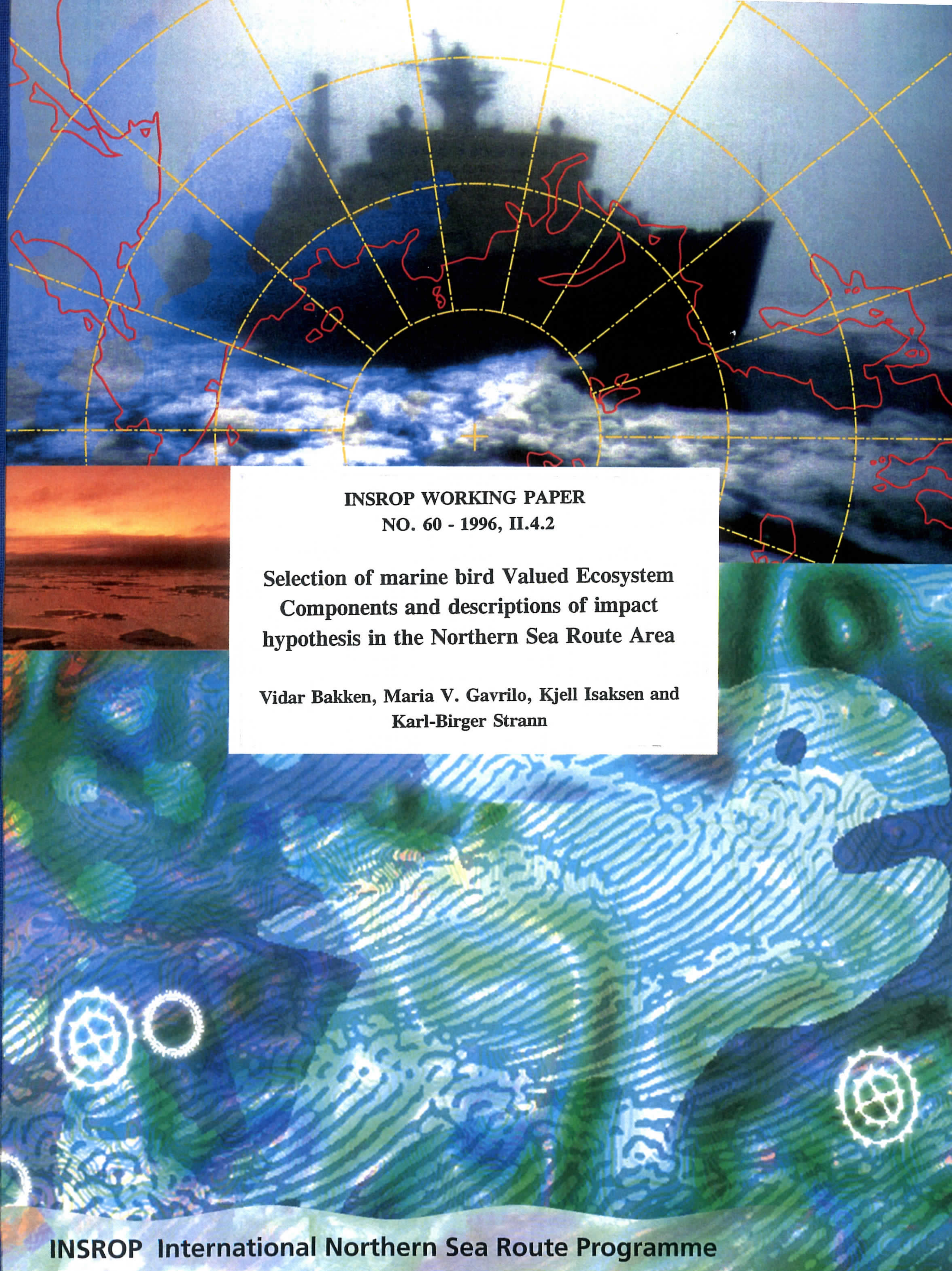

INSROP WORKING PAPER
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Selection of marine bird Valued Ecosystem Components and descriptions of impact hypothesis in the Northern Sea Route Area

Vidar Bakken, Maria V. Gavrilo, Kjell Isaksen and Karl-Birger Strann

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

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Title:	**Selection of marine bird Valued Ecosystem Components and descriptions of impact hypothesis in the Northern Sea Route Area**
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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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Selection of marine bird Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area

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INSROP Working Paper 1996 (final version)

CONTENTS

PREFACE

INSROP Sub-programme II: Environmental Factors, is an integrated, large scale assessment of the potential environmental impacts of shipping, navigation and related activities in the Northern Sea Route (NSR) area. Based on systemized knowledge of environmental conditions in the NSR area, and the identification of the NSR-activities that may cause impact on the Arctic ecosystem and the interests of Indigenous and local Peoples, the Sub-programme will analyse the interactions by combining tailormade Environmental Impact Assessment (EIA)-methods and state-of-the-art information technology (GIS).

The Dynamic Environmental Atlas is one of the four main components of the Sub-programme, concentrating on selected Valued Ecosystem Components (VECs) as priority issues of the EIA. The VECs are selected using criteria like ecological importance, data availability and vulnerability towards the possible NSR-activities.

This Working paper presents results of Sub-programme II project II.4.2, dealing with the VECs of Marine birds. It is described how the modified Adaptive Environmental Assessment and Management (AEAM)-method used in teh INSROP EIA is aplied to marine birds in the NSR-area.

The project is co-ordinated by the Norwegian Polar Institute, and is carried out in co-operation with Arctic and Antarctic Research Institute in St. Petersburg and other institutions in Russia.

The manuscript for this paper was reviewed by Dr. Kenton Wohl, U.S. Fish and Wildlife Service, Alaska. A copy of the review is included at the end of the report.

Oslo, 20 June 1996

Vidar Bakken

INTRODUCTION

Marine birds is an important resource along the Northern Sea Route (NSR). In this vast area, extending from 57°E to 170°E, there are many Arctic bird species, but also species which are mainly found in the Atlantic and the Pacific Oceans. The great north–south gradient also influences the types of bird communities along the route. Some areas are inhabited by nationally and internationally important and, in some instances, threatened species.

The aim of this paper is to identify vulnerable species groups among marine birds along the NSR and to identify which new threats the NSR-activity will lead to for these birds. In this context it is important to pinpoint the importance of a network of protected areas to minimise these threats; of special importance are the management principles in the protected areas and the enforcement of these principles. Protected areas are especially important for marine birds as it is known that habitat degradation and disturbance are among the main threats to some of these birds. A review of the protected areas in the Russian Arctic is given by Volkov and de Korte (1994). The list of Russian wetlands of international importance (Ramsar Sites) was extended in the fall of 1994 according to the order of the Ministry for Ecology (decree No. 1050). It contains 3 sites within the NSR area in Ob' and Yenisey Bays, but there are still important gaps in the Arctic region of Russia (see Lebedeva & Tomkovich 1995). The work on the international level with the Circumpolar Protected Areas Network (CPAN) is important here. The Russian Bird Conservation Union has initiated a program on Important Bird Areas in Russia (see Zubakin 1995), and undoubtedly a considerable part of these areas will coincide with the NSR-area.

METHODOLOGY

We have analysed the effects on marine birds of the factors proposed by Thomassen *et al.* (1994). These factors are pollution (incl. oil spills), noise, waste and physical disturbance. Only the effects of increased ship traffic are analysed, not effects of new settlements and increased activity on land (although additional effects of this is mentioned occasionally in the text). Social and cultural factors are not analysed.

The methodology used here follows the *Assessment System for the Environment and Industrial Activities in Svalbard* (Hansson *et al.* 1990), which in turn is inspired by the *Adaptive Environmental Assessment and Management Methods* (Holling 1978). Parts of the text and some of the impact hypotheses are based on Hansson *et al.* (1990), with the necessary adjustments and additions for the NSR-area.

The first step in the assessment is to identify valued ecosystem components (VEC) for the NSR-area. A VEC is defined as a resource or an environmental feature that (1) is important (not only economically) to a local human population, or (2) has a national or international profile, or (3) 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). A set of impact hypotheses (IH) describing the potential impacts of the relevant development is defined for each VEC. The IHs are categorised in four groups according to their assumed validity and importance (Hansson *et al.* 1990):

A. The hypothesis is not assumed to be valid.

B. The hypothesis is valid and is already verified. Research to validate or invalidate the hypothesis is not required. Surveying, monitoring and/or administrative measures can be recommended.

C. The hypothesis is assumed to be valid. Research, monitoring or surveying is recommended to validate or invalidate the hypothesis. Administrative efforts to mitigate negative effects on the environment may be recommended if the hypothesis is valid.

D. The hypothesis may be valid, but is not worth testing for professional, practical, economic or ethical reasons, or because it is assumed to have minor environmental repercussions. Monitoring, surveillance, and environmental enterprises are recommended to mitigate negative environmental effects.

Only IHs in categories B and C are included in the further assessment; these hypotheses are ranked according to their assumed importance to the VEC. A schematic flow chart for each VEC illustrates the pathways through which the development factors influence the VEC.

See Hansson *et al.* (1990) and Thomassen *et al.* (1994) for further explanation of the methodology.

The categorisation of the impact hypotheses according to their validity is in several cases hampered by lack of knowledge on the ecology of the VECs in question. The validity and importance of the hypotheses are also highly dependent on the development of the shipping activity in the area (sailing frequency, and quality and quantity of cargo) and also the parallel development of land-based activity. There are no reliable scenarios predicting the type and intensity of the new activity within the NSR; the categorisation of the impact hypotheses is mainly based on the authors' own judgement of what is realistic. Some of the hypotheses have been put in category D because they are thought to have only minor significance for the VEC. The processes represented by these hypotheses may still produce a significant cumulative effect in combination with other processes.

VALUED ECOSYSTEM COMPONENTS (VEC)

Three VECs were selected for the marine birds at a Screening and Focusing workshop in Oslo (somewhat modified): *Seabirds*, *Marine wildfowl* and *Waders in resting and feeding areas.* So far only species vulnerable to oil spills have been identified (Gavrilo *et al.* in prep.).

