6. Disturbance results in migration.
7. Installations like pipeline corridors, roads, etc., can affect the migration pattern of reindeer.
8. Disturbance in calving habitats during the calving period can cause reduced calf survival, and in the long term, reduced use of the area.
9. Onland installations can lead to more human traffic with increased hunting.
10. Disturbance from traffic will influence the productivity of grazing rang by wear, erosion etc.
11. Migration requires energy and will impair the physical condition.
12. The grazing pressure will affect available vegetation.
13. Indigenous people hunt wild reindeer.
14. Indigenous people have effect on the migration of domestic reindeer.

2.4.5 Impact Hypotheses (IHs)

An *Impact Hypothesis* is a hypothesis for testing the possible impact arising from a given activity on the VEC. See Table 2.2 for an example of an impact hypothesis for the VECs Domestic and Wild reindeer. The impact hypothesis is illustrated by the schematic flow chart and should be explained and described preferably in scientific terms. The IH is also the basis for recommendations for research, investigations, monitoring and management actions, including mitigating measures.

Table 2.2. Example of a standard report and documentation form for the VEC Protected areas. One form has to be filled out for each IHs (after Thomassen et al. 1999).

VEC: DOMESTIC & WILD REINDEER	IH no.: G1-1/G2-1
Impact hypothesis: Disturbances and traffic will cause increased energy expenditure and reduced grazing time, and accordingly reduced survival and calf production in the affected local reindeer populations.	
Explanation: Traffic affects population distribution and accordingly vegetation availability. This is decisive to physical condition and mortality. Disturbances occurring in late winter cause a sharp increase in energy expenditure during period of negative energy balance. This will increase the danger of adult mortality and of females throwing their calves/aborting (Hansson *et al.* 1990).	
Category: C [)]	
Rationale: Investigations have shown that reindeer often run away from noisy traffic. It seems, however, that thy habituate easier to traffic in the areas that they stay for longer time than in migration areas. Reindeer that have not become habituated to traffic generally avoid areas of disturbance but can gradually become habituated to it and ignore it. Reindeer that are unhabituated to traffic/nice can react with flight/panic when disturbed, sometimes far from the source of disturbance.	
Recommended research: Data on such disturbance from northern Russia should be gathered and evaluated.	
Recommended monitoring and/or surveys: Distribution and numbers are surveyed in areas relevant for development/activity. The surveys should be differentiated according to physical condition, sex and age.	
Recommended management actions: Traffic and other human activities should be located in distance from reindeer migration areas and winter grazing ranges.	
Recommended mitigating measures:	
Literature cited: Hansson *et al.* (1990)	

[)] The impact hypotheses were evaluated according to the following categories:

A. *The hypothesis is assumed not to be valid.*
B. *The hypothesis is valid and already verified. Research to validate or invalidate the hypothesis is not required. Surveys, monitoring, and/or management measures can possibly be recommended.*
C. *The hypothesis is assumed to be valid. Research, monitoring or surveys is recommended to validate or invalidate the hypothesis. Mitigating measures can be recommended if the hypothesis is proved to be valid.*
D. *The hypothesis may be valid, but is not worth testing for professional, logistic, economic or ethical reasons, or because it is assumed to be of minor environmental influence only or of insignificant value for decision making.*

2.4.6 The assessment procedure

The assessment was completed in a sequential fashion where each step was referenced to the INSROP Geographical Information System. The steps were as follows:

1. Baseline data stored in the INSROP Dynamic Environmental Atlas (DEA) (see Brude *et al.* 1998), were combined with the user options concerning NSR activities in time and space (Figure 2.2).
2. Each impact hypothesis in category B or C were brought forward in the assessment system. Two assessment paths are possible: A semi-quantitative path, further developed from Anker-Nilssen (1987) and a qualitative path, developed for INSROP and described in detail by Thomassen *et al.* (1998). Figure 2.3 shows a schematic summary of the two paths.
3. The outcome from the assessment, so-called Potential Impact Level (PIL) indices (1=low; 2=medium; 3=high) give an indication of the potential consequences of the NSR activity options made for each VEC in a specific area (where possible) at a certain time of the year (where possible). Please note that some of the Potential Impact Level indices for operational scenarios are rather radical and could be the object for more critical assessments. We have in this context, however, used contributions concerning vulnerability assessments made by each of the VEC specialists in INSROP. In case of concrete activity plans and descriptions for sailing along NSR, new vulnerability assessments have to be done according to the new scenarios. See

Thomassen *et al.* (1998) for a description of the criteria used in the calculation of the PIL-indices. Chapter 4 in this EIS summarises the results of the impact assessments made for the INSROP EIA..

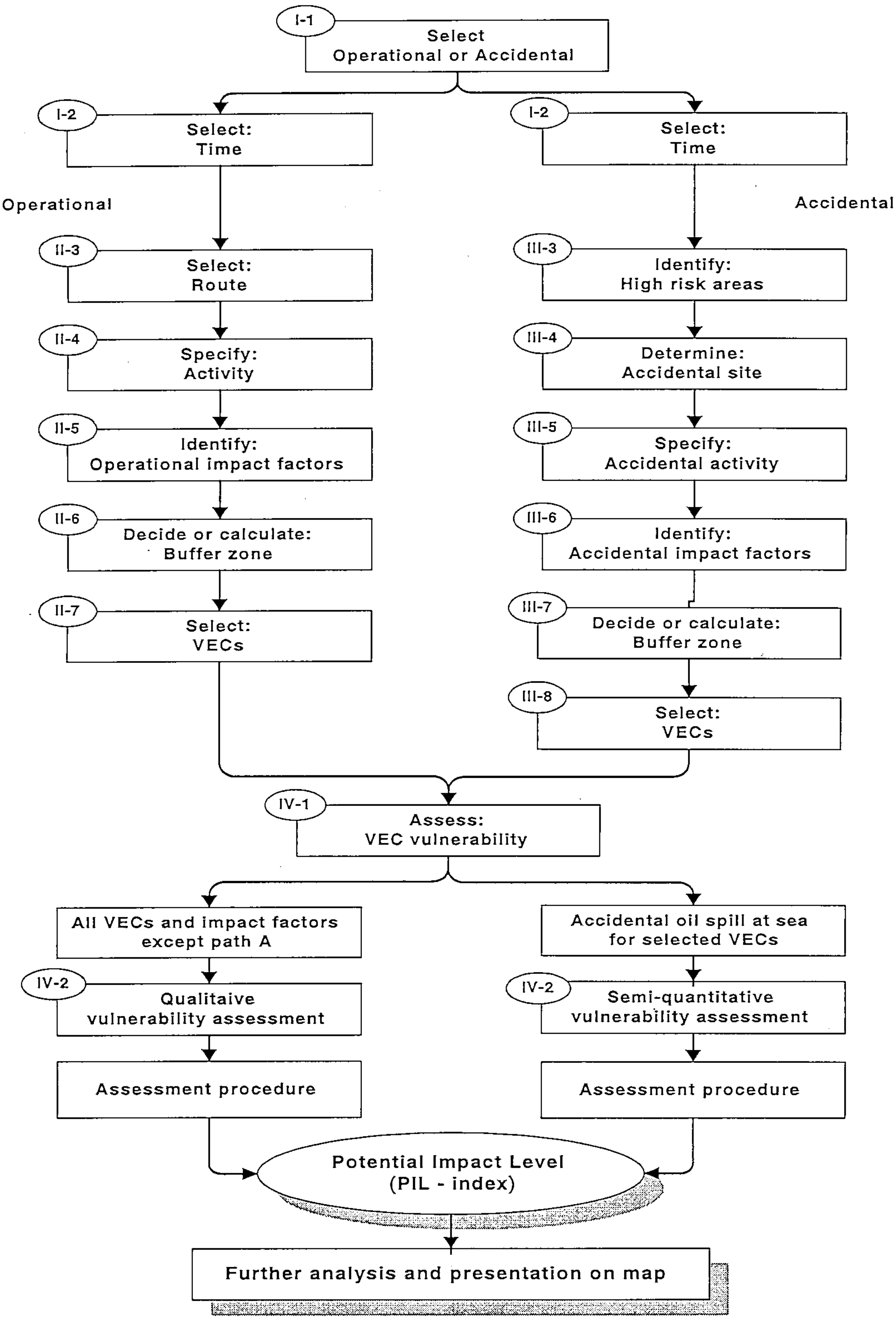

Figure 2.2. INSROP EIA Step by step procedure. Section I is common for operational and accidental activities. In Section II and III respectively operational and accidental activities are split, while section IV deals with vulnerability assessments for selected VECs (after Thomassen et al. 1998).

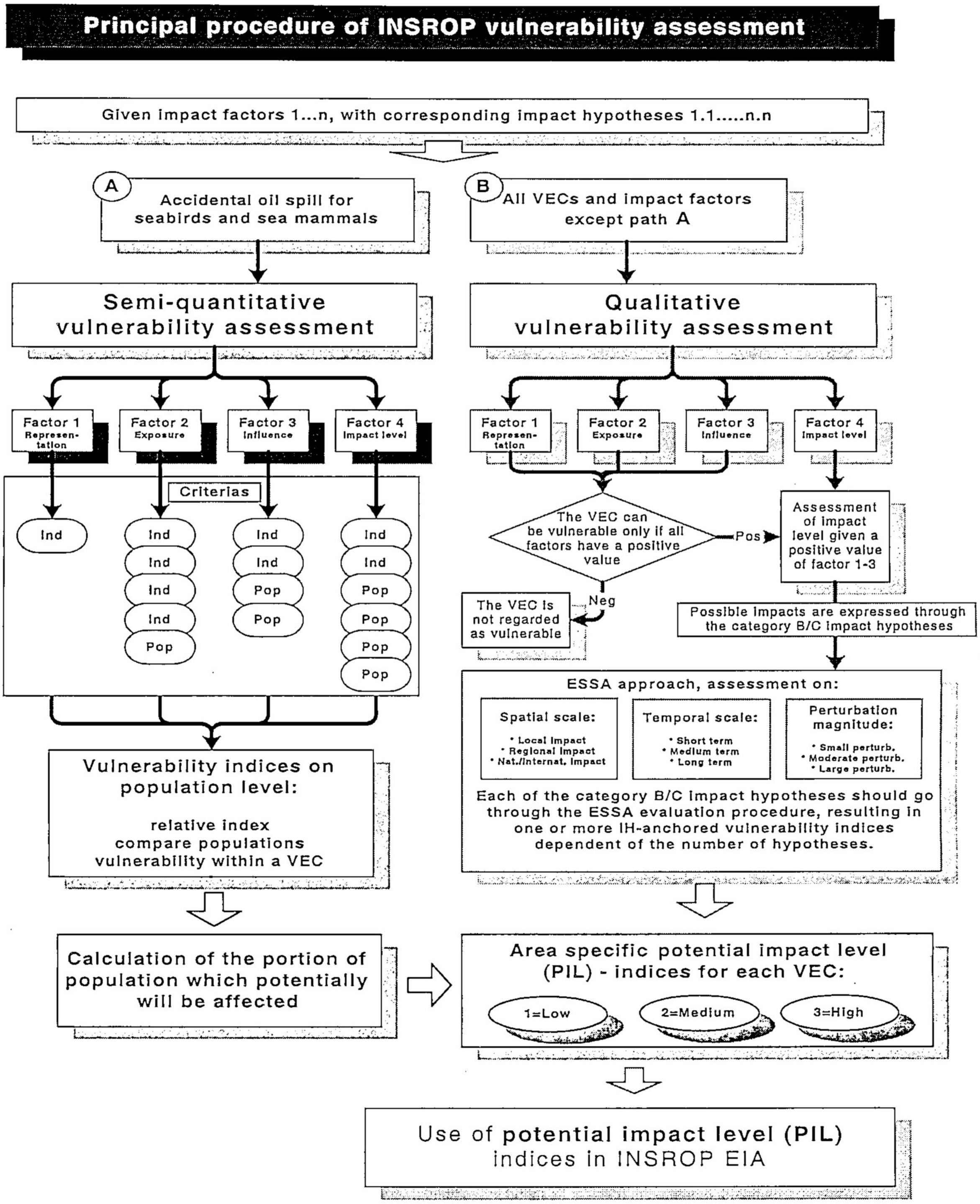

Figure 2.3. Principal procedures of INSROP EIA vulnerability assessment. Two paths (A or B) are possible: semi-quantitative or qualitative assessment (after Thomassen et al. 1998).

2.5 Baseline information

The baseline information in INSROP is of varying types and origin. The INSROP Dynamic Environmental Atlas (DEA) presents the spatial and temporal distribution and abundance of selected components (VECs) given priority due to their expected importance for decision making (Table 2.1).

The VEC information are stored and integrated in the INSROP Dynamic Environmental Atlas (Brude *et al.* 1998). To a large extent, these data have been data collected and systematised from a survey of existing Russian data sources (Gavrilo & Sirenko 1995). In addition, some new information have been collected through field sampling in special areas of the NSR. The database contains more than 4000 georeferenced individual registrations, and consist of the best available information, possible within the economical and financial frames of INSROP. The standard tabular information include attributes like species name, observation counts (mean, minimum and maximum number), location, observation time, trend, reference etc.

Other important information sources which will be of significant value in the assessment of impacts from NSR activities have been the recent international work concerning the Conservation of Arctic Flora and Fauna (CAFF) and the Arctic Monitoring and Assessment Programme (AMAP) organised under the Arctic Environmental Protection Strategy (AEPS) umbrella.

It is however important to notice that the content of INSROP DEA is incomplete to fill the recent requirements in the Russian EIA legislation. Within the time and economical frames of INSROP the reason for this is obvious. The NSR area covers a zone extending from latitude 60E to latitude 170W, from the Kara port to the Bering strait, and extensive field work was defined beyond the scope of Sub-Programme II, as was for example socio-economic analysis and the cost compensation component required in the Russian EIA legislation. The INSROP DEA is a dynamic system which easily can be upgraded to fill the Russian needs, given sufficient economical and time frames.

3. Affected environment

Moe & Semanov (1999) made a summary of the main features with the biophysical environment along the NSR. A synthesis of their work is presented below.

Focus is placed on the environment as habitat for the selected VECs, and biophysical characteristics of importance to possible interactions between the VECs and relevant NSR activities are briefly outlined. Special attention is paid to the concept and role of the DEA.

3.1 Marine environment; ice, water masses & circulation

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

The Arctic Ocean comprises the deep central basins as well as the marginal seas; Chukchi-, East Siberian-, Laptev-, Kara-, Barents- and Beaufort Sea, a total area of 14 million km^2. 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. 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 but contains only 2% of the total volume of water of the Arctic Ocean (Pickard 1975).

Except for the river outlets and estuaries, the surface layer is much the same across the whole Arctic Ocean. 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 seasonally cycling of the Polar Mixed Layer (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 during spring and summer that most of the biological primary production occur.

The surface layer movement is best described as a clockwise circulation (the Beaufort Gyre) in the Canadian Basin, 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.

3.2 Terrestrial environment

The topography of the northern Russia is relative uniform, forming a wide shallow shelf and low relief shoreline landscape. This large-scale character dominates the in-land environment as well, which is made-up of enormous steppe-like tundra and forested areas, e.g. the taiga.

The many large rivers, their main course and a vast number of tributaries, split the landscape monotony, and create large estuaries and deltas at the coast. The contribution by the Russian rivers are more than two thirds of the estimated total of 3,300 km^3 fresh water that enters the Arctic Ocean annually from its major surrounding rivers (Aagaard & Carmack 1989). The large rivers are also carriers of a significant volume of suspended organic and inorganic matter, which partly settles within river outlets, and partly is transported into the Arctic basins. In both cases, the sediment flux is one of the factors controlling the pathway of river-borne contaminants.

The permafrost is a factor that most strongly determines the landscape character of the north. In northern Siberia the ground is frozen up to a depth of 1,600 meters. During summer, all melts in about one meter depth, which creates a poorly drained, often marshy landscape. This upper meter corresponds to the biological active surface layer of the tundra.

3.3 *Fate of pollution*

In comparison with most other areas of the world, the Arctic remains a clean environment (AMAP 1997). Corresponding conclusions were made by the ACOPS fifth meeting in 1996; the seas of the NSR were considered among the clean seas of the world. Results from large-scale research and monitoring programmes like AMAP, ANWAP etc. however, including the steadily growing number of reviews of the sources, transport and effects of contaminants in the Arctic, reflect that the current understanding of pollution issues, their fate and significance, is fragmentary and far from complete. In many cases, like for the Russian shelves, the baseline data is simply not adequate for evaluation of the environmental status or the task of assessing what action is needed.

3.4 *Some Ecological Characteristics*

The main factors controlling life in the Arctic are low temperatures and extreme annual variation in sunlight, with up to three month of darkness during winter, an equivalent amount of continuous sunlight during summer. The highly variable environmental conditions between seasons and years are reflected by corresponding temporal and spatial fluctuations in the biological production and energy consumption at almost all levels of the ecosystem.

The uniformity of the Arctic provides only a limited range of biological niches, and the number of plant and animal species adapted to this environment is accordingly low. The chosen few however, often prospering from lack of interspecies competition, form large populations of invertebrates, saltwater and anadromous fish, seabirds and waterfowl, and mammals.

Three main life strategies for Arctic animals are recognised; those who remains active in the Arctic all year round, those who remain in the Arctic all year, but are only active during the summer, and those who stay in the Arctic only during the summer (Hansen *et al.* 1996). The first group includes most of the larger terrestrial mammals and some birds. These animals are generally well insulated with fur and feathers, and body fat or blubber. The permanent residents also include the marine benthic invertebrates and fish. The second group includes some pelagic, marine invertebrates, terrestrial invertebrates, reptiles and amphibians, and some mammals. During the winter the fauna may develop into a resting stage (e.g. diapause), they are physically adapted to tolerate severe reductions in body temperature, or the animals hibernate. The third group includes most birds and sea mammals. Arctic endemic species, e.g. species confined to the Arctic, are found among the two first groups.

3.4.1 Marine ecosystems

Polar marine ecosystems are, as many other marine systems, mainly based on pelagic unicellular algae (phytoplankton) as the primary producers in the food web. Primary producers are found among all the three more or less distinct systems; the pelagic ecosystem, the ecosystem at the ice, and the benthic ecosystem also including the shoreline communities. The plankton algae however contribute more than 97% of the total primary production (Sakshaug & Skjoldal 1989).

The growth of the plankton algae (e.g. the plankton bloom) is controlled by the light regime and the stratification of the water masses in terms of nutrient abundance and availability, and is closely connected to the ice-edge retreats during spring (c.f. the ice-edge effect). Thus a bloom will trail the ice-edge and sweep across the area of seasonal ice cover.

The phytoplankton is grazed upon by zooplankton, which represents the trophic level next to the primary producers. Copepods are the predominant zooplankters in terms of biomass in the Arctic seas, and their growth peaks some weeks later and last for longer periods than the plankton bloom (cf. match-mismatch strategies). The polar cod is a true representative of the third trophic level of the food web. The species is the main prey for many marine mammals, and is probably the most important «transmitter» of energy from the plankton to the top trophic level vertebrates at the ice (Sakshaug *et al.* 1992). A simplified scheme of the Arctic marine food web is outlined in Figure 3.1.

The flux of energy from the primary producers to the higher trophic levels of zooplankton, fish-birds and birds-mammals, is the main forcing function of marine ecosystems. The transmission pattern however is not quite efficient, most of the energy is spent on sustaining life at each trophic level. Except for the ratio between phyto- and zooplankton, 80-95% of the energy is lost at each trophic level, corresponding to a remaining 0.01-0.8% of the primary production at the forth level of birds-mammals (Sakshaug *et al.* 1992).

The ecosystem dynamics outlined in Figure 3.1 also reflect a scheme of how an impact factor upon an VEC might pass through, and be dissipated by, its hierarchical organisation. The impact factor does not necessarily interact with the population itself, but by the positive or negative influence on the fluxes controlling the rise and fall of the VEC. In terms of oil pollution, which reduce growth and increase mortality, a corresponding decline in the VEC population is evident. The loss of energy at one trophic level reduces the energy available at the higher trophic levels, and ultimately, the entire ecosystem may be adversely affected.

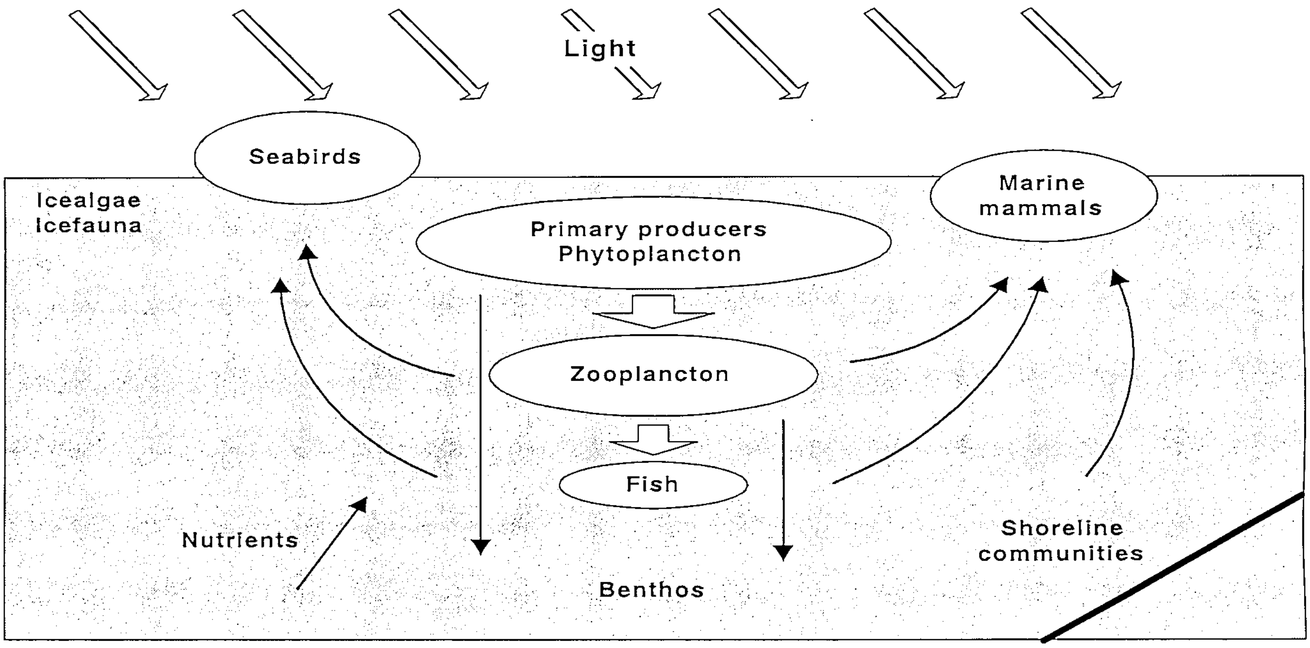

Figure 3.1. A simplified scheme of the Arctic marine food web. The arrows indicate the energy fluxes. (Redrawn after Moe & Semanov 1999).

3.4.2 Terrestrial ecosystems

The Russian Arctic mainland is characterised by large unfragmented and relative intact habitats for the flora and fauna. Given the measure of «absence of large physical human structures», this area represents one of the largest remaining wildernesses in the world (CAFF1996a).

The tundra is a treeless, frozen land where primitive plants such as lichens and moss are the predominate vegetation. Due to the low temperatures and permafrost, the tundra is characterised by low microbial activity and an invertebrate soil fauna which is inactive for many months of the year. Consequently, the organic matter is slowly decomposed in tundra areas, resulting in low primary production, slow plant growth and low biomass per unit area.

Despite the low vegetation productivity, about five million wild and domesticated reindeer live in the Arctic (Hansen *et al.* 1996). The reindeer breeding is the fundamental land use of most of the Northern Indigenous peoples and the most prominent cultural basis (Dallmann 1997).

The taiga forests of Russia are uncomprehendingly enormous, covering the vast majority of Siberia. The plant and animal species composition is relative uniform. Spruce, pine and larch are the predominant tree species within these forests, which also represents a natural resource of significant economical importance.

The smaller lakes and rivers in the Arctic are generally not very productive, partly because of the low nutrient levels in such freshwater, and partly because they are ice-free for only a short period during summer. Such Arctic freshwater systems are poorly buffered and therefore not well able to withstand acidifying pollutants. The small lakes are considered to be among those terrestrial Arctic systems that are most vulnerable to oil (Atlas 1985).

In the larger rivers, the nutrient level is much higher and their production potential is significant. The large volumes of suspended sediments, including organic particulate (humic) matter, and corresponding unstable substrate, makes these rivers less favourable habitats for the freshwater primary and secondary producers. Production peaks are reached in inundated river areas, e.g. the areas flooded during the summer rise of the rivers. All freshwater systems however stand out as relative species-rich oasis and dispersal pathways in the otherwise fairly species-poor taiga, tundra or mountain ecosystems.

3.5 Vulnerability

The organisms and ecosystems of the Arctic are not necessarily more vulnerable than those of other regions. The adaptations render them robust and resilient to natural disturbances and harsh climatic conditions. Their vulnerability lies primarily in that several of the very adaptations, which function successfully in their natural environment, at the same time leave Arctic organisms particularly sensitive to certain human impacts (Hansen *et al.* 1996). The biophysical conditions of the Arctic environment can cause the effects of such impacts to be more long-lasting and complex than at lower latitudes. Some examples on specific attributes of Arctic species and ecosystem with regard to vulnerability, modified after Dunbar (1985), Muir *et al.* (1992), Sakshaug *et al.* (1993), Hansen *et al.* (1996), AMAP (1997), are outlined in the following.

- *Erosion.* Disturbance of the biological active surface layer covering the frozen ground can precipitate dramatic meeting of the underlying ice and result in significant acceleration of the natural erosion.

- *Slow biological processes* lead to slow revegetation of areas where vegetation has been damaged or removed. The slow biological process also affects the flux of organic matter, including organic pollutants. The degradation of petroleum hydrocarbons that are spilled in the cold climate environment may last for decades.

- *Population and ecosystem dynamics* are characterised by *inter alia* lack of competitive mechanisms and simple food webs. The typical Arctic species, where individuals live long and reproduce many times but produce only a few young each time, can sustain several years with high offspring mortality. In these species, the adult individuals, and sometimes in particular the females, constitute the «backbone» of the population, being especially vulnerable. The smaller the population, the more vulnerable it is to increased adult mortality.

As winter survival of Arctic animals is often dependent on their ability to store energy (fat) reserves, the summer and fall feeding activity period is vulnerable to disturbances.

A significant reduction in the population size of key species, transferring energy to animals higher in the food chain, either in case of food shortage, over-exploitation, pollution, or disruptions in their migration patterns, can have serious consequences for species higher in the food chain, as well as for the entire ecosystem.

- *Aggregation.* When large portions of total populations are gathered in small areas, typical for many Arctic species, a single encroachment, such as an acute discharge of pollutants or disturbance, can result in extensive and long-lasting impacts on the entire population. Natural resources in high concentrations are also easily exploitable and attract industrial and economic interests. These growing interests, and the increasingly efficient harvesting technology, make many Arctic species vulnerable to over-exploitation.

- *The habitat and home-range quality* are of crucial importance to many Arctic species, and especially mammals need large, undisturbed territories to meet demands for food, breeding and shelter. Fragmentation of such territories by roads, pipelines or other human activities may alter or block animal movement patterns and disrupt their optimal use of the area. Such disturbances can alter population structures of key Arctic species as well as overall ecosystem dynamics.

- *Accumulation of environmental contaminants* in the food chain all the way up to top predators (raptors, gulls, polar bears, seals, etc.). During lean periods, these higher animals metabolise their stored fat and the contaminants are released into the body.

Ultimately, the accumulation of contaminants may reach the indigenous and local peoples if the natural resources within their main residence area and subsistence branches are affected. AMAP (1997, 1998) has shown that some people in native communities in Canada and on Greenland ingested high levels of the environmental contaminant PCB in their diet of marine mammal lipids.

4. Consequences for the Valued Ecosystem Components

This chapter deals with the assessed impacts from potential NSR activities on the VECs. For the overall synthesis of environmental consequences and recommendations, please refer to chapter 5 and 6. Please note that most of the assessments are based on the qualitative assessment approach. The documentation of the semi-quantitative assessments can be found in Gavrilo *et al.* (1998a). It is also important to note that some of the Potential Impact Level indices for operational scenarios are rather radical, and could be the object for more critical assessments. We have in this context, however, used the contributions concerning vulnerability assessments made by each of the VEC specialists in INSROP. In case of concrete activity plans and descriptions for sailing along NSR, new vulnerability assessments have to be done according to the new scenarios.

The potential NSR activities are the source of different impact factors. When these impact factors meet the resource distribution in time and space, we have the basis for assessing potential impacts or consequences from the NSR activities on the resources in the area. It is convenient in the assessment procedure to operate with seven distinct NSR sub-areas, namely the Kara Sea, the Laptev Sea, the East Siberian Sea, the Chukchi Sea, and the rivers Ob, Yenisei and Lena. In many instances however, the geographical nature of the baseline data is too coarse to have this resolution. The assessments are monthly based when the time resolution allows.

We made a distinction between normal operational traffic along NSR (chapter 4.1 and 4.2) and accidental events (chapter 4.3). Except for some assessed positive effects for indigenous people (chapter 4.2), only activities (with impact factors and impact hypotheses) assessed to give a high potential impact level (PIL index = 3) are dealt with. For selected cases impact maps are shown. The assessments and the discussions made in this chapter are made by the scientists responsible for the VEC impact and vulnerability assessments carried out in INSROP EIA.

4.1 Operational traffic - High potential impact level (PIL index = 3)

The detailed assessments concerning operational traffic for all impact hypotheses resulting in PIL indices 1, 2 and 3 are found in the *standard report forms* in Appendix 2. In this section assessments ending up with high potential impact levels are treated. Table 4.1 summarises the impact hypotheses in this category. Following the Table, each VEC with their respective IHs are treated separately starting with the VEC A1 Benthic invertebrates (see Table 2.1).

Table 4.1. A summary of impact hypotheses for operational traffic along NSR, assessed to give a high potential impact level (PIL index = 3). Area: All Seas = Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea; All NSR = All Sea + Ob, Yenisei and Lena.

Impact factor	Impact hypotheses (IH)	VEC	Area	Time of year
Discharges to sea: chemicals	B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Marine wildfowl *(Chapter 4.1.3)*	All Sea	May-October
	B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	Waders in resting and feeding areas *(Chapter 4.1.4)*	All Sea	August-October
Discharges to sea: minerals	B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Marine wildfowl *(Chapter 4.1.3)*	All Sea	April-October
	B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	Waders in resting and feeding areas *(Chapter 4.1.4)*	All Sea	August-October

General discharges to sea	C-1: *For all marine mammals:* Accidental and operational releases of hydrocarbons and radioactive material to ice, sea and shore can be accumulated through the food chain and reach such high concentrations in marine mammals as to have toxic effects.	Marine mammals; exemplified by Polar bear *(Chapter 4.1.5)*	All Sea	All year
Releases to Sea: Anti fouling agents (TBT)	A1-5: Releases/discharges of anti-fouling paint, like TBT, will affect reproduction in benthic invertebrates.	Benthic invertebrates *(Chapter 4.1.1)*	All Sea	All year
Discharges to land, rivers and lakes (toxic spills, undifferentiated)	F1-9: The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to toxic spills that may destroy spawning areas and fishing grounds.	Indigenous people *(Chapter 4.1.10)*	All NSR	All year
Emissions to air (SO_2 etc.)	F1-11: The NSR will favour industry development leading to SO_2 and other air pollution which will degrade or destroy subsistence areas.	Indigenous people *(Chapter 4.1.10)*	All NSR	All year
Noise and physical disturbance.	C1-4:Traffic in or near denning areas will cause reduced reproduction in the polar bear population.	Polar bear *(Chapter 4.1.5)*	All Sea	October-June
	C2-1: Disturbances resulting from traffic and installations will reduce the walrus population.	Walrus *(Chapter 4.1.6)*	Chukchi Sea	June-September
	C6-2: Disturbance (traffic, ice breaking) will result in a reduction in the local gray whale populations.	Gray whale *(Chapter 4.1.7)*	Chukchi Sea	May-October
	C7-2: Disturbance (traffic, ice breaking) will result in a reduction in the local bowhead whale populations.	Bowhead whale *(Chapter 4.1.8)*	Chukchi Sea	May-October
Physical disturbance: ice breaking, active installations, pipelines, roads	F1-1: Boat traffic on frozen rivers disturbs migration of wild reindeer (and other wildlife) and affects the effectiveness of hunt as a major subsidence.	Indigenous people *(Chapter 4.1.10)*	Yenisei	October-June
	F1-8: Oil/gas pipelines connecting hydrocarbon fields with northern harbours may lead to area segmentation as a hinder for wildlife migration and a general decrease of wildlife resources.	Indigenous people *(Chapter 4.1.10)*	All NSR	All year
	G1-2 & G2-2: Physical encroachment and installations will obstruct the movements of reindeer, may hinder their access to grazing and calving areas and increase their energy needs so that local populations may decrease	Domestic reindeer Wild reindeer *(Chapter 4.1.11)*	All NSR (terrestrial)	All year
Physical disturbance (land devastation, aerial occupation)	F1-7: The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to land disruption and loss of hunting, fishing and breeding grounds.	Indigenous people *(Chapter 4.1.10)*	All NSR	All year
Petroleum development onshore and offshore, and other industrial development	E1-8: Increased industrial development, with constructions of pipelines and transportation systems will disturb selected VECs in the terrestrial, aquatic and marine environment by making barriers and disturbance.	Protected areas *(Chapter 4.1.9)*	All NSR	All year
Rural development including tourism	E1-10: Increased use of NSR will lead to increased population, tourism, hunting and fishing in protected areas, which will be a threat to selected VECs in special and to biological diversity in general.	Protected areas *(Chapter 4.1.9)*	All NSR	All year
	F1-12: With an increased infrastructure, commercial fishing and hunting tourism may take subsistence areas from indigenous population.	Indigenous people *(Chapter 4.1.10)*	All NSR	All year
Hunting	B1-4: Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	Seabirds *(Chapter 4.1.2)*	All Sea	All year

	B2-6: Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	Marine wildfowl *(Chapter 4.1.3)*	All Sea	April-October
Alien cultural impacts	F1-13: Increased infrastructure, through consequent alien settlement and industrialisation, will forward cultural decay among indigenous people.	Indigenous people *(Chapter 4.1.10*	All NSR	All year
Crime	F1-14: Increased infrastructure, alien settlement and industrialisation will lead to an increase of criminal acts against the indigenous population, and partly against their resource base and their means to use the resources (e.g. reindeer theft, robbery, threat).	Indigenous people *(Chapter 4.1.10*	All NSR	All year
Alien commercial interests	F1-15: With increased accessibility and transport facilities, commercial fisheries and hunters may completely deplete the resource basis for indigenous subsidence.	Indigenous people *(Chapter 4.1.10*	All NSR	All year
Nature protection interests	F1-16a: With an increased infrastructure, increased protection interests may lead to the closure of certain areas for indigenous subsidence.	Indigenous people *(Chapter 4.1.10*	All NSR	All year

4.1.1 VEC Benthic invertebrates

Impact factor: Releases to Sea: anti fouling agents (TBT).

Impact hypothesis:	**Rationale for this assessment:**
A1-5: Releases of anti fouling paint like TBT will affect reproduction in benthic invertebrates.	Anti fouling agents (TBT) have recently been proven to cause abnormal sexual development in some snails (imposex, females changing partly into males) (Short *et al.* 1989, Oberdoerster *et al.* 1998). The sensitivity of arctic invertebrate species towards the same type of influence has not been studied, but it is likely that the same types of effect can occur in the NSR area.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
TBT is reported as the most toxic substance deliberately introduced to natural waters (AMAP 1998, quoting Goldberg 1986). Chronic effects are recorded in invertebrates at concentrations of 1 µg/l, and sub lethal effects have been recorded in sensitive species like snails of the genus *Nucella* at a few ng/l. Most prominent effect is development of male gonads in females, making them sterile. This imposex is a world wide problem, and it is strongly correlated with boat traffic and shipping activity (Ellis & Pattisina 1990.). The sensitivity of arctic invertebrate species to TBT is poorly documented, but it is unlikely that arctic species should be less sensitive compared to temperate species. Due to ice scouring, release of TBT during winter navigation is considered to be higher compared to ice free areas, thus increasing the risk of exposure of invertebrates. Direct effects of exposure from TBT in water or sediment are thus considered the most significant impact on the VEC benthic invertebrates.

Indirect effects and their significance:
Indirect effects might occur at higher trophic levels if reproductive disturbance reduces the number of available, large size mollusc prey. This might affect e.g. walrus. Bioaccumulation of the lipophilic TBT is another possible indirect effect on the ecosystem. However, TBT is moderately lipophilic, and has a moderate bioaccumulation factor of 10^3 -10^4. It is at the same time metabolised by vertebrates and invertebrates, which leads to reduced body burden. So far there are no indications that indirect effects of TBT on other invertebrate groups are as prominent a feature as the direct effects on mollusc reproduction.

Cumulative effects and their significance:
With the Arctic being a relatively pristine and uncontaminated area with respect to TBT, very little information exist on probable, cumulative effects of TBT and other impact factors on marine invertebrates.

Conclusions VEC Benthic invertebrates:
The present knowledge leaves little doubt that sensitive species of the large and heterogeneous VEC «benthic invertebrates» are at risk of being significantly affected by the continuos release of TBT from anti fouling paints. The extent and the ecological significance is however difficult to quantify. However, the impact of TBT on invertebrates is very unlikely surpassed by any other operational discharge, emission or release form operational ships traffic in the NSR.

Recommendations VEC Benthic invertebrates:

☛ A basic recommendation will be to restrict the use of TBT containing anti fouling paint on ships trafficking NSR, or even to demand of NSR shipping either no use of TBT or full compliance with IMO standards (if the latter will achieve the same end result). This might be possible, as marine growth on ships hulls generally is low in arctic waters, as such growth is scraped off by ice. However, NSR going ships will sail in low latitude areas for large parts of the year, and thus need the anti fouling treatment.

☛ For monitoring purposes, TBT was not particularly addressed by the AMAP programme. But for the second stage of AMAP, an expert group states: «Due to the paucity of data regarding TBT along the Siberian coast and due to the strong correlation between shipping activity and TBT, it is recommended that the Northern Sea Route be designated as an area of special interest for TBT.» (Svavarsson *et al.* 1998). The monitoring of TBT is now a component of AMAP Phase II Implementation Plan.

4.1.2 VEC Seabirds

Impact factor: Hunting

Impact hypothesis:	**Rationale for this assessment:**
B1-4: Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	Hunting is an old tradition in Russia. Especially with establishment of new settlements along the NSR route, it is possible that the hunting pressure on seabirds will increase, including egg harvesting.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Hunting and egg harvesting will influence directly on the survival and breeding success. The effect on the population will mainly depend on which age groups of birds which are hunted. In general, hunting for adult birds will have a more serious effect to the population than hunting for the juvenile birds.

Indirect effects and their significance:
Hunting and egg harvesting will also disturb the birds. Possible effects may be that birds are scared away from their traditional areas and access to important feeding areas may be limited. Egg harvesting may lead to disturbance in the breeding colonies which may lead to reduced breeding success.

Cumulative effects and their significance:
Hunting and increased traffic in the vicinity of settlements may have significant negative effects locally to the seabird populations.

Conclusions VEC Seabirds:
Hunting may have a significant negative effect in the vicinity of settlements. Russia has quite strict regulations for hunting and egg harvesting, but by experience it is known that a lot of illegal hunting is occurring.

Recommendations VEC Seabirds:

☛ With establishments of new settlements information about hunting regulations should be given. In addition, inspections of the hunting activities should be initiated. The hunting regulations and information about the wildlife should also be distributed to all ships in the NSR area.

4.1.3 VEC Marine wildfowl

Impact factor: Discharges to sea: chemicals

Impact hypothesis:	**Rationale for this assessment:**
B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Many marine ducks live mainly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Toxic substances may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
This impact factor has mainly indirect effects.

Indirect effects and their significance:
Marine ducks mainly feeds on benthos organisms, primarily molluscs. Toxic components from oil spills and other discharge can be accumulated in and/or kill benthos. Especially molluscs readily absorb and accumulate toxic compounds that they are exposed to (Neff *et al.* 1987, Clark 1992). The female eiders are particularly dependent upon a good food supply before the onset of the breeding season. They then accumulate a layer of body fat to manage throughout the incubation period, when they do not feed. If the availability of prey organisms in an area is reduced due to pollution, the females may not be able to accumulate sufficient fat reserves. They will then either not attempt to breed at all, interrupt the breeding before hatching, and/or their physical condition may be so impaired that the mortality rate is increased.

If toxic substances are accumulated in the ducks' prey organisms, these substances may reach high concentrations in the ducks' body tissues or organs, possibly with resulting impaired physical condition, disease and death. After hatching, the females and the chicks mainly feed on crustaceans in the littoral zone. Correspondingly, if these animals accumulate or are killed by toxic substances (such as oil components or dispersants), marine ducks may suffer reduced reproduction and increased mortality. From accidental events it is reported that exposure to oil by ingestion of contaminated food probably was the cause for the massive reproductive failure in Harlequin Ducks that was observed to prevail several years after the *Exxon Valdez* accident in Alaska (Patten 1993).

Cumulative effects and their significance:
Lack of food combined with possible toxic effects to the birds may have a significant negative effect to the populations.

Impact factor: Discharges to sea: minerals including oil

Impact hypothesis:	**Rationale for this assessment:**
B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Many marine ducks live mainly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Toxic substances may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects. It is assumed that the hypothesis is valid.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
This impact factor has mainly indirect effects.

Indirect effects and their significance:
Marine ducks mainly feeds on benthos organisms, primarily molluscs. Toxic components from oil spills and other discharge can be accumulated in and/or kill benthos. Especially molluscs readily absorb and accumulate toxic compounds that they are exposed to (Neff *et al.* 1987, Clark 1992). The female eiders are particularly dependent upon a good food supply before the onset of the breeding season. They then accumulate a layer of body fat to manage throughout the incubation period, when they do not feed. If the availability of prey organisms in an area is reduced due to pollution, the females may not be able to accumulate sufficient fat reserves. They will then either not attempt to breed at all, interrupt the breeding before hatching, and/or their physical condition may be so impaired that the mortality rate is increased.

If toxic substances are accumulated in the ducks' prey organisms, these substances may reach high concentrations in the ducks' body tissues or organs, possibly with resulting impaired physical condition, disease and death. After hatching, the females and the chicks mainly feed on crustaceans in the littoral zone. Correspondingly, if these animals accumulate or are killed by toxic substances (such as oil components or dispersants), marine ducks may suffer reduced reproduction and increased mortality. Exposure to oil by ingestion of contaminated food probably was the cause for the massive reproductive failure in Harlequin Ducks that was observed to prevail several years after the *Exxon Valdez* accident in Alaska (Patten 1993).

Cumulative effects and their significance:
Lack of food or food combined with possible toxic effects to the birds may have a significant negative effect to the populations.

Impact factor: Hunting			
Impact hypothesis: B2-6: Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	**Rationale for this assessment:** Hunting is an old tradition in Russia. Especially with establishment of new settlements along the NSR route, it is possible that the hunting pressure on seabirds will increase, including egg harvesting.		
Results based on: semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Hunting and egg harvesting will influence directly on the survival and breeding success. The effect on the population will mainly depend on which age groups of birds which are hunted. In general, hunting for adult birds will have a more serious effect to the population than hunting for the juvenile birds.

