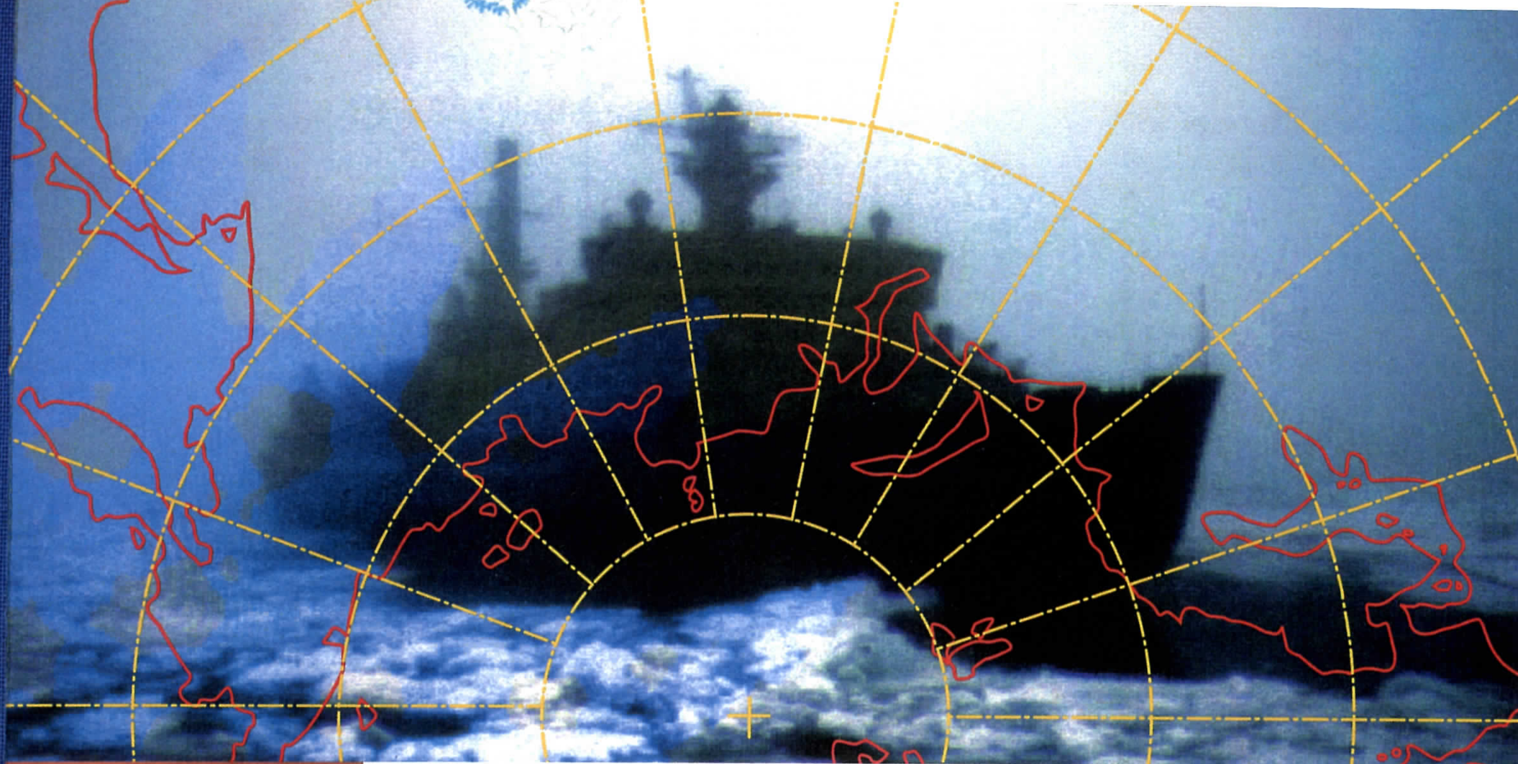

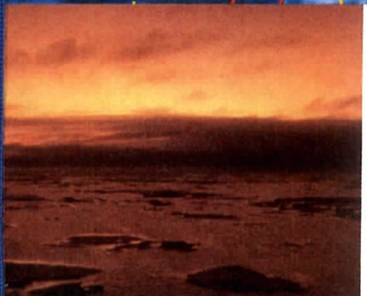

INSROP WORKING PAPER
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Selection of marine mammal Valued Ecosystem Components and description of impact hypotheses in the Northern Sea Route Area