The VEC *Seabirds* consists of species in the orders Gaviiformes, Procellariiformes and Pelecaniformes, and in the suborders Lari and Alcae in the order Charadriiformes. The species found to be vulnerable to oil spills by Gavrilo *et al.* (in prep.) are Red-throated Diver *Gavia stellata*, White-billed Diver *Gavia adamsii*, Pelagic Cormorant *Phalacrocorax pelagicus*, Black-legged Kittiwake *Rissa tridactyla*, Ivory Gull *Pagophila eburnea*, Brünnich's Guillemot *Uria lomvia*, Black Guillemot *Cepphus grylle*, Little Auk *Alle alle* and Horned Puffin *Fratercula corniculata*. All the species in this VEC are true marine birds living in connection with the sea all year round, and their main feeding habitat is in the marine environment.

The VEC *Marine wildfowl* consists of species in the order Anseriformes and includes both true marine species as well as species living close to the sea only parts of the year. The species found to be vulnerable to oil spills by Gavrilo *et al.* (in prep.) are Emperor Goose *Anser canagicus*, Barnacle Goose *Branta leucopsis*, Greater Scaup *Aythya marila*, Common Eider *Somateria mollissima*, King Eider *Somateria spectabilis*, Spectacled Eider *Somateria fischeri*, Steller's Eider *Polysticta stelleri*, Long-tailed Duck *Clangula hyemalis*, Common Scoter *Melanitta nigra*, Velvet Scoter *Melanitta fusca* and Goosander *Mergus merganser*. This group is especially connected to the coast and to areas with brackish waters.

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

We believe those species of marine birds most vulnerable to the NSR-activity are included in these VECs.

LITERATURE

Gavrilo, M. V., Bakken, V., Firsova, L., Isaksen, K., Kaliakin, V., Morozov, V. & Pokrovskaya, I.: Oil vulnerability index for marine birds inhabiting the Northern Sea Route area. INSROP Working Paper (in prep.).

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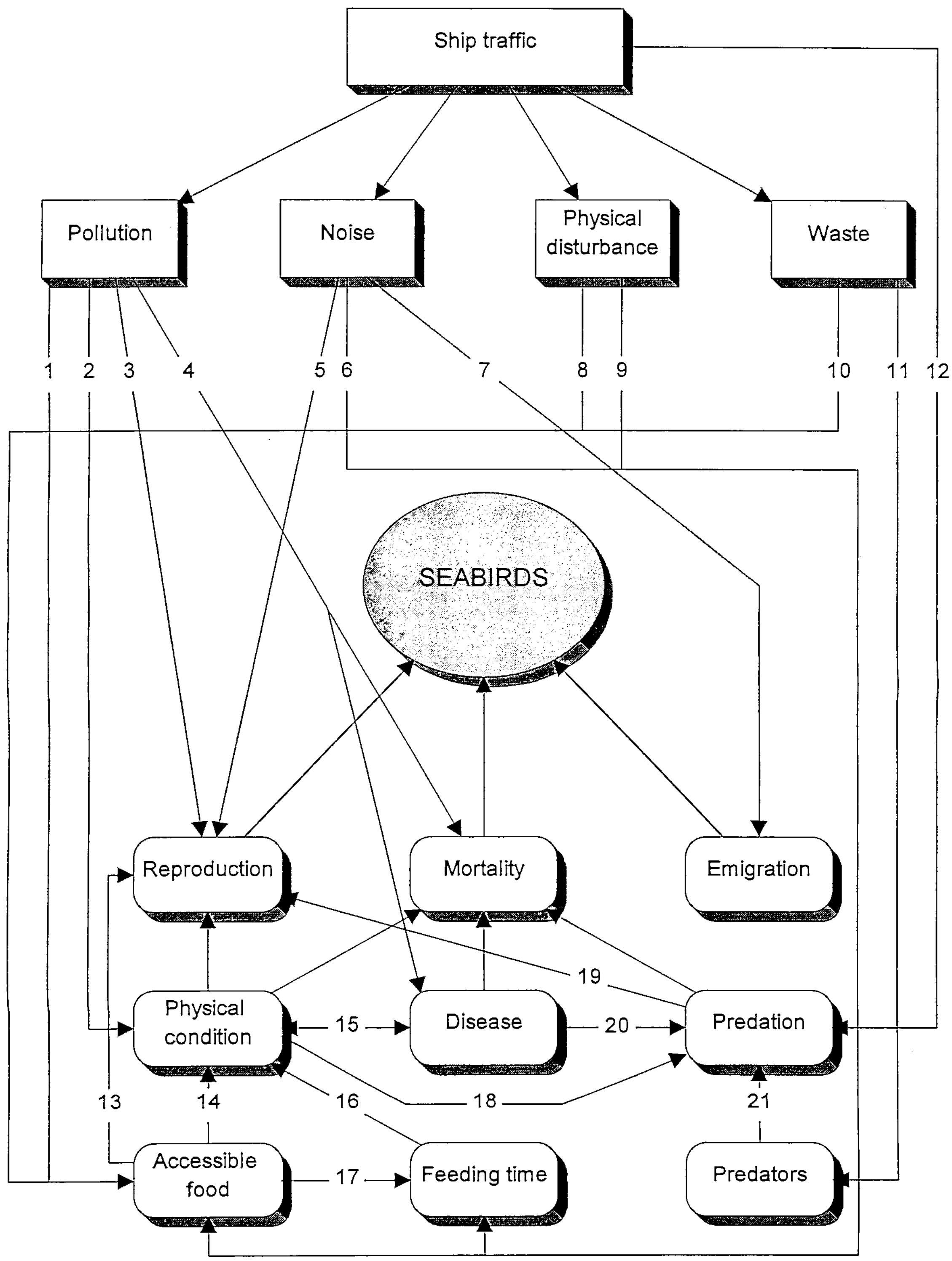
Zubakin, V. A. 1995: New project: Key ornithological areas of Russia. Information materials of the Working Group on Waders, no. 8, p. 14.

VEC 1 SEABIRDS

SCHEMATIC FLOW CHART



LINKAGES

Self-explanatory linkages have not been described

The increased production in the terrestrial ecosystem (as well as the marine) resulting from fertilisation from seabirds has not been included. The seabirds are affected by encroachments both in the breeding and feeding areas.

1. Pollution may lead to reduced access to food by killing or reducing reproduction of food organisms.
2. Oil fouling causes increased energy expenditure, by impairing the insulating properties of the plumage.
3. Pollution can cause reduced reproduction, as eggs and chicks will be soiled by adult birds fouled by oil, or because fouled adults terminate nesting. Accumulation of contaminants may result in decreased reproduction.
4. Pollution can cause disease or direct mortality.
5. Noise can cause the birds to leave the nest for a shorter or longer period, with a resulting increase in egg and chick mortality (both by increasing egg and chick predation, and by exposing eggs and chicks to cold and rain).
6. Noise can stress the birds and temporarily drive them away from feeding areas thereby reducing foraging time.
7. Noise can cause birds to withdraw from an affected area.
8. Physical disturbance to the sea ice and water around propeller of moving ships may change food availability.
9. Physical disturbance (the ship itself, moving of ice floes and opening/closing of ice) can alter the accessibility of food and foraging time.
10. Edible waste can act as food for some species.
11. Edible waste can result in larger populations of large gulls, skuas and Arctic Fox.
12. Ship traffic may result in hunting.
13. Reduction in the accessibility of food can result in food-shortage and chick mortality. If an increase in the accessibility of food takes place, the effect may be positive.
14. The quantity and the quality of the food will to a great extent determine the physical condition of the bird.
15. Impaired physical condition increases disease susceptibility. Disease will impair the physical condition.
16. Reduced foraging efficiency causes increased energy expenditure and accordingly impaired physical condition.
17. Reduced accessibility of food may lead to increased foraging time.
18. Impaired physical condition increases exposure to predation.
19. Predation on eggs and chicks reduces breeding success.
20. Sick and weakened birds will be more prone to predation.
21. Increased populations of large gulls, skuas and Arctic Fox may result in increased predation.

BACKGROUND

Seabirds are an important part of the fauna along the NSR. A large part of the system's energy flow runs via these species. The seabirds also link the marine and terrestrial ecosystems. This is particularly important in the High Arctic. The primary production is here hampered by lack of important nutrients, and the decomposition is slow due to low temperature. Seabirds do, however, supply considerable quantities of essential nutrients to the vegetation, thus stimulating primary production. Nutrients that are returned by the birds to the sea in the form of excrements contribute to higher productivity at sea in areas where seabirds are numerous (Golovkin & Pozdnyakova 1965; Golovkin *et al.* 1972a, b; Golovkin 1982).

VEC 1 *Seabirds* consists of species in the orders Gaviiformes, Procellariiformes, Pelecaniformes and Charadriiformes. The species have been dealt with collectively, as their biology and vulnerability to NSR-activity are relatively similar. Very little quantitative data on seabirds are available from the NSR-area (see Gavrilo & Sirenko 1995). The major part of the breeding colonies in this area are located at islands along the coast. Bird cliffs on the mainland coast are only found on Chukotka (Uspensky 1959; Kondratiev 1986).

Seabirds generally are long-lived birds with low reproductive output and low adult mortality. They are therefore well adapted to the highly variable Arctic environment. However, they are vulnerable to impacts that lead to increased adult mortality, as this cannot easily be compensated for by increased reproduction. This is an important point when considering the validity of the impact hypothesis.

Impact studies must always be seen in relation to the natural conditions of the relevant species, i.e. the natural fluctuations in physical conditions, climate, food availability etc., and accordingly to the stress level. Similarly, serious acute impacts (one or two unsuccessful breeding seasons) can have entirely different effects on a population that is already in decline, than on one that is not.

There are several risks connected to the assessment of the impacts of development activities on seabirds: the seriousness of acute impacts can easily be overrated, while, on the other hand, the significance of negative effects that appear to be less important can just as easily be underrated. Short-term studies concentrating on effects in limited areas run a risk of missing large-scale fluctuations in the system and will therefore be of limited value unless long-term general monitoring is carried out as well.

THE IMPACT HYPOTHESES

Ten hypotheses concerning the potential impact of development activities on the seabird populations along the NSR were evaluated. Three impact hypotheses (IH 4, 7 and 9) were considered to be invalid. Four hypotheses (IH 5, 6, 8 and 10) were considered to be potentially valid, but for the present not worth testing for scientific, practical/economic or other reasons. One hypothesis (IH 1) has been documented as valid, making research for its verification unnecessary. Two hypotheses (IH 2 and 3) were assumed to be valid. Surveys, monitoring and research are proposed for these hypotheses. The impact hypotheses have been listed in classified priorities (I–III):

I.