Indirect effects and their significance:
Hunting and egg harvesting will also disturb the birds. Possible effects may be that birds are scared away from their traditional areas and access to important feeding areas may be limited. Egg harvesting may lead to disturbance in the breeding colonies which may lead to reduced breeding success.

Cumulative effects and their significance:
Hunting and increased traffic in the vicinity of settlements may have significant negative effects locally to the marine wildfowl populations.

Conclusions VEC Marine wildfowl:
Of the impact factors concerning NSR operational traffic both chemicals and minerals discharged into the sea can be a serious threat to marine wildfowl in certain circumstances. In addition, hunting may have a significant negative effect in the vicinity of settlements. Russia has quite strict regulations for hunting and egg harvesting, but by experience it is known that a lot of illegal hunting is occurring.

Recommendations VEC Marine wildfowl:

- ☛ Monitoring of the contamination levels of marine wildfowl should be carried out. If high levels of toxic compounds are found in wildfowl, studies of the resulting effects on reproduction and survival should be initiated.
- ☛ With establishments of new settlements information about hunting regulations should be given. In addition, inspections of the hunting activities should be initiated. The hunting regulations and information about the wildlife should also be distributed to all ships in the NSR area.

4.1.4 VEC Waders in resting and feeding areas

Impact factor: Discharges to sea: chemicals			
Impact hypothesis: B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	**Rationale for this assessment:** Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic substances and may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration. It is assumed that the hypothesis is valid and may become important.		
Results based on: semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
This impact factor has mainly indirect effects.

Indirect effects and their significance:
Most waders are food specialists (see Alerstam *et al.* 1992). Any changes in the access to prey species may have strong negative effects on the populations. Waders are long distance migrants and they are dependent on a few very important stop-over sites with predictable high concentrations of food. At these places they can find satisfactory amounts of food in order to build up energy reserves before setting out on the next long leg (Pienkowski & Evans 1984, Evans 1991).

Cumulative effects and their significance:
Lack of food and also possible toxic effects to the birds may have a significant negative effect to the populations.

<table>
<tr><td colspan="5">Impact factor: Discharges to sea: minerals</td></tr>
<tr><td colspan="2">Impact hypothesis:
B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.</td><td colspan="3">Rationale for this assessment:
Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic substances and may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration. It is assumed that the hypothesis is valid and may become important.</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td></td><td>qualitative assessment:</td><td>X</td></tr>
<tr><td colspan="5">Direct effects and their significance:
This impact factor has mainly indirect effects.</td></tr>
<tr><td colspan="5">Indirect effects and their significance:
Most waders are food specialists (see Alerstam et al. 1992). Any changes in the access to prey species may have strong negative effects on the populations. Waders are long distance migrants and they are dependent on a few very important stop-over sites with predictable high concentrations of food. At these places they can find satisfactory amounts of food in order to build up energy reserves before setting out on the next long leg (Pienkowski & Evans 1984, Evans 1991).</td></tr>
<tr><td colspan="5">Cumulative effects and their significance:
Lack of food and also possible toxic effects to the birds may have a significant negative effect to the populations.</td></tr>
</table>

<table>
<tr><td>Conclusions VEC Waders in resting and feeding areas:
Chemicals and minerals discharged into the sea are recognised as a serious threat to waders in feeding and resting areas.</td></tr>
<tr><td>Recommendations VEC Waders in resting and feeding areas:
☛ Strict regulations and frequent controls of pollution level from ships should be made. Surveys to map areas used as stop-overs during autumn migration. Monitoring of the contamination levels of waders should be carried out. If high levels of toxic compounds are found in waders, studies of the resulting effects on survival should be initiated.</td></tr>
</table>

4.1.5 VEC Polar bear

The first impact hypothesis (C-1) in this chapter is assessed valid for all marine mammals, but is here exemplified for the VEC Polar bear. The second hypothesis is valid only for the VEC Polar bear.

<table>
<tr><td colspan="5">Impact factor: Discharge/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.</td></tr>
<tr><td colspan="2">Impact hypothesis:
C-1: Pollution to ice and water can be accumulated through the food chain and reach such high concentrations in marine mammals as to have a toxic effect.</td><td colspan="3">Rationale for this assessment: While the effects of direct exposure to petroleum have been investigated in marine mammals, there is a shortage of knowledge about the long-term effects of small quantities of oil and other pollutants ingested in food over long periods (Griffiths et al. 1987).</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td></td><td>qualitative assessment:</td><td>X</td></tr>
<tr><td colspan="5">Direct effects and their significance:
Heavy metals, stable chlorides, breakdown products from oil or oil treated with dispersants, and PCBs are relevant substances. Such bio-accumulation has in many areas been traced in fish and marine mammals.</td></tr>
<tr><td colspan="5">Indirect effects and their significance:</td></tr>
<tr><td colspan="5">Cumulative effects and their significance:</td></tr>
</table>

Impact factor: Noise and physical disturbance.			
Impact hypothesis: C1-4: Traffic in or near denning areas will cause reduced reproduction in the polar bear population.	**Rationale for this assessment:** The existence of traditional denning areas presumably indicates that, among the available denning areas, these show the highest individual reproductive success. Displacement from such areas may reduce reproductive success. The effect of disturbance has been studied by Blix & Lentfer (1992) and Amstrup (1994). Measurements indicate that external sounds are barely heard inside dens. Activities not directly affecting dens may thus not be expected to have significantly negative effects. Intense human activity in autumn would give bears en route to traditional denning areas the opportunity to den in other areas. Observations indicate that, after den-break, females with cubs are sensitive to disturbance and may flee from the cubs, which will then die. Possible effects on the population level are difficult to demonstrate by research.		
Results based on:	semi-quantitative assessment:		qualitative assessment: X

Direct effects and their significance: Disturbances/activity in traditional denning areas in the fall may prevent females from denning in optimal areas and at an optimal point in 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.

Disturbances in denning areas may be assumed to have short-term as well as long-term effects: In the short term females can be deterred from denning (fall) or frightened out of their dens (winter), in both cases resulting either in abortion or delivery of the cubs under unfavourable conditions. In the spring she may leave the area too early with the cubs or be frightened into leaving the cubs. In the long term disturbances in a traditionally important area may discourage females from using that area. If it is correct that today's traditional denning areas are the areas which give the highest average reproductive success, this will in principle imply a reduction in the population.

Experience from activities carried out in the spring in the Svalbard denning areas (Hansson & Thomassen, unpublished data) would indicate that during/after den break, industrial activities within sight of the den, and otherwise about 1 km from the denning area, can disturb females with cubs. Canadian researchers have, however, for several years caught and marked pregnant females (fall) and females with cubs (spring) from helicopters near the denning area close to Churchill, Hudson Bay, without being able to prove any reduction in the number of yearlings or the size of the litter (Ramsay & Stirling 1986).

Conclusions VEC Polar bear:
Polar bears are vulnerable to long term pollution of the marine ecosystem and may be vulnerable to long term disturbance especially in denning areas like the Wrangel island.

Recommendations VEC Polar bear:

- Surveys of polar bears in the total NSR area should be performed. The surveying should run as a long-term project to provide accurate data. For economic and logistic reasons some specific impact areas should be selected.
- Installations, activity and traffic should be kept away from areas important to polar bears. If it is decided to locate activities near an area that is vital to the polar bear's migration, food or denning area; study the incidence of bears and their use of the area before, during and after the activity is recommended.
- Disturbance in the most important denning areas that leads to abandonment of breeding might have large effect on the population level. Traffic in the denning areas should be minimised throughout fall, winter and spring.
- In connection with activity in and near denning areas recording of dens and production in the affected area should be monitored.
- Studies of female behaviour and of choice of denning areas in the fall by means of telemetry and observations and den surveys in areas relevant for activity could be performed in order to get more insight to this problem.
- Ethological and physiological study of the effect of disturbance on free-ranging polar bears could be performed, but the implementation of such studies will require large sample size and high costs.
- Polar bears are at the top of the food chain in the Arctic. Pollution will accumulate in bears and that is already a major problem in parts of the INSROP area. It is reasonably to assumed that such pollution will increase with an increased activity along the Northern Sea Route. A standard procedure should be established for the sampling and analyses of tissue, vital organs etc. from marine mammals at selected localities in the NSR area.
- A waste handling system must be developed in the NSR area.

4.1.6 VEC Walrus

<table>
<tr><td colspan="4">Impact factor: Noise and physical disturbance.</td></tr>
<tr><td colspan="2">Impact hypothesis:
C2-1: Disturbances resulting from traffic and installations will reduce the walrus population.</td><td colspan="2">Rationale for this assessment: It has been documented that the walrus may avoid a specific area, and that mortality, especially with calves, may increase because of disturbances (Fay et al. 1984). Potential effects on the population level will be difficult to demonstrate, but, because the number of walrus in western and central parts of the NSR area is low, documented effects on individuals or small herds may also be significant.</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td>qualitative assessment:</td><td>X</td></tr>
<tr><td colspan="4">Direct effects and their significance: 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.</td></tr>
<tr><td colspan="4">Indirect effects and their significance:</td></tr>
<tr><td colspan="4">Cumulative effects and their significance:</td></tr>
</table>

Conclusions VEC Walrus:
It has been documented that the walrus may avoid a specific area, and that mortality, especially with calves, may increase because of disturbances.

Recommendations VEC Walrus:

- Monitoring of local populations with respect to population size, sex and age composition and behaviour should be performed. This should include surveys of occurrence and use of haul-out sites, counts of possible local populations and studies of their seasonal distribution, and studies of the migrations and distribution of walruses.
- Activity in walrus habitats should be regulated through a stipulation of the minimum permitted distance, the establishment of protection zones, and the introduction of landing bans at well-known haul-out sites and feeding areas.

4.1.7 VEC Gray whale

<table>
<tr><td colspan="4">Impact factor: Noise and physical disturbance</td></tr>
<tr><td colspan="2">Impact hypothesis:
C6-2: Disturbance (traffic, ice breaking) will result in a reduction in the local Gray whale populations.</td><td colspan="2">Rationale for this assessment: Increased traffic will lead to increased disturbance which can cause a reduction in local Gray whale populations. Disturbances can cause increased activity and energy expenditure. Icebreaker traffic in breeding and summering areas can cause an increased mortality (Richardson et al. 1995).</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td>qualitative assessment:</td><td>X</td></tr>
<tr><td colspan="4">Direct effects and their significance:
Gray whales winter and reproduce in lagoons along the coast of Baja California, and migrate north to summering areas in the Bering and Chukchi Seas. Reactions to vessels have been studied in winter and to some degree during migration. Little information exists, however, from the northern summering grounds.

Ship traffic and other human disturbance are believed to have been responsible of abandonment of a certain lagoon in the summering area. The lagoon was subsequently reoccupied after shipping decreased (Reeves 1977). During a study at a wintering lagoon where whale watching was partially regulated, no evidence was found that whales moved out of the lagoon when whale-watching vessels were present (Jones & Swartz 1984). Cowles et al. (1981) pointed out that Gray whales continue to migrate along the entire west coast of the United States and Canada each year, despite the presence of enormous numbers of ships and other disturbance. Recent observations have, however, been done of many Gray whales far offshore in the southern California Bight. This might be a result of disturbance causing displacement or that they have been overlooked earlier (Dohl & Guess 1979). According to Bogolovskaya et al. (1981) Gray whales off Chukotka reacted to ships at a distance of about 350-550 meters.</td></tr>
<tr><td colspan="4">Indirect effects and their significance:</td></tr>
<tr><td colspan="4">Cumulative effects and their significance:</td></tr>
</table>

Conclusions VEC Gray whale:
The Gray whales are vulnerable to disturbance from ship traffic, especially in certain confined near shore areas of the NSR in the Chukchi. The population is especially vulnerable due to its small size. It is only found in the Chukchi Sea part of the NSR area.
Recommendations VEC Gray whale:
☛ The Gray whale population in areas with activity should be monitored with respect to size, age composition and distribution of the populations. ☛ More research on the reaction of individual whales to disturbance is important to perform. ☛ Traffic and other activities could be subjected to time and area control in Gray whale areas.

4.1.8 VEC Bowhead whale

<table>
<tr><td colspan="4">Impact factor: Noise and physical disturbance</td></tr>
<tr><td colspan="2">Impact hypothesis:
C7-2: Disturbance (traffic, ice breaking) will result in a reduction in the local bowhead whale populations.</td><td colspan="2">Rationale for this assessment: Increased traffic will lead to increased disturbance which can cause a reduction in local Gray whale populations. Disturbances can cause increased activity and energy expenditure. Icebreaker traffic in breeding and summering areas can cause an increased mortality (Richardson et al. 1995).</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td>qualitative assessment:</td><td>X</td></tr>
<tr><td colspan="4">Direct effects and their significance:
Many studies have been conducted on the effects of different sources of noise on bowhead whales (see Richardson and Malme 1993). Generally, only short term behavioural responses have been documented although possible physiological responses and long term avoidance and population level effects have been hypothesised. Bowheads usually begin to flee when boats approaching rapidly and directly are 1-4 km away. Although strong pulses of sound often are detectable 25-50 km from seismic ships, most bowheads begin to swim away when the ships approach within 8 km. The effect of noise from ice-breaker ships has, however, not been tested. In general, bowhead behaviour is affected temporarily by the close approach of ships and aircraft, and they avoid very loud ongoing noise, although the degree of habituation is unknown, as are the cumulative and long-term consequences of exposure to human-caused noise.

From August to October bowheads are numerous in the eastern part of the NSR area along the coast of the Chukchi Peninsula. The ice condition is one of the factors determining their distribution (Burns 1993). It is not known to what degree bowheads will be attracted by artificial leads held open by ship traffic. It is known that collisions between ships and bowheads occur and 2 out of 72 examined whales had signs of such accidents (Philo et al. 1993). It seems reasonable to assume that such accidents will increase with increased ship traffic. To what degree this could add significantly to the mortality of bowhead whales is unknown.</td></tr>
<tr><td colspan="4">Indirect effects and their significance:</td></tr>
<tr><td colspan="4">Cumulative effects and their significance:</td></tr>
</table>

Conclusions Bowhead whale:
Increased traffic will lead to increased disturbance which can cause a reduction in local bowhead whale populations. The population is vulnerable due to its small size. It is only found in the Chukchi Sea part of the NSR area.
Recommendations Bowhead whale:
☛ The Bowhead whale population in areas with activity should be monitored with respect to size, age composition and distribution of the populations. ☛ More research on the reaction of individual whales to disturbance is important to perform. ☛ Traffic and other activities could be subjected to time and area control in Bowhead whale areas.

4.1.9 VEC Protected areas

<table>
<tr><td colspan="2">Impact factor: Petroleum development on-shore and off-shore, and other industrial development.</td></tr>
<tr><td>Impact hypothesis:
E1-8: Increased industrial development, with constructions of pipelines and transportation systems will disturb selected VECs in the terrestrial, aquatic and marine environment by making barriers and disturbance.</td><td>Rationale for this assessment: Pipelines and roads following an industrial development in Arctic often stretches out for hundreds of kilometres with long lasting barrier impacts and disturbance on selected animals. Investigations also show that to some extent habituation to the impact factors occur. The impacts are area-, season and species dependent.</td></tr>
</table>

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
The construction period often lasts for a long time (years) with intensive traffic by heavy and noisy vehicles. Undisturbed habitats will be disturbed, including key environmental elements like plants, animals and indigenous people. Arctic environments are especially vulnerable to destruction of the thin vegetation cover. Vehicle tracks can be visible for decades. In addition to the construction work it self, pipelines and roads will also lead to an increased erosion of which dramatic examples are reported from Yamal. An alteration of terrain drainage patterns can also be seen, which in particular can be dramatic for swamp areas. Pipelines and roads are regarded as permanent installations and will lead to habitat fragmentation and loss of biodiversity, and will also act as a barrier for migrating animals like domestic and wild reindeer (see Klein & Kuzyakin 1982).

Indirect effects and their significance:
Better access to protected areas as a consequence of road constructions can lead to an increased human use of the areas for hunting, fishing and outdoor recreation, which in turn can result in disturbance of VECs in the area. Disturbance of traditional migrating routs for domestic reindeer can have dramatic consequences for the indigenous people.

Cumulative effects and their significance:

Impact factor: Rural development including tourism

Impact hypothesis:	**Rationale for this assessment:**
E1-10: Increased use of NSR will lead to increased population, tourism, hunting and fishing in protected areas, which will be a threat to selected VECs in special and to biological diversity in general.	The NSR area is an exclusive goal for the tourism industry, and exclusivity in tourism is an increasing phenomenon. If the development of tourism, including hunting and fishing, is of purely economic motivation without strict regulations of the activities, we assume the potential threat to protected areas to be of medium scale on spatial and perturbation. We furthermore assume that the activities will last as long as the economic outcome exist and consequently the effects is on a large temporal scale.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
An increased local population, introduction of alien cultures and better infrastructure can lead to an increased use of protected areas as recreation-, fishing- and hunting grounds, and consequently an increased threat to species and habitats. The accessibility to wilderness areas is difficult and the use of helicopters are increasing. Without strict regulations, this can lead to serious disturbance of the areas.

Indirect effects and their significance:
Disturbance, and commercial hunting and fishing activities may take subsistence areas from the indigenous people (Dallmann 1997).

Cumulative effects and their significance:

Conclusions VEC Protected areas:
Industrial developments in general and petroleum developments in special can lead to serious disturbance of protected areas along NSR. Exposed to this threat are in particular the erosion of a vulnerable vegetation cover, the habitat fragmentation and species of plants and animals. Better accessibility can lead to an increased use of protected areas as recreation-, fishing- and hunting grounds, and consequently an increased threat to species and habitats. The subsistence of the indigenous people will also be threatened. Depending on each protected area, conclusions regarding the other VEC will also be valid here.

Recommendations VEC Protected areas:
- ☛ The most important recommendation will be to «keep away from protected areas».
- ☛ Strict regulations to prevent disturbance of protected areas.
- ☛ Area-, season and species dependent investigations to map the potential impacts are recommended.
- ☛ Depending on each protected area, recommendations regarding the other VEC will also be valid here.

4.1.10 VEC Indigenous people

Impact factor: Physical disturbance: land devastation, aerial occupation

Impact hypothesis:	**Rationale for this assessment:**
F1-7: The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to land disruption and loss of hunting, fishing and breeding grounds.	Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance: Loss of pasture lands and fishing grounds Interruption of migration routes for wildlife Loss of wildlife
Indirect effects and their significance: Local or regional loss of indigenous subsistence Forced relocation and urbanisation Forced transition to alternative livelihood and «modern» lifestyle
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) In the worst case: Cultural extinction of ethnic groups (tribes or peoples)

Impact factor: Physical disturbance			
Impact hypothesis: F1-8: Oil/gas pipelines connecting hydrocarbon fields with northern harbours may lead to area segmentation as a hinder for wildlife migration and a general decrease of wildlife resources.		**Rationale for this assessment:** Hunting grounds and pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity.	
Results based on: semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Interruption of migration routes for wildlife Development of an unpredictable migration pattern of wildlife Loss of wildlife			
Indirect effects and their significance: Local or regional decrease or loss of indigenous subsistence Contribution to forced relocation and urbanisation Contribution to Forced transition to alternative livelihood and «modern» lifestyle			
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) In the worst case: Cultural extinction of ethnic groups (tribes or peoples)			

Impact factor: Discharges to land, rivers and lakes (toxic spills, undifferentiated)			
Impact hypothesis: F1-9: The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to toxic spills that may destroy spawning areas and fishing grounds.		**Rationale for this assessment:** Fishing grounds and spawning areas are important resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity.	
Results based on: semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Loss of fishing grounds Loss of fish as a food resource			
Indirect effects and their significance: Local or regional loss of indigenous subsistence Forced relocation and urbanisation Forced transition to alternative livelihood and «modern» lifestyle			
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) In the worst case: Cultural extinction of ethnic groups (tribes or peoples)			

Impact factor: Emissions to air (SO_2 etc.)

Impact hypothesis:
F1-11: The NSR will favour industry development leading to SO_2 and other air pollution which will degrade or destroy subsistence areas.

Rationale for this assessment:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. It is however technically possible to have northern development without significant SO_x emissions, but the nature of historical and present developments have shown serious emissions in the area.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Loss of pasture lands and fishing grounds
Loss of wildlife

Indirect effects and their significance:
Local or regional loss of indigenous subsistence
Forced relocation and urbanisation
Forced transition to alternative livelihood and «modern» lifestyle

Cumulative effects and their significance:
In combination with other impacts:
Development of «Minority syndrome» due to inability to adopt a different lifestyle.
Increase in health problems.
Loss of cultural identity (individuals or large groups of indigenous people).
In the worst case: Cultural extinction of ethnic groups (tribes or peoples).

Impact factor: Physical disturbance: ice-breaking on frozen rivers

Impact hypothesis:
F1-1: Boat traffic on frozen rivers disturbs migration of wild reindeer (and other wildlife) and affects the effectiveness of hunting as a major subsistence

Rationale for this assessment:
This has been documented for the lower Yenisei river and its estuary. It is especially problematic today, where the shortage of fuel and transportation facilities does not allow the hunters to search for the animals. Expected to be valid to a minor extent throughout the Siberian North.
Hunting of wild reindeer is a major subsistence of the indigenous people of the Taymyr area, and of other indigenous peoples to a somewhat minor extent. Continuous ice-breaking every winter will have a negative, large, long-term effect on indigenous people, where hunting is a major subsistence.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Interruption of migration routes for wildlife
Development of an unpredictable migration pattern of wildlife
Loss of wildlife

Indirect effects and their significance:
Local or regional decrease or loss of indigenous subsistence
Contribution to forced relocation and urbanisation
Contribution to Forced transition to alternative livelihood and «modern» lifestyle

Cumulative effects and their significance:
In combination with other impacts:
Development of «Minority syndrome» due to inability to adopt a different lifestyle
Increase in health problems
Loss of cultural identity (individuals or large groups of indigenous people)
In the worst case: Cultural extinction of ethnic groups (tribes or peoples)

Impact factor: Tourism

Impact hypothesis:
F1-12: With an increased infrastructure, commercial fishing and hunting tourism may take subsistence areas from indigenous population.

Rationale for this assessment:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Loss of pasture lands and fishing grounds for indigenous use
Loss of wildlife for indigenous use

Indirect effects and their significance: Local or regional loss of indigenous subsistence Forced relocation and urbanisation Forced transition to alternative livelihood and «modern» lifestyle
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) In the worst case: Cultural extinction of ethnic groups (tribes or peoples)

Impact factor: Crime				
Impact hypothesis: F1-14: Increased infrastructure, alien settlement and industrialisation will lead to an increase of criminal acts against the indigenous population, and against their resource base and their means to use the resources (e.g. reindeer theft, robbery, threat).	**Rationale for this assessment:** Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Serious increase in economic problems for individuals of groups of indigenous people Increase in health problems				
Indirect effects and their significance: Contribution to forced relocation and urbanisation Contribution to forced transition to alternative livelihood and «modern» lifestyle				
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems				

Impact factor: Alien commercial interests				
Impact hypothesis: F1-15: With increased accessibility and transport facilities, commercial fisheries and hunters may utterly take the resource basis for indigenous subsidence.	**Rationale for this assessment:** Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Loss or partial loss of resource base				
Indirect effects and their significance: Forced relocation and urbanisation Forced transition to alternative livelihood and «modern» lifestyle				
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) Cultural extinction of ethnic groups (tribes or peoples)				

Impact factor: Nature protection interests				
Impact hypothesis: F1-16a: With an increased infrastructure, increased protection interests may lead to the closure of certain areas for indigenous subsidence.	**Rationale for this assessment:** Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Loss or partial loss of resource base				

Indirect effects and their significance: Forced relocation and urbanisation Forced transition to alternative livelihood and «modern» lifestyle
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) Cultural extinction of ethnic groups (tribes or peoples)

Conclusions VEC Indigenous people:

The expected mostly negative impacts on the indigenous peoples' environment are mainly not due to the sea route itself, but due to the expected subsequent industrial and infrastructure development in the Russian North. The NSR could, however, generate many scales of onshore infrastructure and associated development, ranging from minor to major.

The establishment of the NSR in the 1920s made it possible to build up the institutions that physically controlled the North and became the tool for the enforcement of Soviet policies, with all the fundamental social and economic changes they introduced for the entire population of the North, which affected the indigenous societies worst of all.

Since the colonisation of the North, large parts of the indigenous peoples' lands have been gradually converted into areas for alien settlement, transportation routes, industry, forestry, mining and oil production. Their lands and waters have been devastated or polluted, irresponsibly managed and alienated over the heads of their traditional owners and users.

Destruction of the indigenous peoples' environment means destruction of their cultural basis and their social pattern. The result were a large-scale (although not yet complete) social decay of the society, with such well-known symptoms as unemployment, loss of identity, alcoholism, health problems, demographic crisis, etc. Simultaneously achieved benefits like health service, education, etc., are finally broken down almost completely, while traditional ways of life are re-introduced.

There is little hope that an ultimate industrial and infrastructure development will change conditions to the better in the foreseeable future, unless there will be a drastic change in conduct and environmental behaviour of the developers, as well as in the preparedness of all players to involve the indigenous population in decision-making.

Recommendations VEC Indigenous people:

Mitigating measures:

- ☛ **Participation of indigenous peoples:** All industrial and infrastructure development has a price, and indigenous peoples must pay this price voluntarily. All development must pay attention to the fact that the land it occupies has been acquired without ever asking its original inhabitants, and that immense damage already has been done. Having understood this, it turns out clear that the indigenous peoples need to form part of all processes of further development, and their premises need to be viewed and treated on an equal basis.
- ☛ **Compensation for damage already done:** Decision-makers should guarantee that all companies investing in Northern development are to take their share in the environmental and social restoration of the damage caused by the earlier exploitation of the North.
- ☛ **New legislation and law enforcement:** The degree of impact through development in connection with the NSR depends largely on governmental and regional administrative regulations, laws, the establishment of protected areas, agreements with industrial companies, etc. The only way to control development is a new legislation with considerable respect to indigenous land use, and an effective law enforcement.
- ☛ **Establishment of nature reserves:** The establishment of nature reserves in co-operation with the local indigenous societies, guaranteeing that their needs are satisfactorily considered, is another promising approach that has been started, but a significantly wider network of protected areas, and a much better (than presently practised) implementation of environmental regulations is needed.

4.1.11 VEC Domestic reindeer and VEC Wild reindeer

Impact factor: Physical disturbance: Ice breaking, active installations, pipelines, roads	
Impact hypothesis: G1-2 & G2-2: Physical encroachment and installations will obstruct the movements of reindeer, may hinder their access to grazing and calving areas and increase their energy needs so that local populations may decrease.	**Rationale for this assessment:** Operational activities like ice breaking in rivers and straits and active installations will occupy areas and may accordingly reduce the access to grazing ranges and habitats and force animals to leave important areas. They can also function as physical or psychological obstacles to migrations between seasonal habitats, e.g. calving areas, and accordingly affect reproduction and survival (Hansson et al. 1990).

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance: The loss of grazing ranges is a likely outcome of physical encroachments, but the loss will generally be minimal and the effect will be problematic to test. Installations and open rivers and straits in winter are likely to become physical or mental migration barriers if unfavourably located. Such exclusions from important migration and grazing (calving areas can be negative for the population).

According to Klein and Kuzyakin (1994) the western heard of wild reindeer has been affected by northern industrial development. Above ground gas pipeline from Messoyakha gas field to Norilsk made in 1969 effected the migration of 75.000 of the heard of 300.000. The pipeline was later elevated in some areas to allow reindeer pass under. This was effective for 25% of the population. A new line was constructed and fences set up to guide deers away from the line. Today the animals are herded away from Norilsk by fences and have therefore shifted grazing area.

Movement of wild reindeer has been affected by ice breaking in Yenesei river in autumn to prolong shipping to Dudinka. This has caused an increased mortality for reindeer migrating to winter ranges west of Yenesei (Klein and Kuzyakin 1994). Historically wild reindeer migrated between the mainland and the Novosibisrski Islands in summer. In the 1920's the island population was 25.000-30.000 animals. Ice free summers in 1924 and 1930 made many animals to winter at the islands and most of them died. The population decreased to some hundreds and the migration to the mainland stopped. Today the population is about 5.000 and there is still no migration to the mainland (Klein and Kuzyakin 1994). Although this was not an anthropogenic disturbance, it shows how disturbance of migratory routs might have large impact on the population.

Indirect effects and their significance: Anderson (1995b) concluded that open sea lanes maintained by ice-breakers have formed a new barrier for the migration of wild reindeer at Taymyr. The resulting chaotic migratory behaviour has threatened the source of staple foods for indigenous people living through the Lower Yenisei Valley and can be blamed for destroying the local economy of reindeer herding of the Dolgan and Ngo. Further, Dallmann (1997) concluded that oil and gas, as well as associated infrastructure development are the most severe environmental threats towards reindeer breeding culture.

Cumulative effects and their significance:

Conclusions VEC Domestic and VEC Wild Reindeer:.
Operational activities like ice breaking in rivers and straits and active installations will occupy areas and may accordingly reduce the access to grazing ranges and habitats and force animals to leave important areas. Physical disturbance by ice breaking and construction of pipelines will make permanent barriers and can disturb or even destroy the traditional migration routes for domestic and wild reindeer. They can also function as physical or psychological obstacles to migrations between seasonal habitats, e.g. calving areas, and accordingly affect reproduction and survival. Consequently, the subsistence of indigenous people can be threatened.

Recommendations VEC Domestic and VEC Wild Reindeer:.
- Collection of data concerning disturbance from northern Russia should be evaluated.
- Seasonal habitats and migratory patterns in relevant development areas should be surveyed. The surveys must be differentiated with respect to sex, age and variation in physical condition etc., and be normative for mitigating measures.
- Reindeer habitat and migration areas must be considered when decisions are made concerning location of ship routs and installations on land. Special attention must be made on the location of pipelines.
- Important mitigating measures will be:
  - Restrictions on ice breaking in migratory areas and seasons.
  - Avoidance of pipelines in areas where traditional migration occur.
  - Construction of pipeline passage corridors if it is impossible to avoid the above mentioned mitigating measure.

4.2 Operational traffic - Positive impacts

The detailed assessments concerning operational traffic for all impact hypotheses are found in the *standard report forms* in Appendix 2. Most impact factors have been assessed to give negative impacts on the selected VECs. For some impact factors, however, positive impacts have been assessed on the indigenous people. Table 4.2 summarises the impact hypotheses in this category. Following the summary table, each of the actual IHs are treated separately.

Table 4.2. A summary of impact hypotheses for operational traffic along NSR, assessed to give positive impacts on the VEC Indigenous people.

Impact factor	Impact hypotheses	VEC	Area	Time of year
Nature protection interests	F1-16b: With an increased infrastructure, increased protection interests may lead to an increased protection of indigenous resources from alien disruption	Indigenous people	All NSR	All year
Market	F1-17: Possible economic rehabilitation of the northern areas supported by an increased infrastructure may create a marked for indigenous products and thus help to raise indigenous peoples' economic situation.	Indigenous people	All NSR	All year
Tourism	F1-18: Tourism may induce a renovation of traditional indigenous arts and crafts and thus increase the economic base for indigenous subsistence.	Indigenous people	All NSR	All year

4.2.1 VEC Indigenous people

Impact factor: Nature protection interests				
Impact hypothesis: F1-16b: With an increased infrastructure, increased protection interests may lead to an increased protection of indigenous resources from alien disruption	**Rationale for this assessment:** Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: If the juridical framework of the protected area includes the protection of indigenous ways of livelihood, this will directly induce an increase of the indigenous resource base				
Indirect effects and their significance: Positive impact on the cultural survival of indigenous groups				
Cumulative effects and their significance: There is no realistic hope that this positive effect will compensate for the negative effects of the infrastructure development, because protected areas empirically do not cover areas of sufficient size in relation to the lost area				

Impact factor: Market				
Impact hypothesis: F1-17: Possible economic rehabilitation of the northern areas supported by an increased infrastructure may create a market for indigenous products and thus help to raise indigenous peoples' economic situation	**Rationale for this assessment:** There is a very poor market for indigenous products, especially reindeer meat, in Russia outside the indigenous societies, which may increase parallel with an increasing economy			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Increase in economic wealth				
Indirect effects and their significance: Positive impact on the cultural survival of indigenous groups				
Cumulative effects and their significance: Given the present economic situation, this impact may be very positive. In long terms and for most of the people in question, it will – though being a positive side effect of the development - never compensate for the simultaneous loss of resources				

Impact factor: Tourism			
Impact hypothesis: F1-18: Tourism may induce a renovation of indigenous arts and crafts and thus increase the economic base for indigenous subsistence		**Rationale for this assessment:** Commercial arts and crafts have shown to be a possible alternative way (in combination with others) of cultural survival of indigenous nations, e.g. in North America	
Results based on:	semi-quantitative assessment:	qualitative assessment:	X
Direct effects and their significance: Increase in economic wealth			
Indirect effects and their significance: Positive impact on the cultural survival of individuals or indigenous groups			
Cumulative effects and their significance: Given the present economic situation, this impact may be positive. In long terms and for most of the people in question, it will – though being a positive side effect of the development - never compensate for the simultaneous loss of resources			

4.3 Accidental events - High potential impact level (PIL index = 3)

Accidents can theoretically occur all over the NSR area. Historical sailing data along NSR can, however, give us a picture of the frequency and location of ship accidents. These «high risk areas» are most often found in narrow straits and in connection with rivers (Figure 4.1). It is also important to notice the possibilities of accident on land (oil spill from pipeline accidents and accidents with oil storage tanks etc.).

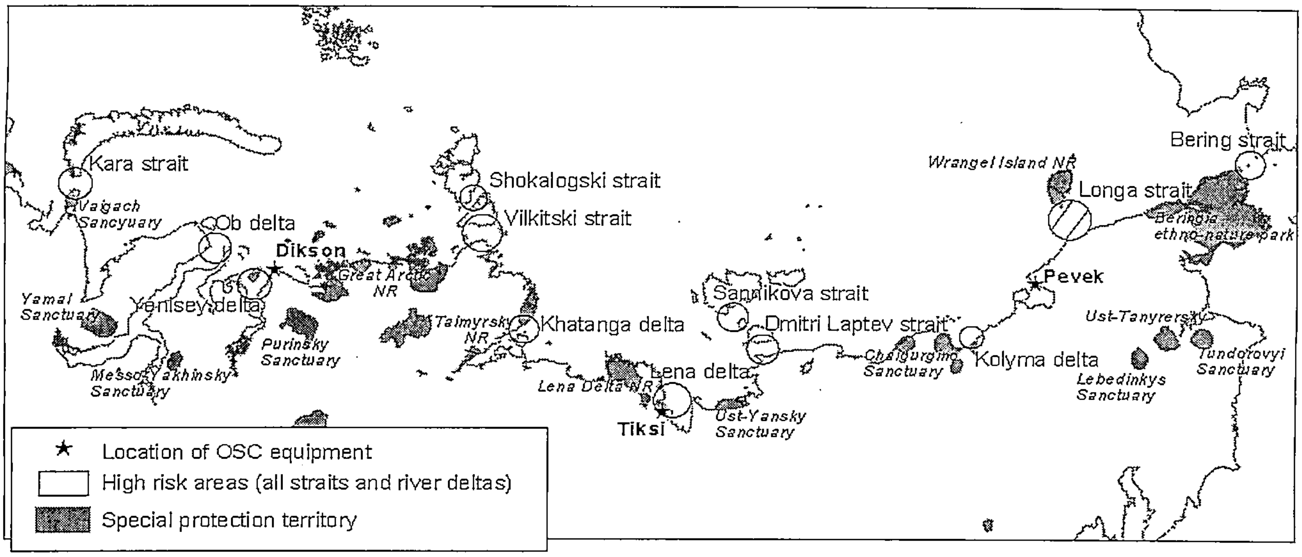

Figure 4.1. High risk areas along NSR (After Moe & Semanov 1999).

The detailed assessments concerning accidental events for all impact hypotheses resulting in PIL indices 1, 2 and 3 are found in the *standard report forms* in Appendix 2. In this section assessments ending up with high potential impact levels are treated. Table 4.3 summarises the impact hypotheses in this category. Following the Table, each VEC with their respective IHs are treated separately starting with the VEC A1 Benthic invertebrates (see Table 2.1).

Table 4.3. A summary of impact hypotheses for accidental events along NSR, assessed to give a high potential impact level (PIL index = 3).). Area: All Seas = Kara Sea, Laptev Sea, East Siberian Sea and Chukchi Sea; All NSR = All Sea + Ob, Yenisei and Lena.

Impact factor	Impact hypotheses	VEC	Area	Time of year
Discharges to sea: hydrocarbons	B1-1: Accidental and operational releases of hydrocarbons to ice, sea or shore may cause increased mortality and reduced reproduction of the seabird populations.	Seabirds *(Chapter 4.3.3)*		
	B2-3: Accidental and operational releases of hydrocarbons to ice, sea or shore may cause increased mortality and reduced reproduction of the wildfowl populations.	Marine wildfowl *(Chapter 4.3.4)*		

	C1-1: Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	Polar bear *(Chapter 4.3.6)*	All sea	All year
	C2-2: Oil pollution from ships will reduce the walrus population	Walrus *(Chapter 4.3.7)*	Kara Sea, East Siberian Sea, Laptev Sea	All year
	C2-2: Oil pollution from ships will reduce the walrus population	Walrus *(Chapter 4.3.7)*	Chukchi Sea	May-November
	C5-1: Oil pollution from ships will cause suffering and death for affected white whales and reduction in the white whale population.	White whale *(Chapter 4.3.8)*	Kara Sea	All year
	C5-1: Oil pollution from ships will cause suffering and death for affected white whales and reduction in the white whale population.	White whale *(Chapter 4.3.8)*	Laptev Sea, East Siberian Sea, Chukchi Sea, Ob, Yenisei, Lena	May-October
	D2-3: Accidental pollution with radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc., will cause major disturbances in the coastal zone, and under certain meteorological conditions also in inland areas (evaporation, precipitation).	Water/land border zone (sensitive areas) *(Chapter 4.3.10)*	All NSR	All year
	F1-5: Accidental pollution from shipwreck affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations, leading to loss of resources for indigenous subsistence	Indigenous people *(Chapter 4.3.12)*	Chukchi Sea, Ob, Yenisei, Lena	All year[1]
Discharges to sea: chemicals	B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Marine wildfowl *(Chapter 4.3.4)*	All sea	May-October
	B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	Waders in resting and feeding areas *(Chapter 4.3.5)*	All sea	August-October
Discharges to sea: minerals	B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	Marine wildfowl *(Chapter 4.3.4)*	All sea	April-October
	B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	Waders in resting and feeding areas *(Chapter 4.3.5)*	All sea	August-October
Discharges to Sea: radioactive material	A1-11: Accidental discharges of radioactive material from ships will affect benthic invertebrates	Benthic invertebrates *(Chapter 4.3.1)*	All NSR	All year
	A2-12: Accidental discharges of radioactive material will increase mortality in fish.	Marine, estuarine and anadromous fish *(Chapter 4.3.2)*	All NSR	All year
	A2-3: Accidental discharges of radioactive materials, in fresh water along the coastal NSR area will cause increased mortality and reduced production in anadromous fish.	Marine, estuarine and anadromous fish *(Chapter 4.3.2)*	Ob, Yenisei, Lena	All year
	D1-1: Accidental discharges of radioactive materials, will affect the resource base for local people.	Human settlements *(Chapter 4.3.9)*	All NSR	All year
	D1-4: Accidental discharges of radioactive materials will interfere with the indigenous peoples hunting and fishing activities.	Human settlements *(Chapter 4.3.9)*	All NSR	All year

Discharges to sea: general	E1-2: Accidents in the vicinity to protected areas will come in conflict with Russian legislation, regulations and aim of protection of protected areas.	Protected areas *(Chapter 4.3.11)*	All NSR	All year
	E1-4: Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will reduce the wilderness quality of the areas extensively.	Protected areas *(Chapter 4.3.11)*	All NSR	All year
	E1-6: Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will cause extensive damage to populations of VECs in vulnerable seasons.	Protected areas *(Chapter 4.3.11)*	All NSR	All year
Releases of oil to limnic and terrestrial environment	E1-9: Pipeline accidents will destroy terrestrial, aquatic and marine habitats severely and reduce the environmental quality of protected areas.	Protected areas *(Chapter 4.3.11)*	All NSR	All year
	F1-10: Oil pipelines connecting oil fields with northern harbours may have accidental leakage and spills causing local degradation or destruction of subsistence areas.	Indigenous people *(Chapter 4.3.12)*	All NSR	All year

1) originally divided in 5-11 (PIL 2-3) and 12-4 (PIL 3)

4.3.1 VEC Benthic invertebrates

Impact factor: Discharges to sea - radioactive material				
Impact hypothesis: A1-11: Accidental discharges of radioactive material from ships will affect benthic invertebrates	**Rationale for this assessment:** As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. In opposition to oil or fertiliser, decay of radionuclides is not affected by environmental parameters like temperature, moisture, sunlight etc., but proceeds at a given rate in any environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. Benthic organisms are particularly susceptible to chronic irradiation because these organisms live in or on the bottom sediments and may continue to consume organic-rich radionuclide contaminated particles long after an initial accident has occurred.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Biological resources will be harmed by the effects of acute and chronic irradiation received from direct exposure and from ingestion of contaminated seawater, sediment and food. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility in exposed organisms.				
Indirect effects and their significance: The structure and functioning of the ecosystem will be altered. Inter-relationships between species (e.g. competitions, predator-prey interactions) and other ecological processes affecting community structure (e.g. recruitment) will be effected. Other organisms, at higher trophic levels will be exposed to radiation effects by feeding on contaminated benthic organisms. The Mollusca, which are efficient bioaccumulator organisms, are prominent in the Arctic and thus is an important starting point for bioaccumulation through the food web. Walrus is known to harvest some species of Mollusca providing an efficient and direct pathway for bioaccumulation to higher trophic levels. Annelida consumption by demersal fish, and in some cases directly by seals also can occur. Organisms at higher trophic levels can be consumed by humans.				

Cumulative effects and their significance: Cumulative effects will occur as a result of multiple radionuclides being released during an accident. The presence of any other chemicals in the environment either due to the accident or that are already present in the environment will also provide a cumulative effect. Cumulative effects to organisms from multiple chemical contaminants have not yet been determined. These effects therefore are presently unknown.

Conclusions VEC Benthic invertebrates: Based on the links between benthic and pelagic organisms in marine food webs the loss of benthic organisms will impact whole ecosystems. The potential loss, due to accidental releases of radioactivity, of this critical ecosystem component must be avoided in order to maintain the present use of the ocean as a food resource for organisms at the top of the food web, including humans.
Recommendations VEC Benthic invertebrates: ☛ To the extent possible, the transport route should avoid shallow areas of high biological productivity. ☛ Should an accident occur, natural recovery (that is, no intervention) of the ecosystem is recommended. However, harvesting of biological resources (both benthic and pelagic organisms) should be discontinued in the area for a minimum of one harvesting season following the accident. ☛ Monitoring the levels of radionuclides in the environment will be needed to verify that dose levels and concentrations are below acceptable standards.