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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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The Fridtjof Nansen Institute, Norway

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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

The Subprogram II of INSROP addresses the selection and evaluation of so-called Valued Ecosystem Components (VECs), to be used in the final environmental impact assessment. The VECs are selected using criteria like ecological importance, data availability and vulnerability towards Northern Sea Route activities.

The present working paper presents results of project II.4.3. Marine mammals. It describes how the method of Adaptive Environmental Assessment and Management (AEAM) is applied to marine mammals in the NSR area.

The project is co-ordinated by the Zoological Museum, University of Oslo, and is carried out in co-operation with institutions in Japan, Russia and USA.

The manuscript for this paper was reviewed by Professor Yasuhiko Naito, National Institute of Polar Research, Tokyo, Japan. A copy of the review is included at the end of the report.

Oslo, 10 February 1996

Øystein Wiig

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1. INTRODUCTION

The main object of the marine mammal project under Insrop is to establish a database containing information on distribution, abundance, migrations and breeding and feeding areas for selected marine mammals in the Northern Sea Route (NSR) area, and to present a discussion of possible impacts of the activity on these species. This information will be used as basis for an Environmental Impact Assessment (EIA). The central point in the EIA is to identify and evaluate key impacts from possible NSR activity on the environment represented by the so-called Valued Ecosystem Components (VECs).

A VEC is defined as a resource or environmental feature that: 1) is important (not only economically) to a local human population, 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 for the focusing of administrative efforts.

In the first part of this paper we present how the VECs were selected. In the second part of the paper we discuss the validity of a number of Impact Hypotheses (IHs) about the possible impact of NSR activity on the selected VECs. Based on this discussion we also recommend further studies and management actions. A more detailed description of the biology of the VECs are given in an other Working Paper by Belikov *et al.* (In prep).

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

2. SELECTION OF VALUED ECOSYSTEM COMPONENTS

2.1. Introduction

During the Project II.2. Screening and Focusing Workshop which was held in Oslo November 1993, most of the mammalian species occurring in the NSR area were evaluated (Hansson *et al.* 1994). It was pointed out that in the selection of VECs it must be focused on species that may potentially be affected by NSR activity, and where detectable changes in the populations may occur as a result of such impacts. It was also agreed that for each species that was given priority, it should be pointed out what is the vulnerable property, period, area and type of behavior. On that basis four VECs were selected: 1. polar bear, 2. walrus, 3. ringed seal, 4. white whale. The selection of VECs was later re-evaluated, and additional species of marine mammals were considered for inclusion as VECs in the present project.

2.2. List of VEC candidates

The following species were regarded as possible marine mammal VECs:

1. Polar bear
2. Walrus
3. Bearded seal
4. Ringed seal
5. Harp seal
6. Spotted seal
7. Narwhal
8. White whale
9. Gray whale
10. Bowhead whale

2.3. Evaluation of VEC candidates

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

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

2.3.1. Polar bear

2.3.1.1. Distribution

The polar bear (*Ursus maritimus*) has a circumpolar distribution, and is confined to Arctic and sub-Arctic ice covered sea areas. The bears are not evenly distributed, but are found in several more or less isolated populations (DeMaster & Stirling, 1981). Three populations are found along the Siberian coast. These are the Franz Josef Land/Novaya Zemlya population, the Laptev population and the Chukchi population, which together consist of about 5300-9700 bears (Wiig *et al.* 1995).

2.3.1.2. Habitat

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

2.3.1.3. Food

The polar bear lives mainly on ringed seals and partly on bearded seals (Lønø 1970, Stirling and Archibald 1977). They also feed on other seals, walruses, white whales, carcasses and whatever they find of birds, eggs etc.