IH 1
Oil slicks at sea may cause increased mortality and reduced reproduction of the seabird populations.

Seabirds are among the most visible victims of oil pollution at sea, and a considerable amount of literature summarising the effects of oil on seabirds and seabird populations is available (*e.g.* Holmes & Cronshaw 1977; Folkestad 1983; Evans & Nettleship 1985; Leighton *et al.* 1985; Piatt *et al.* 1990; Piatt *et al.* 1991; Leighton 1993; Jenssen 1994).

Oil floats on the sea for a while and will foul the plumage of swimming birds. Hence the waterproofing and the heat insulating properties of the feathers will be reduced, and the birds will sink deeper into the water and lose body heat. Increased energy expenditure to keep up body temperature will reduce fat deposits and gradually also muscle tissue. Oiled birds often die from a combination of cold and starvation. The mortality of oiled birds may be especially severe in the cold Arctic environment. The birds will also often ingest oil in their attempts to cleanse themselves. This may lead to reduced reproductive ability and other negative physiological effects (see Trivelpiece *et al.* 1984; Fry & Lowenstine 1985; Leighton *et al.* 1985; Fry *et al.* 1986; Butler *et al.* 1988; Leighton 1993). The passing on of oil from the plumage of adult birds to eggs and nestlings, with an ensuing reduction in hatchability and survival rate, has been observed in several seabird species (Albers 1980, 1983; Leighton 1993). Fry *et al.* (1986) showed that even small doses of oil caused a considerable and prolonged lowered breeding success of exposed birds. The same effects have been demonstrated in seabirds that have been washed and rehabilitated after oil-injuries (Swennen 1977; Morant *et al.* 1981).

Thus, there is no doubt that oil contamination can kill large numbers of seabirds. Whether oil also represents a great threat to seabird populations is contingent upon many factors, such as reproductive strategy, site tenacity and the population development (Baillie & Mead 1982; Piatt *et al.* 1991). Various models have been developed (Ford *et al.* 1982; Samuels & Lanfear 1982; Wiens *et al.* 1984), but at present the biological input data is generally not sufficient to provide useful results. An oil vulnerability index for seabirds has been developed in Norway and used in different impact assessments (Anker-Nilssen 1987; Anker-Nilssen *et al.* 1988; Lorentsen *et al.* 1993; Strann *et al.* 1993; Fjeld & Bakken 1993). This model is also used for the NSR-area (Gavrilo *et al.* in prep.). Other models for indexing seabirds' vulnerability to oil have been developed for other areas (King & Sanger 1979; Williams *et al.* 1995).

II.

IH 2
Disturbances in nesting colonies and feeding areas resulting from the NSR-activity will cause reduced reproduction and/or the abandonment of areas.

Many studies have documented negative effects of 'disturbance' (often the activities of the researchers themselves) on the reproductive success of seabirds in colonies. The effect of disturbance on the numbers of seabird has been well demonstrated in the White Sea (Koryakin 1990). Disturbance may lead to some or all of the seabirds in the colony abandoning their nests permanently, especially if disturbed early in the breeding season (Manuwal 1978; Vermeer 1978). However, most often the disturbance has more indirect influence on the seabirds.

Seabirds are exposed to egg and chick predation (sometimes predation on adult seabirds as well). The predators relevant to the NSR are large falcons (Peregrine Falcon *Falco peregrinus* and Gyrfalcon *F. rusticolus*), skuas (mainly Arctic Skua *Stercorarius parasiticus*), large gulls (Glaucous Gull *Larus hyperboreus* and Herring Gull *L. argentatus*) and Arctic Fox *Alopex lagopus*. For the NSR territory there are no data on predation of the White-tailed Eagle *Haliaeetus albicilla* with regard to seabirds. For the regions with colonial nesting of seabirds only vagrants of this predator are known. Large falcons nest in very restricted numbers in areas with seabird colonies on the New-Siberian Islands (Rutilevsky 1967) and on Wrangel Island (Stishov *et al.* 1991). The predation on seabirds of raptors is small. Under normal conditions predation is not assumed to have serious negative effect on the seabird populations in the area (Krasnov *et al.* 1995).

On Wrangel Island Glaucous Gulls get only 10% of their food from the seabird colonies, and foxes remove about 0.09% of eggs and 0.04% of young and adults from a population of 40,000–80,000 birds (Pridatko 1986). In different colonies on Novaja Zemlja Glaucous Gulls remove 5–10% of guillemot chicks (Uspensky 1956). In exceptional cases the population of the predators (Glaucous Gull) can reach such large numbers that it can affect the reproductive success of seabirds on a larger scale (Kondratiev *et al.* 1987). Mortality due to predation of guillemot chicks leaving their nesting ledges can be from 0.9% to 24% (Williams 1975; Karpovich *et al.* 1980; Pridatko 1986; Gavrilo 1991). Predation on eggs and chicks by gulls constitutes a greater problem in declining bird cliff populations, as the predators are then able to land on the sparsely covered shelves. Under such circumstances the auks are not able to defend eggs and chicks (Birkhead 1977; Tschanz & Barth 1978).

Disturbance in seabird colonies often results in scaring of parent birds causing them to abandon the nesting site. This leaves the eggs or young unprotected for a shorter or longer period. Predators (e.g. large gulls) then have easy access to eggs and young. This has been found by many workers to be one of the most important negative attributes of human disturbance on seabirds (see e.g. Johnson 1938; Gillett *et al.* 1975; Kury & Gochfeld 1975; Robert & Ralph 1975; Ellison & Cleary 1978; Anderson & Keith 1980; Zonfrillo 1993). This is assumed to be an important problem also in the NSR-area, especially in local areas where the carrying capacity for large gulls, skuas and Arctic Fox will increase due to increasing quantities of available food (via edible waste) in critical periods (see IH 3). Disturbance may also lead to increased intraspecific predation on eggs in gull colonies (Anderson & Keith 1980; Hand 1980; McInnes 1980; Burger 1981). The most negative effect of this is expected in Ivory Gull colonies because of the aggressive behaviour of this species in the breeding colonies and the relatively high level of intraspecific predation (Demme 1934; Tomkovich 1986).

Disturbances in seabird colonies often results in panic flight from the colony of adult incubating birds. Eggs and chicks may then be kicked out of the nest or out from the nesting ledge and destroyed or killed. They may also be kicked into crevices etc. where the parent birds are unable to incubate them (Johnson 1938; Kury & Gochfeld 1975; Manuwal 1978; Zonfrillo 1993; W. Vader pers. com.). During a disturbance young prior to fledging may also leave the nest or jump from the breeding ledges before they otherwise would have, with decreased survival as a result (Anderson & Keith 1980; Burger 1981; Zonfrillo 1993; Krasnov *et al.* 1995).

Eggs and especially recently hatched young are only able to withstand short-term exposure to low temperatures. Hatchability of eggs and survival of young may therefore be lowered if left unattended for a longer period. It will also lead to increased energy expenditure for both chicks and adults. Other negative effects of disturbance may be decreased time for incubation, attraction of predators to nest sites, more frequent aggressive encounters between birds, increased expenditure of time and energy for territorial defence and consequently less time available for incubation and offspring care (Burger 1981).

For the NSR-area it is especially important to assess the effects of disturbance from helicopters (used for reconnaissance of ice conditions from ships, transport between ships, and between ships and land). There are conflicting reports on the effects of traffic by helicopter and aircraft on seabirds. Dunnet (1977) did not find any significant reduction in the number of birds present at the nests in a seabird colony in Scotland caused by passing helicopters and small aircraft. The author suggested, however, that the birds may have become habituated as the colony was located on a regular helicopter route from an airport. Fjeld *et al.* (1988) and Olsson & Gabrielsen (1990) did not observe any loss of eggs or chicks as a result of experimental helicopter flights close to Brünnich's Guillemot colonies late in the breeding season in two different regions in Svalbard. Probably few breeding birds were scared from the nesting ledges in both studies. However, non-breeding birds often left the colony at distances up to six kilometres from the helicopter (Fjeld *et al.* 1988). Vermeer (1978) reported that a auk colony was abandoned in British Columbia after a helicopter landed in the breeding period. Zonfrillo (1993) mentions several instances of mass-flight of auks and Gannets *Sula bassana* from colonies over-flown by low-flying aircraft. This resulted in extensive losses of eggs and chicks. Hunt (1987) reviews several episodes of helicopter and aircraft flights close to seabird colonies. Some of the episodes resulted in panic flights from the colonies and considerable egg and chick loss, whereas others seemed to have little effect on the birds. From this evidence it is hard to draw general conclusions about the effects of helicopter and aircraft traffic on seabirds. However, even though the birds in some instances seem to be only marginally affected by this traffic, it is still possible that the disturbance results in stress and increased energy expenditure, and in turn reduced reproductive success and lowered survival (Fjeld *et al.* 1988; Brown 1990).

III.

IH 3
An increase in the populations of large gulls, skuas and Arctic Fox resulting from the dumping of edible waste will cause increased predation on seabirds and their eggs and chicks.

It is widely believed that an increased food supply is one of the most important reasons for the marked increase in the gull populations of various European countries. The increased food availability is partly due to the increasing quantities of edible waste found in garbage dumps and in cities, partly to waste from fisheries and fish processing industry (Mathiason 1964; Bergman 1965; Kadlec & Drury 1968; Harris 1970; Spaans 1971). Because of the improved food availability, the areas have a greater carrying capacity for gulls. One of the most important mechanisms appears to have been a higher rate of survival of juveniles. Earlier these birds would often die when having to compete with adult birds for the limited resources (Harris 1964; see also Strann 1985). Overall breeding success has, however, also been found to be increased by food from garbage dumps (Pons 1992).