4.3.2 VEC Marine, estuarine and anadromous fish

Impact factor: Discharges to sea - radioactive material				
Impact hypothesis: A2-12: Accidental discharges of radioactive material will increase mortality in fish.	**Rationale for this assessment:** As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by acute and chronic irradiation exposures after an accident.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	
Direct effects and their significance: Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility of fish exposed to radioactive discharges. Benthic living fish species are particularly susceptible to chronic irradiation because these organisms live in close connection to the bottom sediments and may continue to consume contaminated prey long after an initial accident has occurred.				
Indirect effects and their significance: The structure and functioning of the ecosystem will be altered. Fish stocks will be reduced which could impact the harvesting of fish resources for human consumption. It may also severely impact food availability for indigenous populations. Because it can take many years for fish stocks to recover from population crashes, the effects could remain important even several years after the occurrence of the accident. If other contaminants are also present in the environment, the recovery of the fish stocks will be prolonged further.				
Cumulative effects and their significance: No cumulative effects will occur in addition to fish mortality.				

Impact factor: Discharges to sea - radioactive material	
Impact hypothesis: A2-3: Accidental discharges of radioactive materials, in fresh water along the coastal NSR area will cause increased mortality and reduced production in anadromous fish	**Rationale for this assessment:** As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel *will result in* the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility. Bottom living fish species are particularly susceptible to chronic irradiation because these organisms live in close contact with the bottom sediments and may continue to consume radionuclide contaminated food long after an initial accident has occurred.

Results based on:	semi-quantitative assessment:		qualitative assessment:	

Direct effects and their significance:
Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility of fish exposed to radioactive discharges. In shallow areas where fish breeding and nursery areas are prevalent, fish species are particularly vulnerable to long term reductions in fish stocks. Fish in shallow, coastal areas are particularly susceptible to chronic irradiation because these fish live in close connection to contaminated bottom sediments and may continue to consume contaminated prey long after an initial accident has occurred.

Indirect effects and their significance:
The structure and functioning of the ecosystem will be altered not only in the coastal zone but in offshore fish migration areas. Fish stocks will be reduced which could impact the harvesting of fish resources for human consumption. It may also severely impact food availability for local indigenous populations who harvest biological resources from the coastal zone. It can take many years for fish stocks to recover from population crashes. The recovery times for fish populations will depend on the extent of contamination but when nursery areas are impacted, the effects can last many years after the occurrence of the accident.

Cumulative effects and their significance:
If other contaminants are also present in the environment, the recovery of the fish stocks will be prolonged even further.

Conclusions VEC Marine, estuarine and anadromous fish:
The potential loss of fish nursery grounds and other ecosystem components due to accidental releases of radioactivity will have widespread impact not only on local resources but in open ocean areas of fish migration and in active fisheries resource areas. These ocean resources and the link between coastal and offshore ocean resources must be protected to maintain the functioning of the ocean ecosystem and for the continued use of the ocean as a food resource for humans.

Recommendations VEC Marine, estuarine and anadromous fish::
☛ To the extent possible, the transport route should avoid areas of high biological productivity and fish harvesting. ☛ Should an accident occur, natural recovery (that is, no intervention) of the ecosystem is recommended. Further, the removal of highly contaminated sediments is recommended. Harvesting of biological resources should be discontinued for several years following the accident in order to minimise the threat of human consumption of contaminated seafood and to allow fish stocks time to recover. ☛ Monitoring the levels of radionuclides in fish, water and sediment for several years will be needed to verify that dose levels and concentrations are below acceptable standards.

4.3.3 VEC Seabirds

Impact factor: Oil				
Impact hypothesis: B1-1. Accidental and operational releases of hydrocarbons to ice, sea or shore may cause increased mortality and reduced reproduction of the seabird populations.	**Rationale for this assessment:** The validity of the hypothesis has been well documented during several oil spill incidents.			
Results based on:	semi-quantitative assessment:	X	qualitative assessment:	
Direct effects and their significance: Seabirds fouled by oil will die or be severely affected by a reduction of the insulating properties of the plumage (increased energy expenditure), and/or by direct poisoning. This will increase mortality and reduce the reproduction in affected local populations. Oil from the plumage of the parents will be passed on to eggs and chicks reducing hatching and fledging success.				
Indirect effects and their significance: An oil spill may reduce the number of individuals in the population. This effect may influence on density-dependent parameters like social behaviour etc, but these effects are not very well known. Oil may also kill important seabird prey species and give negative long-term effects to the population.				
Cumulative effects and their significance: Oil causing a reduction in the number of birds, social behaviour changes and destroying of prey availability may cause serious negative long-term effects to seabird populations.				

Conclusions VEC Seabirds:
There is no doubt that oil contamination can kill large numbers of seabirds. This threat is recognised as one the most serious for seabirds along the NSR-area.
Recommendations VEC Seabirds: ☛ Contingency plans incorporating protection of seabirds should be prepared. ☛ Discharge concentrations should be strictly regulated and controlled. ☛ An updated geographical information system containing data on seabird distribution along the NSR should be maintained for planning of actions in case of an oil spill. ☛ Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels. ☛ Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity. This to be able to assess impacts on the populations in the event of an oil spill. ☛ Prepare oil-drift models for the NSR-area. These models should be used in planning of shipping routes and in planning oil-spill actions to minimise potential effects on seabirds.

4.3.4 VEC Marine wildfowl

Impact factor: Oil				
Impact hypothesis: B2-3: Accidental and operational releases of hydrocarbons to ice, sea or shore may cause increased mortality and reduced reproduction of the wildfowl populations.	**Rationale for this assessment:** The effect of oil spills on birds has been well documented. Marine ducks are very vulnerable, but geese are also exposed (especially Emperor and Barnacle Geese), particularly in the moulting and chick rearing period when they remain mainly in the shore area.			
Results based on:	semi-quantitative assessment:	X	qualitative assessment:	

Direct effects and their significance: Oil will float on the sea for a period after an oil spill and foul the plumage of swimming birds that are exposed to it. The waterproofing and the insulating properties of the feathers will be damaged and the birds will have to spend more energy on maintaining their body temperature, and they may also lose their ability to fly. This will easily result in exhaustion and death. Moreover, the toxic effect of the oil may result in disease and death (see VEC 1 *Seabirds*). Females fouled by oil may transfer the oil to the eggs and thus cause a reduction in breeding success. Also the survival of chicks may be seriously affected if the littoral zone or estuaries are affected by oil spills.
Indirect effects and their significance: An oil spill may reduce the number of individuals in the population. This effect may influence on density-dependent parameters like social behaviour etc, but these effects are not very well known. Oil may also kill important marine wildfowl prey species and give negative long-term effects to the population.
Cumulative effects and their significance: Oil causing a reduction in the number of birds, social behaviour changes and destroying of prey availability may cause serious negative long-term effects to marine wildfowl populations.

Impact factor: Discharges to sea: chemicals			
Impact hypothesis: B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	**Rationale for this assessment:** Many marine ducks live mainly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Toxic substances may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects. It is assumed that the hypothesis is valid.		
Results based on: semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: This impact factor has mainly indirect effects.			
Indirect effects and their significance: Marine ducks mainly feeds on benthos organisms, primarily molluscs. Toxic components from oil spills and other discharge can be accumulated in and/or kill benthos. Especially molluscs readily absorb and accumulate toxic compounds that they are exposed to (Neff *et al.* 1987, Clark 1992). The female eiders are particularly dependent upon a good food supply before the onset of the breeding season. They then accumulate a layer of body fat to manage throughout the incubation period, when they do not feed. If the availability of prey organisms in an area is reduced due to pollution, the females may not be able to accumulate sufficient fat reserves. They will then either not attempt to breed at all, interrupt the breeding before hatching, and/or their physical condition may be so impaired that the mortality rate is increased. If toxic substances are accumulated in the ducks' prey organisms, these substances may reach high concentrations in the ducks' body tissues or organs, possibly with resulting impaired physical condition, disease and death. After hatching, the females and the chicks mainly feed on crustaceans in the littoral zone. Correspondingly, if these animals accumulate or are killed by toxic substances (such as oil components or dispersants), marine ducks may suffer reduced reproduction and increased mortality. Exposure to oil by ingestion of contaminated food probably was the cause for the massive reproductive failure in Harlequin Ducks that was observed to prevail several years after the *Exxon Valdez* accident in Alaska (Patten 1993).			
Cumulative effects and their significance: Lack of food combined with possible toxic effects to the birds may have a significant negative effect to the populations.			

Impact factor: Discharges to sea: minerals			
Impact hypothesis: B2-4: Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	**Rationale for this assessment:** Many marine ducks live mainly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Toxic substances, with special reference to heavy metals, may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects. It is assumed that the hypothesis is valid.		
Results based on: semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
This impact factor has mainly indirect effects.

Indirect effects and their significance:
Marine ducks mainly feeds on benthos organisms, primarily molluscs. Toxic components from oil spills and other discharge can be accumulated in and/or kill benthos. Especially molluscs readily absorb and accumulate toxic compounds that they are exposed to (Neff *et al.* 1987, Clark 1992). The female eiders are particularly dependent upon a good food supply before the onset of the breeding season. They then accumulate a layer of body fat to manage throughout the incubation period, when they do not feed. If the availability of prey organisms in an area is reduced due to pollution, the females may not be able to accumulate sufficient fat reserves. They will then either not attempt to breed at all, interrupt the breeding before hatching, and/or their physical condition may be so impaired that the mortality rate is increased.

If toxic substances are accumulated in the ducks' prey organisms, these substances may reach high concentrations in the ducks' body tissues or organs, possibly with resulting impaired physical condition, disease and death. After hatching, the females and the chicks mainly feed on crustaceans in the littoral zone. Correspondingly, if these animals accumulate or are killed by toxic substances (such as oil components or dispersants), marine ducks may suffer reduced reproduction and increased mortality. Exposure to oil by ingestion of contaminated food probably was the cause for the massive reproductive failure in Harlequin Ducks that was observed to prevail several years after the *Exxon Valdez* accident in Alaska (Patten 1993).

Cumulative effects and their significance:
Lack of food combined with possible toxic effects to the birds may have a significant negative effect to the populations.

Conclusions VEC Marine wildfowl:
The oil spill threat is recognised as one the most serious for marine wildfowl along the NSR-area. An oil spill along the NSR in the summer season, particularly in the moulting period, may kill a great numbers of marine wildfowl and have serious effects on the populations. Being the most marine of the relevant species, the eiders will be the ones that are most likely to come in contact with oil on the sea. Among the geese, Barnacle and Emperor Geese are the most vulnerable species. They will be particularly vulnerable in the chick and moulting periods, when they stay a great deal in the littoral zone. Oiled Emperor Geese have for instance been observed in the Aleutian Islands (Petersen *et al.* 1994). See Gavrilo *et al.* (1998) for a more detailed assessment of the vulnerability of marine wildfowl to oil.

In addition, chemicals and minerals discharged into the sea are a serious threat to marine wildfowl.

Recommendations VEC Marine wildfowl:

- ☛ Contingency plans incorporating protection of wildfowl should be prepared.
- ☛ Discharge concentrations should be strictly regulated and controlled.
- ☛ An updated geographical information system containing data on wildfowl distribution along the NSR should be maintained for planning of actions in case of an oil spill.
- ☛ Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels.
- ☛ Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity. This to be able to assess impacts on the populations in the event of an oil spill.
- ☛ Preparation of oil-drift models for the NSR-area. These models should be used in planning of shipping routes and in planning oil-spill actions to minimise potential effects on wildfowl.
- ☛ Monitoring of the contamination levels of marine wildfowl should be carried out. If high levels of toxic compounds are found in wildfowl, studies of the resulting effects on reproduction and survival should be initiated

4.3.5 VEC Waders in resting and feeding areas

Impact factor: Discharges to sea: chemicals	
Impact hypothesis: B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	**Rationale for this assessment:** Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic substances and may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration. It is assumed that the hypothesis is valid and may become important.
Results based on: semi-quantitative assessment:	qualitative assessment: X
Direct effects and their significance:	
Indirect effects and their significance: Most waders are food specialists (see Alerstam *et al.* 1992). Any changes in the access to prey species may have strong negative effects on the populations. Waders are long distance migrants and they are dependent on a few very important stop-over sites with predictable high concentrations of food. At these places they can find satisfactory amounts of food in order to build up energy reserves before setting out on the next long leg (Pienkowski & Evans 1984, Evans 1991).	
Cumulative effects and their significance: Lack of food and also possible toxic effects to the birds may have a significant negative effect to the populations.	

Impact factor: Discharges to sea: minerals	
Impact hypothesis: B3-2: Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	**Rationale for this assessment:** Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic substances, with special reference to heavy metals, may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration. It is assumed that the hypothesis is valid and may become important.
Results based on: semi-quantitative assessment:	qualitative assessment: X
Direct effects and their significance: This impact factor has mainly indirect effects.	
Indirect effects and their significance: Most waders are food specialists (see Alerstam *et al.* 1992). Any changes in the access to prey species may have strong negative effects on the populations. Waders are long distance migrants and they are dependent on a few very important stop-over sites with predictable high concentrations of food. At these places they can find satisfactory amounts of food in order to build up energy reserves before setting out on the next long leg (Pienkowski & Evans 1984, Evans 1991).	
Cumulative effects and their significance: Lack of food and also possible toxic effects to the birds may have a significant negative effect to the populations.	

Conclusions VEC Waders in resting and feeding areas:
Chemicals and minerals discharged into the sea are recognised as a serious threat to waders in feeding and resting areas.

Recommendations VEC Waders in resting and feeding areas::
- Strict regulations and frequent controls of pollution level from ships should be made.
- Surveys to map areas used as stop-overs during autumn migration.
- Monitoring of the contamination levels of waders should be carried out. If high levels of toxic compounds are found in waders, studies of the resulting effects on survival should be initiated.

4.3.6 VEC Polar bear

Impact factor: Discharges to sea: hydrocarbons.			
Impact hypothesis: C1-1: Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population.		**Rationale for this assessment:** Research has shown that polar bears will become acutely ill and will 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).	
Results based on:	semi-quantitative assessment:	qualitative assessment:	X
Direct effects and their significance: The effect of oil on polar bears has been studied by Øritsland (1976), Øritsland *et al.* (1981) and Hurst & Øritsland (1982). Three research animals were swimming in oil-covered water for respectively 15, 30 and 53 minutes. The animals absorbed great quantities of oil in their pelts and gradually ingested a lot of oil while trying to lick themselves clean. The oil accumulated in the pelt resulted in reduced insulation, skin irritations and a severe loss of hair. The ingestion of oil resulted in vomiting, kidney failure, dehydration, reduction of blood volume, inflammations of the digestive system and kidney and brain damage. Two of the animals died, the third one would under natural conditions also have died. Based on this experiment, Griffiths *et al.* (1987) conclude that even a single, short-term oil spill will, under natural conditions, kill a great number of the affected polar bears. Polar bears live in close contact with the sea. They tend to stay on the ice edge, along leads or in drift ice, often enter the water and migrate over vast areas. In the event of an oil spill in the NSR area, it is likely that a great number of polar bears will be fouled by oil.			
Indirect effects and their significance:			
Cumulative effects and their significance:			

Conclusions VEC Polar bear:
Polar bears are very vulnerable for oil pollution. Bears that are hit by oil will probably die. It is the adult females that are specially important for the populations since it is them that bear the young.

Recommendations VEC Polar bear:

- Surveys of polar bears in the total NSR area should be performed. The surveying should run as a long-term project to provide accurate data. For economic and logistic reasons some specific impact areas should be selected.
- Installations, activity and traffic should be kept away from areas important to polar bears. If it is decided to locate activities near an area that is vital to the polar bear's migration, food or denning area; study the incidence of bears and their use of the area before, during and after the activity is recommended.
- In connection with activity in and near denning areas: Recording of dens and production in the affected area should be monitored.
- General measures against routine leaks and oil spills should be taken.
- Contingency plans to deter polar bears away from approaching less extensive oil spills must be developed. The same applies to contingency plans for capturing and cleaning of fouled bears where feasible, otherwise for destruction.
- In the event of an oil spill, bears in the contaminated area should be monitored.
- Surveys of polar bear occurrence throughout the year in areas where oil spills may be likely, and of local and general migratory patterns.

4.3.7 VEC Walrus

Impact factor: Discharges to sea: hydrocarbons.	
Impact hypothesis: C2-2: Oil spills caused by traffic will reduce the walrus population	**Rationale for this assessment:** : The effect of oil on the walrus has not been examined. In the event of an oil spill, walrus habitats on shore and in the drift-ice are, however, very exposed to oil accumulation (Griffiths *et al.* 1987) . The effects of oil on several other marine mammals are severe (Loughlin 1994). Observations indicate that the animals will not actively avoid oil spills. Because of physiological and behavioural differences this tendency cannot without reservation be transferred to the walrus. The effect of oil on individual walruses does not easily lend itself to research.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
No studies are available on the effect of oil spills on walruses, and the hypothesis is accordingly based on studies of other species.

Walruses stay in shore areas and in open areas on the drift ice, and appear to be relatively selective and conservative in their choice of such locations. If the walrus abandons polluted areas, this may imply that it must begin to use less attractive areas, which in the long term may have negative effects on the population. Given the low number of walruses found in western and central areas today there may be large areas of "unused" good walrus habitats. This fact may lessen the effect of a possible displacement from the areas in current use. This may not be the situation in the Chukchi area.

Apart from damage caused by direct contact with oil, accumulation of oil metabolites and e.g. the remains of dispersants in animals preyed upon by the walrus can be imagined to cause indirect damage through ingestion of toxic substances. In this event, such effects will probably build up over a long period of time, and may be difficult to prove experimentally. Documentation is lacking for walrus, and the assumption is based on the examination of other species. Moreover, many benthic invertebrates are sensitive to toxic substances from oil (Griffiths *et al.* 1987). Oil spills in the feeding areas of the walrus can accordingly damage or kill important prey species, and reduce the walrus's food supply locally.

Indirect effects and their significance:

Cumulative effects and their significance:

Conclusions VEC Walrus:
If walruses do not avoid oil spills, they may quite easily suffer if their habitats are affected by oil. This is especially trough do to their gregarious behaviour. At haul-out sites big flocks can be frightened an rush to the sea in a panic way. Many individuals, especially young animals might be killed. Continuous disturbance of important sites might frighten the walruses away from important areas.

Recommendations VEC Walrus:
- Monitoring of local populations with respect to population size, sex and age composition and behaviour should be performed. This should include surveys of occurrence and use of haul-out sites, counts of possible local populations and studies of their seasonal distribution, and studies of the migrations and distribution of walruses.
- Activity in walrus habitats should be regulated through a stipulation of the minimum permitted distance, the establishment of protection zones, and the introduction of landing bans at well-known haul-out sites and feeding areas.
- Oil spill alert contingency plans should be established near walrus habitats.
- Protection zones should be established around haul-out sites and feeding areas to protect the walrus from routine oil spills.
- In the event of oil spills walrus habitats and fouled individuals should be monitored.

4.3.8 VEC White whale

Impact factor: Discharges to sea: hydrocarbons

Impact hypothesis	Rationale for this assessment
Impact hypothesis: C5-1: Oil pollution from ships will cause suffering and death for affected white whales and reduction in the white whale population.	**Rationale for this assessment:** The effect of oil on white whales has not been examined. The effects of oil on several other marine mammals are severe. Because of physiological and behavioural differences this tendency cannot without reservation be transferred to white whales. Geraci (1990) concluded that bottlenosed dolphins were able to detect and avoid oil on the sea and that contact with oil with be less harmful in cetaceans then for other marine mammals. Oiling in estuaries and at the ice edge might be a risky for white whales due to their gregarious behaviour. The effect on oil exposure through the food chain is not known.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance: 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. There are no data concerning the effects of inhalation of petroleum vapour in cetaceans (Richardson *et al.* 1983). Geraci (1990) concluded, however, that for the short time they persist, vapours are one feature of an oil spill that can threaten the health of a cetacean. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction capacity.
Indirect effects and their significance:
Cumulative effects and their significance:

Conclusions VEC White whales: Oiling in estuaries and at the ice edge might be a risky for white whales due to their gregarious behaviour. Estuaries are especially important in this respect, since huge flocks can be found there during the moulting period in summer.
Recommendations VEC White whales: ☛ Surveys should be performed of local populations with respect to seasonal variation in selected areas, migration, population affiliation, and breeding and moulting areas. ☛ Traffic and other activities should be subjected to time and area control in white whale breeding and moulting areas. ☛ Monitoring of the white whale population should be performed in potential conflict areas. ☛ Oil spill alert contingency plans should be initiated in estuaries where white whales occur. ☛ Monitoring of habitats and fouled individuals in the event of oil spills must be performed. ☛ Studies of the effects of oil pollution on white whales must be initiated in case of an oil spill.

4.3.9 VEC Human settlement

<table>
<tr><td colspan="4">Impact factor: Discharges to sea: radioactive material</td></tr>
<tr><td colspan="2">Impact hypothesis:
D1-1: Accidental discharges of radioactive materials, will affect the resource base for local people.</td><td colspan="2">Rationale for this assessment:
Accidental discharges of radioactive materials will affect the resource base for local people. Depending on the type and amount of the radioactive materials, local people might have to move from an area, and the possibility to utilise resources can be blocked. Another effect is that the resources can be polluted, and not useable.</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td></td><td>qualitative assessment:</td></tr>
<tr><td colspan="4">Direct effects and their significance:
The contamination of sediment, water, and biological resources will occur after an accidental discharge of radionuclides. Local people who live near or visit the contaminated area and/or removal materials from the area will be exposed to radiation either through ingestion of contaminated materials or by direct contact. Radiation exposure of humans can result in chronic and acute effects. At high doses (>1×10^6 µSv), radiation sickness can occur in humans. The risk of cancer death is about 10% per million µSv for doses received rapidly (acute) and might be about half that (5%) for doses received over long period (chronic) (Puskin & Nelson 1994, NCRP 1993, NRPB 1993, ICRP 1990).</td></tr>
<tr><td colspan="4">Indirect effects and their significance:
The acquisition of food from local resources provides a core emotional and spiritual tie within the community The loss of local resources will negatively alter the lives of individuals, their families and their relationship to their community.</td></tr>
<tr><td colspan="4">Cumulative effects and their significance:
As radiation dose increases the risk of cancer death also increases. The risk of cancer death is about 5% per million µSv for doses received over long period (Puskin & Nelson, 1994, NCRP 1993, NRPB 1993, ICRP 1990).</td></tr>
</table>

<table>
<tr><td colspan="4">Impact factor: Discharges to sea: radioactive material</td></tr>
<tr><td colspan="2">Impact hypothesis:
D1-4: Accidental discharges of radioactive materials will interfere with the indigenous peoples hunting and fishing activities</td><td colspan="2">Rationale for this assessment:
Accidental discharges of radioactive materials can give pollution to areas utilised by local fishing and hunting activities. The effect of this can be directly if the resources are destroyed from the hunting or fishing area, or indirectly if the resources become too polluted to utilise.</td></tr>
<tr><td>Results based on:</td><td>semi-quantitative assessment:</td><td></td><td>qualitative assessment:</td></tr>
</table>

Direct effects and their significance: Local people who live near or visit the contaminated area and/or removal materials from the area will be exposed to radiation either through ingestion of contaminated materials or by direct contact. Radiation exposure of humans can result in chronic and acute effects. At high doses (>1x10^6 μSv), radiation sickness can occur in humans. The risk of cancer death is about 10% per million μSv for doses received rapidly (acute) and might be about half that (5%) for doses received over long period (chronic) (Puskin & Nelson 1994, NCRP 1993, NRPB 1993, ICRP 1990).
Indirect effects and their significance: The subsistence based lifestyle integrates cultural values with hunting, gathering and processing of local resources. The acquisition of subsistence foods provides a core emotional and spiritual tie within the community and links them with the past and present (ANWAP 1997). This relationship extends to relationships of kinship, leadership, survival and hunting prowess between communities as well. The loss of local resources will negatively alter the lives of individuals and communities of indigenous peoples.
Cumulative effects and their significance: As radiation dose increases the risk of cancer death also increases. The risk of cancer death is about 5% per million μSv for doses received over long period (Puskin & Nelson 1994, NCRP 1993, NRPB 1993, ICRP 1990).

Conclusions VEC Human settlement: Human exposure to radiation damage is a potential outcome of sea transport. Therefore plans must be developed to minimise the potential for human exposure and to respond to accidents.
Recommendations VEC Human settlement: ☛ An emergency preparedness and response plan should be developed for specific areas where human exposure is likely to occur, to minimise any exposure after an accident.

4.3.10 VEC Water/land border zone

Impact factor: Discharges to sea: hydrocarbons			
Impact hypothesis: D2-3: Accidental pollution with fuel or certain types of cargo, like hydrocarbons, will cause major disturbances in the coastal zone, and under certain meteorological conditions also in inland areas (evaporation, precipitation).	**Rationale for this assessment:** Accidental pollution from crude and bunker oil in the near-shore area can cause serious damage in the coastal zone, with respect to both physical habitats and biological resources. There can be acute and chronic effects on different resources such as birds, fish and shellfish and other invertebrates (Hayes *et al.* 1992). The presence of oil on beaches can also seriously degrade the aesthetic quality of an area . Oil penetrating deep into the surface of soft-bottom areas in the littoral zone can remain for long time periods, causing chronic problems of recontamination, because degradation processes (microbial and physical) are insignificant in Arctic wave protected locations (Owens 1994).		
Results based on:	semi-quantitative assessment:		qualitative assessment: x
Direct effects and their significance: Low energy backshore areas away from the open coast are the final stranding point of drifting oil. Direct effects to organisms are related to toxicity and physical burying and smothering of animals and plants. The water soluble fraction of the oil will be transported by the vertical water movement through the «layda» zone (see explanation in Larsen *et al* 1995), overlying the permanently frozen soil in large parts of the coastal NSR area. This zone can extend several tens of kilometres inland. These areas are biologically rich, serving as a gathering point and feeding areas for aggregations of animals. The habitats are also nursery areas for larvae and juvenile invertebrate and vertebrate organisms Direct toxicity and burying of organisms are the major direct effects, and are as such responsible for the most significant and immediate impacts. Leaking of accumulated oil from surface pools or subsurface reservoirs is also considered a direct effect in this context, causing significant impact over varying time periods.			

Indirect effects and their significance: Indirect effects of oil contamination in the coastal zone are often related to human effort to remove the oil as well as synergistic effects of combined stresses (see next box). The response and clean-up effort leads to increased traffic, noise and physical disturbance. Particularly overland traffic from mechanical response efforts during summer has serious effects on littoral and soft bottom marsh ecosystems, and causes also a disturbing impact on other VEC, e.g. birds and mammals. Indirect effects to the coastal zone VEC itself are thus limited to effects of vehicles, trucks or boats removing oil, as well as chemical and biological agents, if any are used to facilitate natural degradation processes.
Cumulative effects and their significance: Cumulative effects of oil contamination of the coastal zone are a result of the oil, alternative treatment strategies (dispersion, physical removal) while the option of leaving the oil will cause no cumulative or antagonistic effects, but rather increase the seriousness of the direct effects.

Conclusions VEC Water/land border zone: Coastal habitats, particularly soft-bottom low-energy backshore areas, normally receive much attention in oil spill contingency planning (CONCAWE 1981, IMO 1988, Hayes *et al.* 1992, NOAA 1994, Owens 1994, Canadian Coast Guard 1995, Halls *et al.*, 1997, Owens *et al.* 1998). This is basically because removing oil is difficult in such areas, and leaving the oil will cause long term disturbance to theses biologically rich habitats. Nearshore and shorefast ice compounds the environmental damage and difficulty in responding to oil in these Arctic habitats. A shorefast ice-foot or cracked and porous ice can entrain oil for months (Owens 1996), and nearshore ice flows essentially eliminate wave action necessary for the physical degradation of oil (Dickins *et al.* 1990). The melting of this ice in the spring can release significant quantities of nonweathered oil months after the original spill at the beginning of the most biologically active period of the year.
Recommendations VEC Water/land border zone: ☛ For all the reasons described within this matrix a significant oil spill reaching backshore soft-bottom habitats, especially vegetated marshlike habitats will have effects from significant to devastating. In case of a spill, all efforts should be oriented toward keeping oil from reaching these areas. ☛ This includes several *a priori* activities such as identifying all habitats of this nature (coastal classification), prioritising them in terms of their sensitivity, developing an emergency response plan that can be implemented under most environmental conditions, and having response equipment maintained and ready to act in case of an emergency.

4.3.11 VEC Protected areas

Impact factor: Discharges to sea: general				
Impact hypothesis: E1-2: Accidents in the vicinity to protected areas will come in conflict with Russian legislation, regulations and aim of protection of protected areas.	**Rationale for this assessment:** The protected areas along NSR are per definition at least of national importance. An accident is assumed to be of a medium temporal scale, but can severely affect the marine and shore environment. Consequently the perturbation magnitude is assessed to be large, and the conflicts with Russian legislation, regulations and aim of protection can be large.			
Results based on:	semi-quantitative assessment:		qualitative assessment:	X
Direct effects and their significance: Many of the protected areas also include adjacent marine environment, especially around islands and in straits, and can be severely disturbed by ship accidents. An example is the newly extension of the Lena Nature reserve, which also includes the New Siberian Islands. It is obvious that ship accidents with discharges of for example crude oil in this area will come in serious conflict with the aim of protection of nature reserves: *To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state (CAFF 1994).*				
Indirect effects and their significance:				
Cumulative effects and their significance:				

Impact factor: Discharges to sea: general	
Impact hypothesis: E1-4: Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will reduce the wilderness quality of the areas extensively.	**Rationale for this assessment:** The protected areas along NSR are per definition at least of national importance. An accident is assumed to be of a medium temporal scale, but can severely affect the marine and shore environment. Consequently the perturbation magnitude is assessed to be large.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
One of the purposes to protect areas in this part of the world is because of their undisturbed nature with high wilderness quality. The effects will be comparable with the above hypothesis E1-2: Many of the protected areas also include adjacent marine environment, especially around islands and in straits, and can be severely disturbed by ship accidents. An example is the newly extension of the Lena Nature reserve, which also includes the New Siberian Islands. It is obvious that ship accidents with discharges of for example crude oil in this area will reduce the wilderness quality.

Indirect effects and their significance:

Cumulative effects and their significance:

Impact factor: Discharges to sea: general

Impact hypothesis:	**Rationale for this assessment:**
E1-6: Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will cause extensive damage to populations of VECs in vulnerable seasons.	Valued ecosystem components are often valuable elements in protected areas and special attention must be given to theses species. NSR sailing, especially close to islands and in straits, can consequently disturb key elements in protected areas, for accidents assumed to be on a regional scale. Accidents in vulnerable seasons can have significantly larger effects than in other seasons. In this connection, special attention must be made to marine mammals. The perturbation magnitude of accidents is assumed to be of a large magnitude. This hypothesis is connected with corresponding hypotheses for each of the VECs.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
The effects on the VECs in protected areas as a consequence of extensive discharges will be area and time dependent, and the impacts listed for the selected VECs in this paper will be valid also for protected areas, dependent on the VEC distribution in time and space (cf. the respective sections).

Indirect effects and their significance:

Cumulative effects and their significance:

Impact factor: Releases of oil to limnic and terrestrial environment (oil spill)

Impact hypothesis:	**Rationale for this assessment:**
E1-9: Pipeline accidents will destroy terrestrial, aquatic and marine habitats severely and reduce the environmental quality of protected areas.	Pipeline accidents can affect large areas if the leakage drain into lakes and rivers, but the most likely effects will be on a local to a regional scale. The duration of an oil spill pollution in the Arctic environment is assessed to be of medium to large scale dependent on the effectiveness of an oil spill combat. In a protected area, a pipeline accident of a certain magnitude is assumed to give a large perturbation.

Results based on:	semi-quantitative assessment:		qualitative assessment:	X

Direct effects and their significance:
Accidental oil spills in arctic habitats will generally lead to serious impacts on soil, vegetation, peatlands and fens, lakes and rivers. Protected areas are no exception to this, except for the «higher» value in these areas. Due to the inaccessible nature of many of the protected areas, oil combat may be especially difficult with long time lags. The extent of damage will largely be dependent on a quick combat response. The impacts may last for decades in these areas.

Indirect effects and their significance:

Cumulative effects and their significance:

Conclusions VEC Protected areas:
Accidental discharges to the marine, aquatic or terrestrial environment can severely reduce the quality of the protected areas, and will undoubtedly come in conflict with the aim of protection, and thereby Russian legislation and regulations of the area. Accidental oil spills in arctic terrestrial and aquatic habitats will generally lead to serious impacts on soil, vegetation, peatlands and fens, lakes and rivers, which can take decades to restore. The possibilities for an effective oil spill combat is poor, which will increase the consequences compared to other areas. Other VECs in the area can suffer significantly, especially in the marine environment. The subsistence of the indigenous people will also be threatened. Depending on the accidental location and time, conclusions regarding the other VEC will also be valid here (cf. the respective sections).

Recommendations VEC Protected areas:
☛ «Keep away from protected areas» ☛ Effort should be placed on safety navigation in protected areas with special attention put on high risk areas. ☛ Activity and time specific contingency plans should be established with special attention to protected areas. ☛ Time specific sailing regulations should be established to prevent sailing in areas where vulnerable VECs are distributed (for example breeding, moulting and foraging concentrations of birds, denning and migration areas for polar bears, haul-out sites for walrus). ☛ Depending on each protected area, recommendations regarding the other VEC will also be valid here (cf. the respective sections). ☛ Investigations to what extent accidents will have on the values in focus in the protected areas in different seasons, and how this will come in conflict with the legislation and regulations of the areas. Investigations must be area specific.

4.3.12 VEC Indigenous People

Impact factor: Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo			
Impact hypothesis: F1-5: Accidental pollution from shipwreck affects the habitat of sea mammals and other marine resources causing re-localisation of feeding, breeding, and/or resting areas or decrease of populations, leading to loss of resources for indigenous subsistence		**Rationale for this assessment:** Valid for the Bering Strait and Chukchi Sea as well as rivers and estuaries, and outside the NSR along the Pacific coast of Chukotka and Kamchatka, where this may lead to loss of food resources for indigenous subsistence. Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka, and locally in the estuaries. In other areas, indigenous people are less dependent on marine resources, although minor impacts to subsistence could occur locally.	
Results based on:	semi-quantitative assessment:		qualitative assessment: X
Direct effects and their significance: Long-time loss of sea mammal habitats Local or regional loss of wildlife as a food resource			
Indirect effects and their significance: Local or regional loss of indigenous subsistence for a critical time span Contribution to forced relocation and urbanisation Contribution to forced transition to alternative livelihood and «modern» lifestyle			
Cumulative effects and their significance: *In combination with other impacts:* Development of «Minority syndrome» due to inability to adopt a different lifestyle Increase in health problems Loss of cultural identity (individuals or large groups of indigenous people) In the worst case: Cultural extinction of ethnic groups (tribes or peoples)			

Impact factor: Releases of oil to limnic and terrestrial environment			
Impact hypothesis: F1-10: Pipelines connecting oil fields with northern harbours may have accidental leakage and spills causing local degradation or destruction of subsistence areas.		**Rationale for this assessment:** Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity.	
Results based on:	semi-quantitative assessment:		qualitative assessment: X
Direct effects and their significance: Long-time loss of wildlife habitats, pastures and fishing grounds Local or regional loss of wildlife as a food resource			
Indirect effects and their significance: Local or regional loss of indigenous subsistence for a critical time span Contribution to forced relocation and urbanisation Contribution to forced transition to alternative livelihood and «modern» lifestyle			

Cumulative effects and their significance:
In combination with other impacts:
Development of «Minority syndrome» due to inability to adopt a different lifestyle
Increase in health problems
Loss of cultural identity (individuals or large groups of indigenous people)
In the worst case: Cultural extinction of ethnic groups (tribes or peoples)

Conclusions VEC Indigenous people:
The expected mostly negative impacts on the indigenous peoples' environment are mainly not due to the sea route itself, but due to the expected subsequent industrial and infrastructure development in the Russian North.

The establishment of the NSR in the 1920s made it possible to build up the institutions that physically controlled the North and became the tool for the enforcement of Soviet policies, with all the fundamental social and economic changes they introduced for the entire population of the North, which affected the indigenous societies worst of all.

Since the colonisation of the North, large parts of the indigenous peoples' lands have been gradually converted into areas for alien settlement, transportation routes, industry, forestry, mining and oil production. Their lands and waters have been devastated or polluted, irresponsibly managed and alienated over the heads of their traditional owners and users.

Destruction of the indigenous peoples' environment means destruction of their cultural basis and their social pattern. The result were a large-scale (although not yet complete) social decay of the society, with such well-known symptoms as unemployment, loss of identity, alcoholism, health problems, demographic crisis, etc. Simultaneously achieved benefits like health service, education, etc., are finally broken down almost completely, while traditional ways of life are re-introduced.

There is little hope that an ultimate industrial and infrastructure development will change conditions to the better in the foreseeable future, unless there will be a drastic change in conduct and environmental behaviour of the developers, as well as in the preparedness of all players to involve the indigenous population in decision-making.

Recommendations VEC Indigenous people:
Mitigating measures:

- ☛ **Participation of indigenous peoples:** All industrial and infrastructure development has a price, and indigenous peoples must pay this price voluntarily. All development must pay attention to the fact that the land it occupies has been acquired without ever asking its original inhabitants, and that immense damage already has been done. Having understood this, it turns out clear that the indigenous peoples need to form part of all processes of further development, and their premises need to be viewed and treated on an equal basis.
- ☛ **Compensation for damage already done:** Decision-makers should guarantee that all companies investing in Northern development are to take their share in the environmental and social restoration of the damage caused by the earlier exploitation of the North.
- ☛ **New legislation and law enforcement:** The degree of impact through development in connection with the NSR depends largely on governmental and regional administrative regulations, laws, the establishment of protected areas, agreements with industrial companies, etc. The only way to control development is a new legislation with considerable respect to indigenous land use, and an effective law enforcement.
- ☛ **Establishment of nature reserves:** The establishment of nature reserves in co-operation with the local indigenous societies, guaranteeing that their needs are satisfactorily considered, is another promising approach that has been started, but a significantly wider network of protected areas, and a much better (than presently practised) implementation of environmental regulations is needed.

5. Overall environmental consequences

Chapter 4 *Environmental consequences* had its focus on impact factors and impact hypotheses assessed to give a high potential impact level on the selected environmental components (VECs) given priority in INSROP. This chapter focus on the environmental consequences from different NSR impact factors, direct or indirect, in general and on the VECs. Impact factors resulting in low and medium potential impact levels have also been considered here. Each section starts with a general overview of the main impact factors identified in INSROP, and discusses potential impacts which can arise from these in the NSR area (mainly from Moe & Semanov 1999). Conclusions with emphasis put on the VECs, based on the INSROP EIA assessments ending up with **high PIL indices** (shaded boxes), close each section.

5.1 Emissions to air

5.1.1 General

Ivanov *et al.* (1998a) have recently calculated the emissions to air from transit voyages on the NSR, corresponding to container carriers of about 40,000 t/dw with (diesel) engine power of 21,700 kWh (Table 5.1). Please note that the sea-borne transportation volume on the NSR peaked in 1990 by 6.5 mill. tons. In 1991, the volume declined to about 5 mill. tons, also including transit traffic of 200,000 tons/15 voyages (Mikhailichenko & Ushakov 1993).

Table 5.1. *Estimated emissions of CO_2, NO_x, SO_x in metric tons from simulated transit voyages on the NSR by diesel container carriers (40,000 t/dw). Selected Figures for corresponding emissions by the shipping in and out of the Baltic Sea (1990) and the total national Norwegian sea traffic are given for comparisons. [1]) Ivanov et al. (1998a), [2]) Olendrzynski (1997), [3]) Flugsrud & Rypdal (1996), [4]) Igamberdiev et al. (1995), [5]) AMAP (1997).*

Source of emissions	CO_2	NO_x	SO_x
One voyage [1]	4,700	103	112.6
40 voyages [1]	188,000	4,120	4,504
Baltic Sea 1990 – in and out of the basin [2]	-	1,985,000	1,366,000
National Norwegian sea traffic 1993 [3]	3,400,000	71,800	4,700
Smelter complex, Nikel 1992 [4; 5]	1,467,000	5,268,000	181,000
Smelter complex, Norilsk 1992 [4; 5]	8,478,000	2,280,000	1,100,000

Except for the SO_x, the figures for the NSR are comparingly low. However, for more precise evaluation, the traffic within the NSR should be added. In 1991 more than 250 ships were engaged in cargo operations along the NSR, making a total of more than 900 voyages in the Arctic (Mikhailichenko & Ushakov 1993). Some of the older ships may have more recently been phased out; the current number of ships is reported to be 190 (Ivanov *et al.* 1998b). The within NSR contribution may therefor be significant.

The combustion of fossil fuel by sea-borne transportation and developments on the NSR and adjacent areas adds up to the existing atmospheric load of the region. For sulphur-oxides, which are the major acidifying components in the Arctic, most of the load comes from industrial areas further south (AMAP 1997). There is a general trend of decreasing emissions in North America and Europe, but power generation and smelting remain major sources. Within the Arctic, most smelter emissions come from the Nikel, Zapolyarna and Monchegorsk on the Kola Peninsula and from Norilsk in north-western Siberia. Local energy production is generally a small source because the population is sparse.

Considering the emissions to air from shipboard fuel combustion as one of many sources, although currently at relative limited level, the reporting and documentation of the emissions are still of vital importance; - internationally accepted environmental tolerance levels are based on the overall bulk of emissions, their sources, transport and deposition.

For calculating the emissions from ships, standard methods are developed by Lloyd's register of Shipping (Lloyds Register 1995), and the results are made available to EMEP. A pilot version of a tailored concept for implementation of such calculations with regard to Arctic shipping has been developed within the PAME, both including the data collection and a system for sharing data and results (Moe *et al.* 1996). The IT tool-kit of the concept is harmonised towards the INSROP DEA to obtain maximum synergy of the effort needed to make the system operational. To maintain the good working of international programmes like EMEP, it is strongly recommended that the methods applied and the reporting routines for emissions to air are organised in line with international standards during NSR developments, in order to obtain a reliable basis for analyses, management strategies and decision-making by the relevant executive bodies.

5.1.2 INSROP and assessed emissions to air

Emissions to air from ship traffic along NSR are not considered as an important impact regarding the VECs assessed in the INSROP EIA. Depending on the level of the NSR sailing activity, the emissions to air, however, can be important on a regional, and even local scale, concerning eutrophication, ozon formation and acidification. It is also important in the topic of man-made global emissions to air and the corresponding challenge of climate change. The LRTAP convention will probably be central concerning emissions of So_x and No_x in the future.

5.2 Discharges to sea, ice and land

5.2.1 General

Discharges to sea, ice and land comprise a complex of agents and modes, of which the volumes, fates and environmental significance are difficult to assess in details.

Operational activities

Oil and *oily waste* discharged from *regular shipping operations* has been one of the focal issues of IMO and GESAMP during the last decades. In the most recent estimate (for 1989) fuel oil sludge and machinery-space bilges were identified as the largest single source of oil entering the sea through shipping (253,000 tons, GESAMP 1993). The corresponding discharges from tanker operations add to 159,000 tons, while the contribution from marine terminals and dry-docking was 34,000 tons (all on a global scale). In a small, but densely navigated area as the North Sea, about 2,000 tons of oil have been discharged annually to the sea by operational shipping activity (Anon. 1993).