2.3.1.4. Life cycle

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

2.3.1.5. Evaluation

2.3.1.5.1. Ecology

The polar bear is at the top of the Arctic marine food chain. The size of the population has an effect on the size of the population of ringed and bearded seals. They are therefore regarded as moderately important for the ecology in the area.

2.3.1.5.2. Economy

The polar bears are protected in the NSR area (see Wiig *et al.* 1994). The economic importance of polar bears is therefore small. Illegal hunting is, however, an increasing problem. In addition, there are reasons to believe that hunting in some of the areas soon will be legalized. The Chukchi/Bering Sea population is, however, hunted for sustenance by Alaskan Inuits.

2.3.1.5.3. Other human affairs

The polar bear is a symbol for the Arctic and has a high international conservation value. The cultural value for indigenous people in the NSR area is probably relatively high in spite of the fact that hunting is forbidden. In Alaska the population is important also in this respect. The bears are also important in relation to increased tourism in the area.

2.3.1.5.4. Environmental effects of NSR

Polar bears are highly vulnerable to oil pollution. They are curious and often unafraid and are attracted by human activity. Polar bears have a low reproductive potential, which implies that the population can suffer by long term effects if a substantial number of adult animals (particularly females) are affected.

2.3.1.5.5. Data availability

Considerable data exists on the distribution of polar bears in the area and long-term marking and tracking projects are currently underway in central and eastern parts of the area. Further processing of existing primary data is possible while new field work is very expensive.

2.3.2. Walrus

2.3.2.1. Distribution

The walrus (*Odobenus rosmarus*) has a nearly circumpolar distribution. The world population is about 250.000. Most of these are found in the Chukchi/Bering Sea area. About 5.000 are found in the Laptev Sea and less than 1.000 in the Kara Sea.

2.3.2.2. Habitat

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

2.3.2.3. Food

The walrus lives mostly of benthic organisms like bivalves and snails, but small crustaceans, worms, fish, star fish and even other marine mammals are also eaten (Fay 1982).

2.3.2.4. Life cycle

Female walruses usually mature at an age of about five to six years while males are sexually mature at about nine to ten. It takes several more years before the males are large enough to compete socially during mating (Fay 1981). Mating occurs from January to March. The whelping is usually in spring. The single calf suckles for about two years. After weaning females stay with groups of adult females, while males usually wander away to join herds of younger and older males.

2.3.2.5. Evaluation

2.3.2.5.1. Ecology

The large population of walruses in the Chukchi area has as a predator an important impact on the benthic fauna of the area. The populations in the central and western parts of the NSR area are relatively small.

2.3.2.5.2. Economy

The walrus is hunted in the Chukchi/Bering Sea area and is important for the economy here. In the rest of the NSR area it is protected. Illegal hunting probably occurs.

2.3.2.5.3. Other human affairs

The walrus is important for indigenous people, and has a high conservation value. The populations are relatively small in central and western areas but is recovering in the Kara Sea.

2.3.2.5.4. Environmental effects of NSR

Walruses are gregarious so groups rather than individuals may be affected. They are sensitive to disturbance at haul out grounds. They may be affected through pollution of benthic organisms.

2.3.2.5.5. Data availability

Much data are available for the eastern population. Less is known about the present status of the central and western populations. Surveys of haul out grounds in summer and autumn are relatively inexpensive.

2.3.3. Bearded seal

2.3.3.1. Distribution

The bearded seal (*Erignathus barbatus*) is one of the largest northern seals, and has a circumpolar distribution. The population size in different areas is poorly known. The world population is suggested to be in excess of 500.000 individuals (Stirling and Archibald 1979).

2.3.3.2. Habitat

The bearded seal is usually found in association with sea ice in areas with water depth less than 100 m. They are often found in the drifting pack ice. In winters seals make and maintain breathing holes in areas of thinner ice. Bearded seals are solitary animals and are often seen hauled out at the edge of small floes and along leads.