Although the increase in the population of gulls near human settlements is best documented from temperate areas, the same pattern has been observed in arctic areas and here also often including an increase in the population of skuas (e.g. Sdobnikov 1937; Uspensky 1959, 1969; Løvenskiold 1964). In the NSR-area this process has been observed in the Yugorsky Peninsula (Kalyakin 1989). Feeding of large gulls on human waste was also found on Yamal (Danilov *et al.* 1984), on Wrangel Island (Stishov *et al.* 1991), in the north of Yakutiya and Severnaja Zemlja (M. Gavrilo pers. obs.; D. I. Solovieva pers. com.). According to available observations along the coasts of Siberia, Glaucous Gulls seem to be more connected to human settlements than Herring Gulls. Also, all observers note that garbage is mainly consumed by non-breeding gulls or outside the breeding period.

Skuas may also take advantage of human waste as food. On the Murman Coast no waste was recorded in diet of skuas (Krasnov *et al.* 1995). However, skuas were observed to consume waste from fishery, husbandry farms and garbage dumps in most areas along the NSR. The use of human waste as food is most common in Arctic and Long-tailed Skuas, mainly during periods of food shortage (Uspensky 1969; Dorogoy 1981; Danilov *et al.* 1984; Tomkovich 1988; Kalyakin 1989; Stishov *et al.* 1991).

Also, fish which are stunned or exposed to birds by moving ships (for instance by turning ice floes) serve as an additional and more accessible food source. A moving ship, especially in places rich in fish, attracts an enormous number of large gulls and skuas. Thus, one may suggest that the additional food may result both in an increase in the breeding populations of large gulls and skuas due to increased survival in unfavourable periods (especially in spring), and contribute to the formation of non-breeding accumulations near centres of human activity. In the latter case the predators may switch to natural sources of food after depletion of human waste (for instance end of the hunting season) and may cause serious damage to the local population of birds (D. I. Solovieva pers. com.).

RECOMMENDED MEASURES AND STUDIES

The following surveys, monitoring and research assignments should be implemented in connection with new developments potentially affecting seabirds in the NSR area. The projects have been listed in classified priorities (I–III).

I. (To be implemented in connection with IH 1 and 2)

Mapping of breeding colonies, moulting areas, foraging areas and migration routes. There are no recent quantitative data from most breeding colonies and data on distribution at sea are practically absent. Priority should be given to mapping of pre-breeding distribution (especially usage of polynyas) because there are almost no data available for this period.

Objective: To provide an overview of the geographical areas in which seabirds are particularly vulnerable throughout the seasons, so that the timing and localisation of potential ship traffic can be adapted in order to minimise the effect on seabirds, and so that damage potential and the necessary clean-up measures can be quickly determined in the event of oil spills.

Method: Will vary with the species and item to be surveyed. In general, observations should be made from the shore for the sighting of species in coastal waters and ashore, and from ships and helicopters in more open waters.

II. (To be implemented in connection with IH 1, 2 and 3)

Monitoring of the development and breeding success in selected populations near the ship traffic activity and in unaffected areas (control populations). Quantitative data are few today and it is important that standardised monitoring in selected areas starts before the NSR-activity may have effects on seabirds.

Objective: To record possible effects on seabirds resulting from the NSR-activity.

Method: Frequent counts in permanent monitoring plots.

III. (To be implemented in connection with IH 3 – cf. VEC 2 **Marine wildfowl** *)*

Monitoring of populations of large gulls and skuas and their predation pressure on other species of marine birds.

Objective: To detect changes in predator populations. If these populations increase as a result of increased dumping of human waste, actions to reduce waste dumping should be taken.

Method: Standard yearly counts in selected areas.

III. (To be implemented in connection with IH 5 – cf. VEC 2 and VEC 3)

Monitoring of the contamination levels in seabirds.

Objective: To detect changes in contaminant levels in seabirds. If contaminant levels increase, investigations to identify the sources and actions to reduce the discharges should be carried out. Studies of the resulting effects on reproduction and survival should also be initiated if high levels are found.

Method: Standardised analysis of eggs, chicks and adults.

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VEC: SEABIRDS		IH 1

HYPOTHESIS: Oil slicks at sea may cause increased mortality and reduced reproduction of the seabird populations.

EXPLANATION: 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.

CATEGORY: B

RATIONALE: The validity of the hypothesis has been well documented during several oil spill incidents.

MANAGEMENT RECOMMENDATIONS: 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.

SURVEYS: Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels.

MONITORING: Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity, in order to be able to assess impacts on the populations in the event of an oil spill.

RESEARCH: 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: SEABIRDS	**IH 2**

HYPOTHESIS: Disturbances in nesting colonies and feeding areas resulting from the NSR-activity will cause reduced reproduction and/or the abandonment of areas.

EXPLANATION: Disturbance causes stress and possibly abandonment of areas under pressure, reduced foraging efficiency and impaired physical condition. Reproduction can be affected by increased predation rates on unguarded eggs and chicks, eggs and chicks falling out of the nests, and by a reduction in incubation time for brooding adult birds.

CATEGORY: C

RATIONALE: At the sound of sudden noise, seabirds may flee the colonies in panic. Eggs and chicks may be pushed out of their nests. Our knowledge of the short- and long-term population effect of such incidents is however limited. Studies have indicated that seabirds under certain conditions may become accustomed to/will be only marginally frightened by helicopter noise. The effect of noise on seabird concentrations in the feeding areas is not known. The hypothesis is assumed to describe a relevant conflict with potentially harmful effects.

MANAGEMENT RECOMMENDATIONS: Use of aircraft etc. close to nesting colonies and other seabird concentrations must be avoided.

SURVEYS: Surveys should be conducted in order to update the geographical information system concerning important breeding, feeding, moulting and resting areas for seabirds.

MONITORING: Annual monitoring of population development and breeding success in selected areas that are affected by the activity and in unaffected control areas.

RESEARCH: Quantify the effects of the actual disturbance regime on breeding success and population development of seabirds.

VEC: SEABIRDS		IH 3
HYPOTHESIS: An increase in the populations 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.		
EXPLANATION: An increase in ship traffic will cause an increase in food available for large gulls, skuas and Arctic Foxes due to dumping of edible waste, and easier access to marine organisms by breaking ice cover and stunning of fish by propellers. The size of the populations of these predators is probably regulated by food accessibility. Increased populations of predators leads to increased predation and reduced reproduction of the local populations of other seabird species.		
CATEGORY: C		
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 will have a negative effect on the populations of other seabird species. The effect is assumed to be local in character.		
MANAGEMENT RECOMMENDATIONS: All waste should be stored in containers and treated in waste treatment units.		
SURVEYS: Mapping of breeding colonies of large gull and surveys of non-breeding concentration of gulls and skuas.		
MONITORING: Monitoring of breeding populations of large gulls in selected areas.		
RESEARCH: None.		

VEC: SEABIRDS	**IH 4**
HYPOTHESIS: Increased ship traffic will result in reduced local seabird populations due to increased hunting pressure and egg harvesting.	
EXPLANATION: Increased activity will lead to increased hunting and harvesting.	
CATEGORY: A	
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.	
MANAGEMENT RECOMMENDATIONS: Measures to prevent illegal hunting and egg harvesting should be initiated.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: SEABIRDS	IH 5
HYPOTHESIS: Emissions of toxic substances (other than oil-components) from ships or other activity related to the NSR will cause increased mortality and reduced reproduction of seabirds.	
EXPLANATION: Toxic substances in spillage from boats etc. may be accumulated in organs and tissues of seabirds and cause disease or weakening of their physical condition. This may in turn affect the mortality and reproduction in the populations.	
CATEGORY: D	
RATIONALE: The negative effects of toxic compounds on birds have been documented. It will be difficult to enforce discharge regulations in this remote area. Some seabirds are ship followers which may make them more exposed to pollution from ships.	
MANAGEMENT RECOMMENDATIONS: Strict regulations and frequent controls of pollution level from ships should be made.	
SURVEYS: None.	
MONITORING: Monitoring of the contamination levels of seabirds should be carried out. There are no data today on toxic contaminants in seabirds from the NSR-area.	
RESEARCH: If high levels of toxic compounds are found in seabirds, studies of the resulting effects on reproduction and survival should be initiated.	

VEC: SEABIRDS	IH 6
HYPOTHESIS: Oil pollution will cause increased mortality and reduced reproduction in the seabirds' food organisms. Reduced availability of food will result in a reduction in seabird populations.	
EXPLANATION: If the seabirds' nutritional base is damaged by contaminants, the quantity of food available will be reduced and the seabirds' physical condition will be affected. Impaired physical condition can cause a population reduction by increasing mortality due to starvation or predation, and by lowering reproduction.	
CATEGORY: D	
RATIONALE: The effect of oil contaminants on primary producers and primary consumers seems to be limited. The larval stage of seabirds' food organisms, and the fauna and flora otherwise associated to the ice, may be affected. The hypothesis may accordingly be valid in principle. The direct mortality of seabirds as a result of oil spills will, however, probably be far greater than the possible effect of a food deficit caused by oil pollution.	
MANAGEMENT RECOMMENDATIONS: None.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: SEABIRDS	IH 7
HYPOTHESIS: Increased human activity in connection with the NSR (e.g. pollution, hunting and noise) can reduce the populations of large gulls, skuas and Arctic Fox. This will reduce the predation on other seabirds and their eggs and chicks, and have a positive effect on the seabird populations.	
EXPLANATION: Pollution, disturbance, egg harvesting and hunting may reduce local populations of predators. Large gulls may be more prone to egg harvesting than other seabirds because they often nest in areas that are easier to access. They are probably also more prone to intraspecific nest predation during disturbance than are most other seabirds.	
CATEGORY: A	
RATIONALE: In general a reduction in predatory populations as a result of human activity is unlikely. Both large gulls and Arctic Fox are food opportunists and, compared to seabirds, they are hardly vulnerable to oil spills. The predator populations are more likely to be favoured by human activity. The hypothesis is not regarded to be valid.	
MANAGEMENT RECOMMENDATIONS: None.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: SEABIRDS		**IH 8**
HYPOTHESIS: Increased ice-breaker traffic in ice-filled waters will make the access to food organisms easier for seabirds and result in a population increase.		
EXPLANATION: When ice breakers move in ice-covered waters they make more open water available for foraging seabirds, food organisms are stunned by the propellers and ice floes are turned around making ice fauna hiding inside or under the ice exposed for the seabirds. This will increase the availability of food for seabirds.		
CATEGORY: D		
RATIONALE: The drift ice along the NSR is in continual movement, with frequent opening and closing of leads. In areas or periods with dense ice the effect of ice breakers could be of importance for seabirds.		
MANAGEMENT RECOMMENDATIONS: None.		
SURVEYS: None.		
MONITORING: None.		
RESEARCH: None.		