Both atmospheric deposition (adds up to about 80,000 tons annually, AMAP 1997) and natural oil seeps are major pathways contributing to the load of hydrocarbons in the Arctic. There are currently no specific data indicating the level of direct discharges of oil from regular shipping and other human activities within the Arctic. Except for some sporadic incidents (see the sections of accidental spills), the total input of hydrocarbons to the Arctic marine environment is considered generally low.

Hydrocarbons can however be detected in seawater throughout the Arctic. Except for local pollution in harbours, the highest levels occur just off river mouth. Concentrations in the marine waters of the Russian Arctic are generally much higher than those found in North American Arctic waters (AMAP 1997). One explanation might be differences in analytical technique, but oil pollution carried by the large Russian rivers probably contributes. Many smaller spills and frequent leakages from the poor maintained pipelines of the Russian oil transportation system have proven to cause significant impact on the Siberian tundra and taiga (Pearce 1993).

Over the past decades, the fate of oil in the marine environment has been studied extensively in both qualitative and quantitative details. The ecological impacts are better understood, many effects have been measured and some ecotoxicological patterns have become apparent. Assessing the impacts from discharges of oil by *operational activities*, the spills can be characterised by lesser volumes (commonly in the range of some few litres to a couple of tons) but they occur on a frequent basis (e.g. corresponding to frequent low-level contamination).

According to GESAMP (1989) the definition of low-level contamination need to be considered equally on a case-by-case basis, paying attention to the chemical and toxicological characteristics of the substances of interest. In all aspects, the realisation of impact is a function of the natural physical, oceanographical as well as ecological processes. Based on experienced biological effects and documented impact of low-level oil pollution, the following conclusions can be made with regard to the ***marine environment***:

✓ Ultimately, low-level petrogenic hydrocarbons can rapidly be accumulated by marine organisms, either by transport across cell membranes of skin and gills, and/or by contaminated food (Knutzen *et al.* 1992). Via the blood and lymph system the compounds are transported to different body organs where they can be accumulated at several thousand fold the concentration in the ambient water (Malins & Hodgins 1983).

- ✓ Small species will reach the equilibrium fastest, due to the higher ratio of respiratory surface area to body volume than in larger animals. Equilibrium considerations suggest that the accumulation on wet weight basis will generally be highest for species with a high fat content (Knutzen *et al.* 1992). Applied to Arctic species, where significant fat reserves are built up as energy storage implies that the ability of obtaining higher body burden of petrogenic hydrocarbons are more realistic than in temperate regions.
- ✓ Food as an exposure route may be of importance by increasing the doses of toxicants above the exposure of water, or causing biomagnification in the sense of increasing concentrations with higher levels, and thus endanger top predators. Due to processes in the gastrointestinal tract, higher concentrations of substances can be obtained in the predator than in its prey and in water (Connolly & Pedersen 1988). Obviously, this effect will tend to be more manifest for each step in the food web, and will be most evident in top predators.
- ✓ In general, uptake from food plays increasing relative role with increasing size of animals and for each higher trophic level. Consequently, food will usually be the predominant source of contaminants in top predators (Knutzen *et al.* 1992). The accumulation rates however, tend to be balanced towards the elimination of the substances and its derivatives. Relatively high rate of metabolism is common for most petroleum hydrocarbons, and when no longer exposed, the tissues are depurated within weeks or month (Niimi & Palazzo 1986, Knutzen 1989, Knutzen *et al.* 1992). The specific half-life values vary between compounds and organisms.

In terms of regular discharges however, the chronic exposure and uptake will be balanced towards the species depuration capacity. As most marine organisms tend to be migratory, or passively drifting with the predominant current, the environmental vulnerability are assumed to be most pronounced on a local to regional basis, e.g. within front systems, gyres and upwelling areas, where the oceanographical conditions facilitates aggregation of marine organisms at several trophic levels. This is highly relevant for the ice-edge and the polynyas of the NSR, which provides an efficient system to capture and accumulate many fat-soluble compounds in top predators because the primary and secondary production are rapidly and effectively accumulated and transferred, to a large degree in form of lipids, to higher levels in the food web (Falk-Petersen *et al.* 1990, Macdonald & Bewers 1996).

The *antifouling paints* which are employed at present hold active components with a high degree of toxicity to marine organisms. These biocides will diffuse to the water masses in very small concentration. But the degradation is slow and they still impose a pronounced risk to the marine environment. The best-documented effects are those of organo-tin compounds, e.g. TBT, to molluscs. In the North Sea some mollusc populations show severe impact, including induction of male sex characters in females, known as «imposex». This is believed to be a widespread phenomenon (Ellis & Pattisina 1990) and has been observed both on Svalbard and along the Norwegian coast (Berge 1997).

The main source for introduction of TBT to the marine environment today is through the use of antifouling paint. Tailored algorithms have been integrated in the INSROP GIS to estimate the release volumes for given ships (wetted surface), speed and length of route. Rough estimates indicate a release of about 0.6 kg antifouling paint per day from a ship with 15,000 m^3 wetted surface (60.000 Dw/t) at a speed of 12 knots. The corresponding releases of TBT may easily applied if the portion of these components in the paint is known. The concentration levels found in sediments from harbours and in mussels, and the effect in some mollusc species, clearly gives cause for further concern about other effects from TBT pollution and more widespread damage to other species. The extent of this problem, e.g. in the ports, harbours and shipyards of NSR, is unknown. It is highly recommended that the use of antifouling paint containing TBT should be restricted in the NSR, and that the current status should be surveyed.

The introduction of *alien species* by shipping (either through ballast water discharges or attached to the hull) is a well known phenomenon world-wide. This threat is most pronounced in semi-enclosed waters, and significant biotic changes have been observed in the waters of the Black and the Caspian Sea due to the artificial (human) introduction of some lower trophic level species. In ecological context, there are similarities between such semi-enclosed water and the NSR. The niches are few and occupied by species, which makes the Arctic sensitive to introduction of alien species. The debatable question is rather if the species introduced are able to adapt to the harsh environmental conditions of the NSR. The introduction of alien species is addressed in the INSROP EIA, and reference is given to the IMO recommendations to the member countries to map the existing or potential problems that these introductions may cause. In 1991 IMO also published some guidelines for preventing the introduction of unwanted aquatic organisms (and pathogens from ship's ballast water). It is highly recommended that ships in transcontinental traffic on the NSR comply with the mandatory guidelines.

The relevance of offshore, open water organisms maintaining a state of chronic stress provided by regular, low-level oil discharges from ships seems not likely due to the degradation and rapid dilution of the discharges. The scheme above however, is evident for sheltered waters in the vicinity of *harbours and terminal facilities.* These are the most polluted marine environment, in general exposed to chronic, low-level contamination of hydrocarbons and other organic pollutants, heavy metals etc. Run-off and seeps from the industry, landfills and waste storage facilities are experienced to be among the sources of significance. The seaports of the NSR, where the waste storage facilities are insufficient or poorly maintained, are no exception.

The INSROP EIA and ESSN address these aspects, also including the discharges from offshore petroleum activity. The perturbation magnitude is considered moderate in the productive areas of the polynyas and ice-front systems, while moderate to large perturbation is considered for the sheltered waters of harbour facilities.

The ESSN regulations pertaining regular discharges from ships, ship generated waste and shore reception facilities (Semanov *et al.* 1996a, b), also include recommendations on pollution preventing measures for *garbage, waste and sewage*, e.g. other types of waste regularly discharged overboard during ship operations. Discharge from ships is major source of littered shores, and NSR is no exception. Observations confirm the shore as accumulation and 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 the shoreline in a range of more than 4,000 km (Vilchek *et al.* 1996). In perspectives of both current and future activity on the NSR, the implementation of the regulations is highly recommended. Improving the shore reception facilities should be emphasised. At present however, getting compliance with the existing legal instruments appears more important than developing new ones.

In northern Russia, the ***terrestrial environment*** in the areas of petroleum activities is known to suffer significant to oil contamination in terms of numerous smaller and larger spills. It is suggested that up to 10 per cent of western Siberia's oil leaks from pipelines. Land-based wells use similar drilling muds as offshore drilling activities, but different methods of waste disposal. Used muds and sand are often dumped into sumps, or dumped directly into landscape depressions rather than into specially constructed dumps, resulting in environmental damage to larger areas. In the Noyabr'sk district alone, there are some 12,000 oil wells on several thousand separate drilling pads, each pad containing an estimated 50,000 tons of sand (Pearce 1993). The cumulative environmental impact of these releases has proven to be significant in the western Siberia. Primitive drilling technology and poor pipeline maintenance, in addition to the absence of conservation management strategies, have been blamed for the situation.

As for the physical disturbance, the link to sea-borne transportation of oil and gas on the NSR is obvious. In addition to the plans for new pipelines and coastal loading facilities, the rivers are transport media for smaller vessel and barges, as well as for the water-borne pollution from the oil fields. 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 annually only in the Tyumen' North-Komi Republic. Surveys in the oil producing areas of western Siberia, concluded that the real pollution problem may not be surface pollution, but oil and oil contaminated run-off getting into underground water, from where it disperse widely into lakes, swamps and rivers (Pearce 1993). The degradation rates in the Arctic are slow compared to temperate regions, and once entered into the swamps, the oil pollution my persist for decades.

Accidents

Accidental oil spills are considered to pose the largest oil pollution threat to the Arctic (AMAP 1997); - even if large spills are rare, the massive oil contamination can be devastating to the environment. So far, significant spills from the shipping on the NSR are not reported (EPPR 1997). In the **marine environment**, experiences from historical spills in temperate and cold climate have shown that most marine organisms have the ability to be exposed to oil released to the sea. The fate of oil spill at sea can theoretically be calculated by oil drift statistics. See Figure 5.1 for an example from the NSR area. The significance of oil in the marine environment however, varies from species to species and between different organisation levels. In this conflict matrix, the weathering processes have shown to be of vital importance to the exposure and the response of organisms:

✓ Oil is a mixture of hundreds of individual chemical compounds, and released to the sea, oil will immediately undergo a series of changes as a result of physical, chemical and biological processes. In the Arctic, with low temperatures, long periods with no light and seasonal nutrient deficiency, the degradation of oil is assumed to last longer than in temperate regions (Engelhardt 1985, Boesch & Rabelais 1987, Sakshaug *et al.* 1992). Consequently, the Arctic environment is exposed to «fresh» oil, generally assumed to be more toxic than degraded oil, comparatively for longer time periods and over wider distances.

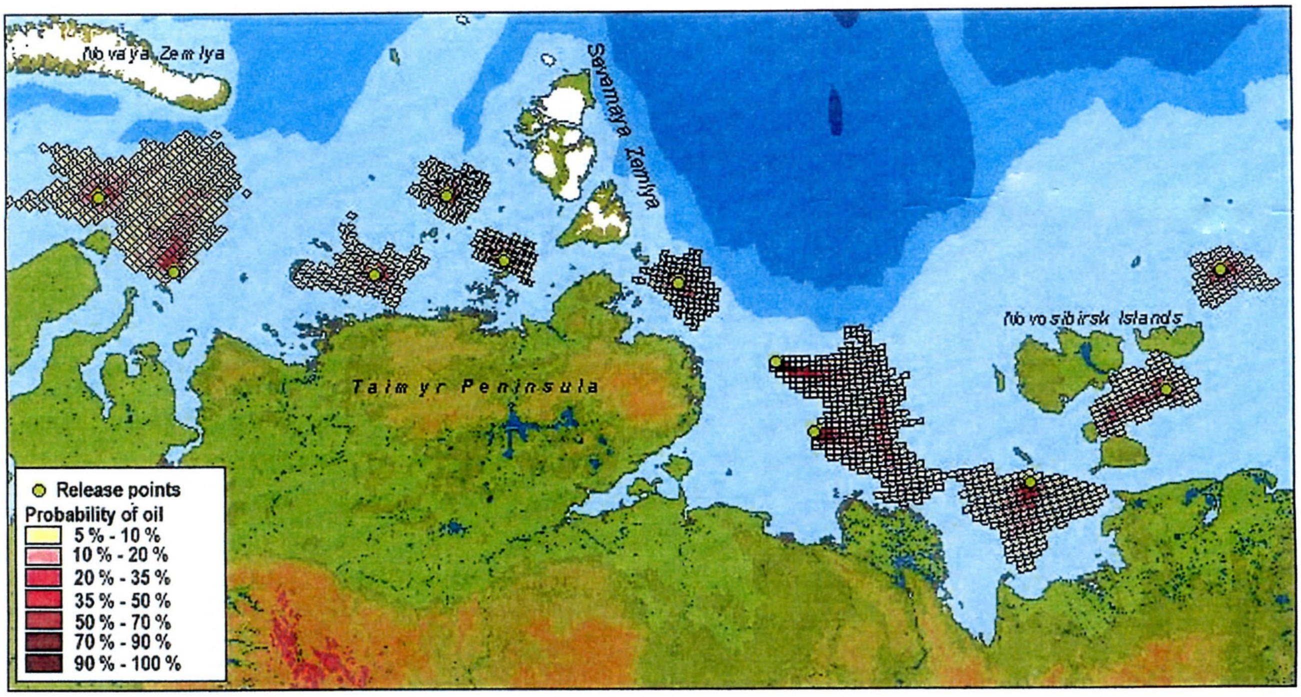

Figure 5.1. Probability for oil contamination for different accidental oil drift scenarios along in the Kara Sea and the Laptev Sea (after Vefsnmo 1998). The discharge positions are randomly selected.

- ✓ Compared to open water releases of oil, the fate of oil in ice-infested waters are somewhat skewed. The oil can be pumped under the ice, «entrapped» in polynyas, or washed onto the ice. Below the ice, the oil can concentrate in ice structures or is encapsulated, forming oil pools that are later released as the ice drifts, melts, or break up. On the ice, oil can be absorbed by snow and transported as slush by wind over longer distances. The degradation of oil in ice is slow, and consequently, the «oil-in-ice» can be transported over wide distances.
- ✓ The shore forms the transition zone between the marine and terrestrial environment, and has shown to be the most exposed to surface oil spills under normal weather conditions. When oil settles on the shore, some parts of the oil tend to accumulate, while other parts re-enter the water Table and will be re-distributed by the next wave. The cycle continues as the oil settles on to the substrate surface and deeper layers of sediments. After an initial phase, the oil will be stabilised in an amount corresponding to the type, age and volume of oil in combination with the current-, tide- and wind forces and the beach's «carrying capacity» of oil. The latter is primarily a function of shore morphology, topography and substrate. Once buried into the sediment, the gradual leakage of oil may be a source of chronic stress for decades.

Historical spills have shown that nearly all ecosystem components are affected by large-scale releases of oil. In the INSROP EIA, relevant issues are addressed and the possible impact qualitatively and semi-quantitatively assessed at VEC level.

The **terrestrial environment** has proven to suffer significantly by heavy oil pollution. Even poorly reported, the many small and larger spills in the west Siberia (cf. Sagers 1994, Zoltai & Kershaw 1995, Vilchek *et al.* 1996), is believed to have posed deleterious impact on soil and vegetation, peatlands and fens, lakes and ponds, as well as regional waterways and rivers. The environmental conditions such as poor drainage, dense forest cover, large spring runoff etc., are considered hindrances to oil spill prevention and quick response. Combined with the nature of the oil, in terms of slow degradation, the oil may be spread over large areas and the environmental damage may not recover within decades.

AMAP (1997) concluded that over much of the Arctic, the levels of persistent organic pollutants (POPs) cannot be related to known use and/or releases from potential sources within the Arctic and can only be explained by long-range transport in the atmosphere or by ocean currents. Sources within the Arctic for organochlorine pesticides (e.g. HCH), industrial chemicals (e.g. PCBs) and anthropogenic combustion products (e.g. chlorinated dioxins etc.) are known, but the fate and significance of all contributions are yet not fully understood. In ecological perspective, there is an obvious link between these pollutants and industrial developments in the NSR area, and consequently, an indirect link to the NSR shipping. The shipping itself however is a marginal contributor to this kind of pollution, and if the transportation pattern does not change significantly in the future, the environmental interactions are not considered a focal issue of pure NSR activity. Besides, the nature of this pollution calls for international concerns and action, and AMAP is regarded the dedicated forum for such studies and assessments. Consequently, these topics were recognised to beyond the scope of detailed assessment in the INSROP EIA.

The same applies to *radioactive losses and releases*. In north-western Russia, there exist a high concentration of radioactive sources, and these sources represent a potential for release of considerable quantities of radionuclides. The environmental risk of these sources have been a focal issue of international research and assessment programmes such as AMAP and ANWAP, and significant effort has been placed on mapping the current status, e.g. identification of sources and levels of contamination, combined with estimations of the risk in the short and the long term. So far, AMAP (1997) has concluded those local sources of radionuclides, such as dumped nuclear waste, nuclear storage sites, accidents and past explosions, have led to local radioactive contamination. The environmental risk however is increasing with the increasing age of the storage facilities, and the dumping and storage sites should be subjected to regular monitoring in line with international accepted methods and quality standards.

With regard to the NSR shipping, which also include the activity of 7 dedicated nuclear icebreakers, there is an obvious – but considered very low risk of nuclear accidents (Pravdin *et al.* 1998). Recent documented cases of near-accidents because of the breakdown of technical equipment, man-induced failures and insignificant compliance with safety routines have shown that there is no guarantee for optimal maintenance and safety in Russia today. Consequently, when «human errors» enter the conflict matrix, the environmental risk is more or less impredictible. In any ways, the operation of nuclear ice-breakers (as well as other nuclear-powered vessels) on the NSR should be monitored in line with the legal instruments in place; e.g. in terms of compliance with the international conventions and programmes dealing with nuclear power generation, processing and waste deposition (cf. the International Atomic Energy Association; the London Dumping Convention etc.). This is also the case for the about 130 lighthouses run by radionuclear thermoelectric generators as well as nuclear power plants, enterprises and institutions using radioactive sources. The potential for accidental release of radioactive material and of corresponding environmental impacts is a significant concern in the Arctic.

5.2.2 INSROP and assessed discharges to sea, ice and land

Based on case histories and results of the INSROP EIA, selected results and conclusions are outlined below.

Shallow water communities. It is evident that shallow water environments have been subjected to severe impact by oil spills elsewhere. In worst case, when heavily contaminated with fresh and toxic oil, which is likely in the Arctic, local shallow water benthic communities can be totally eroded, with nearly no single species left.

Arctic shallow water communities however are poorly developed due to ice scouring, but oil buried in sediments can be a chronic stress factor to the sublittoral species. If areas with unstable sediments are contaminated, secondary transport may result in corresponding contamination of adjacent areas. At intertidal and subtidal sites heavily contaminated by the spills of «Florida» and «Arrow», oil residues persisted in the sediments for 20 years (Teal *et al.* 1992, Vandermeulen & Singh 1994). The interstitial oil continued to be remobilized during the two decades, and appeared to induce stress in the local resident fish fauna even after 20 years (Teal *et al.* 1992).

Based on the scheme for the fate of oil and a method tailored for semi-quantitative analysis of shoreline sensitivity using GIS (Moe *et al.* 1998), sensitivity maps indicating the penetration, accumulation and retention potential of the NSR shoreline can be made (Figure 5.2). The approach has been developed for the shore at Svalbard, and is much in line with corresponding sensitivity mapping and oil spill response planning systems in the United States and Canada (Harper *et al.* 1992, O'Brien *et al.* 1995, Owens & Dewis 1995). In the INSROP DEA however, the information are combined with data on other ecosystem components providing the basis for more complete analyses of the impact potential.

VEC Benthic invertebrates:
Operational: The present knowledge leaves little doubt that sensitive species of the large and heterogeneous VEC «benthic invertebrates» are at risk of being significantly affected by the continuos release of TBT from anti fouling paints. The extent and the ecological significance is however difficult to quantify. However, the impact of TBT on invertebrates is very unlikely surpassed by any other operational discharge, emission or release form operational ships traffic in the NSR.
Accidental: Based on the links between benthic and pelagic organisms in marine food webs the loss of benthic organisms will impact whole ecosystems. The potential loss, due to accidental releases of radioactivity, of this critical ecosystem component must be avoided in order to maintain the present use of the ocean as a food resource for organisms at the top of the food web, including humans.

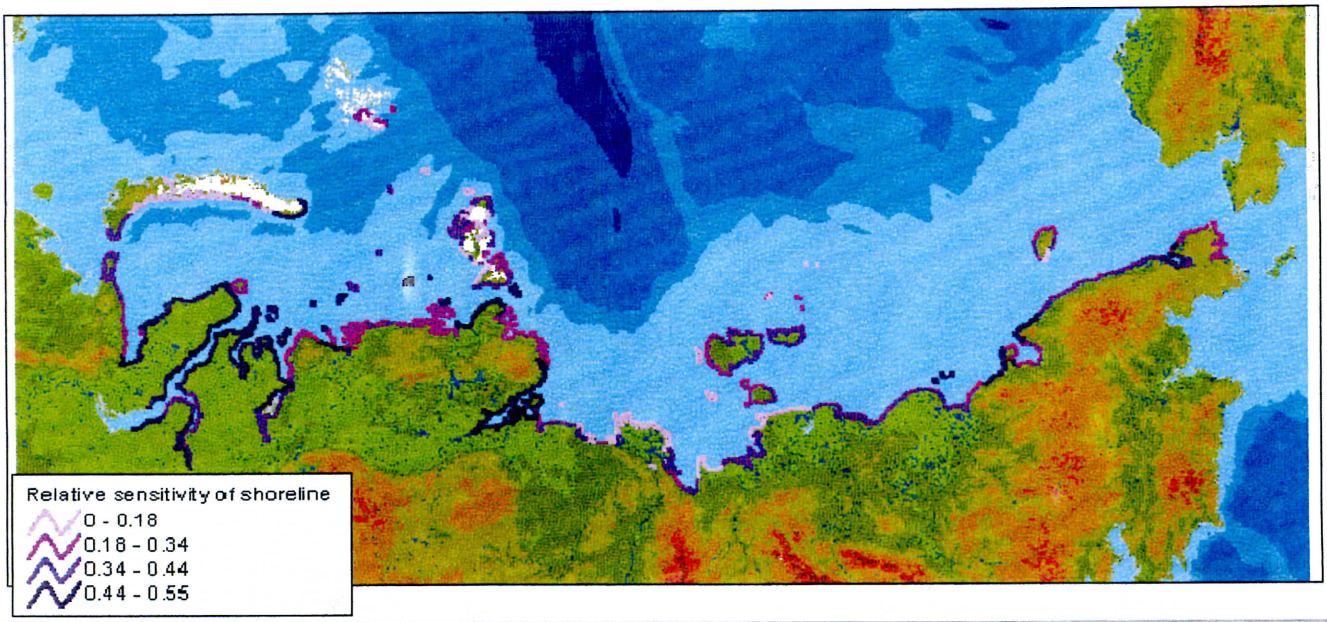

Figure 5.2. Shoreline sensitivity; based interaction of oil and sediment. The relative sensitivity indicates the shore's accumulation potential and retention capacity of oil. The analysis is based on data in the DEA (Larsen et al 1998a) and tailored GIS applications (Moe et al. 1998).

Plankton communities – ice edge dynamics. Experience from oil spills indicates that oil spills can have transitory effects on plankton at the site of contamination. The plankton communities at the ice-edge however, differ significantly from those in open waters. The spatial distribution in the earlier phase of the bloom is limited to the ice-edge, where aggregations of significant density are formed. In case of oil perturbation in areas of high abundance, the number of organisms exposed can be high. The presence of ice may be compared to shoreline attributes with regard to oil accumulation and organism exposure. In such habitats the lower trophic level species, especially the smaller crustaceans (like e.g. copepods), are among the species most heavily affected in historical oil spill incidents (Teal & Howarth 1984).

Correspondingly, the match between different trophic levels can be interfered, and indirect effects on the higher trophic levels may be the ultimate result. If the ice-edge is heavily contaminated by oil, the whole range of effects is likely to occur; from sublethal effects, bioaccumulation and biomagnification at each organisational level - to acute mortality at lower organisational levels and mis-match and reduced survival at higher trophic levels. All ecosystem levels may be influenced. *This conclusion applies to «regional» geographical areas, the Arctic ice-edge ecosystem as whole is not threatened by a single oil spill.*

Fish. Several studies have shown that the fish eggs and larvae are the most susceptible to any kind of pollution. The results however show large variations in sensitivity for different species and different types and weathering stages of oil (Malins & Hodgins 1983, Capuzzo 1987). The water-soluble fraction of the oil (WSF) is considered the most toxic to fish. The concentrations of WSF however is rapidly decreasing with depth, leaving a limited part of the water column contaminated by WSF above the tolerance levels. Taken into consideration the relative large spawning areas of most marine fish species and a correspondingly low number of eggs and larvae exposed to harmful concentrations, a perturbation magnitude at population level are not likely. *Extensive spawning over limited areas, as the ice-edge, polynyas and river estuaries, are exceptions of this assumption.*

Later developmental stages, i.e. juvenile and adult fish, tend to be more resistant and less vulnerable to oil pollution. Additionally, adult fish are able to detect and may escape from oil contaminated water even at very low oil concentrations (Boehle 1986). With the exception of the «Amoco Cadiz» incident, significant mortality in marine fish stocks caused by oil spills has not been observed (cf. review in Teal & Howarth 1984, Spies 1987, Moe *et al.* 1993). Pink salmon was significantly affected in the Prince Williams Sound during the «Exxon Valdez» spill, confirming the vulnerability of the river estuaries to oil.

VEC Marine, estuarine and anadromous fish:
Accidental: The potential loss of fish nursery grounds and other ecosystem components due to accidental releases of radioactivity will have widespread impact not only on local resources but in open ocean areas of fish migration and in active fisheries resource areas. These ocean resources and the link between coastal and offshore ocean resources must be protected to maintain the functioning of the ocean ecosystem and for the continued use of the ocean as a food resource for humans.

Birds. It is evident that birds, and especially those spending most of their time at sea (e.g. the seabirds), are most vulnerable to surface oil spills. The birds may be affected in several ways, but oil fouling is probably the critical factor. When the plumage is clogged by oil, the insulation capacity is significantly reduced and the bird may suffer to death from thermal stress. The baseline information on the distribution of vulnerable species in time and space is critical when assessing impacts in this context. Figure 5.3 shows an example from the INSROP DEA on the distribution of Brunnichs Guillemot (Brude *et al.* 1998).

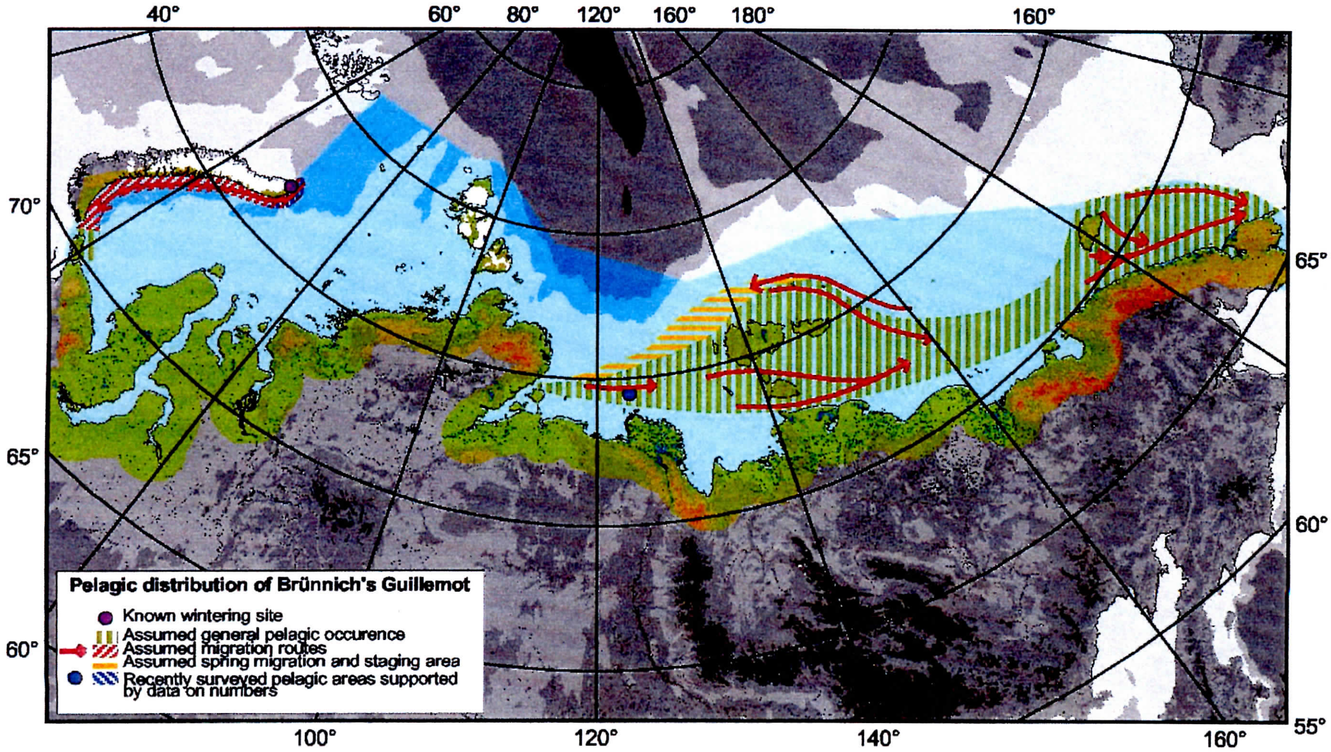

Figure 5.3. Pelagic distribution of Brunnichs Guillemot in the NSR area (non investigated areas in gray shade). After Brude et al. (1998).

The impacts of oil spills on birds are well documented for a number of specific incidents (Clark 1984, Anker-Nilssen *et al.* 1988, Piatt *et al.* 1990, Heinmann 1993, Moe *et al.* 1993). Auks, but also Eider, Steller's Eider, Long-Tailed Duck and Razorbill are commonly among the victims. Evidence of correlation between amount of damage and amount of oil has not been established for seabirds; - even small spills can cause heavy mortality. The reason for this is assumed to be the significant fluctuations in the seasonal distribution, and species-specific feeding, behaviour and reproductive patterns. Given the distribution of bird species in time and space it is possible to assess the potential impacts by calculating Potential Impact Level (PIL indices), for example in the breeding season (Figure 5.4).

The fate of surface oil is addressed by the INSROP Sub-programme I (Vefsnmo & Løvås *in prep.*) in terms of calculating the drift and spreading of oil in selected areas of the NSR. In the INSROP EIA, the results of the calculations are used to indicate the likely impact and environmental risk.

Combining the distribution of a single species at a certain time period with oil drift statistics, semi-quantitative measures of likely impact in terms of *the temporal and spatial co-occurrence of seabirds and oil* can be indicated. The scheme for oil spills in the Kara Sea (Vefsnmo & Løvås *in prep.*) and breeding colonies of Brunnich's Guillemot shows a probability of about 6-24% for overlap between surface oil from spills in the central Kara Sea and the breeding colony at northern Novaya Zemlya. This site is the only breeding colony of Brunnich's Guillemot in the region, a factor that reduces the recovery potential of the species. The vulnerability score is correspondingly increased (cf. Gavrilo *et al.* 1998a) and significant impact is likely if oil strikes these waters during the breeding period.

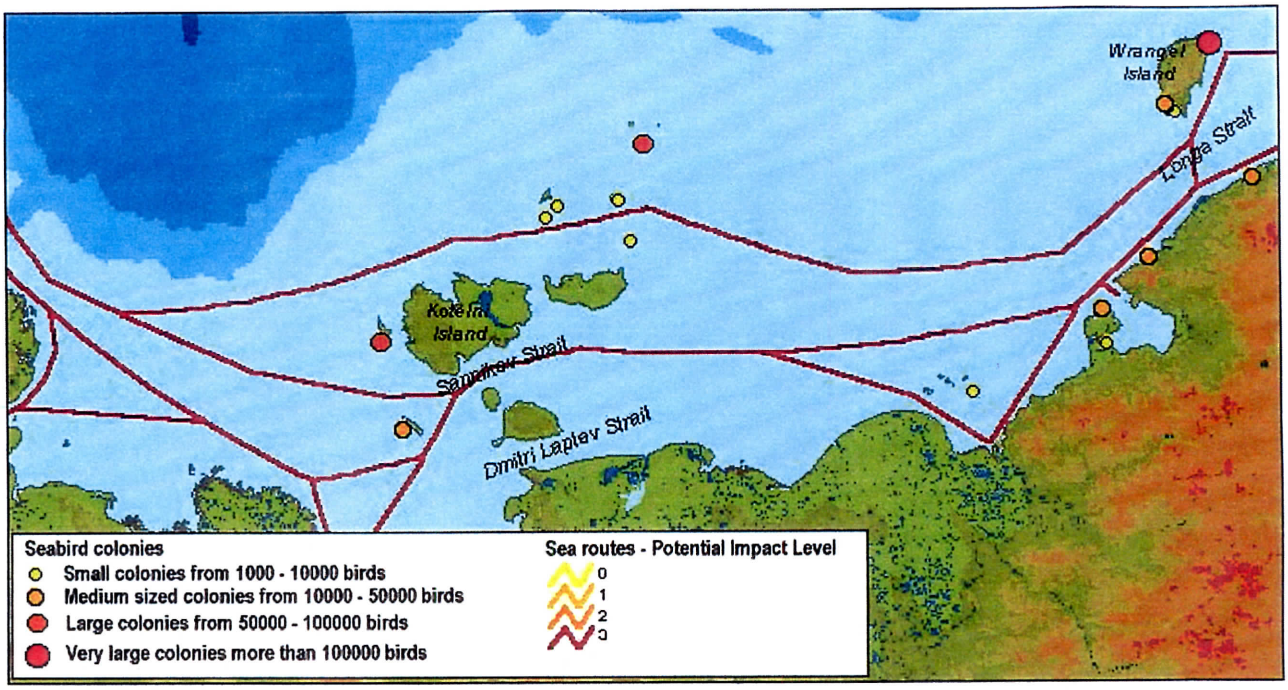

Figure 5.4. Distribution of seabird colonies in the eastern part of the NSR area, and potential impact level for accidental discharge of oil along the sea routes.

VEC Seabirds:
Accidental: There is no doubt that oil contamination can kill large numbers of seabirds. This threat is recognised as one the most serious for seabirds along the NSR-area.

VEC Marine wildfowl:
Operational: Of the impact factors concerning NSR operational traffic both chemicals and minerals discharged into the sea are a serious threat to marine wildfowl. In addition, hunting may have a significant negative effect in the vicinity of settlements. Russia has quite strict regulations for hunting and egg harvesting, but by experience it is known that a lot of illegal hunting is occurring.
Accidental: The oil spill threat is recognised as one the most serious for marine wildfowl along the NSR-area. An oil spill along the NSR in the summer season, particularly in the moulting period, may kill a great numbers of marine wildfowl and have serious effects on the populations. Being the most marine of the relevant species, the eiders will be the ones that are most likely to come in contact with oil on the sea. Among the geese, Barnacle and Emperor Geese are the most vulnerable species. They will be particularly vulnerable in the chick and moulting periods, when they stay a great deal in the littoral zone. Oiled Emperor Geese have for instance been observed in the Aleutian Islands (Petersen *et al.* 1994). See Gavrilo *et al.* (1998a) for a more detailed assessment of the vulnerability of marine wildfowl to oil.

In addition, chemicals and minerals discharged into the sea are a serious threat to marine wildfowl.

VEC Waders in resting and feeding areas:
Operational and accidental:: Chemicals and minerals from operational traffic and accidental events discharged into the sea are recognised as a serious threat to waders in feeding and resting areas.

Marine mammals. Polar bears, seals and whales can be affected by large oil spills directly by fouling of oil, inhalation of toxic hydrocarbons and ingestion of oil, and indirectly by adverse effects on prey species or habitats important to those species. Wiig *et al.* (1996) have formulated a series of relevant IHs based on the current knowledge and understanding of this issue.

<u>Polar bears.</u> Laboratory studies have shown that polar bears may suffer to death if fouled by oil. Fortunately, there are no relevant case histories of such events. Polar bears however live in close contact with the sea, they tend to

stay on the ice edge, along leads or in drift ice, and often enter the water and migrate over vast areas (Figure 5.5). These factors imply that oil fouling is much likely. For a solitaire species like the Polar bear, one question is rather to indicate a reasonable number of individuals that can be affected; e.g. «present» in the influence area of a single spill. Given the distribution pattern of the Polar bear (Belikov *et al.* 1998a, b), impact on the pollution level seems not very likely. On the other hand, the Polar bear is considered a symbol of the Arctic, and the perceived effects of single fouled and dead polar may very evolve into a symbol of the overall environmental threat and damage.

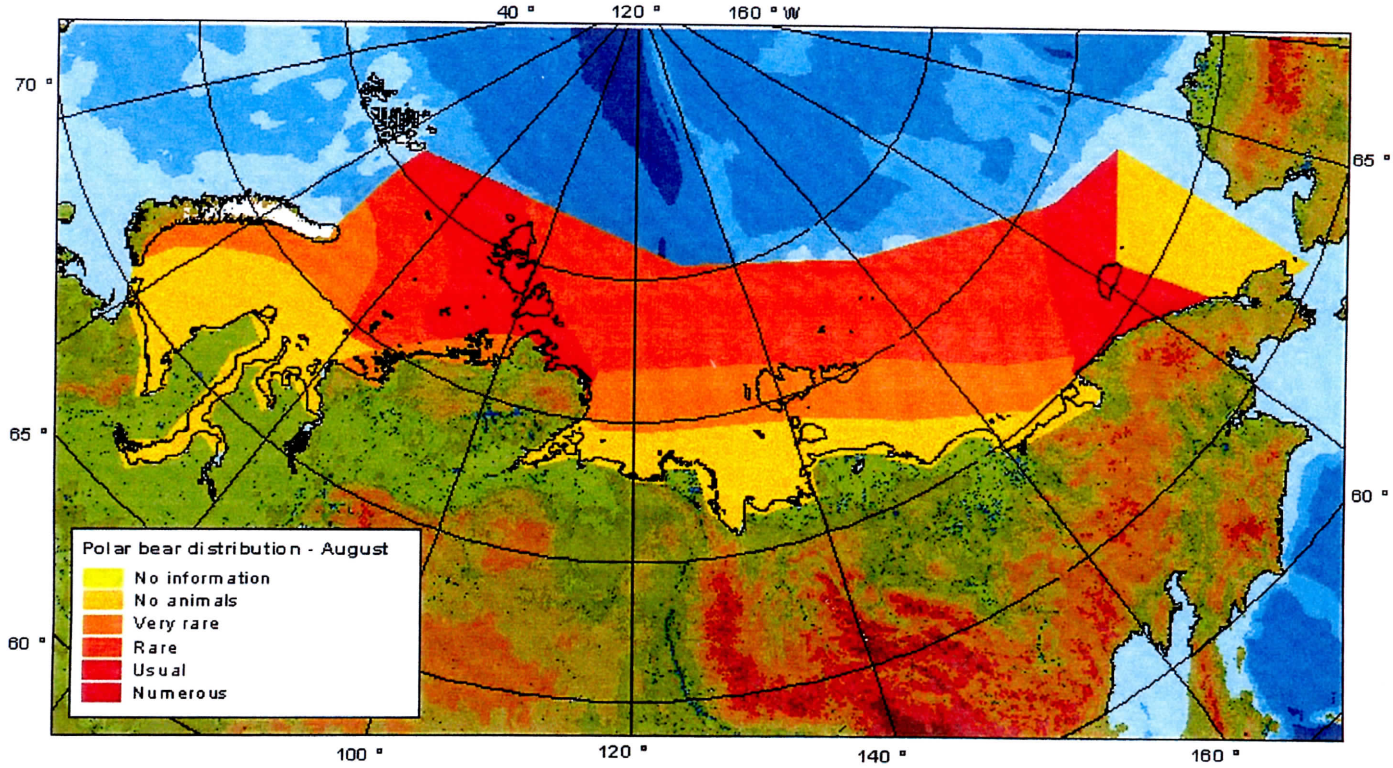

Figure 5.5. Distribution of Polar bear in the NSR area in August (after Brude et al. 1998).

VEC Polar bear:
Operational: Polar bears are vulnerable to long term pollution of the marine ecosystem and may be vulnerable to long term disturbance especially in denning areas like the Wrangel island.
Accidental: Polar bears are very vulnerable for oil pollution. Bears that are hit by oil will probably die. It is the adult females that are specially important for the populations since it is them that bear the young.

<u>Seals.</u> Both laboratory and field data strongly indicate that seals are vulnerable to acute oil pollution. Existing world-wide data on the impact of oil pollution to seals and seal populations however, indicate limited impact at the population level (St. Aubin 1990). Reported casualties are in general very low. However, monitoring studies during and after major oil spill incidents are in general limited and the quality of the data is therefore poor. An exception to this is the «Exxon Valdez» incident, where harbour seals were exposed to relatively fresh oil and significant mortality is reported (Frost *et al.* 1994).

Of the NSR species, *walrus* is probably among the most vulnerable species. The animals aggregate in shore areas and in open areas on the drift ice in large numbers (Figure 5.6), and may easily suffer if their habitats are affected by oil (Figure 5.7).

VEC Walrus:
Operational: It has been documented that the walrus may avoid a specific area, and that mortality, especially with calves, may increase because of disturbances.
Accidental: If walruses do not avoid oil spills, they may quite easily suffer if their habitats are affected by oil. This is especially trough do to their gregarious behaviour. At haul-out sites big flocks can be frightened an rush to the sea in a panic way. Many individuals, especially young animals might be killed. Continuous disturbance of important sites might frighten the walruses away from important areas.

Figure 5.6. Distribution of Walrus in the NSR area in June.

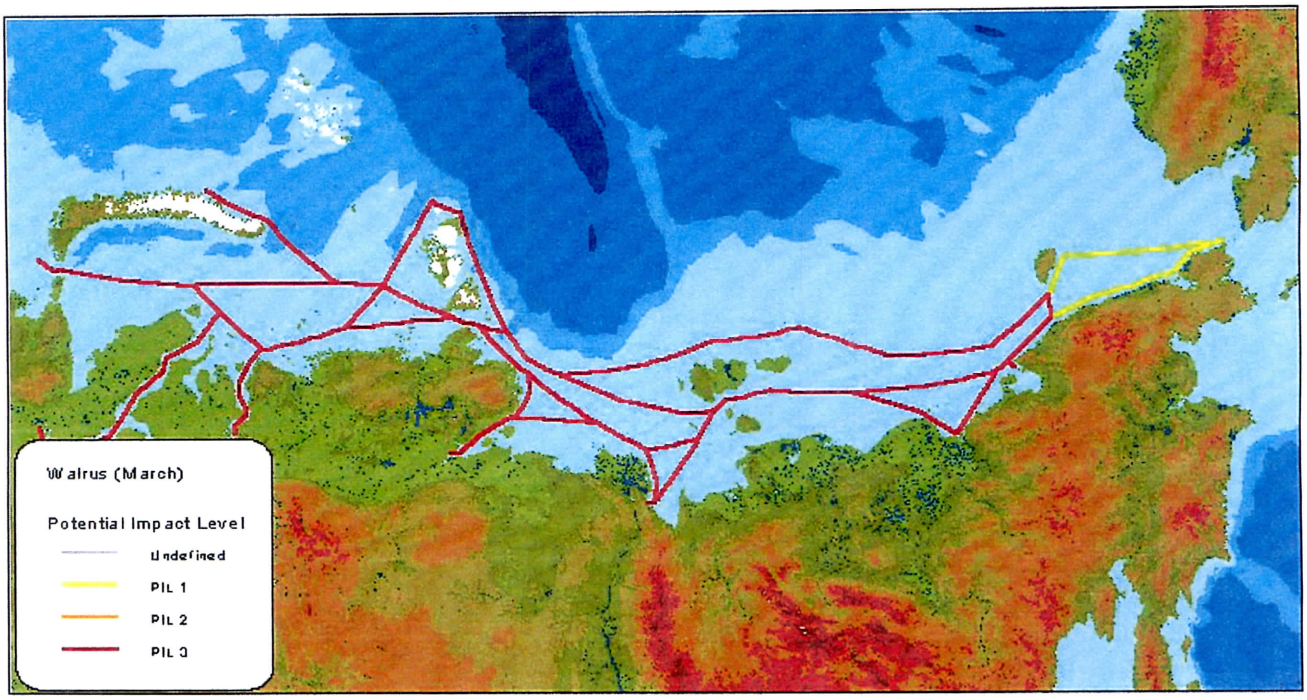

Figure 5.7. Walrus potential impact levels for accidental discharge of oil in the NSR area in March.