2.3.3.3. Food

The principal prey are bottom living invertebrates, mainly crustaceans and mollusks, and some fish.

2.3.3.4. Life cycle

Males and female mature at five to seven years old. Breeding occurs from March to May. The pup is born on the ice 11 months later.

2.3.3.5. Evaluation

2.3.3.5.1. Ecology

The bearded seal is important as food for polar bears.

2.3.3.5.2. Economy

The bearded seal is hunted by Inuits and has been hunted commercially by the Russians.

2.3.3.5.3. Other human affairs

The bearded seal is important for Inuits not only as food but also as source of skin, ropes, dog harness etc.

2.3.3.5.4. Environmental effects of NSR

The bearded seal may be affected through pollution of their prey and by destruction of breeding habitat.

2.3.3.5.5. Data availability

Some data are available on distribution. New data are relatively difficult to obtain due to uncertain survey methodology and low densities.

2.3.4. Ringed seal

2.3.4.1. Distribution

The circumpolar ringed seal (*Phoca hispida*) is the smallest and most abundant Arctic seal. The total world population is unknown (Frost and Lowry 1981).

2.3.4.2. Habitat

Ringed seals are inhabitants of the permanent pack-ice but congregate on landfast ice for breeding. Some populations also breed in stable drifting pack-ice (Finley *et al.* 1983). In the breeding season the adults are found in the stable fast ice, while non-breeders frequent more peripheral ice and moving pack (Frost and Lowry 1981). Early in summer the seal molts, still in the same areas. In late summer all ages and both sexes move out to the permanent pack-ice or to the remnants of ice near the shore where they remain into early spring.

2.3.4.3. Food

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

2.3.4.4. Life cycle

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

2.3.4.5. Evaluation

2.3.4.5.1. Ecology

The ringed seal is important as a predator and as the main food for polar bears.

2.3.4.5.2. Economy

The ringed seal is very important as food source for Inuits and others.

2.3.4.5.3. Other human affairs

The ringed seal has no special conservation or cultural value, apart from its importance for Inuits..

2.3.4.5.4. Environmental effects of NSR

Ice breaker activity may destroy the breeding lairs of ringed seal during spring. Oil spills may foul ringed seals and oil may be transported to the breeding lair and contaminate the pup.

2.3.4.5.5. Data availability

Extensive data exists on the distribution of ringed seals in the NSR area. Methods for surveying this species over larger areas are not reliable.

2.3.5. Harp seal

2.3.5.1. Distribution

The harp seal (*Phoca groenlandica*) is found in North Atlantic waters. Total world population is in excess of 2 millions. The White Sea/Barents Sea stock is only partly distributed in the NSR area.

2.3.5.2. Habitat

The harp seals breed on the fast ice and congregate in large herds. During the rest of the year they are true pelagic seals. The Barents Sea stock breed in the White Sea and move north to feed in summer and autumn. They move south again when the ice cover increases in winter.

2.3.5.3. Food

The harp seal is an opportunistic feeder, primarily on pelagic fish and crustaceans.

2.3.5.4. Life cycle

The harp seal matures at an age of three to six years. The females form large breeding aggregations in the pack ice where the pup is born in February/March. They are weaned within two weeks. Mating occurs when the pups are weaned.

2.3.5.5. Evaluation

2.3.5.5.1. Ecology

The harp seal has little importance for the total NSR area.

2.3.5.5.2. Economy

Little importance for the economy of people in the area.

2.3.5.5.3. Other human affairs

Not important for other human affairs in the area.

2.3.5.5.4. Environmental effects of NSR

The harp seal may partly be affected by ship traffic.

2.3.5.5.5. Data availability

The population in the Barents Sea is fairly well known.

2.3.6. Spotted seal

2.3.6.1. Distribution

The spotted seal (*Phoca largha*) is mostly distributed south of the Bering Strait but partly also in the Chukchi Sea. The world population is about 400.000 (Quakenbush 1988). The spotted seal is found in the NSR area only during summer.