VEC: SEABIRDS		**IH 9**
HYPOTHESIS: The propellers on the ships will whirl up sand and mud from the bottom and reduce the visibility for diving seabirds.		
EXPLANATION: The waters along the NSR are very shallow. Mud and sand can easily be whirled up in the water. Diving seabirds are dependent on sight to catch their prey, and reduced visibility may destroy feeding areas.		
CATEGORY: A		
RATIONALE: It is quite possible that mud and sand can be whirled up from the bottom, but this will probably only have local effects and will not be any serious threat to the diving seabirds. Muddy water is also common today in the outlets of the big rivers.		
MANAGEMENT RECOMMENDATIONS: None.		
SURVEYS: None.		
MONITORING: None.		
RESEARCH: None.		

VEC: SEABIRDS		**IH 10**

HYPOTHESIS: Ship traffic will cause increased mortality and reduced reproduction in seabirds' food organisms. Reduced availability of food will result in a decrease in seabird population.

EXPLANATION: The action of the ships' propellers kills small invertebrates and fish, especially their eggs and larvae. Destruction of the ice cover may result in reduced populations of under-ice communities. Increased mortality and reduced reproduction in the seabirds' food organisms will reduce the quantity of food available for seabirds. This may increase mortality and reduce reproduction.

CATEGORY: D

RATIONALE: In the spawning areas and areas where mass accumulation of eggs and larvae occurs, the break-up of ice cover and the action of propellers may increase the mortality and reduce the reproduction (see Matishov 1992). This especially applies in areas used for spawning by Polar Cod which has very delicate eggs that develop protected under the ice (see Borkin 1990). The polar cod is a key species in the Arctic ecosystem and a reduction in this species will have a negative effect on the populations of fish-eating seabirds. In principle, the hypothesis can be significant. Its significance depends on the intensity of shipping, coincidence of ship traffic in space and time with the areas and time of spawning.

MANAGEMENT RECOMMENDATIONS: Areas where spawning and mass concentrations of larvae occur must be excluded from the shipping routes in the periods when these concentrations occur.

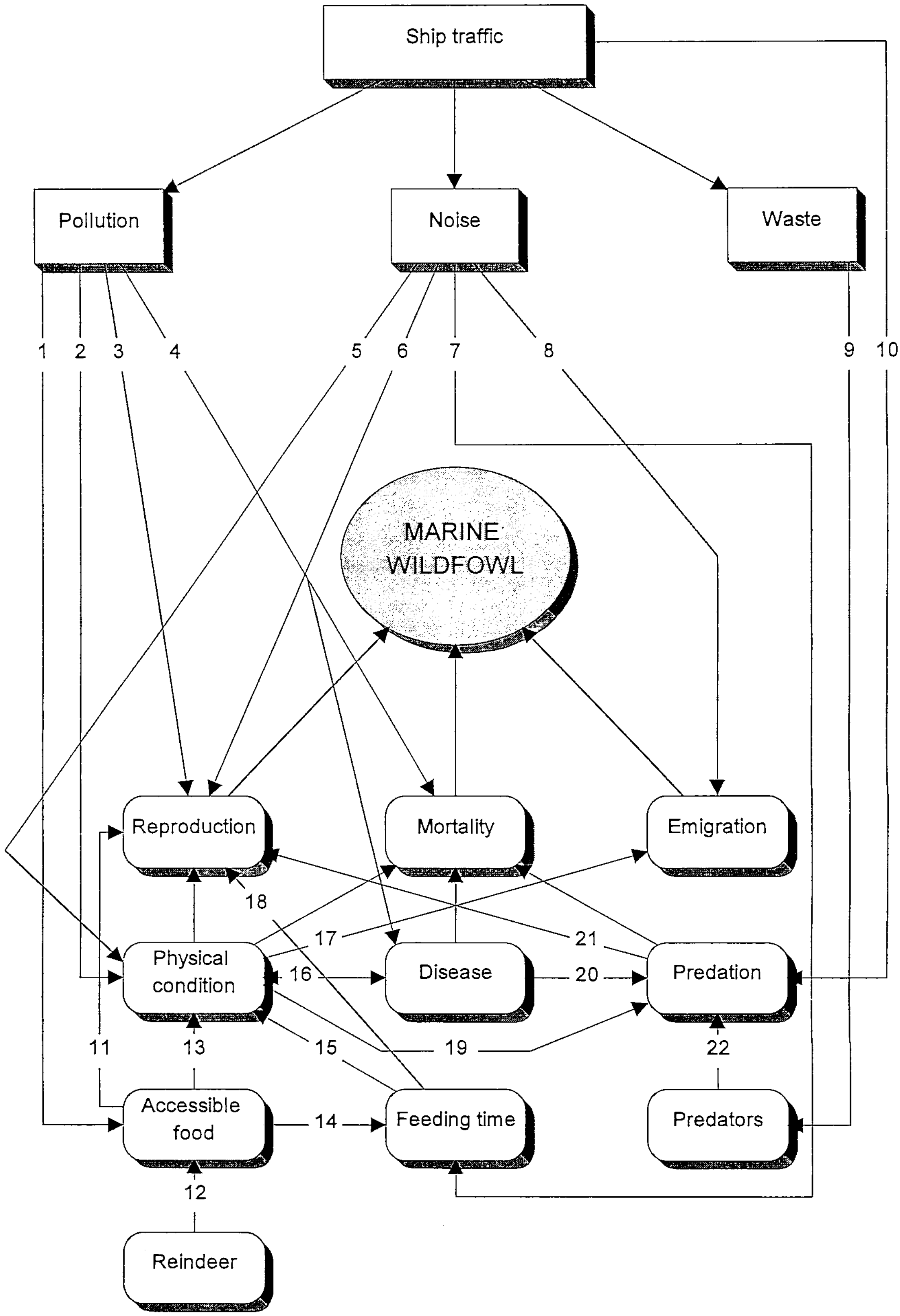
SURVEYS: Mapping of the spawning areas and places of mass larvae concentrations (survey should be carried out within the project II.4.3).

MONITORING: None.

RESEARCH: None.

VEC 2: MARINE WILDFOWL

SCHEMATIC FLOW CHART



LINKAGES

Self-explanatory linkages have not been described

Marine wildfowl are affected by NSR-activity in breeding areas along the coast, in moulting and rearing areas, and in resting areas throughout the migration. Food organisms have not been specified nor the effects of extended land-based activity.

1. Pollution can kill food organisms and thus reduce access to food.
2. Oil spills will result in increased energy expenditure by the reduction of feather insulation.
3. Pollution can result in reduced reproduction by adult fouled birds soiling eggs and chicks, and by toxic effects.
4. Pollution can cause disease or mortality.
5. Noise can scare birds, increase energy expenditure and result in impaired physical condition.
6. Noise can cause females to leave the nest for shorter or longer periods, with a resulting increase in egg and chick mortality.
7. Noise can cause birds to withdraw from affected areas. This may lead to less time being available for feeding (due to the disturbance and searching for new feeding areas). At the same time more time may actually be needed because of new feeding areas having lower quality.
8. Noise can stress the birds and temporarily drive them away from feeding areas thereby reducing foraging time.
9. The dumping of waste can affect the populations of large gulls, skuas and Arctic Fox.
10. Ship traffic may result in hunting.
11. A reduction in the accessibility of food may decrease reproductive success.
12. The Reindeer (*Rangifer tarandus*) can be a grazing competitor for geese.
13. The quantity and the quality of the food will to a great extent determine the physical condition when available foraging time is limited (especially during the breeding and migration periods).
14. A reduction in the accessibility of food will increase feeding time.
15. Reduced feeding time (or feeding in areas of lower quality) will result in impaired physical condition.
16. Impaired physical condition will increase disease susceptibility. Disease will impair the physical condition.
17. Impaired physical condition because of inadequate food supply can result in emigration. Emigration requires energy and will therefore impair the physical condition.
18. More time spent feeding, results in less time available for brooding of eggs and protection of young, which in turn results in lowered reproduction.
19. Impaired physical condition will increase exposure to predation.
20. Sick and weakened birds will be more prone to predation.
21. Predation is one of the most important factors limiting reproduction.
22. Increase in the populations of large gulls, skuas and Arctic Fox may result in increased predation.

BACKGROUND

Marine ducks, geese and swans (order Anseriformes) have been grouped in one VEC (Marine wildfowl) because their biology is similar in several respects. Most of them are strongly attached to the littoral zone and river estuaries during the greater part of the time they spend along the NSR. Accordingly their vulnerability to NSR-activity is relatively similar, and the impact hypotheses put forward will to a great extent apply to all species within this group.

Wildfowl is an important component of the ecosystems along the NSR. In some areas they can dominate in biomass among terrestrial vertebrates, and play an important role in the energy flow in the ecosystem. Forming large aggregations in the moulting areas, wildfowl not only consume a large amount of food, but the fertilising effect of their excreta is important for the productivity of the areas they use (see for example Bazely & Jefferies 1985; Vyshkvartsev & Lebedev 1986; Bazely 1989).

Some of the geese often swim from the breeding areas on small islands to feeding areas with the chicks. During the moulting period in late summer they are flightless, and if disturbed they flee to the sea. This make them especially vulnerable for oil spills in these periods. Also the marine ducks are flightless during moulting in summer and several species gather in flocks in shallow coastal areas to moult.

The reproduction and survival of wildfowl along the NSR vary strongly from year to year depending on ice conditions and stage in lemming cycle. Some years may have very high mortality and low reproduction of some species. Like seabirds, many wildfowl species are sensitive to increased adult mortality. For instance, population stability of marine ducks is dependent on relatively high adult survival (Goudie *et al.* 1994).

THE IMPACT HYPOTHESES

Eight hypotheses concerning the potential impact of NSR-activity upon marine wildfowl have been evaluated. One hypothesis (IH 8) is considered to be invalid. Two hypotheses (IH 6 and 7) are considered to be potentially valid, while at the time not worth following up with studies. Three hypotheses (IH 1, 2 and 3) are considered as valid. Two hypotheses (IH 4 and 5) are assumed to be valid and important to examine more closely with monitoring and/or research. The impact hypotheses have been listed in classified priorities (I–III).