Whales. Except for the «Exxon Valdez» incident, reliable case histories on oil spill impact on whales are generally poor. In the Prince William's Sound however, 14 individually known killer whales were reported as missing. Although there was a temporal and spatial correlation between the missing whales, no clear cause-and-effect relationship could be documented (Dalheim & Matkin 1994). Similarly, effects on Humpback whales could not be scientifically proven (Ziegesar *et al.* 1994). The indices reported however, do not eliminate impact on whales in the NSR in case of large oil spills. In this regard, heavy oil contamination of estuaries, polynyas and at the ice edge, is considered a worst case.

VEC White whales:
Oiling in estuaries and at the ice edge might be a risky for white whales due to their gregarious behaviour. Estuaries are especially important in this respect, since huge flocks can be found there during the moulting period in summer, and because these habitats probably are important when the whales give birth and the neonates spend their first few months.

Human settlement (indigenous people are treated as a separate issue). Various pollutants are the main source of impact factors giving direct effects on human settlements from ship traffic along NSR. In the INSROP EIA only radioactive accidental discharges are assessed to give high potential impacts.

In addition, any release of *minerals* in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), transported in bulk. Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented. In case of a grounding, however, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pellets will change the substrate granulometry, but this impact is considered local, and thus of limited significance at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high concentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assessed based on releases of fuel e.g. diesel or bunker oil.

Accidental discharges of *fertilisers* will locally give an increase in nutrients to the water masses. In the surrounding areas there might be toxic effects to marine and anadromous fishes. Another effect is the release of nutrients which might give higher production of primary producers in the area, depending on the type of fertiliser. High production of algae can under some circumstances give a depletion and lack of oxygen both in the water masses and in the bottom sediment (eutrofication). Locally there can be a change in the balance between the nutrients required for primary production, and other species of phytoplankton compared to a «normal situation» can be favoured (e. e. toxic algae). Russian fertiliser industry and potential cargo segment for the NSR are addressed by Isakov et al. (1999).

Accidental *discharges of hydrocarbons* are assessed to give a medium impact on human settlements, except for indigenous people, and can give pollution to different resources utilised by local people. This can be directly when the resources are too polluted to use as food, or the resource is removed from the area where it is utilised. Another effect can be on resources for export.

The most serious consequences for human settlements are assessed to arise from accidental discharges of *radioactive materials*, which can pollute areas utilised for local fishing and hunting activities. The effect of this can be directly if the resources are destroyed from the hunting or fishing area, or indirectly if the resources become too polluted to utilise. Depending on the type and amount of the radioactive materials, local people might have to move from an area, and the possibility to utilise resources can be blocked.

VEC Human settlement:
Human exposure to radiation damage is an undesirable outcome of sea transport. Therefore plans must be developed to minimise the potential for human exposure and to respond to accidents.

Water/land border zone. Following an operational traffic along NSR, the construction of harbour facilities (land filling etc.) can cause major local changes in the coastal zone. This can be through local changed current systems which again can change the surrounding land areas (Hachmeister *et al.* 1991). Landfills might also affect the ice conditions with earlier freeze-up in the fall and later break up in the spring (Hachmeister *et al.* 1991). Changes in sea ice and oceanographic conditions also affect migrating and feeding habitat of anadromous fishes during the summer open-water feeding. Such effects may in turn lead to changes in the dynamics of the fish populations (Hachmeister *et al.* 1991). A habitat change will occur with dumping of stones and sand in the sea, with a change in the surrounding sediment picture, probably covering larger areas.

Garbage and litter will locally cause aesthetic disturbance. Many types of garbage and litter (plastic) need a long time to decompose, and will remain in the coastal zone for a long time. During the decomposition, the plastic constituents will continuously be released to the environment. Some types of waste or cargo (e. g. timber) will extensively change the natural wave processes on the beaches, and thus influence the sediment transport and sedimentation pattern. This again will lead to changes of beaches and banks in the coastal zone. However, the flora and fauna if the intertidial zone is in most areas of NSR relatively sparse due to ice-scouring, meaning that the number of organisms affected by the changes will be low.

Even though environmental effects of mineral carrying vessels wrecked in open waters are sparsely documented, any release of minerals in larger quantities is expected to occur from an *accidental* event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), transported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pellets will change the substrate granulometry, but this impact is considered local, and thus of limited significance at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high concentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assessed based on releases of fuel e.g. diesel or bunker oil.

However, most serious for the environmental consequences in the coastal zone is the accidental pollution from crude and bunker. Acute effects on different resources as birds, fish and shellfish can occur. The oil can also pollute beaches with respect to aesthetic disturbance. The oil can penetrate into the surface in the littoral zone and make chronic pollution in a long time scale.

VEC Water/land border zone:
Coastal habitats, particularly soft-bottom low-energy backshore areas, normally receive much attention in oil spill contingency planning (CONCAWE 1981, International Maritime Organisation 1988, Hayes *et al.* 1992, NOAA 1994, Owens 1994, Canadian Coast Guard 1995, Halls *et al.*, 1997, Owens *et al.* 1998). This is basically because removing oil is difficult in such areas, and leaving the oil will cause long term disturbance to theses biologically rich habitats. Nearshore and shorefast ice compounds the environmental damage and difficulty in responding to oil in these Arctic habitats. A shorefast ice-foot or cracked and porous ice can entrain oil for months (Owens 1996), and nearshore ice flows essentially eliminate wave action necessary for the physical degradation of oil (Dickins *et al.* 1990). The melting of this ice in the spring can release significant quantities of nonweathered oil months after the original spill at the beginning of the most biologically active period of the year.

Protected areas. Protected areas have been classified in different categories according to different properties of the areas (Figure 5.8). The main cause of protection vary, extending from traditional habitat conservation and protection of single species to conservation of biological diversity and scientific purpose. Also, the vulnerability of protected areas can vary throughout the year; the breeding season is for instance in general more vulnerable than the winter season. Consequently, the potential environmental impacts from an extended use of NSR will also vary according to the characteristics of each single protected area and season.

VEC Protected areas:
Accidental discharges to the marine, aquatic or terrestrial environment can severely reduce the quality of the protected areas, and will undoubtedly come in conflict with the aim of protection, and thereby Russian legislation and regulations of the area. Accidental oil spills in arctic terrestrial and aquatic habitats will generally lead to serious impacts on soil, vegetation, peatlands and fens, lakes and rivers, which can take decades to restore. The possibilities for an effective oil spill combat is poor, which will increase the consequences compared to other areas. Other VECs in the area can suffer significantly, especially in the marine environment. The subsistence of the indigenous people will also be threatened. Depending on the accidental location and time, conclusions regarding the other VEC will also be valid here (cf. the respective sections).

Indigenous people. If oil is spilled in the subsistence areas of indigenous peoples, the long-term impact may interact with their utilisation of natural resources such as fishing, hunting and reindeer breeding. Primarily, the habitat's carrying capacity may be lost for some periods of time, secondary, restrictions may be placed on the utilisation of the resources itself. The latter was implemented in the wake of the «Exxon Valdez» spill, where fishing and hunting were restricted in certain areas for some periods of time. Species observed contaminated were not recommended for human consumption. In both cases, the interactions provide an interference to the indigenous peoples' dependency of natural resources as well as their traditional trade branches.

VEC Indigenous people:
The potential impacts from an accidental oil spill are assessed to be on a local or possible regional scale. For special areas like the Bering Strait and Chukchi Sea as well as rivers and estuaries, this may lead to loss of food resources for indigenous subsistence. Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka. Outside the NSR along the Pacific coast of Chukotka and Kamchatka, the situation can be identical.

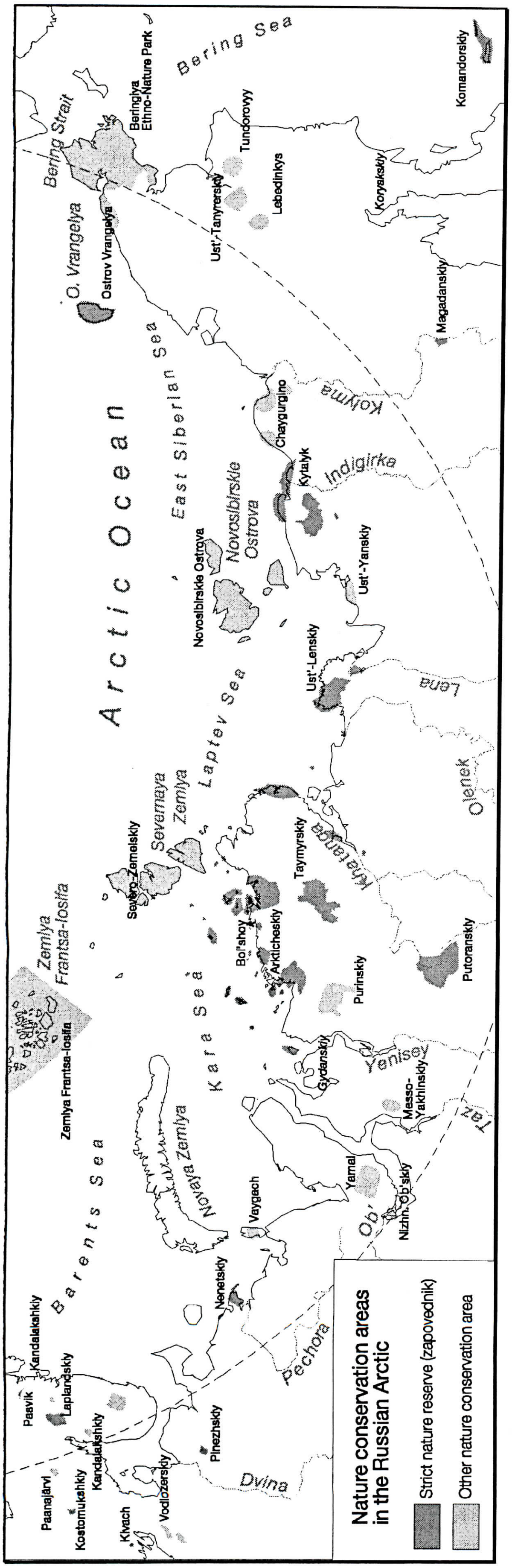

Figure 5.8. Protected areas in the northern part of Russia (compiled by W. Dallmann). Notice that the exact borders of «Koryakskiy» and «Gydanskiy» lack, and the locations are indicated roughly.

5.3 Physical disturbance and noise

5.3.1 General

The **physical disturbance** by the *regular operations* of ship and navigation in ice-infested water is generally considered of marginal significance to the marine environment. There will be some organisms adversely affected, like the ice flora and fauna, but the area of influence is rather small. The breaking of ice can turn the ice upside down, and expose the organisms, which in turn will be accessible to the birds in the wake of the ships. This is a well known phenomenon considered as a positive effect to the birds. Migrating animals like the polar bear may be disturbed by the activity, providing escape reactions and increasing energy consumption to the individuals affected. The significance to the population however, is most likely of minor importance.

The physical disturbance by shipping may be more pronounced to animals regularly occupying, or showing preferences to certain limited areas, or habitats to breed, forage or rest. The presence of extensive navigation, including noise, close to such areas may reduce the quality of the area, and ultimately, the area may be abandoned.

Because of the large volume of particles transported by many Russian rivers, the process of shoaling makes regularly dredging quite necessary in the vicinity of *harbour facilities* and in river shipping lanes. The dredging is known to cause resuspension of sediment. If the sediment is contaminated, like it is in many harbours (AMAP 1997), the dredging may be a significant pathway of wider drift and spreading of the contaminated sediment (GESAMP 1994). Large depositional zones of contaminated sediments are known in the Yenisei (Champ *et al.* 1995). Such areas as well as harbour sediment provide potential reservoirs for contaminants that should be carefully considered prior to dredging. Baseline studies to identify the sediment type and level of contamination combined with simulation of the water turbidity have proven to be effective measures to find the most environmentally friendly technique for dredging. The environmental significance of dredging has been addressed by OSPARCOM and the London Dumping Convention in terms of implementation of regulations on technical and environmental measures for dredging and dredged material (PRAM 1997).

Land-based petroleum development are known to cause physical disturbance to the terrestrial environment in terms of the installation itself and the corresponding pipelines for the oil and gas transportation. The encroachment of the soil top layer in the pipeline corridor and its vicinity appears to be the most immediate effect of the pipeline construction. Disturbance of the thin layer of vegetation covering a frozen soil can precipitate dramatic meeting of the underlying ice, and result in extensive erosion. On the tundra large impacts such as vehicle tracks on thawed ground can remain visible for decades. Slow re-vegetation makes the Arctic flora highly vulnerable to physical disturbances and the natural recovery will last for years.

Excavation and land-fills for pipelines and the transport-maintenance roads can cause alternation of terrain drainage patterns, including blocking water flow and rising water Table on the upslope side and draining of the downslide side of the pipeline and roads. The subsequent alternation of the soil-water fluxes and freezing-refreezing processes will destabilise the natural ground conditions (e.g. soil maturing-drainage); the erosion processes are accelerated, and thereof cause reduction of the local resident vegetation. If more important waterways are influenced, a gradual expansion of the impact zone is not unlikely in the long term. In such cases, the capacity of the habitat to support the natural flora- and fauna elements will be generally reduced.

The swamp areas can be considered as particularly vulnerable to alteration of terrain drainage patterns. In such areas extensive use of wood material is normally required to obtain the necessary strength of service and transport roads (- up to 3,000 m^3 of wood material per kilometre of swamp crossing are reported by Russian sources). Wood material is definitely a renewable resource, but deforestation is considered an adverse environmental effect. Trees, like spruce, take about 100-150 years to reach their full size in the taiga region. Deforested areas are ecologically unstable, and such areas have lost major features to support the natural resident flora and fauna elements. The succession to pre-disturbed (dis)equilibrium can last for decades.

Once constructed, the pipeline and the corridor are permanently present in terms of an alteration of the natural environment. In this context, the pipeline represents a type of habitat fragmentation.

Everywhere in the oilfields around Noyabr'sk, the oil metropol of western Siberia, there is evidence of the way that environmental damage goes hand in hand with the industry (Pearce 1993): - the forests are littered with abandoned machinery, rusting pipes and rolls of high-tension cable; - million of trees has been felled to make way for the oil workers; - large areas of the forest have been destroyed by fires that blaze during the summer. In 1989, some

2,000 fires consumed 200,000 hectares in the region; - the terrain is fragmented by the many drilling pads and roads. Land is wasted on a massive scale. Every road sits within an 80-metre swathe of cleared forest or on sand embankments running through the swamp, and two or three tracks often run parallel to the road, each with its own cleared way.

The link to sea-borne transportation of oil and gas on the NSR is obvious, national and international oil companies have developed plans for transportation alternatives from the rich fields of Pechora to central Europe via the deep sea harbours on Kola. Consequently, the «Siberian scandal» (Pearce 1993) are considered of international concerns. Detailed assessments of problems were recognised beyond the scope of the INSROP EIA in an early phase. Except for the economic feasibility of sea-borne oil transportation, there were no consent to the obvious links between onshore oil development and the NSR; priorities were made on purely shipping and marine environment issues. Nevertheless, natural resource management is essential if Russia wants to overcome its present economic difficulties without creating overwhelming environmental costs for future generations – and prevention is probably the best cure.

Ship operations are known to cause **noise** from ice breaking and pressure fluctuations in the water, which act on the hull surface in the vicinity of the propeller. Many marine mammals communicate by emitting sounds that pass through water. Such sounds can be received across great distances and can influence the behaviour of these animals. The interactions between this type of man-made sound and marine mammals have been studied extensively during the last decades (Richardson *et al.* 1995).

The use of helicopters are diverse, for example in the transportation of labours and goods forth and back to offshore petroleum installations, as a help in ship navigation in severe ice conditions, in rescue operations, or in oil spill combat situations. This traffic generates noise which can have impacts on the animal life like sea mammals, reindeer in particular in the calving season. Most known are probably the impacts on seabirds in vulnerable seasons, hypothesised by Bakken *et al.* (1996).

At the sound of sudden noise, seabirds may flee the colonies in panic. Eggs and chicks can be pushed out of their nests. The knowledge of the short and the long-term population effect of such activities is however limited. Studies have indicated that seabirds under certain conditions may become accustomed to, and will be only marginally frightened by helicopter noise. The effect of noise on seabird concentrations in the feeding areas is not known. Ultimately, disturbance by noise cause stress and possible abandonment of influenced areas, reduced foraging efficiency and impaired physical condition. Reproduction can be effected by increased predation rates on unguarded eggs and chicks falling out of the nest, and by reduction in incubation time for brooding adult birds.

5.3.2 INSROP and assessed physical disturbances and noise

As shown above, physical disturbance and noise can have quite different impacts on the environment, directly or indirectly. The seabirds are sensitive to helicopter noise, and are vulnerable in the breeding season. Marine mammals respond more to noise emitted by the propeller on ships. Barriers like pipelines roads and leads can prevent animals like reindeer to use their traditional migration routes. Protected areas can loose much of their wilderness and undisturbed quality and physical disturbance can thereby come in conflict with the aim of protection and legislation.

In the INSROP EIA, Wiig *et al.* (1996) have made a review of the sources and possible impacts on the selected marine mammals in the NSR area. As an example we show the discussion for bowhead whale. Generally, only short-term behavioural responses have been documented although possible physiological responses and long term avoidance and population level effects have been hypothesised. The endangered Bowhead whale, considered a vulnerable species to noise, usually begins to flee when boats approaching rapidly and directly are 1-4 km away. Although strong pulses of sound often are detectable 25-50 km from seismic ships, most bowheads begin to swim away when the ship approaches within 8 km. The effect of noise from icebreakers has however not been studied. In general, bowhead behaviour is affected temporarily by the close approach of ships and aircraft, and they avoid very load ongoing noise, although the degree of habituation is unknown, as are cumulative and long-term consequences of exposure to man-made noise.

The Bowhead is numerous in the eastern part of the NSR, along the Chukchi Peninsula, from August to October. The ice conditions are one of the factors determining their distribution. It is not known to what degree bowheads will be attracted by artificial leads held open by ship traffic. It is known that collisions between ships and bowheads occur and 2 out of 72 examined whales had signs of such accidents. Consider the current population status also a function of man-made activities during the last decades, it seems reasonable to assume that such accidents will increase with increased shipping frequency within the home-range. The significance to population mortality however, is considered unknown.

The Walrus show preference for specific shores where they haul out to rest during summer and autumn. The presence of extensive navigation, including noise, close to such areas may reduce the quality of the area, and ultimately, the area may be abandoned. Considering a certain range of disturbance (including noise) that may affect the resident walruses, the estimated number of animals affected by a given shipping lane and frequency can be calculated using the buffer routines of the INSROP GIS. Based on the results, recommendations on more environmentally safer routes can be identified for certain areas and periods of time. In this example, with significant parts of the Walrus population haul out at the Wrangel Island, the routes should be at a certain distance from the coast to avoid disturbance of the animals.

VEC Walrus:
Operational: It has been documented that the walrus may avoid a specific areas, and that mortality, especially with calves, may increase because of disturbances. At haul-out sites (in particular at the Wrangel island) big flocks can be frightened an rush to the sea in a panic way by disturbance. Many individuals, especially young animals might be killed. Continuous disturbance of important sites might frighten the walruses away from important areas.

VEC Gray whale:
Operational: The Gray whale population is vulnerable to disturbance from ship traffic. The population is especially vulnerable due to its small size. It is only found in the Chukchi Sea part of the NSR area.

VEC Bowhead whale:
Operational: Increased traffic will lead to increased disturbance which can cause a reduction in local bowhead whale populations. The population is vulnerable due to its small size. It is only found in the Chukchi Sea part of the NSR area.

VEC Protected areas:
Industrial developments in general and petroleum developments in special can lead to serious disturbance of protected areas along NSR. Exposed to this threat are in particular the erosion of a vulnerable vegetation cover, the habitat fragmentation and species of plants and animals. The subsistence of the indigenous people will also be threatened. Depending on each protected area, conclusions regarding the other VEC will also be valid here.

VEC Domestic and VEC Wild Reindeer:.
Operational activities like ice breaking in rivers and straits and active installations will occupy areas and may accordingly reduce the access to grazing ranges and habitats and force animals to leave important areas. Physical disturbance by ice breaking and construction of pipelines will make permanent barriers and can disturb or even destroy the traditional migration routes for domestic and wild reindeer. They can also function as physical or psychological obstacles to migrations between seasonal habitats, e.g. calving areas, and accordingly affect reproduction and survival. Consequently, the subsistence of indigenous people can be threatened.

5.4 Changes of development pattern

5.4.1 General

Prior to the Soviet Union collapse, the indigenous peoples of the north have suffered significantly due to ignorant and inconsistent national politics and management strategies (Vakhtin 1992, Leksin & Andreyeva 1995). Most recently however, the need to provide conditions conductive to the adoption of individual place- and culture-specific solutions within the context of more broadly based political initiatives, have been emphasised in the national and international decision making communities. To reflect these growing concerns, activities that may be harmful to the linkage between the environment and ethnicity should be carefully considered.

In the INSROP the socio-cultural interaction between NSR developments and indigenous peoples has been addressed by the Sub-programme IV (cf. Anderson 1995, Boyakova *et al.* 1996, Schindler 1996, Golonev *et al.* 1998, Sokolova & Yakolev 1998). Indirect interactions however, e.g. when natural resources become affected and this impact interact with the indigenous peoples' dependency of their environment, are emphasised within the Sub-programme II. Dallmann has formulated 10 IHs on such interactions (Thomassen *et al.* 1998, 1999), covering all the main impact factors .

Two of these impact factors reflect the potential impact of *physical disturbance* of *the terrestrial environment*. For migratory species such as reindeer, aboveground pipeline structures are perceived as physical hindrances. It is experienced in northern Norway that even minor alien structures can cause disturbance and alteration to migratory routes of reindeer. In the western Taymyr, oil and gas pipelines deflected the migration of some 75,000 wild reindeer from the herd (Klein & Kuzyakin 1982). Reindeer breeding is of vital importance to indigenous peoples in the Russian north (Vakhtin 1992, Dallmann 1997), and this type of habitat fragmentation may indirectly form an additional interference to their culture and economy. Figure 5.9 shows residence and subsistence areas for indigenous people in part of the NSR area.

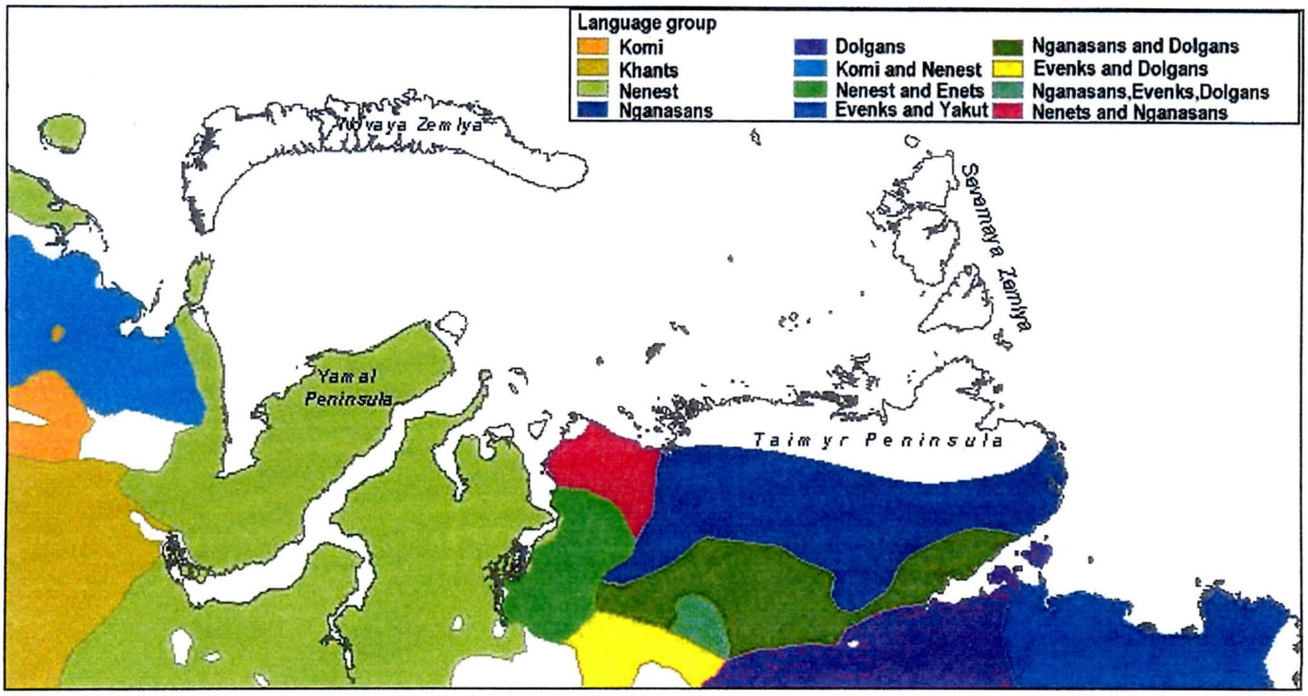

Figure 5.9. Residence and subsistence areas of indigenous peoples in northern Siberia (after Brude et al, 1998).

Forming an important item on the Agenda of the Rio-conference on «Sustainable development» in 1994, significant emphasis have recently been placed on the problems related to land devastation, habitat fragmentation and loss of biodiversity within the international and national scientific community and national and authority bodies. Today, the environmental concerns of these topics are integrated in environmental management strategies at several levels (CAFF 1996, AEPS 1997).

Changes in development patterns can also lead to a change in the use and utilisation of undisturbed habitats. Development of infrastructure, increased rural development, alien commercial interests and increased wildlife tourism with hunting and fishing as key elements, can be a threat to the arctic environment in general and to the many protected areas along NSR in special. The impacts can be severe without strict regulations in transportation to and utilisation of these northerly impassable and inaccessible sensitive areas.

5.4.2 INSROP and assessed changes of development pattern

VEC Seabirds and Marine wildfowl:
Operational: Hunting may have a significant negative effect in the vicinity of settlements. Russia has quite strict regulations for hunting and egg harvesting, but by experience it is known that a lot of illegal hunting is occurring.

VEC Protected areas:
Operational: Better accessibility can lead to an increased use of protected areas as recreation-, fishing- and hunting grounds, and consequently an increased threat to species and habitats. The subsistence of the indigenous people will also be threatened. Depending on each protected area, conclusions regarding the other VEC will also be valid here

VEC Indigenous people:
Operational: The expected mostly negative impacts on the indigenous peoples' environment are mainly not due to the sea route itself, but due to the expected subsequent industrial and infrastructure development in the Russian North.

The establishment of the NSR in the 1920s made it possible to build up the institutions that physically controlled the North and became the tool for the enforcement of Soviet policies, with all the fundamental social and economic changes they introduced for the entire population of the North, which affected the indigenous societies worst of all.

Since the colonisation of the North, large parts of the indigenous peoples' lands have been gradually converted into areas for alien settlement, transportation routes, industry, forestry, mining and oil production. Their lands and waters have been devastated or polluted, irresponsibly managed and alienated over the heads of their traditional owners and users.

Destruction of the indigenous peoples' environment means destruction of their cultural basis and their social pattern. The result were a large-scale (although not yet complete) social decay of the society, with such well-known symptoms as unemployment, loss of identity, alcoholism, health problems, demographic crisis, etc. Simultaneously achieved benefits like health service, education, etc., are finally broken down almost completely, while traditional ways of life are re-introduced.

There is little hope that an ultimate industrial and infrastructure development will change conditions to the better in the foreseeable future, unless there will be a drastic change in conduct and environmental behaviour of the developers, as well as in the preparedness of all players to involve the indigenous population in decision-making.

6. Recommendations

This chapter is divided into to sections.

The first is of general nature and based on the main results from INSROP and from general knowledge on the Arctic environment and industrial activities, including shipping and petroleum development and navigation. Some recommendations are made on measures to mitigate the corresponding adverse environmental interactions. The recommendations are tiled to relevant research and initiatives in the Arctic as well as topics with relevance to possible Arctic developments. This section is mainly from Moe & Semanov (1999).

The second section is more specific and VEC focused, and summarises the main recommendations (shaded boxes) given by the scientists responsible for the VEC impact and vulnerability assessments carried out in INSROP EIA.

6.1 General recommendations and mitigating measures

6.1.1 General

Shipping along the NSR will undoubtedly develop; today the transportation of oil and gas from the rich petroleum field of western Siberia seems most promising (Backlund 1995, Ramsland 1995, 1996, Ramsland & Hedels 1996, EPPR 1997). In combination with other factors, shipping and development may bring about irrevocable degradation of the NSR nature unless due measures and environmental management strategies are implemented and maintained.

Even in the current economical state, a number of national programs on assessment of the Arctic development and interactions with the environment are carried out. For example, one of the main sections of the Federal program «The World Ocean» is devoted to shipping in the Arctic. The Federal program «Risks reduction of natural and technical emergencies in the Russian Federation till 2005» is another example. Considerable funds are provided to petroleum companies for impact assessments and diminishing the environmental impact caused by the development of oil and gas production on the Arctic shelf of Russia.

Russia participates actively in IMO and in other international programs aimed at the Arctic environment pollution prevention. In 1998 IMO will consider the Code of Polar Navigation developed with participation of Russia. In accordance with the Code, Arctic navigation is only open for those ships that meet the requirements concerning construction, equipment and competency of the personnel. Waste discharges from ships should comply with MARPOL 73/78 standards for special areas.

The PAME is striving to recognise the status of Arctic waters as a «special area» or a «particularly sensitive area» by IMO. To substantiate this status PAME considers the necessity of establishing centres for systematic collection of information about shipping in the Arctic. Proposals have been made on the development of a reporting and analyses system for navigation routes and frequency, including systemised statistics on emissions to air and discharges to sea (Moe *et al.* 1996). The information obtained will be used for a large-scale impact assessment of Arctic navigation (PAME 1996).

Within the EPPR component risk assessment of shipping in the Arctic are evaluated. Sufficiency of international agreement for co-ordination of response actions in case of emergencies is being studied and guidelines for oil spills clean up techniques in the Arctic are being developed. A draft version of the guidelines for offshore oil and gas development, including a corresponding EIA concept, was presented in May 1997 (Anon. 1997). In 1998-99 another project is planned for implemented, aimed at identification of particular sensitive areas to oil pollution in the Arctic. Some simple and robust principles are developed, and the INSROP DEA will be used for the identifications of such areas within the NSR.

The first phase of AMAP provides the most important overall assessment of the Arctic environment. In the second phase, the Arctic environmental monitoring will continue on specific topics and in geographical areas identified during the first phase. The ecological approach will be strengthened; measures will also include the current impact on population levels. The CAFF will maintain their effort with regard to conservation of the Arctic flora and fauna. A number of other bilateral and multinational initiatives, including several World Bank projects, also aim to improve the current environmental risk in several ways and on several organisation levels.

In this context, the procedural manuals and guidelines for pollution preparedness and response developed during INSROP may form a significant contribution to the picture. The many legal instruments to prevent pollution however, whether aimed at shipping, oil discharges, dumping of radioactive waste etc., have shown to be insignificant in competition with other, short-term economical priorities. *At present, getting compliance with existing legal instruments appears to be more important than developing new ones.* Consequently, one of the challenges is to implement management strategies for permanent implantation of the acceptance of sustainable development - both among the public as well as the stakeholders of commercial industry and authority bodies. This however, is not done overnight.

6.1.2 Mitigating measures

General

Task and activity specific measures will be identified during the concluding assessments and analyses of the INSROP EIA. Based on general knowledge and experience obtained during the INSROP, recommendations on some overall measures can be given at the current state. An outline of these is outlined in the following.

- ✓ The NSR EAPS should be used for environmental screening and Preliminary EIA when considering developments within the NSR area. However, activity specific analyses and assessments should be made on potential impact on the environment and indigenous peoples in line with national EIA regulations as well as AEPS (1997), Anon. (1997).
- ✓ The World Bank has developed checklists on mitigating measures (World Bank 1991) for the most relevant activities and developments in the NSR. These recommendations should be considered normative to any development in the NSR.
- ✓ «Keep clear of nature conservation areas»; these areas are assumed to reflect national as well as international priorities with regard to nature quality, representativity and biodiversity. It is the overall intention of CAFF (1996), that the CPAN Strategy and Action Plan will «facilitate implementation of initiatives to establish, within the context of an overall Arctic conservation strategy, an adequate and well managed network of protected areas that has high probability of maintaining the dynamic biodiversity of the Arctic region in perpetuity». This means that nature conservation is a dynamic process, and appropriate attention also must be made to the national principles and mechanisms that have been identified for protected area selection in each of the Arctic countries.
- ✓ Vessel traffic management systems should be carefully considered for ports and loading facilities constructed or reconstructed for sea-borne oil transportation. Only tankers with double hull (in accordance with MARPOL) should be employed in the trade (which is not the case in the eastern NSR), and furthermore that quality of harbour operation is of the highest level and fully covered by implementation of the ISM code.
- ✓ Port authorities in Sweden and Rotterdam have launched a Green Award System of reduced port dues to any vessel owner who has put particular emphasis into increasing safety and providing increasing training to crews to improve their technical merit and quality. Tankers with segregated ballast tanks will automatically qualify for a 10% reduction in port dues. This system will also take into account increased crew awareness in caring for the environment as well as improving the environmental impact of any ship. Applied to the NSR, such means may appeal to the public environmental concerns as well as to owners as a means of improving company image. Corresponding means on insurance fares should also be considered.
- ✓ The use of antifouling paint containing TBT should be avoided.
- ✓ It is recommended that ships in transcontinental traffic on the NSR comply with the IMO guidelines for preventing the introduction of unwanted aquatic organisms (and pathogens from ship's ballast water).
- ✓ Radioactive pollution is definitely not a single Russian problem, and this topic should be monitored in line with the legal instruments in place; e.g. in terms of compliance with the international conventions and programmes dealing with nuclear power generation, processing and waste deposition (cf. International Atomic Energy Association; London Dumping Convention etc.).

Emissions to air

Except for significant local emissions from the smelter industry, the current emissions in the NSR area is relative low (AMAP 1997). Increased shipping and navigation, and corresponding developments offshore and on land, will inevitably increase the emissions.

Emissions to air are a matter of international concern and should be dealt with by the relevant international instruments, bodies and programmes. It is strongly recommended that the relevant national authorities implement routines for technical measures to keep the emissions at a minimum, and that the emissions are reported to the relevant bodies in line with international standards.

North Sea operators have spent significant effort on reducing the emissions from oil production and loading facilities during the last years, and it is recommended to implement best available technology for corresponding developments in the NSR.

Physical disturbance

In the marine and estuarine environment, depositional zones and harbour sediments provide potential reservoirs for contaminants. Baseline studies to identify the sediment type and level of contamination combined with simulation of the water turbidity have proven to be effective measures to find the most environmentally friendly technique for dredging. The environmental significance of dredging should be addressed in line with OSPARCOM and the London Dumping Convention in terms of implementation of regulations on technical and environmental measures for dredging and dredged material (PRAM 1997).

Noise

Development plans, both for offshore and land-based activities, should ensure transportation alternatives (for example establishing helicopter corridors like on Svalbard) to minimise noise in sensitive areas. The interactions are addressed in the INSROP EIA for conservation areas, birds and mammals, and these results should be used in an early screening phase.

Discharges to sea, ice and land

Emphasis should be placed on the implementation of – and ensure the compliance with the procedural manuals and guidelines on environmental safety prepared during INSROP. Two major elements of the NSR oil spill contingency plan, e.g. detection of spills – and normalisation of areas affected by spills, should be made special attention. The NSR EAPS should be made operational to all relevant stakeholders, including ship owners and managers.

Effort should be placed on the ongoing work on classification the NSR as a special area for MARPOL annex I and V wastes. Certain volumes of ship generated waste will be discharged and stored into port reception facilities which are a part of municipal waste processing facilities. This means *inter alia* that the shore reception facilities should be significantly improved in line with the recommendations made by GESAMP (1993), Semanov *et al.* (1997).

The Russian governments should be urged to ratify the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990. In this context, the NSR oil pollution emergency plans on ships and at ports is in line with the recommendations by GESAMP (1993).

Russian oil extraction and transportation should be better managed. New policies for preventive maintenance should replace current policies of improvising damage control. Not only requirements to best available practise and environmentally friendly technical solutions, but also measures for environmental remediation of the western Siberian environment should be integrated in future developments of national and international companies prior to project implementation. Such measures have been discussed by the World Bank and joint Russian-US programmes, but has as far the authors know, currently not been fully enforced on project basis.

Changes in development pattern

Development activities that may be harmful to the linkage between the environment and ethnicity, e.g. reindeer herding, fishing, hunting etc. should be carefully considered. In this regard the EIA should be regarded a participatory instrument, with the stakeholders, industry and management bodies as well as relevant minority groups, participating on equal basis in the process.

The interference between the environment, indigenous peoples and developments is probably most pronounced for land-based activities. In this connection the following elements should be carefully considered:

- ✓ Best available technology should be applied to any petroleum development in the sensitive Arctic environment. It is of utmost importance that environmental management strategies should be implemented on a regional basis.
- ✓ Activity specific oil spill contingency plans should be implemented (e.g. corresponding to standards in other Arctic countries). The plans should be based on the five main elements; detection of the spill; warning to relevant parties; combat of the spill; evacuation of the personnel endangered by the spill; normalisation of the spill. Many clean up operations are known to cause increasing impact to the environment. The oil spill contingency plans should therefore include normative on environmentally friendly clean up operations.

- ✓ The frequency of pipeline oil spills can be reduced by better corrosion protection; i.e. impressed current cathodic corrosion protection.
- ✓ The magnitude of major oil spills can be reduced by increasing the number of isolation valves (ESD valves) along pipeline routes, thus reducing the distance between isolation valves, especially in the most vulnerable areas.
- ✓ The presence of pipelines, corridors, and transport roads are all alien elements in an undisturbed wilderness area. Physical barriers or blockage of wildlife migratory routes should be avoided. New structures should be sited as close as possible to existing pipelines, or within existing corridors.
- ✓ Aboveground pipelines are, if laid across areas populated by reindeer, documented to delay and deflect migration of the animals. Elevated sections of the pipeline and fencing have apparently helped in guiding the reindeer from industrialised areas.
- ✓ Landfill and road strengthening constructions should be designed to optimise free water flow.
- ✓ Restoration of landfills and excavation sites should be ensured by replantation of soil and vegetation.
- ✓ Complete deforestation of larger areas should be avoided. Leaving a patchy distribution of single trees in deforest areas will improve the restoration abilities.
- ✓ Proper waste management routines - both at construction site and for transport and recycling - should be applied during construction and installation of pipelines.
- ✓ Development of a drying procedure, which minimises the consumption of methane, is recommended.

6.2 Specific VEC focused recommendations

The recommendations given below are based on the impact factors assessed to give a high potential impact level on the VEC. Recommendations of a more general nature are included where adequate.

VEC Benthic invertebrates:

- ☛ A basic recommendation will be to restrict the use of TBT containing anti fouling paint on ships trafficking NSR, or even to demand of NSR shipping either no use of TBT or full compliance with IMO standards (if the latter will achieve the same end result). This might be possible, as marine growth on ships hulls generally is low in arctic waters, as such growth is scraped off by ice. However, NSR going ships will sail in low latitude areas for large parts of the year, and thus need the anti fouling treatment.
- ☛ For monitoring purposes, TBT was not particularly addressed by the AMAP programme. But for the second stage of AMAP, an expert group states: «Due to the paucity of data regarding TBT along the Siberian coast and due to the strong correlation between shipping activity and TBT, it is recommended that the Northern Sea Route be designated as an area of special interest for TBT.» (Svavarsson *et al.* 1998). The monitoring of TBT is now a component of AMAP Phase II Implementation Plan.
- ☛ To the extent possible, the transport route should avoid shallow areas of high biological productivity.
- ☛ Should an accident occur, natural recovery (that is, no intervention) of the ecosystem is recommended. However, harvesting of biological resources (both benthic and pelagic organisms) should be discontinued in the area for a minimum of one harvesting season following the accident.
- ☛ Monitoring the levels of radionuclides in the environment will be needed to verify that dose levels and concentrations are below acceptable standards.

VEC Marine, estuarine and anadromous fish:

- ☛ To the extent possible, the transport route should avoid areas of high biological productivity and fish harvesting.
- ☛ Should an accident occur, natural recovery (that is, no intervention) of the ecosystem is recommended. Further, the removal of highly contaminated sediments is recommended. Harvesting of biological resources should be discontinued for several years following the accident in order to minimise the threat of human consumption of contaminated seafood and to allow fish stocks time to recover.
- ☛ Monitoring the levels of radionuclides in fish, water and sediment for several years will be needed to verify that dose levels and concentrations are below acceptable standards.

VEC Seabirds:

- ☛ With establishments of new settlements information about hunting regulations should be given. In addition, inspections of the hunting activities should be initiated. The hunting regulations and information about the wildlife should also be distributed to all ships in the NSR area.
- ☛ Contingency plans incorporating protection of seabirds should be prepared.
- ☛ Discharge concentrations should be strictly regulated and controlled.
- ☛ An updated geographical information system containing data on seabird distribution along the NSR should be maintained for planning of actions in case of an oil spill.
- ☛ Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels.
- ☛ As a precautionary measure, the use of helicopters, or regular helicopter routes, should be avoided close to nesting colonies and other seabird concentrations during certain periods of the year. The most important seabird colonies are mapped in the INSROP DEA (Gavrilo 1998b), and should be used in planning helicopter routes when such activities become apparent.
- ☛ Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity. This to be able to assess impacts on the populations in the event of an oil spill.
- ☛ Prepare oil-drift models for the NSR-area. These models should be used in planning of shipping routes and in planning oil-spill actions to minimise potential effects on seabirds.