2.3.6.2. Habitat

The spotted seals breed on the pack ice but during the ice-free period of the year they are found along the shores. They are not able to maintain breathing holes in the ice.

2.3.6.3. Food
The food of spotted seals is fish, crustaceans and cephalopods. The diet varies regionally and with the season.

2.3.6.4. Life cycle
Females attain sexual maturity at three to four years and males some years later. Pups are born in February to May and there is a pair bond between the male and the female during the breeding season.

2.3.6.5. Evaluation
2.3.6.5.1. Ecology
The spotted seal has minor importance for the ecology in the NSR area.

2.3.6.5.2. Economy
The spotted seal has no importance for the economy in the area.

2.3.6.5.3. Other human affairs
The spotted seal has no specific conservation or cultural value.

2.3.6.5.4. Environmental effects of NSR
Environmental effects on spotted seals are mainly through possible pollution of food species.

2.3.6.5.5. Data availability
The distribution of spotted seals in the NSR area is fairly well known. Reliable survey methods do not exist.

2.3.7. Narwhal
2.3.7.1. Distribution
The narwhal (*Monodon monoceros*) is a partly circumpolar species, but is most abundant in East Canada and Greenland (Hay and Mansfield 1989). The total population size is poorly known. The number found in the NSR area is not known.

2.3.7.2. Habitat
The narwhal follows the boundary of the pack ice, but may also be seen in nearshore ice- free waters. They are most often seen in small pods.

2.3.7.3. Food
The narwhal mainly eats squid, but also fish and crustaceans.

2.3.7.4. Life cycle
The female becomes mature at an age of four-seven years, the male some time later. Mating is probably in spring and the calf is born the next summer.

2.3.7.5. Evaluation

2.3.7.5.1. Ecology

The narwhal has little importance for the ecology in the area.

2.3.7.5.2. Economy

The narwhal has no importance for the economy.

2.3.7.5.3. Other human affairs

No special importance for other human affairs.

2.3.7.5.4. Environmental effects of NSR

It is believed that narwhals are very sensitive to underwater noise.

2.3.7.5.5. Data availability

Little data exist on the narwhals in the NSR area. New data are difficult to obtain.

2.3.8. White whale

2.3.8.1. Distribution

The white whale (*Delphinapterus leucas*) has a circumpolar Arctic and partly Sub-Arctic distribution. The world population have been suggested to be in the vicinity of 60.000 (Brody 1989). About half of these are believed to be found in the Bering/Chukchi Sea area.

2.3.8.2. Habitat

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

2.3.8.3. Food

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

2.3.8.4. Life cycle

The female becomes sexually mature at an age of about five years while the male is mature at about nine. The calves are born in spring and summer. Mating takes place about 14 months before that.

2.3.8.5. Evaluation

2.3.8.5.1. Ecology

The white whale is important for the ecology of the area as a primary marine predator.

2.3.8.5.2. Economy

The white whale is to some degree hunted in the NSR area and has some economic importance.

2.3.8.5.3. Other human affairs
It is also important for the Inuit culture.

2.3.8.5.4. Environmental effects of NSR
The effects of NSR activity on white whales will mainly be through noise that frightens them away from important summer areas and estuaries.

2.3.8.5.5. Data availability
The distribution of white whales in the area is fairly well known. New investigations are expensive.

2.3.9. Gray whale
2.3.9.1. Distribution
The Gray whale *(Eschrichtius robustus)* occurs in coastal waters of the North Pacific Ocean, Bering and Chukchi Seas. The total population size is about 15.000 (Reeves and Mitchell 1988). Most of them are found in the East Pacific stock which extends from Baja California and into the Chukchi Sea.

2.3.9.2. Habitat
The Gray whale is found primarily in coastal waters and probably remains closer to shore than any other large cetacean. From late May to early October the eastern population congregates in the shallow waters of the northern and western Bering Sea, Chukchi Sea and the Beaufort Sea. In October to January they move to the southern part of their distribution area about 18.000 km away. In the spring they move north again.