I.

IH 3
Oil slicks in marine areas may cause increased mortality and reduced reproduction of the wildfowl populations.

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.

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.* (in prep.) for a more detailed assessment of the vulnerability of marine wildfowl to oil.

II.

IH 1

Disturbances 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.

Marine wildfowl are very vulnerable to disturbance from traffic and noise (see Korschgen & Dahlgren 1992a, b). To avoid predation and the cooling of eggs and chicks, these birds normally have a high incubation constancy, i.e. the eggs are left only seldom, and for short periods. Incubating birds are, however, easily scared from the nest when disturbed, which makes eggs or chicks easy prey for predators like Glaucous Gull, Herring Gull, Arctic Skua and Arctic Fox. Moreover, eggs and chicks may die from cold if the adults, due to disturbance, are unable to keep them warm for prolonged periods. Rewarming of cooled eggs also requires additional energy from the adult.

Incubating eiders may abandon their nest if disturbed, especially early in the incubation period (Koryakin 1982, 1983, 1986). Emperor Goose has been found to be little vulnerable to disturbance during egg-legging and incubation, but if disturbed, parents may abandon newly hatched chicks unable to follow (Petersen *et al.* 1994). A study carried out in Svalbard indicated that the Glaucous Gull would take eggs in 12.5 % of the cases when incubating female Common Eiders left their nests (Mehlum 1991). Human disturbance has also been found to result in a significant increase in the predation on ducklings (Åhlund & Götmark 1989; Keller 1991; Mikola *et al.* 1994). Predation pressure on unguarded eggs and young may be particularly high in years of low lemming densities.

Some of the species, e.g. Brent Geese are very shy and may flee the nest even if the disturbance is several hundred meters away. Another possible effect of disturbance of the breeding area is that the birds leave and try to settle in undisturbed areas. The reproductive success will then probably be reduced, as suitable breeding areas most likely are a limited resource. Moreover, competition for suitable breeding areas in the areas free from disturbance will be greater, within as well as between the species. This will in turn result in reduced reproduction and possibly population decrease of the weaker species. If they succeed in finding a new suitable breeding site, birds moving to other areas to breed due to disturbance will breed late in the season. This will result in increased energy expenditure, reduced reproduction, reduced time for building up body reserves for autumn migration and increased mortality.

II.

IH 2

Disturbances 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.

Geese are very vulnerable to disturbances in resting, moulting and feeding areas. They may react to human activity such as helicopter and aircraft traffic at a distance of up to twenty kilometres, especially during moulting (Madsen 1984; Bélanger & Bédard 1989; Jensen 1990; Mosbech & Glahder 1991; Jacobsen & Tyler 1994; Petersen *et al.* 1994; Ward *et al.* 1994). When reacting actively to disturbances the geese will use extra energy to flee from the danger and will in addition have less time for feeding. This will in both cases result in impaired physical condition. Studies of several species of geese have indicated that moulting geese that are disturbed and flee from an area can lose several hundred grams of body weight in the course of a few days (e.g. Owen & Ogilvie 1979, Belman 1981; see also Taylor 1993, Miller 1994, Miller *et al.* 1994).

It is essential for arctic geese to have sufficient fat deposits for the southward migration in the fall. An increase in traffic in the vicinity of the traditional moulting areas and resting areas used during the migration may result in reduced food uptake, impaired physical condition and increased mortality. Traditional feeding areas for geese have been fertilised with geese excrements for many years, leading both to a rich vegetation and a nutritional composition of the vegetation that is favourable to the geese (Derksen *et al.* 1982). If displaced by disturbance to new feeding areas it may take many years to develop vegetation of similar quality.

II.

IH 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 ducks mainly feed 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 sustain them 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).

III.

IH 5

An increase in populations of large gulls, skuas and Arctic Fox resulting from increased dumping of edible waste will cause increased predation on marine wildfowl and their eggs and chicks.

Eggs and chicks of marine wildfowl are important prey for large gulls, skuas and Arctic Fox. An increase in the populations of these predators can represent a danger to the local populations of marine wildfowl. Ship traffic and related activities can cause increased dumping of food waste, which may attract large gulls, skuas and Arctic Fox. Increased supply of food may result in increased reproduction, lower mortality, and accordingly a population increase among these predators (see also IH 3 for the VEC *Seabirds*).

RECOMMENDED MEASURES AND STUDIES

The following studies should be implemented in connection with development activities potentially involving the impacts referred to in IH 1, 2, 3, 4 and 5. The studies have been listed in classified priorities (I–III).

I. (To be implemented in connection with IH 1, 2, 3)

Important breeding, moulting and resting areas for marine wildfowl along the NSR-area should be surveyed.

Objective: To investigate whether the NSR-activity involves the risk of affecting important areas for marine wildfowl. Activity should be avoided in areas where significant conflicts may arise.

Method: Traditional inventories.

II. (To be implemented in connection with IH 1, 2, 3, 4 and 5)

Monitoring of the number of breeding, moulting and resting wildfowl in affected areas and in unaffected control areas.

Objective: To record effects of the NSR-activity on wildfowl.

Method: To be coordinated in long-term registrations (counts every year in an initial period of at least 5 years, and then counts every 2–3 years). Moulting flocks with juveniles, or nests in breeding colonies, should be counted. Can be compared with existing winter counts.

III. (To be implemented in connection with IH 5 – cf. VEC 1 Seabirds)

Monitoring of populations of large gulls and skuas and their predation pressure on other species of marine birds.

Objective: To detect changes in predator populations. If these populations increase as a result of increased dumping of human waste, actions to reduce waste dumping should be taken.

Method: Standard yearly counts in selected areas.

III. (To be implemented in connection with IH 4 – cf. VEC 1 and VEC 3)

Monitoring of the contamination levels in marine wildfowl.

Objective: To detect changes in contaminant levels in wildfowl. If contaminant levels increase, investigations to identify the sources and actions to reduce the discharges should be carried out. Studies of the resulting effects on reproduction and survival should also be initiated if high levels are found.

Method: Standardised analysis of eggs, chicks and adults.

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VEC: MARINE WILDFOWL	**IH 1**

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.

EXPLANATION: If disturbed, breeding birds may leave eggs and be separated from young for a period. The eggs and young will be exposed to cold and moisture, and they will also easily fall prey to large gulls, skuas and foxes. Lasting/heavy disturbances can deter birds from returning to the breeding area or result in abandonment of eggs.

CATEGORY: B

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. The hypothesis is accordingly considered to be valid and important.

MANAGEMENT RECOMMENDATIONS: Protection of the most important breeding areas and strict regulation of aircraft traffic in areas important for breeding wildfowl.

SURVEYS: Mapping of breeding areas for marine wildfowl within the area.

MONITORING: Monitoring of the number of breeding/moulting marine wildfowl in selected areas.

RESEARCH: Investigate if the disturbance regime has significant negative effects on reproduction and population development.

VEC: MARINE WILDFOWL	IH 2

HYPOTHESIS: Disturbances 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.

EXPLANATION: The birds will use more energy on flights, and at the same time gain less energy from grazing. This can cause increased mortality and will be particularly decisive in connection with the fall migration, since especially juvenile birds need to be in good physical condition in order to survive the migration. It may also cause reduced reproductive success as the females are dependent upon large energy reserves to be able to accomplish the incubation.

CATEGORY: B

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.

MANAGEMENT RECOMMENDATIONS: Traffic encroachments must be regulated in vulnerable areas. Important resting, moulting, and feeding areas should be protected.

SURVEYS: As for IH 1.

MONITORING: Monitoring of marine wildfowl in resting, moulting and feeding areas that potentially may be affected by NSR-activity.

RESEARCH: As for IH 1.

VEC: MARINE WILDFOWL	IH 3
HYPOTHESIS: Oil slicks in marine areas may cause increased mortality and reduced reproduction of the wildfowl populations.	
EXPLANATION: Wildfowl (both adults and young) 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 reproduction in affected local populations. Oil from the plumage of the parents may be passed on to eggs, reducing hatching success.	
CATEGORY: B	
RATIONALE: 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. An oil spill along the NSR in the summer season, particularly in the moulting period, may kill great numbers of marine wildfowl and have serious effects on the populations. The hypothesis is valid.	
MANAGEMENT RECOMMENDATIONS: 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.	
SURVEYS: Breeding, feeding, moulting and migration concentrations should be surveyed, to document the present population levels.	
MONITORING: Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity, in order to be able to assess impacts on the populations in the event of an oil spill.	
RESEARCH: 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 wildfowl.	

VEC: MARINE WILDFOWL	IH 4

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.

EXPLANATION: Contamination of the feeding organisms of the marine ducks can cause reduced availability of food and/or in ingestion of high concentrations of toxins. This may lead to weakened physical condition and thereby reduced reproduction and increased mortality, which will cause a reduction in the population.

CATEGORY: C

RATIONALE: Many marine ducks live chiefly 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 and may become important in the event of oil spills.

MANAGEMENT RECOMMENDATIONS: Strict regulations and frequent controls of pollution level from ships should be made.

SURVEYS: None.

MONITORING: Monitoring of the contamination levels of marine wildfowl should be carried out. There are no data today on toxic contaminants in wildfowl from the NSR-area.

RESEARCH: If high levels of toxic compounds are found in wildfowl, studies of the resulting effects on reproduction and survival should be initiated.

VEC: MARINE WILDFOWL	IH 5

HYPOTHESIS: An increase in 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.

EXPLANATION: Self-explanatory.

CATEGORY: C

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. The hypothesis is assumed to be valid, but the effect is supposed to be mainly of local character.

MANAGEMENT RECOMMENDATIONS: All waste should be stored in containers and treated in waste treatment units.

SURVEYS: Mapping of breeding colonies of large gull and surveys of non-breeding concentration of gulls and skuas.

MONITORING: Monitoring of population size of large gulls and Arctic Fox.

RESEARCH: None.

VEC: MARINE WILDFOWL	**IH 6**

HYPOTHESIS: Increased ship traffic will result in reduced local populations of wildfowl due to increased hunting pressure and egg harvesting.

EXPLANATION: Self-explanatory.