VEC Marine wildfowl:

- ☛ Monitoring of the contamination levels of marine wildfowl should be carried out. If high levels of toxic compounds are found in wildfowl, studies of the resulting effects on reproduction and survival should be initiated.
- ☛ With establishments of new settlements information about hunting regulations should be given. In addition, inspections of the hunting activities should be initiated. The hunting regulations and information about the wildlife should also be distributed to all ships in the NSR area.
- ☛ Contingency plans incorporating protection of wildfowl should be prepared.
- ☛ Discharge concentrations should be strictly regulated and controlled.
- ☛ An updated geographical information system containing data on wildfowl distribution along the NSR should be maintained for planning of actions in case of an oil spill.
- ☛ Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels.
- ☛ Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity. This to be able to assess impacts on the populations in the event of an oil spill.
- ☛ Preparation of oil-drift models for the NSR-area. These models should be used in planning of shipping routes and in planning oil-spill actions to minimise potential effects on wildfowl.
- ☛ Monitoring of the contamination levels of marine wildfowl should be carried out. If high levels of toxic compounds are found in wildfowl, studies of the resulting effects on reproduction and survival should be initiated.

VEC Waders in resting and feeding areas:

- ☛ Strict regulations and frequent controls of pollution level from ships should be made.
- ☛ Surveys to map areas used as stop-overs during autumn migration.
- ☛ Monitoring of the contamination levels of waders should be carried out. If high levels of toxic compounds are found in waders, studies of the resulting effects on survival should be initiated.

VEC Polar bear:

- ☛ Surveys of polar bears in the total NSR area should be performed. The surveying should run as a long-term project to provide accurate data. For economic and logistic reasons some specific impact areas should be selected.
- ☛ Installations, activity and traffic should be kept away from areas important to polar bears. If it is decided to locate activities near an area that is vital to the polar bear's migration, food or denning area; study the incidence of bears and their use of the area before, during and after the activity is recommended.
- ☛ Disturbance in the most important denning areas that leads to abandonment of breeding might have large effect on the population level. Traffic in the denning areas should be minimised throughout fall, winter and spring.
- ☛ In connection with activity in and near denning areas recording of dens and production in the affected area should be monitored.
- ☛ Studies of female behaviour and of choice of denning areas in the fall by means of telemetry and observations and den surveys in areas relevant for activity could be performed in order to get more insight to this problem.
- ☛ Ethological and physiological study of the effect of disturbance on free-ranging polar bears could be performed, but the implementation of such studies will require large sample size and high costs.
- ☛ Polar bears are at the top of the food chain in the Arctic. Pollution will accumulate in bears and that is already a major problem in parts of the INSROP area. It is reasonably to assumed that such pollution will increase with an increased activity along the Northern Sea Route. A standard procedure should be established for the sampling and analyses of tissue, vital organs etc. from marine mammals at selected localities in the NSR area.
- ☛ A waste handling system must be developed in the NSR area.
- ☛ General measures against routine leaks and oil spills should be taken.
- ☛ Contingency plans to deter polar bears away from approaching less extensive oil spills must be developed. The same applies to contingency plans for capturing and cleaning of fouled bears where feasible, otherwise for destruction.
- ☛ In the event of an oil spill, bears in the contaminated area should be monitored.
- ☛ Surveys of polar bear occurrence throughout the year in areas where oil spills may be likely, and of local and general migratory patterns.

VEC Walrus:

- ☛ Monitoring of local populations with respect to population size, sex and age composition and behaviour should be performed. This should include surveys of occurrence and use of haul-out sites, counts of possible local populations and studies of their seasonal distribution, and studies of the migrations and distribution of walruses.
- ☛ Activity in walrus habitats should be regulated through a stipulation of the minimum permitted distance, the establishment of protection zones, and the introduction of landing bans at well-known haul-out sites and feeding areas.
- ☛ Oil spill alert contingency plans should be established near walrus habitats.
- ☛ Protection zones should be established around haul-out sites and feeding areas to protect the walrus from routine oil spills.
- ☛ In the event of oil spills walrus habitats and fouled individuals should be monitored.

VEC White whale:

- ☛ Surveys should be performed of local populations with respect to seasonal variation in selected areas, migration, population affiliation, and breeding and moulting areas.
- ☛ Traffic and other activities should be subjected to time and area control in white whale breeding and moulting areas.
- ☛ Monitoring of the white whale population should be performed in potential conflict areas.
- ☛ Oil spill alert contingency plans should be initiated in estuaries where white whales occur.
- ☛ Monitoring of habitats and fouled individuals in the event of oil spills must be performed.
- ☛ Studies of the effects of oil pollution on white whales must be initiated in case of an oil spill.

VEC Gray whale:

- ☛ The gray whale population in areas with activity should be monitored with respect to size, age composition and distribution of the populations.
- ☛ More research on the reaction of individual whales to disturbance is important to perform.
- ☛ Traffic and other activities could be subjected to time and area control in gray whale areas.

VEC Bowhead whale:

- ☛ The bowhead whale population in areas with activity should be monitored with respect to size, age composition and distribution of the populations.
- ☛ More research on the reaction of individual whales to disturbance is important to perform.
- ☛ Traffic and other activities could be subjected to time and area control in bowhead whale areas.

VEC Human settlement:

- ☛ An emergency preparedness and response plan should be developed for specific areas where human exposure is likely to occur.

VEC Water/land border zone:

- ☛ For all the reasons described within this matrix a significant oil spill reaching backshore soft-bottom habitats, especially vegetated marsh like habitats will have effects from significant to devastating. In case of a spill, all efforts should be oriented toward keeping oil from reaching these areas.
- ☛ This includes several *a priori* activities such as identifying all habitats of this nature (coastal classification), prioritising them in terms of their sensitivity, developing an emergency response plan that can be implemented under most environmental conditions, and having response equipment maintained and ready to act in case of an emergency.

VEC Protected areas:

- ☛ «Keep away from protected areas»
- ☛ Effort should be placed on safety navigation in protected areas with special attention put on high risk areas.
- ☛ Activity and time specific contingency plans should be established with special attention to protected areas.
- ☛ Time specific sailing regulations should be established to prevent sailing in areas where vulnerable VECs are distributed (for example breeding, moulting and foraging concentrations of birds, denning and migration areas for polar bears, haul-out sites for walrus).
- ☛ Depending on each protected area, recommendations regarding the other VEC will also be valid here (cf. the respective sections).
- ☛ Investigations to what extent accidents will have on the values in focus in the protected areas in different seasons, and how this will come in conflict with the legislation and regulations of the areas. Investigations must be area specific.

VEC Indigenous people:

- ☛ *Participation of indigenous peoples:* All industrial and infrastructure development has a price, and indigenous peoples must pay this price voluntarily. All development must pay attention to the fact that the land it occupies has been acquired without ever asking its original inhabitants, and that immense damage already has been done. Having understood this, it turns out clear that the indigenous peoples need to form part of all processes of further development, and their premises need to be viewed and treated on an equal basis.
- ☛ *Compensation for damage already done:* Decision-makers should guarantee that all companies investing in Northern development are to take their share in the environmental and social restoration of the damage caused by the earlier exploitation of the North.
- ☛ *New legislation and law enforcement:* The degree of impact through development in connection with the NSR depends largely on governmental and regional administrative regulations, laws, the establishment of protected areas, agreements with industrial companies, etc. The only way to control development is a new legislation with considerable respect to indigenous land use, and an effective law enforcement.
- ☛ *Establishment of nature reserves:* The establishment of nature reserves in co-operation with the local indigenous societies, guaranteeing that their needs are satisfactorily considered, is another promising approach that has been started, but a significantly wider network of protected areas, and a much better (than presently practised) implementation of environmental regulations is needed.

VEC Domestic reindeer and VEC Wild reindeer:

- ☛ Collection of data concerning disturbance from northern Russia should be evaluated.
- ☛ Seasonal habitats and migratory patterns in relevant development areas should be surveyed. The surveys must be differentiated with respect to sex, age and variation in physical condition etc., and be normative for mitigating measures.
- ☛ Reindeer habitat and migration areas must be considered when decisions are made concerning location of ship routs and installations on land. Special attention must be made on the location of pipelines.
- ☛ Important mitigating measures will be:
    - ☛ Restrictions on ice breaking in migratory areas and seasons.
    - ☛ Avoidance of pipelines in areas where traditional migration occur.
    - ☛ Construction of pipeline passage corridors if it is impossible to avoid the above mentioned mitigating measure.

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The EIA process has been the overall aim of the INSROP Sub-programme II: Environmental Factors, from the very beginning. The main tasks, e.g. the baseline data inventory, the integration of baseline in the INSROP GIS, development of the Dynamic Environmental Atlas and tailoring the assessment routines and methods, have all aimed at the concluding assessment and analyses of possible impact. This fact has at least two implications; the process has last for 6 years; and a significant number of scientists and experts have been involved in the work. Consequently, the participants shall be acknowledged in two-fold, first for their inspiring co-operation and contribution to maintain the momentum of the project for so many years (despite the steadily decrease in funding); and thence, everybody should be thanked for their comments, hard-core facts and documentation. In this context, Gennady S. Semanov, the Russian Sub-programme co-ordinator and the Russian EIA-reference group are especially acknowledged. Also thanks to the late Gerald W. Garner. The following list intend to serve as reference to the key contributors of the INSROP EIA process. If anybody is missing, it is the authors full responsibility.

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8. List of acronyms

ACOPS	Advisory Committee on Protection of the Sea
AEAM	Adaptive Environmental Assessment and Management
AEPS	Arctic Environmental Protection Strategy
AMAP	Arctic Monitoring and Assessment Programme
ANWAP	Arctic Nuclear Waste Assessment Program
CAFF	Conservation of Arctic Flora and Fauna
CNIIMF	Central Marine Research & Design Institute, St.Petersburg, Russia
CO_2	Carbon dioxide
CPAN	Circumpolar Protected Areas Network
DEA	Dynamic Environmental Atlas
EA	Environmental Assessment
EAPS	Environmental Assessment and Planning System
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMEP	Co-operative programme for monitoring and evaluation of the long range transmission of air pollution in Europe
EPPR	Emergency Prevention Preparedness and Response
ESSN	Environmental Safety of Ship Navigation (INSROP)
EU	European Union
FNI	Fridtjof Nansen Institute, Oslo, Norway
GIS	Geographical Information System
IF	Impact factor
IH	Impact hypothesis
IMO	International Maritime Organisation
INSROP	International Northern Sea Route Programme
IT	Information Technology
LRTAP	Long Range Treaty on Air Pollution
MARPOL	International Convention for the Prevention of Pollution from Ships
NGO	Non-governmental Organisation
nm	Nautical miles
NO	Nitrogen oxide
NSR	Northern Sea Route
OSPARCOM	The convention for the Protection of the Marine Environment of the North-East Atlantic
OVOS	Russian abbreviation of Assessment of Environmental Impacts
PAME	Protection of the Arctic Marine Environment
PEIA	Preliminary Environmental Impact Assessment
PIL	Potential Impact Level
PML	Polar mixed layer
POP	Persistent Organic Pollutants
SEA	Strategic Environmental Assessment
SER	The State Ecological Review
SO	Sulphur oxide
SOF	Ship and Ocean Foundation, Tokyo, Japan
TBT	Anti fouling agents
TEK	Traditional Ecological Knowledge
UL	Classification category on ice going vessels
ULA	Classification category on ice going vessels
UN ECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
VEC	Valued Ecosystem Component
VOC	Volatile Organic Component

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Appendix

1. **Summary table for the vulnerability assessments.**
2. **Standard report form - operational and accidental vulnerability assessments.**
3. **Review and the authors response to this.**

Appendix 1: Summary table of the qualitative vulnerability assessments.

Table A1. Summary of the qualitative vulnerability assessments (cf. Appendix 2). The different impact hypotheses can be found in appendix 2. Region: 1=Kara Sea; 2=Laptev Sea; 3=East Siberian Sea; 4=Chukchi Sea; 5=Ob; 6=Yenisei; 7=Lena.

Activity	IF	VEC	IH	Region	Month min	Month max	Spatial	Temporal	Perturbation	Value score	PIL
Operational	Alien commercial interests	Indigenous people	F1-15	1-7	1	12	3	3	3	27	3
Operational	Alien cultural impacts	Indigenous people	F1-13	1-7	1	12	3	3	3	27	3
Operational	Discharges to sea: chemicals	Marine wildfowl	B2-4	1-4	5	10	2	3	2	12	3
Operational	Discharges to sea: chemicals	Waders in resting and feeding areas	B3-2	1-4	8	10	2	3	2	12	3
Operational	Crime	Indigenous people	F1-14	1-7	1	12	3	3	2	18	3
Operational	Discharges of dry cargo, garbage and litter	Indigenous people	F1-6	1-4	1	12	1	1	1	3	1
Operational	Discharges to land, rivers and lakes (toxic spills, undifferentiated)	Indigenous people	F1-9	1-7	1	12	2	3	3	18	3
Operational	Discharges to sea: hydrocarbons	Plant and animal life in polynyas	A3-5	1-4	11	5	2	2	1	4	1
Operational	Discharges to Sea; Fuel residues & sludge	Benthic invertebrates	A1-3	1-7	1	12	2	2	2	8	2
Operational	Discharges to Sea; Fuel residues and sludge	Marine, estuarine and anadromous fish	A2-21	1-7	1	12	2	2	1	4	1
Operational	Discharges to Sea; Garbage and litter	Water/land border zone (sensitive areas)	D2-2	1-7	1	12	3	2	1	6	2
Operational	Discharges to sea: hydrocarbons	Benthic invertebrates	A1-2	1-4	1	12	2	2	2	8	2
Operational	Discharges to sea: hydrocarbons	Plant and animal life in polynyas	A3-1	1-4	11	5	2	1	3	6	2
Operational	Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge	Indigenous people	F1-4a	4	1	12	2	3	1	6	2
Operational	Emission to air (exhaust gasses)	Indigenous people	F1-4b	4	1	12	2	2	1	4	1
Operational	Emission to air (SO_2 etc.)	Indigenous people	F1-11	1-7	1	12	2	3	3	18	3
Operational	Emission to air (sulfides, fluorides, heavy metals, stable chlorides, PCBs, radioactivity)	Domestic and wild reindeer	G1-4/ G2-4	1-7	1	12	1	3	2	6	2
Operational	Garbage & litter (Discharge to sea)	Seabirds	B1-3	1-4	1	12	1	3	2	6	2
Operational	Garbage & litter (Discharge to sea)	Marine wildfowl	B2-5	1-4	4	10	1	3	2	6	2
Operational	General discharges to sea	Polar bear	C-1	1-4	1	12	2	3	2	12	3
Operational	General discharges to sea	Walrus	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	Bearded seal	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	Ringed seal	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	White whale	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	Grey whale	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	Bowhead whale	C-1	1-4	1	12	2	3	1	6	2
Operational	General discharges to sea	Protected areas	E1-1	1-4	1	12	3	3	1	9	2
Operational	General discharges to sea	Protected areas	E1-3	1-4	1	12	3	3	1	9	2
Operational	General discharges to sea	Protected areas	E1-5	1-4	1	12	1	2	2	4	1
Operational	Helicopter noise	Seabirds	B1-2	1	5	8	1	3	2	6	2
Operational	Helicopter noise	Seabirds	B1-2	2-4	5	9	1	3	2	6	2
Operational	Helicopter noise	Marine wildfowl	B2-1	1-4	6	7	1	3	2	6	2
Operational	Helicopter noise	Marine wildfowl	B2-2	1-4	8	10	1	3	2	6	2
Operational	Helicopter noise	Waders in resting and feeding areas	B3-1	1-4	8	10	1	3	2	6	2
Operational	Helicopter noise	Polar bear	C1-4	1-4	10	4	2	2	2	8	2
Operational	Helicopter noise	Polar bear	C1-5	1-4	10	4	2	1	1	2	1

Activity	IF	VEC	IH	Region	Month min	Month max	Spatial	Temporal	Perturbation	Value score	PIL
Operational	Helicopter noise	Walrus	C2-1	1-4	6	9	2	2	2	8	2
Operational	Helicopter noise	Ringed seal	C4-1	1-4	1	12	2	1	1	2	1
Operational	Helicopter noise	White whale	C5-2	1-4	5	10	2	2	2	8	2
Operational	Helicopter noise	Grey whale	C6-2	4	5	10	2	2	2	8	2
Operational	Helicopter noise	Bowhead whale	C7-2	4	5	10	2	2	2	8	2
Operational	Helicopter noise	Protected areas	E1-1	1-4	1	12	3	3	1	9	2
Operational	Helicopter noise	Protected areas	E1-3	1-4	1	12	3	3	1	9	2
Operational	Helicopter noise	Protected areas	E1-5	1-4	1	12	1	2	2	4	1
Operational	Hunting	Seabirds	B1-4	1-4	1	12	2	3	2	12	3
Operational	Hunting	Marine wildfowl	B2-6	1-4	4	10	2	3	2	12	3
Operational	Hunting	Domestic and wild reindeer	G1-3/ G2-3	1-7	1	12	1	2	1	2	1
Operational	Ice breaking	Indigenous people	F1-1	6	10	6	2	3	3	18	3
Operational	Ice breaking	Indigenous people	F1-1	5,7	10	6	1	3	1	3	1
Operational	Ice breaking	Indigenous people	F1-2	5,6,7	10	6	2	2	2	8	2
Operational	Industrial development	Protected areas	E1-8	1-4	1	12	2	3	2	12	3
Operational	Minerals (Discharge to sea)	Marine wildfowl	B2-4	1-4	4	10	2	3	2	12	3
Operational	Minerals (Discharge to sea)	Waders in resting and feeding areas	B3-2	1-4	8	10	2	3	2	12	3
Operational	Municipal waste (Discharge to sea)	Polar bear	C1-2	1-4	1	12	2	1	1	2	1
Operational	Nature protection interests	Indigenous people	F1-16a	1-7	1	12	2	3	3	18	3
Operational	Noise; engines	Plant and animal life in polynyas	A3-2	1-4	11	5	2	1	3	6	2
Operational	Noise; ice-breaking	Plant and animal life in polynyas	A3-2	1-4	11	5	2	1	2	4	1
Operational	Noise; propeller	Plant and animal life in polynyas	A3-2	1-4	11	5	2	1	3	6	2
Operational	Oil (Discharge to sea)	Waders in resting and feeding areas	B3-3	1-4	8	10	2	1	3	6	2
Operational	Petroleum development on-shore and off-shore	Protected areas	E1-8	1-4	1	12	2	3	2	12	3
Operational	Physical disturbance	Polar bear	C1-4	1-4	10	4	2	2	2	8	2
Operational	Physical disturbance	Polar bear	C1-5	1-4	10	4	2	1	1	2	1
Operational	Physical disturbance	Walrus	C2-1	1-4	6	9	2	2	2	8	2
Operational	Physical disturbance	Ringed seal	C4-1	1-4	1	12	2	1	1	2	1
Operational	Physical disturbance	White whale	C5-2	1-4	5	10	2	2	2	8	2
Operational	Physical disturbance	Grey whale	C6-2	4	5	10	2	2	2	8	2
Operational	Physical disturbance	Bowhead whale	C7-2	4	5	10	2	2	2	8	2
Operational	Physical disturbance	Protected areas	E1-1	1-4	1	12	3	3	1	9	2
Operational	Physical disturbance	Protected areas	E1-3	1-4	1	12	3	3	1	9	2
Operational	Physical disturbance	Protected areas	E1-5	1-4	1	12	1	2	2	4	1
Operational	Physical disturbance, general	Domestic and wild reindeer	G1-1/ G2-1	1-7	1	12	1	2	2	4	1
Operational	Physical disturbance; ice breaking, active installations, pipelines, roads	Domestic and wild reindeer	G1-2/ G2-2	1-7	1	12	2	3	3	18	3
Operational	Physical disturbance noise	Indigenous people	F1-3	4	5	10	2	2	2	8	2
Operational	Physical disturbance (land devastation, aerial occupation)	Indigenous people	F1-7	1-7	1	12	3	3	3	27	3
Operational	Physical disturbance	Indigenous people	F1-8	1-7	1	12	2	3	3	18	3
Operational	Physical disturbance; construction	Water/land border zone (sensitive areas)	D2-1	1-7	6	10	1	2	3	6	2
Operational	Physical disturbance; ice breaking	Marine, estuarine and anadromous fish	A2-13	1-4	11	5	2	1	2	4	1
Operational	Physical disturbance; ice breaking	Human settle-ments	D1-2	5,6,7	11	5	1	1	3	3	1
Operational	Physical disturbance; Landfills	Water/land border zone (sensitive areas)	D2-1	1-7	1	12	1	3	3	9	2

Activity	IF	VEC	IH	Region	Month min	Month max	Spatial	Temporal	Perturbation	Value score	PIL
Operational	Propeller noise	Polar bear	C1-4	1-4	10	4	2	2	2	8	2
Operational	Propeller noise	Polar bear	C1-5	1-4	10	4	2	1	1	2	1
Operational	Propeller noise	Walrus	C2-1	1-4	6	9	2	2	2	8	2
Operational	Propeller noise	Ringed seal	C4-1	1-4	1	12	2	1	1	2	1
Operational	Propeller noise	White whale	C5-2	1-4	5	10	2	2	2	8	2
Operational	Propeller noise	Grey whale	C6-2	4	5	10	2	2	2	8	2
Operational	Propeller noise	Bowhead whale	C7-2	4	5	10	2	2	2	8	2
Operational	Propeller noise	Protected areas	E1-1	1-4	1	12	3	3	1	9	2
Operational	Propeller noise	Protected areas	E1-3	1-4	1	12	3	3	1	9	2
Operational	Propeller noise	Protected areas	E1-5	1-4	1	12	1	2	2	4	1
Operational	Releases to Sea; Anti fouling agents (TBT)	Benthic invertebrates	A1-2	1-4	1	12	2	2	2	8	2
Operational	Releases to Sea; Anti fouling agents (TBT)	Benthic invertebrates	A1-3	1-7	1	12	2	2	2	8	2
Operational	Releases to Sea; Anti fouling agents (TBT)	Benthic invertebrates	A1-5	1-4	1	12	2	3	2	12	3
Operational	Releases to Sea; Anti fouling agents (TBT)	Plant and animal life in polynyas	A3-1	1-4	11	5	2	1	3	6	2
Operational	Releases to Sea; Anti fouling agents (TBT)	Plant and animal life in polynyas	A3-5	1-4	11	5	2	2	2	8	2
Operational	Rural development	Protected areas	E1-10	1-4	1	12	2	3	2	12	3
Operational	Tourism	Protected areas	E1-10	1-4	1	12	2	3	2	12	3
Operational	Tourism	Indigenous people	F1-12	1-7	1	12	2	2	3	12	3

Activity	IF	VEC	IH	Region	Month min	Month max	Spatial	Temporal	Perturbation	Value score	PIL
Accidental	Discharges to sea: chemicals	Marine wildfowl	B2-4	1-4	5	10	2	3	2	12	3
Accidental	Discharges to sea: chemicals	Waders in resting and feeding areas	B3-2	1-4	8	10	2	3	2	12	3
Accidental	Discharges of dry cargo, garbage and litter	Indigenous people	F1-6	1-4	1	12	1	1	1	3	1
Accidental	Discharges of oil to limnic and terrestrial environment	Protected areas	E1-9	1-4	1	12	2	3	3	18	3
Accidental	Discharges to sea and air; radioactive material	Benthic invertebrates	A1-11	1-7	1	12	2	3	3	18	3
Accidental	Discharges to Sea; Bunker and diesel oil	Marine, estuarine and anadromous fish	A2-3	5-7	1	12	1	2	3	6	2
Accidental	Discharges to sea; bunker and diesel oil	Benthic invertebrates	A1-12	1-7	1	12	1	2	2	4	1
Accidental	Discharges to Sea; Bunker and diesel oil	Marine, estuarine and anadromous fish	A2-11	1-4	1	12	1	2	1	2	1
Accidental	Discharges to Sea; Chemicals	Benthic invertebrates	A1-16	1-7	1	12	1	2	3	6	2
Accidental	Discharges to Sea; Crude and bunker oil	Plant and animal life in polynyas	A3-3	1,2,3,4	11	5	1	2	3	6	2
Accidental	Discharges to Sea; Crude and bunker oil	Plant and animal life in polynyas	A3-3	1,2,3,4	11	5	1	2	3	6	2
Accidental	Discharges to Sea; Crude and bunker oil	Plant and animal life in polynyas	A3-3	1,2,3,4	11	5	1	2	3	6	2
Accidental	Discharges to Sea; Crude and bunker oil	Plant and animal life in polynyas	A3-3	1,2,3,4	11	5	1	2	3	6	2
Accidental	Discharges to sea; Crude oil	Benthic invertebrates	A1-13	1-7	1	12	1	3	3	9	2
Accidental	Discharges to Sea; Crude oil	Marine, estuarine and anadromous fish	A2-3	5-7	1	12	1	3	3	9	2
Accidental	Discharges to Sea; Crude oil	Marine, estuarine and anadromous fish	A2-11	1-4	1	12	1	2	2	4	1
Accidental	Discharges to sea: hydrocarbons	Water/land border zone (sensitive	D2-3	1-7	1	12	2	3	3	18	3

		areas)									
Activity	IF	VEC	IH	Region	Month _min	Month _max	Spatial	Temporal	Pertubation	V_score	PIL
Accidental	Discharges to sea: hydrocarbons	Plant and animal life in polynyas	A3-1	1-4	11	5	1	3	3	9	2
Accidental	Discharges to sea: hydrocarbons	Plant and animal life in polynyas	A3-4	1-4	11	5	1	2	3	6	2
Accidental	Discharges to sea: hydrocarbons	Human settlements	D1-1	1-7	1	12	1	3	3	9	2
Accidental	Discharges to sea: hydrocarbons	Human settlements	D1-4	1-7	1	12	1	3	3	9	2
Accidental	Discharges to sea; Fertiliser	Benthic invertebrates	A1-15	1-7	1	12	1	2	3	6	2
Accidental	Discharges to Sea; Fertiliser	Marine, estuarine and anadromous fish	A2-3	5-7	5	11	1	2	3	6	2
Accidental	Discharges to Sea; Fertiliser	Human settlements	D1-1	1-7	1	12	1	2	2	4	1
Accidental	Discharges to Sea; Fertilisers	Plant and animal life in polynyas	A3-1	1-4	11	5	1	1	3	3	1
Accidental	Discharges to Sea; Fertilisers	Plant and animal life in polynyas	A3-3	1-4	11	5	1	1	3	3	1
Accidental	Discharges to Sea; Minerals	Marine, estuarine and anadromous fish	A2-3	5-7	1	12	1	3	2	6	2
Accidental	Discharges to Sea; Minerals	Water/land border zone (sensitive areas)	D2-3	1-7	1	12	1	3	3	9	2
Accidental	Discharges to Sea; Minerals	Benthic invertebrates	A1-14	1-7	1	12	1	3	1	3	1
Accidental	Discharges to Sea; Minerals	Plant and animal life in polynyas	A3-1	1-4	11	5	1	2	2	4	1
Accidental	Discharges to Sea; Minerals	Plant and animal life in polynyas	A3-3	1-4	11	5	1	1	2	2	1
Accidental	Discharges to Sea; Minerals	Human settlements	D1-1	1-7	1	12	1	2	2	4	1
Accidental	Discharges to Sea; Radioactive material	Marine, estuarine and anadromous fish	A2-12	1-7	1	12	2	3	3	18	3
Accidental	Discharges to Sea; Radioactive material	Marine, estuarine and anadromous fish	A2-3	5-7	1	12	2	3	3	18	3
Accidental	Discharges to Sea; Radioactive material	Plant and animal life in polynyas	A3-1	1-4	11	5	1	3	3	9	2
Accidental	Discharges to Sea; Radioactive materials	Human settlements	D1-1	1-7	1	12	2	3	3	18	3
Accidental	Discharges to Sea; Radioactive materials	Human settlements	D1-4	1-7	1	12	2	3	3	18	3
Accidental	Discharges to Sea; Radioactive materials	Plant and animal life in polynyas	A3-3	1-4	11	5	1	2	3	6	2
Accidental	General discharges to sea	Protected areas	E1-2	1-4	1	12	3	2	3	18	3
Accidental	General discharges to sea	Protected areas	E1-4	1-4	1	12	3	2	3	18	3
Accidental	General discharges to sea	Protected areas	E1-6	1-4	1	12	2	2	3	12	3
Accidental	General discharges to sea	Protected areas	E1-7	1-4	1	12	2	1	3	6	2
Accidental	Helicopter noise	Protected areas	E1-2	1-4	1	12	3	2	3	18	3
Accidental	Helicopter noise	Protected areas	E1-4	1-4	1	12	3	2	3	18	3
Accidental	Helicopter noise	Protected areas	E1-6	1-4	1	12	2	2	3	12	3
Accidental	Helicopter noise	Protected areas	E1-7	1-4	1	12	2	1	3	6	2
Accidental	Minerals (Discharge to sea)	Marine wildfowl	B2-4	1-4	4	10	2	3	2	12	3
Accidental	Minerals (Discharge to sea)	Waders in resting and feeding areas	B3-2	1-4	8	10	2	3	2	12	3
Accidental	Oil (Discharge to sea)	Waders in resting and feeding areas	B3-3	1-4	8	10	2	1	3	6	2
Accidental	Oil (Discharge to sea)	Polar bear	C1-1	1	1	12				High	3
Accidental	Oil (Discharge to sea)	Polar bear	C1-1	2-4	1	12	2	3	2	12	3
Accidental	Oil (Discharge to sea)	Walrus	C2-2	1	1	12				High	3
Activity	IF	VEC	IH	Region	Month	Month	Spati	Temp	Pertu	V_sco	PIL

					_min	_max	al	oral	bation	re	
Accidental	Oil (Discharge to sea)	Walrus	C2-2	2,3	1	12	2	3	2	12	3
Accidental	Oil (Discharge to sea)	Walrus	C2-2	4	5	11	2	3	2	12	3
Accidental	Oil (Discharge to sea)	Walrus	C2-2	4	12	4	2	1	1	2	1
Accidental	Oil (Discharge to sea)	White whale	C5-1	1	1	12				High	3
Accidental	Oil (Discharge to sea)	White whale	C5-1	2-4	5	10	2	3	2	12	3
Accidental	Oil (Discharge to sea)	Bearded seal	C3-2	1-4	1	12	2	2	1	4	1
Accidental	Oil (Discharge to sea)	Ringed seal	C4-2	1-4	1	12	2	2	1	4	1
Accidental	Petroleum development on-shore	Protected areas	E1-9	1-4	1	12	2	3	3	18	3
Accidental	Physical disturbance	Protected areas	E1-2	1-4	1	12	3	2	3	18	3
Accidental	Physical disturbance	Protected areas	E1-4	1-4	1	12	3	2	3	18	3
Accidental	Physical disturbance	Protected areas	E1-6	1-4	1	12	2	2	3	12	3
Accidental	Physical disturbance	Protected areas	E1-7	1-4	1	12	2	1	3	6	2
Accidental	Propeller noise	Protected areas	E1-2	1-4	1	12	3	2	3	18	3
Accidental	Propeller noise	Protected areas	E1-4	1-4	1	12	3	2	3	18	3
Accidental	Release of liquid cargo (hydrocarbons)	Indigenous people	F1-5	4-7	5	11	1-2	3	3	9-18	2-3
Accidental	Release of liquid cargo (hydrocarbons)	Indigenous people	F1-5	4-7	12	4	2	3	3	18	3
Accidental	Release to land, rivers and lakes (oil spills)	Indigenous people	F1-10	1-7	1	12	1	2	3	6	2

	(positive impact)	Indigenous people	F1-16b	1-7	1	12					
	(positive impact)	Indigenous people	F1-17	1-7	1	12					
	(positive impact)	Indigenous people	F1-18	1-7	1	12					

Appendix 2: Vulnerability assessment - Standard report form

Appendix 2 contains standard report forms for the qualitative vulnerability assessments of the VECs/Impact hypotheses. The assessments have been done by the scientists responsible for the VECs in INSROP. Please refer to the guide for the EIA implementation in INSROP (Thomassen et al. 1998) for a description of the step by step procedure in the assessments.

VEC BENTHIC INVERTEBRATES

ACCIDENTAL vulnerability assessment - Standard report form

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		Adult benthic invertebrates are present all year, juveniles during part of the year
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		Spread of radionuclides attached to particles will increase exposure to benthic organisms
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea and air; radioactive material

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors
Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-11	**Valid impact factor (from 3 above):** Discharges to sea and air of radioactive materials.	Category
Impact hypothesis:	Accidental discharge of radioactive material from ships will affect benthic invertebrates	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x3	18	3

Rationale:
As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. In opposition to oil or fertiliser, decay of radionuclides is not affected by environmental parameters like temperature, moisture, sunlight etc. ,but proceeds at a given rate in any environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility. Benthic organisms are particularly susceptible to chronic irradiation because these organisms live in or on the bottom sediments and may continue to consume organic-rich radionuclide contaminated particles long after an initial accident has occurred.

ACCIDENTAL vulnerability assessment - Standard report form

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		Adult benthic invertebrates are present all year, juveniles during part of the year
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		Exposure is dependent on oil being spread vertically in the water, either through dissolving, sedimentation or use of dispersants
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea; bunker and diesel oil.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-12	Valid impact factor (from 3 above): Discharges to sea; bunker and diesel oil.	Category
Impact hypothesis:	Accidental discharges of bunker or diesel oil will cause increased mortality in shallow water benthic invertebrates	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X			X		1x2x2	4 (Low)	1

Rationale:

Grounding of ships is a frequent reason for accidental release of oil to the marine environment. Regardless of type of cargo transported, the risk of loss of diesel or fuel oil is present whenever a ship runs a ground. Cargo vessels of the size that will travel the NSR will carry a storage of 200 - 400 tonnes of bunker oil, which might become released to the coastal environment. Bunker and diesel oil are more acute toxic to marine life than to crude oil, which means that a smaller volume of diesel will have a larger toxic effect on marine life compared to crude oil. In the Arctic marine environment, benthic invertebrates occur at the largest numbers and biomass below the ice scouring depth (see e.g. Larsen *et al.* 1996). The invertebrate fauna in shallow water above the average ice scouring is dominated by opportunistic, short lived groups, which can readily recover after a natural disturbance like ice scouring. Being dominated by opportunistic forms, recovery after e.g. an oil spill to pre spill conditions in shallow areas will take place relatively rapidly. An oil slick drifting on the surface will have a limited vertical extent down in the water column, meaning that the occurrence of most invertebrate at a depth of some meters will reduce the overlap and thereby the conflict between impact factor and the resource.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		Benthic invertebrates are found in the NSR area year round
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		Even though the probability of an accident varies throughout the year, the potential is contionously present whenever traffic occurs
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: Crude oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-13	**Valid impact factor (from 3 above):** Discharges to sea: Crude oil	Category
Impact hypothesis:	A major oil spill arising from a tanker accident will affect benthic invertebrates, measured as changes in community structure and biomass, and on the sub-acute level increase hydrocarbon body burdens.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X	(x)				X			X	1x3x3	9 (medium)	2

Rationale:
Several tanker accidents like the Amoco Cadiz, Exxon Valdez, Braer, Sea Empress have demonstrated the profound, long lasting, but in many cases recoverable effects of a major discharge of crude oil. Any oil spill is unique, with differences in volume, type of oil, time of release, location of release, weather, clean up effort invested etc. This again leads to major differences in environmental impact. Benthic invertebrates along the NSR have their highest density at water depths from approx. 10 meters, which is below the level where ice scouring is decisive factor. After the Braer accident, which happened on the south west coast of the Shetlands during January 1993, the very severe weather conditions contributed to oil being traced in sediments at water depths of more than 100 meters (Ritchie & O'Sullivan 1994), illustrating the range of potential spread also to deeper sea bed areas.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-14	Valid impact factor (from 3 above): Discharges to Sea; Minerals	Category
Impact hypothesis:	Accidental release of iron ore (pellets) will cause alterations in substrate granulometry, and thereby change species diversity in benthic invertebrate communities	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X	X			1x3x1 = 3	3 (low)	1

Rationale:
Minerals, like iron ore are transported in bulk, meaning that loss of all or parts of the cargo in case of a collision or a grounding is probable. Granules of ore will accumulate at the bottom at or near the site of the accident, and the extent of the impacted area will thus be small. This enables a relatively easy recovery, given that the site is accessible to recovery equipment. If the ore is left on site, the change in substrate will be permanent, and new colonisation will begin, as long as toxic or repelling componds are not washed out from the material. The evaluation of the hypothesis is made under the assumption that the iron ore is left on site, and that no leaking of toxic or repelling agents take place.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: Fertiliser

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-15	Valid impact factor (from 3 above): Discharges to sea: Fertiliser	Category
Impact hypothesis:	Accidental release of fertiliser form a ship wreck will through stimulation of primary production cause increased availability of food particles for benthic invertebrates	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3	6 (medium)	2

Rationale:
Transported soluble cargo like agricultural fertiliser might, in case of an accident, become released to the marine environment. During the summer period, phytoplankton growth is in many Arctic areas limited by the availability of inorganic nutrients, primarily Nitrogenous compounds. As fertilisers are easily dissolved in water, this impact factor will tend to become spread with the water currents. The evaluation is based on covering all the year, but during the winter, light will prevent the primary production, and nutrients will become spread, dependent on the current conditions.
First of all, a nutrient enrichment might be visible in the amount of phytopalnkton which develop, but as sedimenting plankton is a major food source for benthic invertebrates, an enrichment might also be detected in the benthos. However, in the light of realism, it will probably be very difficult to document any effects in the benthos following the described series of events.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Benthic invertebrates	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		see IH A1-13
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		see IH A1-13
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea: Chemicals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-16	**Valid impact factor (from 3 above):** Discharges to Sea: Chemicals	Category
Impact hypothesis:	Chemical dispersants used in clean up operations will increase mortality in benthic invertebrates	B

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3	6 (medium)	2

Rationale:
Chemical dispersion is often an preferred solution in case of an oil spill. Dispersion might reduce the impacts caused on e.g. marine birds, an at the same time illustrate the willingness and ability of the responsible parties to actually amend any impacts of an accident. Dispersants are in many cases toxic compounds with an inherent toxicity, but it is often difficult to document effects of dispersants under field conditions, due to combined effects with the oil. In Russia, the use of dispersants is restricted, and the basis for oil contingency planning is manual clean up of the oil. Relatively few dispersants are approved for use, and toxicity is a major criteria for the evaluation.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Benthic invertebrates	Month:	1-12
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea: Hydrocarbons

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-2	Valid impact factor (from 3 above): Discharges to Sea; bunker oil	Category
Impact hypothesis:	Operational discharges of hydrocarbons and anti fouling agents will affect survival of pelagic larvae of benthic invertebrates at certain times of the year.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X			X		2x2x2=8	Medium	2

Rationale:
Cooling and drainage water containing small amounts of hydrocarbons are continuously released from ships in operation. The pelagic larvae of several benthic invertebrate species are assumed to be present during spring and summer, which is also the period of the most intensive shipping activity. The hypothesis is put up as being valid throughout the year, as life cycle strategies and spawning periods in Arctic benthos is very sparsely studied, and in reality, we do not know the exact spawning period of most species.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Benthic invertebrates	Month:	1-12
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Releases to Sea; TBT/Anti-fouling paint

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-2	Valid impact factor (from 3 above): Releases to Sea; TBT/Anti-fouling paint	Category
Impact hypothesis:	Operational discharges of hydrocarbons and anti-fouling agents will affect survival of pelagic larvae of benthic invertebrates at certain times of the year.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X			X		2x2x2=8	medium	2

Rationale:
Anti-fouling agents are applied to repel or kill e.g settling invertebrate larvae (like algae, balanoids etc.), and thus make the substrate inaccessible. Anti fouling paints work in two ways; being toxic to the organims, some are killed directly upon settling, and as the agents are designed to gradually slip off the surface, any surviving organisms will loos their grip and also be washed off. This again will give spreading of the toxicant in the water colums and eventually in the sediments. Effects of anti-fouling paints will be pronounced along the NSR, but as the larvae are expected only to be present during a short periode each year the temporal scale might be lower than indicated here. Further research is needed to verify the extent of this conflict.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Benthic invertebrates	Month:	1 - 12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea; Fuel residues and sludge

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-3	**Valid impact factor (from 3 above):** Discharges to sea; Fuel residues and sludge	**Category**
Impact hypothesis:	Chronic pollution with e.g. anti-fouling paint, fuel residues etc., will cause accumulation of pollutants in benthic invertebrates.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X			X		2x2x2=8	medium	2

Rationale:
Repeatedly exposure to sub lethal concentrations of hydrocarbons is proved to cause accumulation of e.g. PAH in filtering inverterbates like bivalves. The direct effects of this is not known in arctic benthic invertebrates, but accumulation in filtering invertebrates will give transport or accumulation of PAH in different parts of the food web.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Benthic invertebrates	Month:	1 - 12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea; Anti fouling Agents (TBT)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-3	Valid impact factor (from 3 above): Discharges to sea; Anti fouling Agents (TBT)	Category
Impact hypothesis:	Chronic pollution with e.g. anti-fouling paint, fuel residues etc., will cause accumulation of pollutants in benthic invertebrates.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X			X		2x2x2=8	medium	2

Rationale:
Anti fouling agents (TBT) have recently been proven to cause abnormal sexual development in snails (Imposex, males changing partly into females) (Short et al. 1989; Oberdoerster et al. 1998). The direct effects of this is not known in arctic benthic invertebrates, but accumulation in filtering invertebrates will give transport or accumulation of PAH in different parts of the food web. The sensitivity of arctic invertebrate species towards the same type of influence has not been studied, but it is likely that the same types of effect can occur in the NSR area.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Benthic invertebrates	Month:	1 - 12
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Releases to Sea; Anti fouling paint (TBT)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A1-5	**Valid impact factor (from 3 above):** Releases to Sea; Anti fouling paint (TBT)	**Category**
Impact hypothesis:	Releases of anti-fouling paint will affect reproduction in benthic invertebrates.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x2=12	High	3

Rationale:
Anti fouling agents (TBT) have recently been proven to cause abnormal sexual development in snails (Imposex, males changing partly into females) (Short et al. 1989; Oberdoerster et al. 1998). The sensitivity of arctic invertebrate species towards the same type of influence has not been studied, but it is likely that the same types of effect can occur in the NSR area.

VEC MARINE, ESTUARINE AND ANADROMOUS FISH

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 **Screening of vulnerability dependent factors**

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 **Assessment of vulnerability significance**

IH no. A2-11	**Valid impact factor (from 3 above):** Discharges to Sea; Crude oil	Category
Impact hypothesis:	Accidental discharges of oil will increase mortality in pelagic eggs and larvae of marine fish	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X			X		1x2x2= 4	low	1

Rationale:
During the summer the anadromous species migrate out to the marine environment to feed. Both marine and anadromous species may thus be affected in case of an accident during the summer season. Many of the marine fish species spawn during the spring time, and the eggs and larvae of these speciments have a potential to be exposed for oil or oil components mixed in the water column. The lethal or sub-lethal effects on fish egg and larva are depending on the concentration and toxisity of oil/oil components. The effect is also dependent on the amount and how deep the oil/oil components are mixed in the water column. Lethal and sublethal effects in fish eggs exposed for crude oil are documented (Serigstad 1991).

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Bunker and diesel oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-11	Valid impact factor (from 3 above): Discharges to Sea; Bunker and diesel oil	Category
Impact hypothesis:	Accidental discharges of oil will increase mortality in pelagic eggs and larvae of marine fish	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X		X			1x2x1= 2	low	1

Rationale:
During the summer the anadromous species migrate out to the marine environment to feed. Both marine species and anadromous species may thus be affected by an oil spill in case of an accident during the summer season. The lethal or sub-lethal effects on fish egg and larva are depending on the concentration and toxisity of oil/oil components. The effect is also dependent on the amount and how deep the oil/oil components are mixed in the water column. Directs lethal effects from bunker oil on fish eggs and larva are documented (Longwell 1978), and changed development in the eggs and larva (Kunholdt 1978).

ACCIDENTAL vulnerability assessment - Standard report form

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area*):	1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Radioactive material

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability-dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-12	Valid impact factor (from 3 above): Discharges to Sea; Radioactive material	Category
Impact hypothesis:	Accidental discharges of radioactive material will increase mortality in fish.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X				X	2x3x3=18	18	3

Rationale:
As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility. Benthic living fish species are particularly susceptible to chronic irradiation because these organisms live in close connection to the bottom sediments and may continue to consume contaminated prey long after an initial accident has occurred.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	11-5
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance; Ice breaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-13	**Valid impact factor (from 3 above):** Physical disturbance; Ice breaking	Category
Impact hypothesis:	Physical disturbance from e.g. ice floes being overturned during shipping will increase mortality in marine fish species.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X		X				X		2x1x2=4	low	1

Rationale:
During the ice breaking, ice floes are overturend. The polar cod (*Boreogadus saida*) is in some life stages close connected to the under ice habitat where it feed and hide for predators (Welch et al 1992). When the ice floes are overturend, individuals will follow with the ice floes and currents made of ice breaking to the ice surface. This will increase the mortality in the polar cod population through predation and suffication.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Fuel residues and sludge

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-21	**Valid impact factor (from 3 above):** Discharges to Sea; Fuel residues and sludge	**Category**
Impact hypothesis:	The Whitefish (Coregonidae sp.) is a key fish group in most rivers and coastal waters along the NSR. Operational discharges affecting reproduction, migration and survival in Coregonids will cause major impacts in the rest of the food chain.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X		X			2x2x1=4	low	1

Rationale:
If the reproduction, migration and survival in key species like Coregonids are affected, there might be large impacts for the food web. A key species is important in transfer of energy in the food web, and also in structuring the biological community it is a part of. Some species of the Coregonids are planktivourous, and through predation on the pelagic plankton they play a major role in energy transfer from primary producers to higher trophic levels. Other species are piscivorous, and act as top predators in the food web. Some of these species are important in the fisheries in the area, particularly for local use.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-3	Valid impact factor (from 3 above): Discharges to Sea; minerals	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, e.g. hydrocarbons, minerals and fertiliser., in rivers along the NSR area will cause increased mortality and reduced production in anadromous fish populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X		X		1x3x206	medium	2

Rationale:
Any release of minarals in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), tansported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pettets will change the substrate granulometry, but this impact is considered local, and thus of limited significanse at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high consentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assed based on releases of fuel e.g. diesel or bunker oil.

Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	5-11
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Fertiliser

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-3	**Valid impact factor (from 3 above):** Discharges to Sea; Fertiliser	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, e.g. hydrocarbons, minerals and fertiliser., in rivers along the NSR area will cause increased mortality and reduced production in anadromous fish populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
Accidental discharges of fertilisers will locally give an increase in nutrients to the water masses. In the surrounding areas there might be toxic effects to different fish species (Chouhan and Pandey 1987; Pande and Pande 1988; Zoccarato et al 1995), and also reduced feeding and growth rates (Planichamy et al. 1985) Another effect is the relase of nutrients which might give higher production of primary producers in the area, depending on the type of fertiliser. High production of algea can under some circumstances give a depletion and lack of oxygen both in the water masses and in the bottom sediment (eutrofication) which can be followed by an increased fish mortality (Boyd 1985). On the other hand, increased production in the lower trophic levels will probably increase the production of food items for different fish species.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-3	Valid impact factor (from 3 above): Discharges to Sea; Crude oil	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, e.g. hydrocarbons, minerals and fertiliser., in rivers along the NSR area will cause increased mortality and reduced production in anadromous fish populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
During the summer the anadromous species migrate out to the marine environment to feed. Both marine species and anadromous species may thus be affected in case of an accident during the summer season. Most of the marine fish species spawn during the spring time, and the eggs and larvae of these speciments have a potential to be exposed for oil or oil components mixed in the water column. The lethal or sub-lethal effects on fish egg and larva are depending on the concentration and toxisity of oil/oil components. The effect is also dependent on the amount and how deep the oil/oil components are mixed in the water column.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Bunker and diesel oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-3	Valid impact factor (from 3 above): Discharges to Sea; Bunker and diesel oil	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, e.g. hydrocarbons, minerals and fertiliser., in rivers along the NSR area will cause increased mortality and reduced production in anadromous fish populations.	C

Scale parametres									Vulnerability score	Vulnerability	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
During the summer the anadromous species migrate out to the marine environment to feed. Both marine species and anadromous species may thus be affected in case of an accident during the summer season. The lethal or sub-lethal effects on fish egg and larva are depending on the concentration and toxisity of oil/oil components. The effect is also dependent on the amount and how deep the oil/oil components are mixed in the water column.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine, estuarine and anadromous fish	Month:	1-12
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Radioactive material

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A2-3	Valid impact factor (from 3 above): Discharges to Sea; Radioactive material	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, e.g. hydrocarbons, minerals and fertiliser., in rivers along the NSR area will cause increased mortality and reduced production in anadromous fish populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x3=18	high	3

Rationale:
As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility. Bottom living fish species are particularly susceptible to chronic irradiation because these organisms live in close contact with the bottom sediments and may continue to consume radionuclide contaminated food long after an initial accident has occurred.

VEC PLANT AND ANIMAL LIFE IN POLYNYAS

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; hydrocarbons

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	Valid impact factor (from 3 above): Discharges to Sea; hydrocarbons	Category
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
	X		X					X	2x1x3=6	medium	2

Rationale:
The NSR traffic will in a high degree be located to leads and polynas and will thereby give high risk of impacts. In these open waters there will be a higher primary production during the productive period compared to areas with ice cover. The primary production will give rise to a higher secondary production, and therby aggregate predators on higher trophic levels to polynas. The combination with high NSR traffic and aggregation of organisms will give rise to greater effects from the traffic compared to ice covered areas. Sea mammals needs open water to breath, and have to stay in a polluted polyna if the distance to unpolluted open waters is to large.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	2, 1, 3

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Releases to Sea; Anti fouling agents (TBT)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	**Valid impact factor (from 3 above):** Releases to Sea; Anti fouling agents (TBT)	**Category**
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X		X					X	2x1x3=6	medium	2

Rationale:
The NSR traffic will in a high degree be located to leads and polynas and will thereby give high risk of impacts. In these open waters there will be a higher primary production during the productive period compared to areas with ice cover. The primary production will give rise to a higher secondary production, and therby aggregate predators on higher trophic levels to these areas. The combination with high NSR traffic and aggregation of organisms will give rise to greater effects from the traffic compared to ice covered areas.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude oil and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	**Valid impact factor (from 3 above):** Discharges to Sea; Crude oil and bunker oil	Category
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
In polynas the production and aggregation of organisms are higher compared to ice covered areas. An oil discharge will give lethal and sub-lethal effects on these. Depending on the amount of oil and the size of the polyna, the oil can cover all the open water and give reduced primary production, and also large direct lethal effects on all organisms in the area. Sea mammals needs open water to breath, and have to stay in a polluted polyna if the distance to unpolluted open waters is to large.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	Valid impact factor (from 3 above): Discharges to Sea; minerals	Category
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X			X		1x2x2=4	low	1

Rationale:
Any release of minarals in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), tansported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pettets will change the substrate granulometry, but this impact is considered local, and thus of limited significanse at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high consentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assed based on releases of fuel e.g. diesel or bunker oil.

Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Fertiliser

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	Valid impact factor (from 3 above): Discharges to Sea; Fertiliser	Category
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C .

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X			X					X	1x1x3=3	low	1

Rationale:
Accidental discharges of fertilisers will locally give an increase in nutrients to the water masses. In the surrounding areas there might be toxic effects to marine and anadromous fishes. Another effect is the relase of nutrients which might give higher production of primary producers in the area, depending on the type of fertiliser. High production of algea can under some circumstances give a depletion and lack of oxygen both in the water masses and in the bottom sediment (eutrofication). Locally there can be a change in the balance between the nutrients required for primary produciton, and other species of phytoplanton compared to a "normal situation" can be favourised (e. e. toxic algae) (Cabrini et al. 1995; Hanslik and Rahmel 1995).

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Radioactive materials

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-1	**Valid impact factor (from 3 above):** Discharges to Sea; Radioactive materials	**Category**
Impact hypothesis:	Any effects of NSR traffic will be manifested to a greater extent in polynyas than in other areas	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Noise; ice breaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-2	Valid impact factor (from 3 above): Noise; ice breaking	Category
Impact hypothesis:	Noise from ice-breaking, engines and propellers will scare fish, mammals and seabirds away from important feeding, resting and breeding areas in and near polynyas.	C

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
	X		X				X		2x1x2=4	low	1

Rationale:
The effect of NSR traffic will be located to leads and polynas. In these open waters there will be a higher primary production during the productive period compared to areas with ice cover. The primary production will give rise to a higher secondary production, and therby aggregate predators on higher trophic levels to these areas. The combination with high NSR traffic and aggregation of organisms will give rise to greater effects from the traffic compared to ice covered areas. Mammals and seabirds will probably be scared away from the polynas to areas covered by ice with less prey organisms. The effect can be reduced feeding and condition in these animals. Another possibility with the same result is that noise can scare away the prey species from areas where top predators normally aggregate.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Noise; Engines

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-2	**Valid impact factor (from 3 above):** Noise; Engines	**Category**
Impact hypothesis:	Noise from ice-breaking, engines and propellers will scare fish, mammals and seabirds away from important feeding, resting and breeding areas in and near polynyas.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X		X					X	2x1x3=6	medium	2

Rationale:
The effect of NSR traffic will be located to leads and polynas. In these open waters there will be a higher primary production during the productive period compared to areas with ice cover. The primary production will give rise to a higher secondary production, and therby aggregate predators on higher trophic levels to these areas. The combination with high NSR traffic and aggregation of organisms will give rise to greater effects from the traffic compared to ice covered areas. Mammals and seabirds will probably be scared away from the polynas to areas covered by ice with less prey organisms. The effect can be reduced feeding and condition in these animals. Another possibility with the same result is that noise can scare away the prey species from areas where top predators normally aggregate.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Noise; propeller

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-2	Valid impact factor (from 3 above): Noise; propeller	Category
Impact hypothesis:	Noise from ice-breaking, engines and propellers will scare fish, mammals and seabirds away from important feeding, resting and breeding areas in and near polynyas.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X		X					X	2x1x3=6	medium	2

Rationale:
The effect of NSR traffic will be located to leads and polynas. In these open waters there will be a higher primary production during the productive period compared to areas with ice cover. The primary production will give rise to a higher secondary production, and therby aggregate predators on higher trophic levels to these areas. The combination with high NSR traffic and aggregation of organisms will give rise to greater effects from the traffic compared to ice covered areas. Mammals and seabirds will probably be scared away from the polynas to areas covered by ice with less prey organisms. The effect can be reduced feeding and condition in these animals. Another possibility with the same result is that noise can scare away the prey species from areas where top predators normally aggregate.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-3	**Valid impact factor (from 3 above):** Discharges to Sea; Crude and bunker oil	**Category**
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc. in polynyas will affects primary production, and thus the whole feeding network.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
In polynas the production and aggregation of organisms are higher compared to ice covered areas. An oil discharge will give lethal and sub-lethal effects on these. Depending on the amount of oil and the size of the polyna, the oil can cover all the open water and give reduced primary production. This will again give reduced feeding possibilities for the herbivorous zooplankton, and this group can be dramatically reduced with effects on the whole food web structure. If the oil is removed, both the primary and secondary producers will be transported into the area with the water mass transport and recolonize the polyna.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Radioactive materials

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-3	Valid impact factor (from 3 above): Discharges to Sea; Radioactive materials	Category
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc. in polynyas will affects primary production, and thus the whole feeding network.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
As documented in several investigations of dumped nuclear reactors residing in Arctic Seas, major accidents such as a collision of a nuclear ice-breaker or cargo vessel will result in the release of a large number of fission products, activation products and actinides into the marine environment. For purposes of evaluating the impacts from such discharges the following radionuclides are usually considered: ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. Long-range spreading of radioactive contamination will occur by water mass transport, attachment and subsequent transport with particles and by incorporation into ice. The most deleterious environmental impacts will occur to marine ecosystems in the immediate vicinity of the accident. The impacts will depend on the basic structure and composition of the ecosystems in the areas of concern, the responses of organisms to radiation, the quantities of radionuclides that are present in the organisms and their habitat, and the impact of internal- and external-emitting radionuclides on reproductive success. The risks to biological resources are caused by the effects of acute and chronic irradiation. Detrimental effects include doses and dose rates causing mortality, sterility, and decreased fertility.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-3	**Valid impact factor (from 3 above):** Discharges to Sea; minerals	**Category**
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc. in polynyas will affects primary production, and thus the whole feeding net-work.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X			X				X		1x1x2=2	low	1

Rationale:
Any release of minarals in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), tansported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pettets will change the substrate granulometry, but this impact is considered local, and thus of limited significanse at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high consentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assed based on releases of fuel e.g. diesel or bunker oil.

Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Fertiliser

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-3	**Valid impact factor (from 3 above):** Discharges to Sea; Fertiliser	**Category**
Impact hypothesis:	Accidental discharges of radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc. in polynyas will affects primary production, and thus the whole feeding net-work.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X			X					X	1x1x3=3	low	1

Rationale:
Accidental discharges of fertilisers will locally give an increase in nutrients to the water masses. In the surrounding areas there might be toxic effects to marine and anadromous fishes. Another effect is the relase of nutrients which might give higher production of primary producers in the area, depending on the type of fertiliser. High production of algea can under some circumstances give a depletion and lack of oxygen both in the water masses and in the bottom sediment (eutrofication). Locally there can be a change in the balance between the nutrients required for primary produciton, and other species of phytoplanton compared to a "normal situation" can be favourised (e. e. toxic algae) (Hanslik and Rahmel 1995; Cabrini et al. 1995).

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-4	Valid impact factor (from 3 above): Discharges to Sea; Crude and bunker oil	Category
Impact hypothesis:	Even minor accidental oil spills in polynyas will cause suffering and death to seabirds and marine mammals	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
In polynas, both seabirds and mammals are concentrated due to the aggregation of prey organisms. Even a small oil spill in an area like this can give rise to high mortality in the bird and mammal populations. (Se also own chapters on mammals and birds).

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea; crude and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-5	Valid impact factor (from 3 above): Discharges to sea; crude and bunker oil	Category
Impact hypothesis:	Chronic pollution of polynyas with e.g. anti-fouling paint and/or hydrocarbons from fuel, affects reproduction and survival of individuals at all trophic levels	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X		X			2x2x1=4	low	1

Rationale:
Chronic pollution in a polyna will probably affect both survival and reproduction of organisms in the area. This can be due to the direct effect from the pollutant on one type of organisms, but pollutants can also be concentrated at some levels in the food web.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Plant and animal life in polynyas	Month:	11-5
		Area:	1, 2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Releases to Sea; Anti fouling agents (TBT)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. A3-5	Valid impact factor (from 3 above): Releases to Sea; Anti fouling agents (TBT)	Category
Impact hypothesis:	Chronic pollution of polynyas with e.g. anti-fouling paint and/or hydrocarbons from fuel, affects reproduction and survival of individuals at all trophic levels	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X			X			X		2x2x2=8	medium	2

Rationale:
Chronic pollution in a polyna will probably affect both survival and reproduction of organisms in the area. This can be due to the direct effect from the pollutant on one type of organisms, but pollutants can also be concentrated at some levels in the food web.

VEC SEABIRDS

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Seabirds	Month:	1-12
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: garbage and litter

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B1-3	**Valid impact factor (from 3 above):** Discharges to sea: garbage and litter	**Category**
Impact hypothesis:	An increase in the population of large gulls, skuas and Arctic Fox resulting from increased food availability (dumping of edible waste etc.) will cause increased predation on seabirds and their eggs and chicks.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
The large gulls and skuas are food opportunists and will benefit from the food waste from human activity. An increase in the dumping of food waste is therefore likely to cause an increase in the populations of large gulls and skuas. This may have a negative effect on the populations of other seabird species. The effect is assumed to be local in character.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Seabirds	Month:	5-8
		Area:	1

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Helicopter noise

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B1-2	Valid impact factor (from 3 above): Helicopter noise	Category
Impact hypothesis:	Disturbance in or near nesting colonies and feeding areas resulting from the NSR activity (traffic of ships, helicopters and aeroplanes) will cause reduced reproduction and/or the abandonment of areas.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
At the sound of helicopter, seabirds may flee the colonies in panic. Eggs and chicks may be pushed out of their nests or they become more exposed to predation. The knowledge of the short- and long-term population effects is limited. The effect of helicopter noise in feeding areas is not known.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Seabirds	Month:	5-9
		Area:	2, 3, 4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Helicopter noise

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B1-2	Valid impact factor (from 3 above): Helicopter noise	Category
Impact hypothesis:	Disturbance in or near nesting colonies and feeding areas resulting from the NSR activity (traffic of ships, helicopters and aeroplanes) will cause reduced reproduction and/or the abandonment of areas.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
At the sound of helicopter, seabirds may flee the colonies in panic. Eggs and chicks may be pushed out of their nests or they become more exposed to predation. The knowledge of the short- and long-term population effects is limited. The effect of helicopter noise in feeding areas is not known.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Seabirds	Month:	1-12
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B1-4	Valid impact factor (from 3 above): Hunting	Category
Impact hypothesis:	Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
Hunting and egg harvesting is unlikely to become so extensive as to become a problem when considering new ship traffic along the NSR only. Surveys, research or monitoring is not recommended. The hypothesis may however be valid if the activity also will result in establishment of new settlements or other expansion of activity on land.

VEC MARINE WILDFOWL

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	5-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: chemicals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-4	Valid impact factor (from 3 above): Discharges to sea: chemicals	Category
Impact hypothesis:	Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
2					3		2		12	High	3

Rationale:
Many marine ducks live chiefly on benthos organisms, primarily molluscs and crustaceans in the sub-littoral zone. Minerals may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	4-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: garbage and litter

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-5	**Valid impact factor (from 3 above):** Discharges to sea: garbage and litter	Category
Impact hypothesis:	An increase in the populations of large gulls, skuas and arctic fox resulting from increased dumping of edible waste will cause increased predation on wildfowl and their eggs and chicks.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
Species of marine wildfowl are exposed to considerable predation from large gulls, skuas and Arctic Fox. These predators are food opportunists and their local populations are likely to increase if the availability of food due to edible waste from human activity increases. Increased populations of large gulls, skuas and Arctic Fox can cause increased predation on local marine ducks and goose populations.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	6-7
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Helicopter noise

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-1	Valid impact factor (from 3 above): Helicopter noise	Category
Impact hypothesis:	Disturbance near breeding areas can result in reduced reproduction of marine wildfowl through increased predation and reduced egg and chick survival, and may lead to abandonment of breeding areas.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
It has been documented that geese in particular very easily leave their nest if disturbed, that heavy disturbances can deter them from returning, and that unguarded nests of wildfowl are frequently exposed to predation from large gulls, skuas and Arctic Fox.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	8-10
		Area:	1-4

1 **Screening of vulnerability dependent factors**

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Helicopter noise

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 **Assessment of vulnerability significance**

IH no. B2-2	Valid impact factor (from 3 above): Helicopter noise	Category
Impact hypothesis:	Disturbance in resting, moulting and feeding areas will result in increased energy expenditure, less time for food intake and accordingly increased mortality of adult wildfowl and reduced reproductive success.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
The autumn migration has been documented to be a critical period for several species of wildfowl, especially geese and swans. They need to be left undisturbed to be able to build up energy reserves prior to the migration. Disturbances during this period can particularly result in migration failure of juveniles of the year. The importance of the energy reserves of the female in spring for reproductive success is also well documented.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	4-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Hunting

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-6	Valid impact factor (from 3 above): Hunting	Category
Impact hypothesis:	Increased human presence due to an increase in ship traffic and number and size of harbours and other settlements will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		6	High	3

Rationale:
Increased hunting pressure and egg harvesting will probably become a major problem with establishment of new settlements or other extension of activity on land in the NSR-area.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Marine wildfowl	Month:	4-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-4	Valid impact factor (from 3 above): Discharges to sea: minerals	Category
Impact hypothesis:	Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		6	Medium	2

Rationale:
Many marine ducks live chiefly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Minerals may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Marine wildfowl	Month:	5-10
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea, chemicals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-4	Valid impact factor (from 3 above): Discharges to sea, chemicals	Category
Impact hypothesis:	Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		6	Medium	2

Rationale:
Many marine ducks live mainly on benthos organisms, primarily molluscs and crustaceans in the sub-littoral zone. Toxic chemicals may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Marine wildfowl	Month:	4-10
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B2-4	Valid impact factor (from 3 above): Discharges to sea: minerals	Category
Impact hypothesis:	Toxic substances discharged into the sea may be accumulated in, and will possibly kill, benthic fauna forming part of the diet of marine ducks. This may result in reduced access to food and possibly poisoning of birds, and accordingly reduced reproduction and increased mortality.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
Many marine ducks live chiefly on benthos organisms, primarily molluscs and crustaceans in the sub-littoral zone. Minerals may kill these food organisms. The female duck is particularly dependent upon adequate access to food before the breeding season, as she will live mainly on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, will therefore have negative effects.

VEC WADERS IN RESTING AND FEEDING AREAS

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Waders in feeding and resting areas	Month:	8-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: chemicals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-2	Valid impact factor (from 3 above): Discharges to sea: chemicals	Category
Impact hypothesis:	Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		6	Medium	2

Rationale:
Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic minerals may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Helicopter noise

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-1	Valid impact factor (from 3 above): Helicopter noise	Category
Impact hypothesis:	Disturbances in resting and feeding areas can result in reduced possibility for the waders to store enough energy for the autumn migration.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
Waders may be disturbed by helicoper noise, especially in the staging areas. It has been documented that arctic waders are very dependent on allocated energy for successful breeding and migration. Disturbance may prevent the waders in feeding and result is reduced energy allocation.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-2	Valid impact factor (from 3 above): Discharges to sea: minerals	Category
Impact hypothesis:	Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic minerals may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area:	1-4

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-3	**Valid impact factor (from 3 above):** Discharges to sea: oil	**Category**
Impact hypothesis:	Oil spills affecting concentrations of waders in resting and feeding areas will cause increased mortality resulting both from direct oiling and habitat degradation.	C

Scale parametres											
Spatial scale			**Temporal scale**			**Perturbation magnitude**			**Vulnera-bility score** Product of S, T and P	**Vulnera-bility** Low/Medium/High	**PIL index** 1-3
L	R	N/I	S	M	L	S	M	L			
	2		1					3	6	Medium	2

Rationale:
Species that swim at open sea (phalaropes) or in pools (*e.g.* some *Tringa*-species), and species foraging at the shoreline like the Purple Sandpiper, will be more vulnerable than species that do not have these behaviours. All species using coastal feeding areas may be affected by habitat degradation following oil spills and associated clean-up activities.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: chemicals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-2	Valid impact factor (from 3 above): Discharges to sea: chemicals	Category
Impact hypothesis:	Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL.index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			3			2		12	High	3

Rationale:
Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic chemicals may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>Exposure</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>Influence</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance -

IH no. B3-2	Valid impact factor (from 3 above): Discharges to sea: minerals	Category
Impact hypothesis:	Discharged toxic and harmful substances that affects the feeding areas of waders may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food for the waders.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
Most waders live mainly on marine invertebrates that live on the surface (snails, mussels) or within the top layer of the mudflats (worms, tellins). Toxic minerals may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on allocating fat deposits before the autumn migration. If food availability at these important stop-overs are reduced this can be very negative for their possibilities of carrying through a normal migration.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Waders in resting and feeding areas	Month:	8-10
		Area*):	1-4

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea: oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. B3-3	Valid impact factor (from 3 above): Discharges to sea: oil	Category
Impact hypothesis:	Oil spills affecting concentrations of waders in resting and feeding areas will cause increased mortality resulting both from direct oiling and habitat degradation.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2		1					3	6	Medium	2

Rationale:
Species that swim at open sea (phalaropes) or in pools (*e.g.* some *Tringa*-species), and species foraging at the shoreline like the Purple Sandpiper, will be more vulnerable than species that do not have these behaviours. All species using coastal feeding areas may be affected by habitat degradation following oil spills and associated clean-up activities.

VEC MARINE MAMMALS

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Polar bear	Month:	Jan. – Dec.
		Area*):	Kara, Laptev, E. Siberian

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-1	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	**Category**
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12		3

Rationale:
The polar bear is a single resource with a regional distribution.
Recovery of the polar bear population after a major oil spill may take more time than one generation.
The effects of a major oil spill on the polar bear population may probably be detected statistically, provided sufficient basis data.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Polar bear	Month:	Jan. – Dec.
		Area*):	Chukchi

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-1	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	**Category**
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3		2		18		3

Rationale:
The polar bear is a single resource with international distribution. Recovery of the polar bear population after a major oil spill may take more time than one generation. The effects of a major oil spill on the polar bear population may probably be detected statistically, provided sufficient basis data.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Walrus	Month:	Jan. – Dec.
		Area*):	Kara, Laptev and E. Siberian Seas

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C2-2	Valid impact factor (from 3 above): Release of liquid cargo (hydrocarbons)	Category
Impact hypothesis:	Oil pollution from ships will reduce the walrus population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12		3

Rationale:
The walrus is a single resource with a regional distribution. Recovery of the walrus population after a major oil spill may take more time than one generation. The effects of a major oil spill on the walrus population may probably be detected statistically, provided sufficient basis data.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Walrus	Month:	November-April
		Area*):	Chukchi Sea

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>*Representation*</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C2-2	Valid impact factor (from 3 above): Release of liquid cargo (hydrocarbons)	Category
Impact hypothesis:	Oil pollution from ships will reduce the walrus population.	C

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3	1			1			3		1

Rationale:
The walrus is a single resource with international distribution.
Recovery of the walrus population after a major oil spill *at this time of the year and in this area* will probably not take more time than one generation .
The effects of an oil spill on the walrus population at this time of the year may probably not be detected statistically.

There are few walruses in the area at this time of the year and few will therefore be directly affected. If haul-out sites are contaminated by heavy oil when the walruses return to these sites in spring and summer more animals will be affected.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Walrus	Month:	May-October
		Area*):	Chukchi Sea

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C2-2	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	**Category**
Impact hypothesis:	Oil pollution from ships will reduce the walrus population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3		2		18		3

Rationale:
The walrus is a population with a international distribution.
Recovery of the walrus population after a major oil spill may take more time than one generation.
The effects of a major oil spill on the walrus population may probably be detected statistically, provided sufficient basis data.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Bearded seal	Month:	January-December
		Area*):	Kara, Laptev, E. Siberian and Chukchi Seas

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C3-2	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	**Category**
Impact hypothesis:	Oil pollution from ships will cause suffering and death for affected bearded seals and reduction in local bearded seal populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8		2

Rationale:
The bearded seal is a single resource with a regional distribution.
Recovery of the bearded seal population after a major oil spill may be judged to take approximately one generation.
The effects of an oil spill on the bearded seal population may not be detected statistically provided sufficient basis data.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Ringed seal	Month:	January-December
		Area*):	Kara, Laptev, E. Siberian and Chukchi Seas

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C4-2	Valid impact factor (from 3 above): Release of liquid cargo (hydrocarbons)	Category
Impact hypothesis:	Oil pollution from ships will cause suffering and death for affected ringed seals and reduction in local ringed seal populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8		2

Rationale:
The ringed seal is a single resource with a regional distribution.
Recovery of the ringed seal population after a major oil spill may be judged to take approximately one generation (about five years).
The effects of an oil spill on the ringed seal population may not be detected statistically provided sufficient basis data.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	White whale	Month:	May-October
		Area*):	Laptev, E. Siberian and Chukchi Seas, Ob, Yenisei, Lena

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>Exposure</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>Influence</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C5-1	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	**Category**
Impact hypothesis:	Oil pollution from ships will cause suffering and death for affected white whales and reduction in the white whale population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12		3

Rationale:
The white whale is a single resource with a regional distribution.
Recovery of the white whale population after a major oil spill may take more time than one generation.
The effects of an oil spill on the white whale population may probably be detected statistically, provided sufficient basis data.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	White whale	Month:	November-April
		Area*):	Laptev, E. Siberian and Chukchi Seas

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*		X	VEC not in the area, and consequently not assessed further here
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C5-1	Valid impact factor (from 3 above): Release of liquid cargo (hydrocarbons)	Category
Impact hypothesis:	Oil pollution from ships will cause suffering and death for affected white whales and reduction in the white whale population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3

Rationale:

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	October-May
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-4	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Installations and traffic of ships, helicopters, aeroplanes and other motorised vehicles in or near denning areas will cause reduced reproduction in the polar bear population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8		2

Rationale:
The polar bear is a single resource with a regional distribution.
Recovery of the polar bear population may be suggested to take approximately one generation.
The effects may probably be detected statistically, provided sufficient basis data.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	October-May
		Area:	Chukchi

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-4	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Installations and traffic of ships, helicopters, aeroplanes and other motorised vehicles in or near denning areas will cause reduced reproduction in the polar bear population	C

Scale parametres									Vulnerability score	Vulnerability	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
		3		2			2		12		3

Rationale:
The polar bear is a single resource with a regional distribution. Recovery of the polar bear population may be suggested to take approximately one generation. The effects may probably be detected statistically, provided sufficient basis data.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	January-December
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-5	**Valid impact factor (from 3 above):** - Noise - Physical disturbance	**Category**
Impact hypothesis:	Disturbances and obstacles caused by ship traffic, ship support and infrastructure in polar bear migration and feeding areas will result in a reduced population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2		1			4		1

Rationale:
The polar bear is a single resource with a regional distribution.
Recovery of the polar bear population may take about one generation.
The effects may probably not be detected statistically.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	January-December
		Area:	Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-5	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Disturbances and obstacles caused by ship traffic, ship support and infrastructure in polar bear migration and feeding areas will result in a reduced population	C

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2		1			6		2

Rationale:
The polar bear is a single resource with a regional distribution.
Recovery of the polar bear population may probably take abot one generation.
The effects may probably not be detected statistically.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Walrus	Month:	Januar-December
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C2-1	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Installations and traffic of ships, helicopters and aeroplanes, especially near haul-out sites, will result in disturbance and reduction in the walrus population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8		2

Rationale:
The walrus is a single resource with a regional distribution. Recovery of the walrus population may be suggested to take approximately one generation. The effects may probably be detected statistically, provided sufficient basis data.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Walrus	Month:	Januar-December
		Area:	Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C2-1	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Installations and traffic of ships, helicopters and aeroplanes, especially near haul-out sites, will result in disturbance and reduction in the walrus population.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2			2		12		3

Rationale:
The walrus is a single resource with international distribution. Recovery of the walrus population may be suggested to take approximately one generation (min. five years). The effects may probably be detected statistically, provided sufficient basis data.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Bearded seal	Month:	January-December
		Area:	Kara, Laptev, E. Siberian and Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C3-1	**Valid impact factor (from 3 above):** - Noise - Physical disturbance	Category
Impact hypothesis:	Traffic of ships, helicopters and aeroplanes will result in disturbance and reduction in the local bearded seal populations	C

Scale parametres									Vulnerability score	Vulnerability	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
	2		1			1			2		1

Rationale:
The bearded seal is a single resource with a regional distribution.
Recovery of the ringed seal population will probably take less than one generation.
The effects may probably not be detected statistically.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Ringed seal	Month:	January-December
		Area:	Kara, Laptev, E. Siberian and Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C4-1	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Traffic of ships, helicopters and aeroplanes will result in disturbance and reduction in the local ringed seal populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2		1			1			2		1

Rationale:
The ringed seal is a single resource with a regional distribution.
Recovery of the ringed seal population will probably take less than one generation.
The effects may probably not be detected statistically.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	White whale	Month:	May-October
		Area:	Kara, Laptev, E. Siberian and Chukchi Seas, Ob, Jenesei, Lena

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C5-2	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Traffic of ships and ice breaking will result in disturbance and reduction in the local white whale populations.	C

Scale parametres									Vulnerability score	Vulnerability	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
	2			2			2		8		2

Rationale:
The white whale is a single resource with a regional distribution. Recovery of the white whale population may be suggested to take approximately one generation. The effects may probably be detected statistically, provided sufficient basis data.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Grey whale	Month:	May-October
		Area:	Chukchi Sea

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C6-2	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Traffic of ships will result in disturbance and reduction in the local gray whale populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2			2		12		3

Rationale:
The grey whale is a single resource with international distribution.
Recovery of the population may be suggested to take at least one generation.
The effects may probably be detected statistically, provided sufficient basis data.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Bowhead whale	Month:	May-October
		Area:	Chukchi Sea

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	Yes		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	Yes		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	Yes		If yes, list valid impact factors. - Noise - Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C7-2	Valid impact factor (from 3 above): - Noise - Physical disturbance	Category
Impact hypothesis:	Ice-breaking and traffic of ships will result in disturbance and reduction in the local bowhead whale populations.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2			2		12		3

Rationale:
The bowhead whale is a single resource with international distribution.
Recovery of the population may be suggested to take at least one generation.
The effects may probably be detected statistically, provided sufficient basis data.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	January-December
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges of municipal/household wastes.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-2	Valid impact factor (from 3 above): Discharges of municipal/household wastes.	Category
Impact hypothesis:	Discharges of edible waste from harbour facilities and ships will cause a local increase in the polar bear population.	B

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2		1			1			2		1

Rationale:
The polar bear is a single resource with a regional distribution.
«Recovery» of the population will probably take less than one generation.
The effects is judged to be of an order of magnitude that cannot be detected statistically.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Polar bear	Month:	January-December
		Area:	Kara, Laptev, E. Siberian and Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges of municipal/household wastes.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C1-2	Valid impact factor (from 3 above): Discharges of municipal/household wastes.	Category
Impact hypothesis:	Discharges of edible waste from harbour facilities and ships will cause a local increase in the polar bear population.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3	1			1			3		1

Rationale:
The polar bear is a single resource with international distribution.
«Recovery» of the population will probably take less than one generation.
The effects is judged to be of an order of magnitude that cannot be detected statistically.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VECs:	Polar bear	Month:	January-December
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C-1	Valid impact factor (from 3 above): Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.	Category
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12		3

Rationale:
The polar bear has a regional distribution.
Recovery of the population will probably take more than one generation.
The effects is judged to be of an order of magnitude that can be detected statistically, provided sufficient basis data.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VECs:	Polar bear	Month:	January-December
		Area:	Chukchi Seas

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C-1	**Valid impact factor (from 3 above):** Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.	**Category**
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3		2		18		3

Rationale:
The polar bear has international distribution.
Recovery of the population will probably take more than one generation.
The effects is judged to be of an order of magnitude that can be detected statistically, provided sufficient basis data.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VECs:	Walrus, bearded seal, ringed seal, white whale	Month:	January-December
		Area:	Kara, Laptev, E. Siberian

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C-1	**Valid impact factor (from 3 above):** Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.	**Category**
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3	1			6		2

Rationale:
The effect is on a group of resources that each has a regional distribution.
Recovery of the affected populations of the different species will probably take more than one generation.
The effects is judged to be of an order of magnitude that cannot be detected statistically.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VECs:	Walrus, grey whale and bowhead whale	Month:	January-December
		Area:	Chukchi

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. C-1	**Valid impact factor (from 3 above):** Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.	Category
Impact hypothesis:	Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3	1			9		2

Rationale:
The effect is on a group of resources that each has a international distribution. Recovery of the affected populations of the different species will probably take more than one genera-tion. The effects is judged to be of an order of magnitude that cannot be detected statistically.

VEC WATER/LAND BORDER ZONE (sensitive areas)

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Water/land border zone (sensitive areas)	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance; landfills

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D2-1	Valid impact factor (from 3 above): Physical disturbance; landfills	Category
Impact hypothesis:	Activities related to construction of necessary harbour facilities, such as area occupation, land filling etc. will cause major local changes in the coastal zone	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
Construction of harbour facilities (land filling etc.) will probably cause major local changes in the coastal zone. This can be through local changed current systems which again can change the surrounding land areas (Hachmeister et al. 1991). Landfills might also affect the ice conditons with earlier freeze-up in the fall and later break up in the spring (Hachmeister et al. *op cit.*). Changes in sea ice and oceanographic conditions also affect migrating and feeding habitat of anadromous fishes during the summer open-water feeding. Such effects may in turn lead to changes in the dynamics of the fish populations (Hachmeister et al. *op cit.*).

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Water/land border zone (sensitive areas)	Month:	6-10
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance; Construction

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D2-1	**Valid impact factor (from 3 above):** Physical disturbance; Construction	Category
Impact hypothesis:	Activities related to construction of necessary harbour facilities, such as area occupation, land filling etc. will cause major local changes in the coastal zone	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x2x3=6	medium	2

Rationale:
Construction of harbour facilities (land filling etc.) will probaly cause major local changes in the coastal zone.
Directly, there will be a change in the habitats with dumping of e.g. stones and sand. When dumping material in the sea, particles from the material will be released to the water masses. There will also be a disturbance of the sediments. These will give rise to higher sedimentation of particles in the surrounding areas, and probably cover existing habitats. During the construction period there will be noise from the activity which might scare away animals, both terrestic and marine. Construction during the dark period or during the night need use of light, and this might scare away some species, and attract some other.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Water/land border zone (sensitive areas)	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges t Sea; Garbage and litter

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D2-2	**Valid impact factor (from 3 above):** Discharges to Sea; Garbage and litter	**Category**
Impact hypothesis:	Floating waste will accumulate in sheltered areas of the coastal zone, causing aesthetic disturbance and providing substrates that will be colonised by invertebrates	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		X		X		X			3x2x1=6	medium	2

Rationale:
Garbage and litter will locally cause aesthetic disturbance. Many types of garbage and litter (plastic) need a long time to decompose, and will remain in the coastal zone for a long time. During the decomposition, the plastic constituents will continuously be released to the environment. Some types of waste or cargo (e. g. timber) will extensively change the natural wave processes on the beaches, and thus influence the sediment transport and sedimentation pattern. This again will lead to changes of beaches and banks in the coastal zone. However, the flora and fauna if the intertidial zone is in most areas of NSR relatively sparse due to ice-scouring, meaning that the number of organisms affected by the changes will be low.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Water/land border zone (sensitive areas)	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D2-3	**Valid impact factor (from 3 above):** Discharges to Sea; Crude and bunker oil	Category
Impact hypothesis:	Accidental pollution with radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc., will cause major disturbances in the coastal zone, and under certain meteorological conditions also in inland areas (evaporation, precipitation).	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x3=18	high	3

Rationale:
Accidential pollution from cruide and bunker oil can give serious damage on the coastal zone. There can be acute effects on different resources as birds, fish and shellfish. The oil can also pollute beaches with respect to esthetic disturbance. The oil can penetrate into the surface in the littoral zone and make chronic pollution in a long time scale.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Water/land border zone (sensitive areas)	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D2-3	Valid impact factor (from 3 above): Discharges to Sea; Minerals	Category
Impact hypothesis:	Accidental pollution with radioactive materials, fuel or certain types of cargo, like hydrocarbons, fertilisers, ore etc., will cause major disturbances in the coastal zone, and under certain meteorological conditions also in inland areas (evaporation, precipitation).	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
Any release of minarals in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), tansported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pettets will change the substrate granulometry, but this impact is considered local, and thus of limited signifi-canse at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high consentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assed based on releases of fuel e.g. diesel or bunker oil.

Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented.

VEC HUMAN SETTLEMENTS

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human Settlements	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; radioactive materials.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-1	**Valid impact factor (from 3 above):** Discharges to Sea; radioactive materials.	**Category**
Impact hypothesis:	Accidental discharges of radioactive materials , fuel and certain types of cargo will affect the resource base for local people.	B

Scale parameters									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x3=18	high	3

Rationale:
Accidental discharges of radioactive materials will affect the resource base for local people. Depending on the type and amount of the radioactive materials, local people might have to move from an area, and the possibility to utilise resources can be blocked. Another effect is that the resources can be polluted, and not useable.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to sea; Crude oil and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-1	**Valid impact factor (from 3 above):** Discharges to sea; Crude oil and bunker oil	Category
Impact hypothesis:	Accidental discharges of radioactive materials , fuel and certain types of cargo will affect the resource base for local people.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
Accidental discharges of hydrocarbons can give pollution to different resources utilised by local people. This can be directly when the resources are too polluted to use as food, or the resource is removed from the area where it is utilised. Another effect can be on resources for export. The marked will not have e. g. fish from an area with pollution, even if the fish itself is unpolluted.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	1-12-
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Minerals

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-1	Valid impact factor (from 3 above): Discharges to Sea; Minerals	Category
Impact hypothesis:	Accidental discharges of radioactive materials , fuel and certain types of cargo will affect the resource base for local people.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X			X		1x2x2=4	low	1

Rationale:
Any release of minarals in larger quantities is expected to occur from an accidental event involving the wrecking of a cargo ship. The most probable mineral cargo is iron ore (pellets), tansported in bulk. In case of a grounding, the cargo will be released to the coastal environment, but will accumulate locally around the wreck. This makes the potential for removing/recovering the cargo fairly high. Iron pettets will change the substrate granulometry, but this impact is considered local, and thus of limited significanse at the present level. As soon as the pellets come into contact with the sea water, corrosion will commence. The oxidation of the iron can lead to higher concentrations of iron in water and sediments locally around the grounding site. Even though iron is an essential mineral, it is toxic to living organisms if found in sufficiently high consentrations (Underwood & Mertz 1987). However, in an ecological damage context, iron released from ship-wrecks is not considered the worst major environmental problem, and the impacts of a grounding is more likely to be assed based on releases of fuel e.g. diesel or bunker oil.

Environmental effects of mineral carrying vessels having sunk in the open sea are sparsely documented.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	1-12-
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Fertiliser

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-1	**Valid impact factor (from 3 above):** Discharges to Sea; Fertiliser	Category
Impact hypothesis:	Accidental discharges of radioactive materials , fuel and certain types of cargo will affect the resource base for local people.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X			X		1x2x2=4	low	1

Rationale:
Accidental discharges of fertilisers will locally give an increase in nutrients to the water masses. In the surrounding areas there might be toxic effects to marine and anadromous fishes. Another effect is the release of nutrients which might give higher production of primary producers in the area, depending on the type of fertiliser. High production of algea can under some circumstances give a depletion and lack of oxygen both in the water masses and in the bottom sediment (eutrofication). Locally there can be a change in the balance between the nutrients required for primary produciton, and other species of phytoplanton compared to a "normal situation" can be favourised (e. e. toxic algae).