CATEGORY: D

RATIONALE: The hypothesis is valid, but increased hunting pressure and egg harvesting will probably only become a major problem with establishment of new settlements or other extension of activity on land in the NSR-area. Effects of such activity is not assessed here.

MANAGEMENT RECOMMENDATIONS: Measures to prevent illegal hunting and egg harvesting should be initiated.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: MARINE WILDFOWL	IH 7

HYPOTHESIS: Extensive disturbance in breeding areas will reduce the number of suitable breeding areas and lead to reduced reproduction and reduced population sizes of marine wildfowl.

EXPLANATION: Extensive disturbance may make an area unsuitable for breeding. The competition for localities unaffected by disturbance will grow when the total number of nesting sites in an area decreases. Fewer pairs will be able to breed and the populations will be reduced. Development of new infrastructure on land may in addition occupy or destroy important breeding areas.

CATEGORY: D

RATIONALE: The number of available nesting sites can in many cases be a factor delimiting the size of the breeding populations. There are also indications that there may be direct competition between some of the species. The hypothesis may be valid.

MANAGEMENT RECOMMENDATIONS: Traffic near important nesting areas must be avoided.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: MARINE WILDFOWL	IH 8

HYPOTHESIS: Increased human activity in connection with the NSR (e.g. pollution, hunting and noise) can reduce the populations of large gulls, skuas and Arctic Fox. This will result in a reduction in predation of breeding marine wildfowl. This will give reduced mortality and increased reproduction of wildfowl.

EXPLANATION: Pollution, disturbance, egg harvesting and hunting may reduce local populations of predators. Large gulls may be more prone to egg harvesting than other seabirds because they often nest in areas that are easier to access. They are probably also more prone to intraspecific nest predation during disturbance than are most other seabirds. This will have a positive effect on the populations of wildfowl.

CATEGORY: A

RATIONALE: In general there is little reason to believe that the large gulls and Arctic Fox populations will be reduced as a result of human activity unless active measures are taken to combat these species. The predator populations will most likely be favoured by human activity. The hypothesis is not regarded to be valid.

MANAGEMENT RECOMMENDATIONS: None.

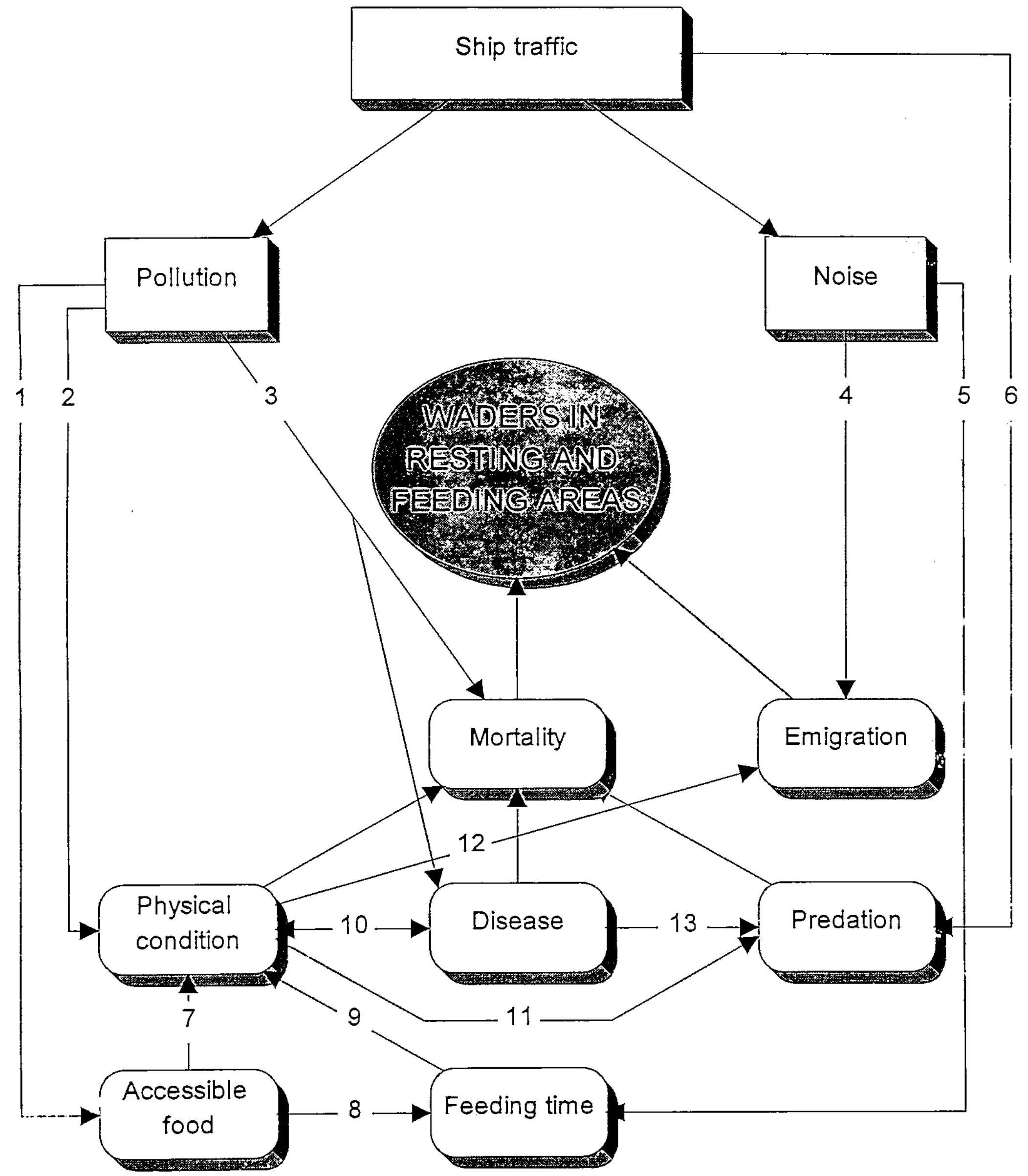
SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC 3: WADERS IN RESTING AND FEEDING AREAS

SCHEMATIC FLOW CHART



LINKAGES

Self-explanatory linkages have not been described

1. Pollution may lead to reduced access to food by causing increased mortality and/or lowered reproduction of food organisms. Contamination of feeding areas may make them unsuitable for feeding and resting waders.
2. Oil fouling causes increased energy expenditure, by impairing the insulating properties of the plumage.
3. Pollution may cause disease or direct mortality.
4. Noise can cause birds to withdraw from an affected area.
5. Noise can stress birds and cause reduced foraging time.
6. Ship traffic may result in increased hunting.
7. The quantity (and the quality) of food will to a great extent determine the physical condition of the birds.
8. Reduced access to food will increase foraging time.
9. Reduced foraging efficiency causes reduced energy gain, increased energy expenditure and accordingly impaired physical condition.
10. Impaired physical condition increases disease susceptibility. Disease will impair the physical condition.
11. Impaired physical condition increases exposure to predation.
12. The physical condition of the bird is crucial for the time of migration departure.
13. Sick birds are more prone to predation.

BACKGROUND

Waders are among the most numerous species groups of birds in the tundra ecosystem (Stishov *et al.* 1989). They are recognised as vulnerable on the resting and feeding areas before and during autumn migration. When they arrive at the breeding grounds in spring they migrate directly to the breeding site. Many species use feeding areas along the coast during breeding. When breeding is finished in summer or autumn, they gather in large flocks in special areas, often close to the sea. These areas are important for feeding and resting before and also during migration. The waders are long-distance migrants and are dependent on a few important stop-overs in order to build up fat deposits for their next leg. Stop-overs are known to be sites of strong inter- and intra-specific competition for waders, and stop-overs are therefore considered to be bottle-necks for wader populations (Evans *et al.* 1979; Schneider & Harrington 1981). Factors influencing the food access and feeding time during the pre-migration period or at stop-over sites during migration are important for this VEC.

If NSR-activity will include dredging that will alter the water level, such changes may have great impact on resting and feeding areas for waders. This event is not analysed here, but should be included if dredging is to be a part of the NSR-activity.

THE IMPACT HYPOTHESES

Three hypotheses concerning the potential impact of the NSR-activity on waders in resting and feeding areas were evaluated. All three hypotheses (IH 1, 2 and 3) were considered to be potentially valid. The impact hypotheses have been listed in classified priorities (I–II).

I.

IH 1

Disturbances in resting and feeding areas can result in reduced possibility for the waders to store enough energy for the autumn migration.

Studies have shown that waders are vulnerable to disturbance in resting and feeding areas (Morrison 1984; Senner & Howe 1984; Pfister *et al.* 1992). It is also shown that waders can get used to disturbance from boats and cars, but not from helicopters (Furness 1973; Burger 1981; Pfister *et al.* 1992). The NSR ship traffic itself will probably not cause any serious disturbances for the waders, but the use of helicopters (from ships) may have negative effects.

II.

IH 2
Toxic substances released into feeding and resting areas may be accumulated in, and possibly kill, organisms that are normally preyed upon by waders, so that waders are poisoned or their food supply is reduced, which in turn may cause increased mortality.

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).

A number of oil spills around the world have shown that mudflats are very vulnerable to oil spills. The oil tends to sink into the substrate and so cause long-term negative effects to the infauna (Vandermeulen 1982; Teal & Howarth 1984). However, too little information is available to tell if oil spills may have serious effects on organisms that are normally preyed upon by waders within this study area. The effect of an oil spill on the infauna is shown through a direct decrease in density of all species (Coull & Palmer 1984). The further north a spill occurs, the longer time it takes for nature to be restored after an oil spill incident.

II.

IH 3
Oil spills affecting concentrations of waders in resting and feeding areas will cause increased mortality resulting both from direct oiling and habitat degradation.

After an accident, oil will land on the beaches and in estuaries and foul the plumage of waders that are exposed to it. The insulating properties of the birds' feathers will be reduced and they will have to spend more energy on maintaining normal body temperature. They may also lose their ability to fly. This will easily result in exhaustion and death. Moreover, the toxic effect of the oil ingested with food and during feather cleaning may result in disease and death (see VEC 1 *Seabirds*).