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	11-5
		Area:	5, 6, 7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance; Icebreaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-2	**Valid impact factor (from 3 above):** Physical disturbance; Icebreaking	Category
Impact hypothesis:	Breaks in the ice render traditional routes for livestock and fishermen/hunters inaccessible	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X				X				X	1x1x3=3	low	1

Rationale: The ice breaking will make leads, and depending on the physical conditions the leads can be larger by currents and wind. In areas with hunting and fishing from the ice, the leads can make it difficult for the local people to reach areas they have utilised before. Also for the migration of reindeer this can be a problem.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	1-12
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Radioactive materials

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-4	Valid impact factor (from 3 above): Discharges to Sea; Radioactive materials	Category
Impact hypothesis:	Accidental discharges of radioactive materials ,fuel and certain types of cargo will interfere with the indigenous peoples hunting and fishing activities.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	X				X			X	2x3x3=18	high	3

Rationale:
Accidental discharges of radioactive materials can give pollution to areas utilised by local fishing and hunting activities. The effect of this can be directly if the resources are destroyed from the hunting or fishing area, or indirecly if the resources become too polluted to utilise.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Human settlements	Month:	1-12-
		Area:	1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to Sea; Crude oil and bunker oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. D1-4	**Valid impact factor (from 3 above):** Discharges to Sea; Crude oil and bunker oil	**Category**
Impact hypothesis:	Accidental discharges of radioactive materials ,fuel and certain types of cargo will interfere with the indigenous peoples hunting and fishing activities.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
X					X			X	1x3x3=9	medium	2

Rationale:
Accidental discharges of oil can give pollution to areas utilised by local fishing and hunting activities. The effect of this can be directly if the resources are destroyed from the hunting or fishing area, or indirecly if the resources become too polluted to utilise.

VEC PROTECTED AREAS

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	1-7 [1]

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. • Physical disturbance • Noise • Discharges to sea

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-1	Valid impact factor (from 3 above): Physical disturbance; Noise; Discharges to sea	Category
Impact hypothesis:	Normal NSR operational traffic adjacent to protected areas will come in conflict with Russian legislation, regulations and aim of protection of protected areas.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3	1			9	Medium	2

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: The protected areas along NSR are per definition at least of national importance, and an extended use of NSR is expected to last for several years. Moreover, the perturbation magnitude from a normal operational sailing is assessed to be small.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Protected areas	Month:	1-12
		Area*):	1) 1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. • Physical disturbance • Noise • Discharges to sea

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-2	**Valid impact factor (from 3 above):** Physical disturbance; Noise; Discharges to sea	Category
Impact hypothesis:	Accidents in the vicinity to protected areas will come in conflict with Russian legislation, regulations and aim of protection of protected areas.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2				3	18	High	3

Rationale:
1) In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: The protected areas along NSR are per definition at least of national importance. An accident is assumed to be of a medium temporal scale, but can severely affect the marine and shore environment. Consequently the perturbation magnitude is assessed to be large, and the conflicts with Russian legislation, regulations and aim of protection can be large.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	1) 1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. • Physical disturbance • Noise • Discharges to sea

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-3	Valid impact factor (from 3 above): Physical disturbance; Noise; Discharges to sea	Category
Impact hypothesis:	Normal NSR operational traffic adjacent to protected areas will disturb the wilderness quality of the areas significantly.	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3	1			9	Medium	2

Rationale:
1) In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: The protected areas along NSR are per definition at least of national importance, and an extended use of NSR is expected to last for several years. Moreover, the perturbation magnitude from a normal operational sailing is assessed to be of smaller importance to the wilderness quality.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Protected areas	Month:	1-12
		Area*):	1) 1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		-
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance and noise; Discharges to sea: • Cargo (crude oil, chemicals), fuel and ballast water

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-4	**Valid impact factor (from 3 above):** Physical disturbance; Noise; Discharges to sea of cargo (crude oil, chemicals), fuel and ballast water	Category
Impact hypothesis:	Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will reduce the wilderness quality of the areas extensively.	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3		2				3	18	High	3

Rationale:
1) In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: The protected areas along NSR are per definition at least of national importance. An accident is assumed to be of a medium temporal scale, but can severely affect the marine and shore environment. Consequently the perturbation magnitude is assessed to be large.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	[1] 1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. • Physical disturbance • Noise • Discharges to sea

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-5	**Valid impact factor (from 3 above):** Physical disturbance; Noise; Discharges to sea	**Category**
Impact hypothesis:	Normal NSR operational traffic adjacent to protected areas will disturb selected VECs, especially marine mammals.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1				2			2		4	Low	1

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: Valued ecosystem components are often valuable elements in protected areas and special attention must be given to theses species. NSR sailing, especially close to islands and in straits, can consequently disturb key elements in protected areas, assumed to be on a local scale. Sailing in vulnerable seasons can have potentially larger effects than in other seasons. In this connection, special attention must be made to marine mammals. The perturbation magnitude of operational traffic is nevertheless assumed to be of a medium magnitude. This hypothesis is connected with corresponding hypotheses for each of the VECs.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Protected areas	Month:	1-12
		Area*):	[1] 1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance and noise; Discharges to sea: • Cargo (crude oil, chemicals), fuel and ballast water

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-6	**Valid impact factor (from 3 above):** Physical disturbance; Noise; Discharges to sea of cargo (crude oil, chemicals), fuel and ballast water	Category
Impact hypothesis:	Accidents in the vicinity to protected areas can lead to extensive discharges of cargo, fuel an ballast water, which will cause extensive damage to populations of VECs in vulnerable seasons.	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2				3	12	High	3

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: Valued ecosystem components are often valuable elements in protected areas and special attention must be given to theses species. NSR sailing, especially close to islands and in straits, can consequently disturb key elements in protected areas, for accidents assumed to be on a regional scale. Accidents in vulnerable seasons can have significantly larger effects than in other seasons. In this connection, special attention must be made to marine mammals. The perturbation magnitude of accidents is assumed to be of a large magnitude. This hypothesis is connected with corresponding hypotheses for each of the VECs.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	[1] 1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance: • Clean-up operations Noise: • Helicopter; ice breaking; Discharges to sea

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-7	**Valid impact factor (from 3 above):** Physical disturbance: *clean-up operations*; Noise; *helicopter, ice breaking*; Discharges to sea	**Category**
Impact hypothesis:	Clean-up operations following an ship accident will lead to physical disturbance and noise, which will cause serious disturbance to selected VECs in vulnerable seasons.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2		1					3	6	Medium	2

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: Clean-up operations normally involve a lot of people and extensive use of motor vehicles (ship, helicopter, plane) which clearly will disturb VECs in vulnerable seasons. The effect is assumed to be on a regional scale, but of relatively short duration. The perturbation magnitude, however, can in vulnerable seasons for selected VECs in the area be large.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	[1] 1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Petroleum development on-shore and off-shore; Mining industry: • Permanent structures, pipelines, roads railways

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-8	**Valid impact factor (from 3 above):** Petroleum development on-shore and off-shore; Mining industry: Permanent structures, pipelines, roads railways	Category
Impact hypothesis:	Increased industrial development, with constructions of pipelines and transportation systems will disturb selected VECs in the terrestrial, aquatic and marine environment by making barriers and disturbance.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: Pipelines and roads following an industrial development in Arctic often stretches out for hundreds of kilometres with long lasting barrier impacts and disturbance on selected animals. Investigations also show that to some extent habituation to the impact factors occur. The impacts are area-, season and species dependent.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Protected areas

Month:	1-12
Area*):	1) 1-7

*) Influence zone can be determined by oil drift models

NB! For vulnerability assessed by using the semi-quantitative model, only the fields «Vulnerability», «PIL-index» and «Rationale» shall be filled in. Process shall be documented elsewhere.

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>*Representation* </u>*(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Petroleum development on-shore: • Discharges to limnic (and marine) and terrestrial environment of crude oil

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-9	**Valid impact factor (from 3 above):** Petroleum development on-shore: Discharges to limnic (and marine) and terrestrial environment of crude oil	**Category**
Impact hypothesis:	Pipeline accidents will destroy terrestrial, aquatic and marine habitats severely and reduce the environmental quality of protected areas.	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
1) In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: Pipeline accidents can affect large areas if the leakage drain into lakes and rivers, but must the most likely effects will be on a local to a regional scale. The duration of an oil spill pollution in the Arctic environment is assessed to be of medium to large scale dependent on the effectiveness of an oil spill combat. In a protected area, a pipeline accident of a certain magnitude is assumed to give a large perturbation.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7

VEC:	Protected areas	Month:	1-12
		Area:	[1] 1-7

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. • Rural development • Tourism

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. E1-10	**Valid impact factor (from 3 above):** Rural development; Tourism	**Category**
Impact hypothesis:	Increased use of NSR will lead to increased population, tourism, hunting and fishing in protected areas, which will be a threat to selected VECs in special and to biological diversity in general.	C

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3		2		12	High	3

Rationale:
[1] In concrete cases it is recommended to identify each protected area, and run the assessment according to localisation and status of protection.
Scale parameters: The NSR area is an exclusive goal for the tourism industry, and exclusivity in tourism is an increasing phenomenon. Together with increased population, introduction of alien cultures and better infrastructure this will lead to an increased use of protected areas as recreation-, fishing- and hunting grounds, and consequently an increased threat to species and habitats. If the development of tourism, including hunting and fishing, follow *the «new western economy outcome pattern»* without strict regulations of the activities, we assume the potential threat to protected areas to be of medium scale on spatial and perturbation. We furthermore assume that the activities will last as long as the economic outcome exist and consequently the effects is on a large temporal scale.

VEC INDIGENOUS PEOPLE

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	October - June
		Area:	Yenisey

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Ice-breaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-1	Valid impact factor (from 3 above): Ice-breaking on frozen rivers	Category
Impact hypothesis:	Boat traffic on frozen rivers disturbs migration of wild reindeer (and other wildlife) and affects the effectiveness of hunting as a major subsidence	B

Scale parametres									Vulnera-bility score	Vulnera-bility	PIL index
Spatial scale			Temporal scale			Perturbation magnitude			Product of S, T and P	Low/Medium/High	1-3
L	R	N/I	S	M	L	S	M	L			
	2				3			3	18	High	3

Rationale:
This has been documented for the lower Yenisey river and its estuary by Anderson (1995). It is especially problematic today, where the shortage of fuel and transportation facilities does not allow the hunters to search for the animals. Expected to be valid to a minor extent throughout the Siberian North.
Hunting of wild reindeer is a major subsistence of the indigenous people of the Taymyr area, and of other indigenous peoples to a somewhat minor extent. Continuous ice-breaking every winter will have a negative, large, long-term effect on indigenous people, where hunting is a major subsistence.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	October - June
		Area:	Ob, Lena, (other rivers)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Ice-breaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-1	**Valid impact factor (from 3 above):** Ice-breaking on frozen rivers	**Category**
Impact hypothesis:	Boat traffic on frozen rivers disturbs migration of wild reindeer (and other wildlife) and affects the effectiveness of hunting as a major subsidence	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1				3		1			3	Low	1

Rationale:
This has been documented for the lower Yenisey river and its estuary by Anderson (1995). It is especially problematic today, where the shortage of fuel and transportation facilities does not allow the hunters to search for the animals. Expected to be valid to a minor extent throughout the Siberian North.

Hunting of wild reindeer is a major subsistence of the indigenous people of the Taymyr area, and of other indigenous peoples to a somewhat minor extent. Continuous ice-breaking every winter will have a negative, large, long-term effect on indigenous people, where hunting is a major subsistence.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	October - June
		Area:	Ob, Yenisey, Lena, (other rivers)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Ice-breaking

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-2	**Valid impact factor (from 3 above):** Ice-breaking on frozen rivers	**Category**
Impact hypothesis:	Boat traffic on frozen rivers disturbs migration of domestic reindeer and affects the ecological basis of reindeer breeding	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8	Medium	2

Rationale: Reindeer breeding is the most important subsistence of most indigenous groups of the Russian North, and disturbed migration routes could prevent the animals to reach calving grounds in time, etc.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	May - October
		Area:	Chukchi Sea (incl. Bering Strait)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Human activity (physical disturbance, noise, etc.)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-3	Valid impact factor (from 3 above): physical disturbance noise etc.	Category
Impact hypothesis:	Intensive traffic in coastal waters may cause emigration of marine mammals (walrus, seals)	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2			2		8	Medium	2

Rationale:
Valid for the Bering Strait and Chukchi Sea, and outside the NSR along the Pacific coast of Chukotka and Kamchatka. Walrus gathering places in the Bering Strait have changed in recent years, but it is not proven that this is caused by ship traffic. Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Chukchi Sea (incl. Bering Strait)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-4a	Valid impact factor (from 3 above): Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo, and fuel residues, sludge and bilge.	Category
Impact hypothesis:	Pollution from ships affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3	1			6	Medium	2

Rationale:
Valid for the Bering Strait and Chukchi Sea, and outside the NSR along the Pacific coast of Chukotka and Kamchatka, where this may lead to loss of food resources for indigenous subsistence.
Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka. For evaluation of magnitude and perturbation see IH C1.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Chukchi Sea (incl. Bering Strait)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *<u>Representation</u> (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	?		If yes, list valid impact factors. Emission of exhaust gasses to air

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-4b	**Valid impact factor (from 3 above):** Emission to air (exhaust gasses)	**Category**
Impact hypothesis:	Pollution from ships affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2		1			?	?	?

Rationale:
Valid for the Bering Strait and Chukchi Sea, and outside the NSR along the Pacific coast of Chukotka and Kamchatka, where this may lead to loss of food resources for indigenous subsistence. Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Kara, Laptev, E. Siberian and Chukchi Sea

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges of dry cargo, garbage and litter

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-6	Valid impact factor (from 3 above): Discharges of dry cargo, garbage and litter	Category
Impact hypothesis:	Littering of beaches (waste from shipping) may lead to depletion of coastal gathering grounds	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1			1			1			3	Low	1

Rationale:
Beaches are in many areas gathering grounds for indigenous people, and feeding grounds of sea birds (geese) that in return are a food resource for the people.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Indigenous people	Month:	May - November
		Area:	Chukchi Sea (incl. Bering Strait), Ob, Yenisey, Lena (and other rivers)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-5	**Valid impact factor (from 3 above):** Release of liquid cargo (hydrocarbons)	Category
Impact hypothesis:	Accidental pollution from shipwreck affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations, leading to loss of resources for indigenous subsistence	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	1-2				3			3	9-18	Med.-High	2-3

Rationale:
Valid for the Bering Strait and Chukchi Sea as wel as rivers and estuaries, and outside the NSR along the Pacific coast of Chukotka and Kamchatka, where this may lead to loss of food resources for indigenous subsistence.
Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka. For evaluation of magnitude and perturbation see IH C2.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Indigenous people	Month:	December - April
		Area:	Chukchi Sea (incl. Bering Strait), Ob, Yenisey, Lena (and other rivers)

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-5	**Valid impact factor (from 3 above):** Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo	**Category**
Impact hypothesis:	Accidental pollution from shipwreck affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations, leading to loss of resources for indigenous subsistence	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Valid for the Bering Strait and Chukchi Sea as wel as rivers and estuaries, and outside the NSR along the Pacific coast of Chukotka and Kamchatka, where this may lead to loss of food resources for indigenous subsistence.
Sea mammals are a major food source for the indigenous people of the Bering Strait and Chukotka. For evaluation of magnitude and perturbation see IH C2.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Indigenous people	Month:	January - December
		Area:	Kara, Laptev, E. Siberian Sea

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Release of liquid cargo (hydrocarbons)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-5	Valid impact factor (from 3 above): Discharges/release of fuel oil, diesel oil, radioactive material, liquid cargo	Category
Impact hypothesis:	Accidental pollution from shipwreck affects the habitat of sea mammals and other marine resources causing relocalisation of feeding, breeding, and/or resting areas or decrease of populations, leading to loss of resources for indigenous subsistence	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3	1			6	Low	1

Rationale:
In these areas, indigenous people are little dependent on marine resources, although minor impacts to subsistence could occur locally.

<u>ACCIDENTAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Indigenous people	Month:	January - December
		Area:	Kara, Laptev, E. Siberian and Chukchi Sea

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges of dry cargo, garbage and litter

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-6	Valid impact factor (from 3 above): Discharges of dry cargo, garbage and litter	Category
Impact hypothesis:	Littering of beaches (waste from shipping) may lead to depletion of coastal gathering grounds	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1			1			1			3	Low	1

Rationale:
Beaches are in many areas gathering grounds for indigenous people, and feeding grounds of sea birds (geese) that in return are a food resource for the people.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 **Screening of vulnerability dependent factors**

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance (land devastation, aerial occupation)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 **Assessment of vulnerability significance**

IH no. F1-7	**Valid impact factor (from 3 above):** Physical disturbance	Category
Impact hypothesis:	The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to land devastation and loss of hunting, fishing and breeding grounds.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3			3	27	High	3

Rationale:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of these areas is presently leading to the cultural extinction of many indigenous groups.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-8	Valid impact factor (from 3 above): Physical disturbance	Category
Impact hypothesis:	Oil/gas pipelines connecting hydrocarbon fields with northern harbours may lead to areal segmentation as a hinder for wildlife migration and a general decrease of wildlife resources.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Hunting grounds and pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of these areas is presently leading to the cultural extinction of many indigenous groups.

<u>OPERATIONAL</u> vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>*Representation*</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: <u>*Exposure*</u> *(probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: <u>*Influence*</u> *(probability of effect if in contact).*	X		If yes, list valid impact factors. Discharges to land, rivers and lakes (toxic spills, undifferentiated)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-9	Valid impact factor (from 3 above): Discharges to land, rivers and lakes (toxic spills, undifferentiated)	Category
Impact hypothesis:	The NSR will favour hydrocarbon development, industry development and mining in northern areas, leading to toxic spills that may destroy spawning areas and fishing grounds.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Fishing grounds and spawning areas are important resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of such areas is presently leading to the cultural extinction of many indigenous groups.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Emission to air (SO_2 etc.)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-11	Valid impact factor (from 3 above): Emission to air (SO_2 etc.)	Category
Impact hypothesis:	The NSR will favour industry development leading to SO_2 and other air pollution which will degrade or destroy subsistence areas.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of these areas is presently leading to the cultural extinction of many indigenous groups.

OPERATIONAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to II-7.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: <u>Representation</u> *(time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *<u>Exposure</u> (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *<u>Influence</u> (probability of effect if in contact).*	X		If yes, list valid impact factors. Tourism

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-12	**Valid impact factor (from 3 above):** Tourism	**Category**
Impact hypothesis:	With an increased infrastructure, commercial fishing and hunting tourism may take subsistence areas from indigenous population.	B

Scale parametres									Vulnerability score	Vulnerability	PIL index
Spatial scale			Temporal scale			Perturbation magnitude					
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2			2				3	12	High	3

Rationale:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of these areas is presently leading to the cultural extinction of many indigenous groups.

ACCIDENTAL vulnerability assessment - Standard report form

Basic information obtained through Step I-2 to III-8.

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Release to land, rivers and lakes (oil spills)

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-10	Valid impact factor (from 3 above): Release to land, rivers and lakes (oil spills)	Category
Impact hypothesis:	Pipelines connecting oil fields with northern harbours may have accidental leakage and spills causing local degradation or destruction of subsistence areas.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1				2				3	6	Medium	2

Rationale:
Hunting and fishing grounds as well as pasture lands are the resource bases of Arctic indigenous peoples' subsistence. They form the basis of their welfare and of their cultural identity. Extensive loss of these areas is presently leading to the cultural extinction of many indigenous groups.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Alien cultural impacts

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-13	**Valid impact factor (from 3 above):** Alien cultural impacts	Category
Impact hypothesis:	Increased infrastructure, through consequent alien settlement and industrialisation, will forward cultural decay among indigenous people.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3			3	27	High	3

Rationale:
Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Crime

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-14	Valid impact factor (from 3 above): Crime	Category
Impact hypothesis:	Increased infrastructure, alien settlement and industrialisation will lead to an increase of criminal acts against the indigenous population, and partly against their resource base and their means to use the resources (e.g. reindeer theft, robbery, threat).	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3		2		18	High	3

Rationale:
Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Alien commercial interests

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-15	Valid impact factor (from 3 above): Alien commercial interests	Category
Impact hypothesis:	With increased accessibility and transport facilities, commercial fisheries and hunters may utterly take the resource basis for indigenous subsidence.	B

Scale parameters											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
		3			3			3	27	High	3

Rationale:
Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Indigenous people	Month:	January - December
		Area:	Entire area

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Nature protection interests

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. F1-16a	**Valid impact factor (from 3 above):** Nature protection interests	**Category**
Impact hypothesis:	With an increased infrastructure, increased protection interests may lead to the closure of certain areas for indigenous subsidence.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnerability score	Vulnerability	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Indigenous cultures are subject to a special vulnerability because of their close dependence on the natural environment, which forms the basis of their cultural identity.

VEC DOMESTIC REINDEER & VEC WILD REINDEER

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Domestic and wild reindeer	Month:	All year
		Area:	Terrestrial part of NSR

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance: Ice breaking, active installations, pipelines, roads

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. G1-2 & G2-2	**Valid impact factor (from 3 above):** Physical disturbance: Ice breaking, active installations, pipelines, roads	Category
Impact hypothesis:	Physical encroachment and installations will obstruct the movements of reindeer, may hinder their access to grazing and calving areas and increase their energy needs so that local populations may decrease.	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
	2				3			3	18	High	3

Rationale:
Operational activities like ice breaking in rivers and straits and active installations will occupy areas and may accordingly reduce the access to grazing ranges and habitats and force animals to leave important areas. They can also function as physical or psychological obstacles to migrations between seasonal habitats, e.g. calving areas, and accordingly affect reproduction and survival. For example Klein and Kuzyakin (1994) reported that the western heard of wild reindeer has been affected by northern industrial development. Above ground gas-pipeline from Messoyakha gas field to Norilsk made in 1969 effected the migration of 75.000 of the heard of 300.000. The pipeline was later elevated in some areas to allow reindeer pass under. This was effective for 25% of the population. A new line was constructed and fences set up to guide deers away from the line. Today the animals are herded away from Norilsk by fences and have therefore shifted grazing area.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Domestic and wild reindeer	Month:	All year
		Area:	Terrestrial part of NSR

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Emissions to air: Sulfides, fluorides, heavy metals, stable chlorides, PCBs and radioactivity.

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. G1-4/G2-4	Valid impact factor (from 3 above): Emissions to air: Sulfides, fluorides, heavy metals, stable chlorides, PCBs and radioactivity.	Category
Impact hypothesis:	Pollution from ship traffic and industrial activity will be accumulated in grazing vegetation and will affect the health condition of local reindeer populations.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1					3		2		6	Medium	2

Rationale:
Emissions into air of pollutants will gradually be assimilated into the vegetation and be found in concentrations in the internal organs of reindeer feeding on these plants. High concentrations can cause illness and reduce fertility of reindeer and reindeer consumers. Sulfides, fluorides, heavy metals, stable chlorides, PCBs are relevant substances in addition to radioactivity. The effects is known and substantiated on various animal species exposed to high levels of pollution. This was especially through for radioactivity after the Chernobyl accident (AMAP 1998).

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Domestic and wild reindeer	Month:	All year
		Area:	Terrestrial part of NSR

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Change of development patterns: hunting

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. G1-3/G2-3	Valid impact factor (from 3 above): Change of development patterns: hunting	Category
Impact hypothesis:	Increased ship traffic and industrial activity will lead to increased illegal hunting and decreased reindeer populations.	B

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1				2		1			2	Low	1

Rationale:
Poaching and uncontrolled hunting of domestic as well as wild reindeer is known to take place in northern Russia. Increased industrial activity will bring more people to places where poaching is easy and tempting. According to Syroechkovskii (1995) the wild reindeer at Kola increased after 1968 while the domestic reindeer decreased. At that time the total population was about 20.000. The hunting of wild reindeer increased. Helicopters were used in hunting and the poaching increased. In 1984 the total population had decreased to 2.000 animals.

In western Siberia the wild reindeer population hardly not exceed 20.000 by the early 1980's. Later it has decreased due to hunting from vehicles and helicopters (Syroechkovskii 1995). Organised hunting of wild reindeer in Taymyr was in the period from 1971 to 1981 500.000 animals. In addition were 200.000 killed by poaching. Surprisingly the rate of increase of the population increased from 14.4% in 1975 to 23.8% in 1981. At Severnaya Zemlya there were only about 100 wild reindeer in 1984. Poaching has greatly diminished the population. According to Belikov et al.(1998a) poaching has become one of the strongest negative factors affecting many reindeer populations in northern Russia.

OPERATIONAL vulnerability assessment - Standard report form

VEC:	Domestic and wild reindeer	Month:	All year
		Area:	Terrestrial part of NSR

1 Screening of vulnerability dependent factors

Vulnerability dependent factors	Yes	No	Comments
1. The VEC must be in the area where the impact factor occurs. Factor 1: *Representation (time in the area).*	X		
2. The VEC must have the possibility to come in contact with the impact factor. Factor 2: *Exposure (probability of contact with the impact factor when the VEC and the area overlap).*	X		
3. The impact factor must have an effect on the VEC. Factor 3: *Influence (probability of effect if in contact).*	X		If yes, list valid impact factors. Physical disturbance: General disturbance

Potential vulnerability of the VEC requires a positive value (yes) on each of the factors

Vulnerability dependent factor 4 will be assessed through point 2 below.

2 Assessment of vulnerability significance

IH no. G1-1/G2-1	**Valid impact factor (from 3 above):** Physical disturbance: General disturbance	Category
Impact hypothesis:	Disturbances and traffic will cause increased energy expenditure and reduced grazing time of reindeer, and accordingly reduced survival and calf production in the affected local populations	C

Scale parametres											
Spatial scale			Temporal scale			Perturbation magnitude			Vulnera-bility score	Vulnera-bility	PIL index
L	R	N/I	S	M	L	S	M	L	Product of S, T and P	Low/Medium/High	1-3
1				2			2		4	Low	1

Rationale:
Traffic affects population distribution and accordingly vegetation availability. This is decisive to physical condition and mortality. Disturbances occurring in late winter might cause a sharp increase in energy expenditure during period of negative energy balance. This will increase the danger of adult mortality and of females throwing their calves/aborting.

Appendix 3: Review of the paper and the authors response to the review

NORTHERN SCIENCE AND CONTAMINANTS RESEARCH DIRECTORATE

NATURAL RESOURCES AND ENVIRONMENT BRANCH, NORTHERN AFFAIRS PROGRAM, DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS, LES TERRASSES DE LA CHAUDIERE ✐ OTTAWA, ONTARIO
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February 11, 1999

Claes Lykke Ragner
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Dear Claes:

<u>Review of INSROP - "ENVIRONMENTAL IMPACT STATEMENT"</u>

Please find here my review of the INSROP Environmental Impact Statement (EIS) prepared by Thomassen et al.

In conducting this review I have examined the full text including the aggregated results and conclusions, but I am not reporting on appendices 1 and 2. The latter detail the results of the authors analysis and it is not appropriate for me to comment. However, that being said, I did find myself sometimes being surprised by the "probable index level" (PIL) of 3 (high) being accorded to some of the impact hypotheses evaluations for operational (as distinct from accidental) scenarios. In most cases the impact factor is of a low and/or geographically restricted level of intensity and the severity of impact depends a good deal on the impact factor and the VEC or its habitat being in the same place. In other words, they have accorded a PIL 3 level for those discrete instances where impact factor and special vulnerability coincide. In addition, chemical partitioning especially with particle active substances can dramatically effect the bio-availability of pollutants in estuaries and on large coastal shelves. The authors show that they are well aware of these factors (they make the same points themselves very well in sections 5, 6, and 8). They also often make it clear in the evaluation of the hypothesis, but in other cases the qualification is not made, and Table 4.1 indicating VEC temporal and spatial scales increased my concerns. If the authors agree, one "fix" would be to add a third paragraph containing an explanatory sentence or two in "Section 4". It could also refer the reader to Sections 5, 6 and 8 for the synthesis which puts everything into context. It may also be true that I am often reacting to the rationale presented as to why the hypothesis should be evaluated, rather than to the results of the evaluation itself . If this is the case, then others will probably make the same mistake and a little more contextual clarification as suggested above would help.

My copy did not include the "Executive Summary". If this has yet to be prepared, the authors may like to consider moving "Section 8 - Concluding Remarks" to the front of the document to fill this role. I thought that it presents a good balanced view of the overall conclusions. It also addresses to some extent my concerns about some of the PIL-3 evaluations.

Despite the above comments, I have no significant concerns with the paper and recommend that it can be published. Before this occurs however, the authors may wish to consider the points described in the remainder of my review given below and in the attached annex.

As with my review of the "Guide to EIA Implementation in INSROP Phase II" I found a few instances where the English gives rise to some difficulties, and I have noted more important instances in the attached annex with some suggested alternative language. There are also a few occasions where text appears to be missing and I noted these in the annex, together with a few technical questions which I address to the authors. Also in my review of the "guide", I suggested that an annex of acronyms would be helpful, and I think this is also the case here. The same annex could of course be used in both papers. I have not noted the occasions where simple editing is needed.

The difficulty which the authors faced was to apply a methodology which attempts to apply a rigorous analysis of a development scenario without having that scenario available. Not an easy task. They are to be commended in having completed their assignment by creating hypothetical scenarios upon which they have conducted as vigorous analysis as the circumstances allowed. I hope that their work is promoted and made widely available, regardless of whatever may be the ultimate fate of the "International Northern Sea Route". There is much in this EIS which is of a wide and generic relevance.

Yours sincerely

DAVID P STONE
Director: Northern Science and Contaminants Research

ANNEX

Review of INSROP - ENVIRONMENTAL IMPACT STATEMENT.

General Comment: While the quality of the analysis and technical work is high,, the report does show signs of not yet being quite finished. For example, figures are sometimes labelled as Fig xxx, and on some occasions the meaning of the text is not clear. I have made suggests concerning some of the latter but have not addressed them all.

Executive Summary: This is missing in my copy. See my covering letter. If this has yet to be prepared, the authors may like to consider moving "Section 8 - Concluding Remarks" to the front of the document to fill this role. I thought that it presents a good balanced view of the overall conclusions.

Preface, second paragraph: The Northern Sea Route (NSR) does not "cover almost half of the northern part of the earth". It is a zone or band of varying width which extends over so many miles from longitude "x" to longitude "y". Or you could say it extends over "z" proportion of the earths circumference at a specified longitude.

Section 2.4.1, Last sentence: The word "uncertain" may be more suitable than the existing "unstable".

Section 2.4.6, First sentence: I read this and the remainder of the paragraph several times before I realized that they are an overarching introduction to the remaining three paragraphs in this section. As it is essential that the reader fully understands how the assessment was conducted, I would suggest something along the following lines:

"The assessment was completed in a sequential fashion where each step was referenced to the INSROP Geographic Information System. The steps were as follows:

1) Baseline data stored in ....in time and space (Fig 2.2)
2) Each impact hypothesis........by Thomassen et al (1998). Fig 2.3 shows ....two paths.
3) The outcome.........for the INSROP EIA."

Section 2.5 Last paragraph, Third sentence: Same comment as given above for the Preface, second paragraph, concerning a zonal definition of the geographic extent of the NSR.

Section 3.1, First paragraph: There is a technical inaccuracy here. There is no significant salt flux between the sea and the atmosphere. If there was, salinity would not be a conservative property. The authors have it right in the fourth paragraph of this section.

Section 3.1, Last paragraph, first sentence: The Beaufort Gyre and the Canada Basin are not synonymous. They are two different entities.

Section 3.4.2, Second paragraph, second sentence: I was a little surprised to see the statement "an almost complete lack of invertebrate soil fauna". This is not my area but when I did a little project once on Svalbard the soil was teaming with nematodes, tardigrades, colembola, etc! I suspect the point is that they are not active for many months of the year.

Section 3.4.2, Fourth paragraph, second sentence: Perhaps this and the following sentence could be expanded a little to ensure that the logic is clear. Are the authors here saying that Arctic lakes tend to be acidic (low buffering), therefore oligotrophic, and hence lacking a bacterial flora capable of biodegrading hydrocarbons? Or are the thoughts behind the penultimate and final sentences quite separate, the first referring to acidifying substances and the second to oil?

Section 3.5, Last paragraph, last sentence: As the more substantive and fully referenced AMAP report is now available, perhaps it too should be referenced here. The high dietary intake of PCBs is also seen in Greenland. In both instances it is related to the consumption of marine mammal lipids.

Section 4, Second paragraph, first sentence: This sentence opens with a confusing phrase which I think could be simply removed. Therefore I would suggest something like "We made a distinction......"

Section 4.1 Impact Factor "Alien commercial interests"-"Impact Hypothesis". The English of the phrase "utterly take" is rather unusual and the authors may like to substitute the phrase "completely deplete" or "severely deplete".

Section 4.1.1 Conclusions or Recommendations: The authors may wish to include here a comment on the most recent activities of IMO regarding TBT regulation. Again this is not my area, but I think further TBT restrictions are being targeted. One recommendation could simply be to demand of NSR shipping either no use of TBT or full compliance with IMO standards if the latter will achieve the same end result.

Section 4.1.1 Conclusions: The monitoring of TBT in AMAP has moved beyond being a recommendation from an expert group as indicated by the authors. It is now a component of the AMAP Phase II Implementation Plan.

Section 4.1.3 Impact Factor "Discharges to sea - Minerals: The word "minerals" in English is not usually employed to include oil. Therefore I suggest the description of the impact factor could read: "Discharges to sea: minerals including oil".

Section 4.1.3 Impact Factor "Discharges to sea - Minerals, Impact Hypothesis B2-4, Last sentence of "Indirect effects and their significance": I would question whether the example of Harlequin Duck reproductive failure attributed to ingestion of contaminated food following a catastrophic spill on the scale of the Exxon Valdez is relevant to a hypothesis concerned with operational discharges.

Section 4.1.3 Conclusions: This is a good example of the concern that I expressed in my covering letter concerning the allocation of a PIL-3 rating to some of the scenarios without any time and space qualifications. In certain circumstances, there can be no question that a PIL-3 is appropriate, but in others it is difficult to relate such a rating to routine operational activities.

Section 4.1.7 Conclusions: Given the evidence, is this not a rather radicle conclusion? I would have expected something indicating that the Grey Whales may be vulnerable in certain confined near shore areas of the NSR in the Chukchi. Such a conclusion would still support the authors recommendations.

Section 4.1.10 Impact Factor - The NSR will favour industry development leading to SOx....: The PIL-3 is presumably here accorded because of the nature of historical and present facilities. It is technically possible to have northern development without significant SOx emissions.

Section 4.1.10 Conclusions (-also concerning the entire section): Presumably, the NSF could generate many scales of onshore infrastructure and associated development, ranging from minor to major. It may be worth pointing this out since the hypotheses present the major end of the development scale which may not be the most probable scenario.

Sections 4.2 and 4.2.1: The word "disruption" may be better than "devastation" as used in the impact hypotheses statements. Disruption or even significant disruption would be an easier outcome to hypothesize than devastation .

Sections 4.3.1, and 4.3.2 : For accidents involving radioactivity, so much depends on whether there was total loss of containment, the nature of the lost material and the sedimentation characteristics of the receiving environment. I am not sure that the evaluation of these hypotheses are in harmony with studies conducted on low and high level discharges at sea and I suggest that the authors check with Per Strand at the Norwegian Radiation Protection Agency.

Section 4.3.4 Impact Factor "Discharge to sea-chemicals and Impact Factor "Discharge to sea-minerals: It is difficult to detect what the difference is between these two hypotheses. I think there is a difference and it relates to the nature of the substance being released but in this case I doubt if the evaluation of the two hypotheses could use identical text.

Section 4.3.5 Impact Factor "Discharge to sea-chemicals; and Impact Factor "Discharge to sea-minerals: Same comment as immediately above.

Section 4.3.6 Conclusions and Direct effects: I do not have the Oritsland papers with me and it is now a long time ago. However, I think I recall an important detail concerning the polar bear exposure study. That is that the bears showed a strong avoidance reaction to the oil. They did not want to enter it, and the experiment only proceeded by giving them no choice.

Section 4.3.9 Conclusions: This is another hypothesis which I would recommend be shown to Per Strand. Since we are here dealing with accidental releases I question if it is fair to say that "human exposure to radiation damage IS an undesirable outcome of sea transport." There may be no exposure from this source and if there is, any damage would be expected to follow the well documented statistical probability distributions.

Section 4.3.10 Impact Factor: Discharges to sea: Hydrocarbons: If the Impact factor is hydrocarbons, why does the Impact hypothesis deal first with radionuclides, then other types of cargo, including fertilisers?

Section 5 and 6: As noted in my covering letter, I particularly liked these two sections. Anything which the authors can do to further draw the attention of the reader of Section 4 to these later two sections would improve the entire report.

Section 5.1.2: The authors may wish to check this conclusion with Harold Dovland at the Norwegian Ministry of Environment. I think it may depend on the dominant atmospheric trajectories from the shipping source. If it is out to sea, then marine buffering capacity would dominate, but if it is blowing onto the shore it may be different. The LRTAP Convention is becoming very interested in marine SOx and NOx emissions.

Section 5.2.1 Operational Activities, Third paragraph, second sentence. I think the end of this sentence should read ".....in North American Arctic waters...."

Section 5.2.1 Accidents, Third paragraph, first sentence: The word transitory means of short duration in time. I think the authors mean the word "transition".

Section 5.2.1 Accidents, Last paragraph, last sentence: This is a very broad statement which could easily be challenged. However, it would be much easier to defend a statement such as "The potential for accidental release of radioactive material and of corresponding environmental impacts is a significant concern in the Arctic."

Section 5.2.2: There are two incomplete references to figures in this section (oil and shoreline; and, oil and seabirds).

Section 5.2.2 VEC White Whales: Are the estuaries not also where the whales give birth and the neonates spend their first few months?

Section 5.2.2 Human Settlement, Third paragraph: Are fertilisers an existing or expected NSR cargo?

Section 5.2.2 Penultimate paragraph, second sentence: There is a small difficulty with the English. Something cannot be irretrievably lost (gone for ever) for some period of time.

Section 6.1.1 Second paragraph, third sentence: I did not understand the meaning of the word "softening". There are also many acronyms in this section which should be spelled out and or defined in an annex.

Section 6.2 VEC Benthic invertebrates, second paragraph: The monitoring of TBT in AMAP has moved beyond being a recommendation from an expert group as indicated by the authors. It is now a component of the AMAP Phase II Implementation Plan.

Section 8: Please note the suggestion in my covering letter of giving this excellent section more prominence and of perhaps converting it into the Executive Summary. There are several references to "fig xxxxxx" remaining in the text.

The authors response to the review:

We would like to thank David P. Stone for his constructive review of this Environmental Impact Statement for the Northern Sea Route. We have tried revise the report in accordance with his review, but in some few instances the contributors have disagreed with the review or feel to explain the confusion. Their response follow below.

JørnThomassen
Kjell A. Moe
Odd Willy Brude

General

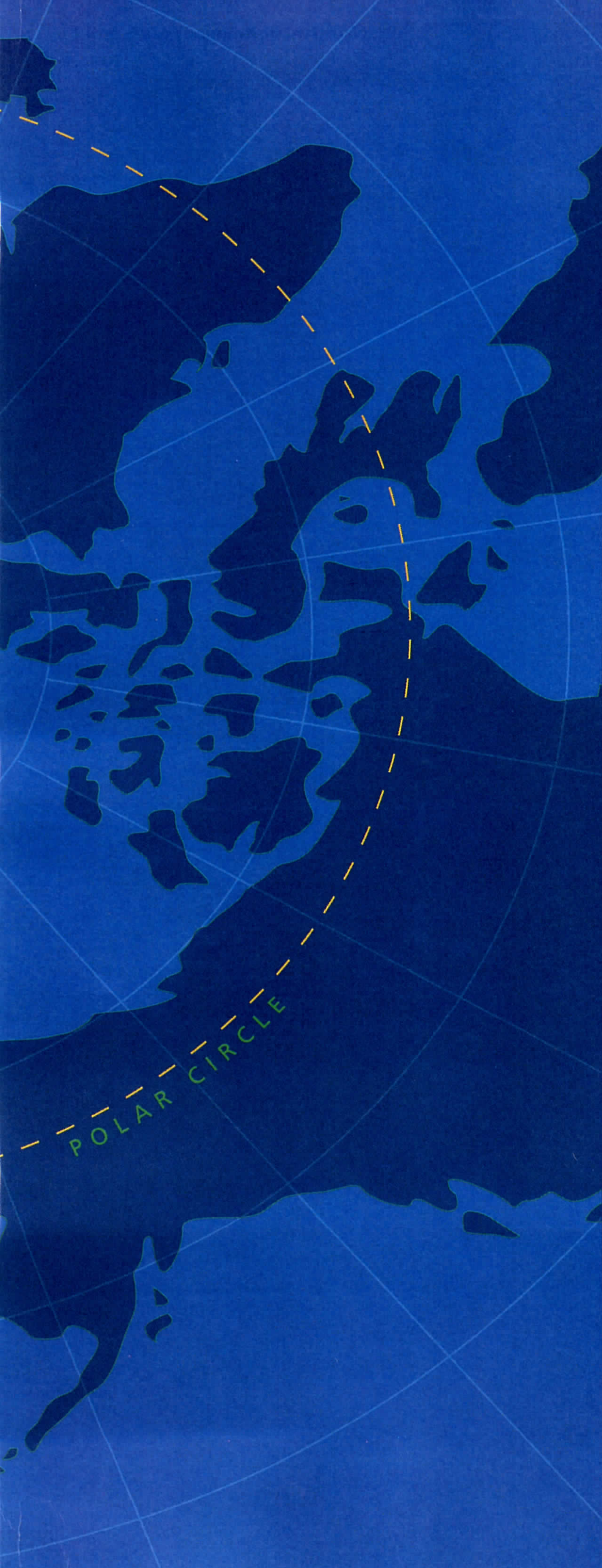
The authors agree with the review that some of the Potential Impact Level indices for operational scenarios are rather radical and could be the object for more critical assessments. We have in this context, however, used the contributions concerning vulnerability assessments made by each of the VEC specialists in INSROP. In case of concrete activity plans and descriptions for sailing along NSR, new vulnerability assessments have to be done according to the new scenarios.

Specific

Review: Sections 4.3.1, and 4.3.2: For accidents involving radioactivity, so much depends on whether there was total loss of containment, the nature of the lost material and the sedimentation characteristics of the receiving environment. I am not sure that the evaluation of these hypotheses are in harmony with studies conducted on low and high level discharges at sea and I suggest that the authors check with Per Strand at the Norwegian Radiation Protection Agency.

Response: The criteria and conclusions presented in support of the radioactivity VECs were compiled by a radioactivity expert using information derived from reports prepared by the Arctic Nuclear Waste Assessment Program, the International Arctic Seas Assessment Program, and the Joint Norwegian-Russian Expert Group.

The reviewer is correct in his consideration of the loss of containment, the nature of the lost material and the sedimentation characteristics of the receiving environment as important factors in evaluating accidental releases of radioactivity. In a large-scale risk assessment these aspects of radiation transport and exposure would be evaluated in detail. However, for the purposes of the present activity, the primary focus of the VECs is from the perspected of potentially affected biological resources. Therefore the response to the VECs and supporting information focuses on the biological resources. It is the biological resources which are the ultimate endpoint of concern regarding radioactivity exposure and therefore it is appropriate to focus on biological aspects in an abbreviated presentation format, as is the case with VECs. (Response by Lars-Henrik Larsen).



The three main cooperating institutions of INSROP

Ship & Ocean Foundation (SOF), Tokyo, Japan.

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

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.

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

The Fridtjof Nansen Institute (FNI), Lysaker, Norway.

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