The only waders being pelagic outside the breeding season are the phalaropes, *Phalaropus lobatus* and *P. fulicarius*. These species will be most exposed to oil spills. Observations from the Kara Sea have shown that phalaropes may occur regularly in open waters far from the coast (M. Gavrilo pers. obs.). Most other waders do not swim in open waters and will thus be less exposed to oil than swimming birds. They may, however, be affected while feeding on oiled shores. Some species like the Purple Sandpiper *Calidris maritima* and some *Tringa*-species like Spotted Redshank *Tringa erythropus*, regularly swim in ponds. Larger waders like the Bar-tailed Godwit *Limosa lapponica* feed while wading often quite far out in the water. They put their heads under water while feeding and the belly is very often well into the water. The waders may also ingest oil while feeding on invertebrates in the mud.

Many feeding and resting grounds for waders are well sheltered from the sea, at least in the western part of the NSR-area (V. Bakken and M. Gavrilo pers. obs.). It is not expected that oil spill will be an important negative factor for the waders in this area. However, estuaries that are situated at the mouth of major rivers with important inland harbours, may get an increased number of ship calls caused by the opening of the NSR for ship traffic. If so, these estuaries may be exposed to a higher risk of oil pollution.

An oil spill reaching the coast and the following clean-up activities will make the affected beaches unsuitable as feeding areas for waders. This may result in displacement of waders and in higher densities of birds in alternative areas, which often will be of lower quality for the waders. High densities of birds can have various negative effects, including reduced prey detectability, increased aggression between birds, prolonged feeding time and increased energy expenditure while searching for new feeding areas (see Senner & Howe 1984).

RECOMMENDED MEASURES AND STUDIES

The following studies should be implemented in connection with the NSR-activity involving the impacts referred to in IH 1, 2, and 3. The studies have been listed in classified priorities (I–III).

I. (To be implemented in connection with IH 1, 2, 3)

Important resting and feeding areas for waders along the NSR-area should be mapped.

Objective: To find whether the NSR-activity involves the risk of affecting resting and feeding waders. Activity should be avoided in areas where significant conflicts may arise.

Method: Traditional inventories.

II. (To be implemented in connection with IH 1, 2, and 3)

Monitoring of the number of waders in areas potentially affected by the NSR-activity and in unaffected control areas.

Objective: To record changes in the number of waders using important stop-over sites caused by the NSR-activity.

Method: To be coordinated in long-term registrations (counts every year in an initial period of at least 5 years, and then counts every 2–3 years).

III. (To be implemented in connection with IH 2 – cf. VEC 1 and VEC 2)

Monitoring of the contamination levels in waders using coastal resting and feeding areas.

Objective: To detect changes in contaminant levels in waders. If contaminant levels increase, investigations to identify the sources and actions to reduce the discharges should be carried out. Studies of the resulting effects on reproduction and survival should also be initiated if high levels are found.

Method: Standardised analysis of body tissues.

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VEC: WADERS		IH 1

HYPOTHESIS: Disturbances in resting and feeding areas can result in reduced possibility for the waders to store enough energy for the autumn migration.

EXPLANATION: Disturbances of migrating birds at the stop-over sites may lead to a reduced intake of food. This can reduce the accumulation of fat and extra protein needed for the demanding autumn migration. Such a reduction in allocated energy can impair the birds' ability to fly to the most suitable wintering areas forcing them to winter in areas with less favourable conditions. This can lead to a much higher winter mortality than expected both in adults and first-year birds. Furthermore, a low quality wintering area may also offer the birds less possibilities to allocate energy before the spring migration which in turn reduces the reproduction in the arctic breeding areas. Development of new infrastructure on land may in addition occupy or destroy important resting and feeding areas.

CATEGORY: C

RATIONALE: It has been documented that arctic waders are very dependent on allocated energy for successful breeding and migration.

MANAGEMENT RECOMMENDATIONS: Protection of the most important stop-overs along the Siberian coast. Use of aircraft etc. close to important stop-overs must be avoided.

SURVEYS: Surveys of stop-over sites used during autumn migration should be conducted.

MONITORING: Monitoring of the occurrence of roosting waders at major stop-over sites.

RESEARCH: Quantify the effects of the actual disturbance regime on the survival of waders.

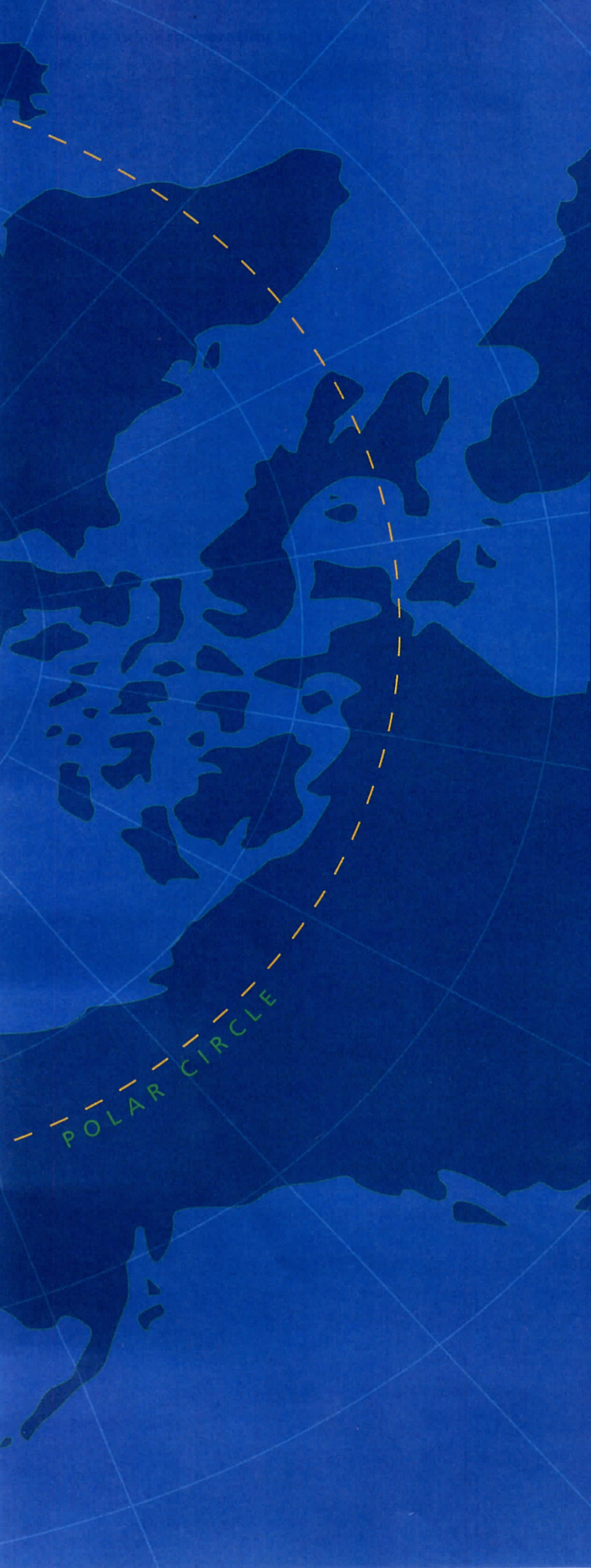
VEC: WADERS		**IH 2**
HYPOTHESIS: Toxic substances released into feeding areas may accumulate in, and possibly kill, organisms which are normally preyed upon by waders. This can lead to direct poisoning or reduced access to food.		
EXPLANATION: Contamination of the waders' feeding organisms may cause a reduction in the quality of the food through ingestion of high concentrations of toxins. This may lead to weakened physical condition with following reduced reproduction and in severe cases, increased adult mortality.		
CATEGORY: C		
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 substances may kill and reduce the density of these animals. Being long distance migrants waders are very dependent on accumulating fat deposits before the autumn migration. If food availability at these important stop-overs is 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.		
MANAGEMENT RECOMMENDATIONS: Strict regulations and frequent controls of pollution level from ships should be made.		
SURVEYS: Surveys to map areas used as stop-overs during autumn migration.		
MONITORING: Monitoring of the contamination levels of waders should be carried out. There are no data today on toxic contaminants in waders from the NSR-area.		
RESEARCH: If high levels of toxic compounds are found in waders, studies of the resulting effects on survival should be initiated.		

VEC: WADERS	IH 3
HYPOTHESIS: Oil spills affecting concentrations of waders in resting and feeding areas will cause increased mortality resulting both from direct oiling and habitat degradation.	
EXPLANATION: Oil spills will land on beaches and foul the plumage of the birds. Since oil destroys the insulation properties of the plumage waders must spend more energy for maintaining their normal body temperature and less energy will be stored as fat and proteins. This restricts the birds' possibility to accomplish the autumn migration, or it can even result in exhaustion or death. Oil fouling of beaches and subsequent clean-up activities will make the affected areas unsuitable as feeding areas for waders.	
CATEGORY: C	
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.	
MANAGEMENT RECOMMENDATIONS: Contingency plans incorporating protection of waders should be prepared. Discharge concentrations should be strictly regulated and controlled. An updated geographical information system containing data on wader distribution along the NSR should be maintained for planning of actions in case of an oil spill.	
SURVEYS: Important feeding and resting areas within the NSR should be surveyed, to document the present population levels.	
MONITORING: Monitoring of the population development should be started with the survey mentioned above and continued parallel to the activity, in order to be able to assess impacts on the populations in the event of an oil spill.	
RESEARCH: 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 waders.	

REFEREE'S COMMENTS

Generally, a very nice piece of work and a good review of vulnerability literature. You may want to cite 'King and Sanger, Oil Vulnerability Index For Marine Oriented Birds', in 'Conservation of Marine Birds of Northern North America, Bartonek and Nettleship (eds.)'. I don't recall ever seeing this line-of-logic of impacts/hypotheses/management-research recommendations used like you have done. The only idea that caught my eye in my very cursory review was the 'ship traffic/increased hunting' hypothesis (p. 21). I believe I would classify that as 'not assumed to be valid'. I doubt that an increase in shipping would create a need for new settlements. I would guess that the new shipping economy/jobs/local income would create a reduction of the need for subsistence use of seabirds.

I don't believe the IH numbers (p. 6) are in synchrony with their explanations on the following pages; e.g., p. 18 etc. I like the idea to survey leads/polynyas for winter concentrations of birds. Obviously, ships will use the leads too. On the other hand, I wonder if the ships will make additional food available to birds as they ply those leads? I have not heard if birds follow icebreakers in ice-covered areas?



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.