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

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

2.3.9.5. Evaluation
2.3.9.5.1. Ecology
The Gray whale is important for the ecology of the eastern part of the NSR area as a large predator on benthic organisms. Its feeding behavior also has an effect on the bottom sediments in the area.

2.3.9.5.2. Economy

The Gray whale has little economic significance in the NSR area. Some are taken as subsistence harvest by Inuits. Whale watching is of economic importance in the southern range of the population.

2.3.9.5.3. Other human affairs

Relatively high conservation value and some importance for Inuits.

2.3.9.5.4. Environmental effects of NSR

Effects of NSR activity mainly through disturbance. Oil spills may pollute major food species.

2.3.9.5.5. Data availability

The distribution in the NSR area is fairly well known. The cost of new field data is high.

2.3.10. Bowhead whale

2.3.10.1. Distribution

The bowhead (*Balaena mysticetus*)whale is distributed from the Barents Sea and west to the Bering and Okhotsk Seas. Total population size is about 8.000, and most of them are found in the Bering Sea stock (Burns *et al.* 1993). The other stocks are nearly extinct.

2.3.10.2. Habitat

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

2.3.10.3. Food

The diet consists mainly of zooplankton like copepods, amphipods and euphausiids. They feed in the summer and live mostly of stored fat in the winter.

2.3.10.4. Life cycle

The reproductive biology is poorly known. Females presumably mature at an age of about 15 years. Calving interval seems to be about 3-4 years. Breeding probably occur during the summer feeding migration to the north.

2.3.10.5. Evaluation

2.3.10.5.1. Ecology

The Bowhead has relatively little importance for the ecology within the NSR area.

2.3.10.5.2. Economy

The bowhead is totally protected but Inuits in Alaska and Siberia are allowed to take some for subsistence use. The species is very important for these people.

2.3.10.5.3. Other human affairs

The bowhead whale is nearly extinct in most of its distribution range and has a high conservation value. It also has high cultural value for Inuits.

2.3.10.4.5. Environmental effects of NSR

The effect of NSR activity on bowheads will be mainly through physical disturbance.

2.3.10.5.5. Data availability

The distribution of bowheads in the NSR area is fairly well known and compiled.

2.4. Selection of VECs

Table 1 sums up the evaluation of each of the possible VECs selected. The polar bear and the walrus were the possible VECs that seem to be most important based on the present evaluation. The bearded seal, the ringed seal, the white whale, the Gray whale and the bowhead whale were the second most important group, while the harp seal, the spotted seal, and the narwhal were regarded as less important as VECs in the NSR area.

Based on this evaluation the following seven VECs were selected:
VEC C1 Polar bear
VEC C2 Walrus
VEC C3 Bearded seal
VEC C4 Ringed seal
VEC C5 White whale
VEC C6 Gray whale
VEC C7 Bowhead whale

A further description of the biology of the VECs are given by Belikov *et al.* (in press).

Table 1. Evaluation of the relative importance (0 = low - 3 = high) of possible VECs in the Northern Sea Rout area.

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

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3. DOCUMENTATION OF SELECTED VECs

The central point in the Environmental Impact Assessment (EIA) is to identify and evaluate key impacts from possible NSR activity on the environment represented by the VECs.

Possible impacts can be divided into two main parts: 1. Impact from normal operation and 2. Impact from accidents. In addition to these comes part 0. Impact from present activity. The existing, operational and accidental approach will principally be the same, even though the impact factors and the ecosystem components differ in value. In INSROP the impact prediction and significance is done by defining and describing Impact Hypotheses (IHs) about how VECs are linked to impact factors.

When describing IHs in relation to marine mammals VECs we have based our work on the impact factors described by Thomassen *et al.* (1994). The IHs are evaluated and placed in one of the following priority 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 possible 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.

In order to do this, schematic flow charts for each of the selected VECs are constructed and explained. The charts show the linkage between developments (NSR activity), system components (natural factors important to the VEC) and the VEC and the linkages are listed. Self-explanatory linkages have not been described.

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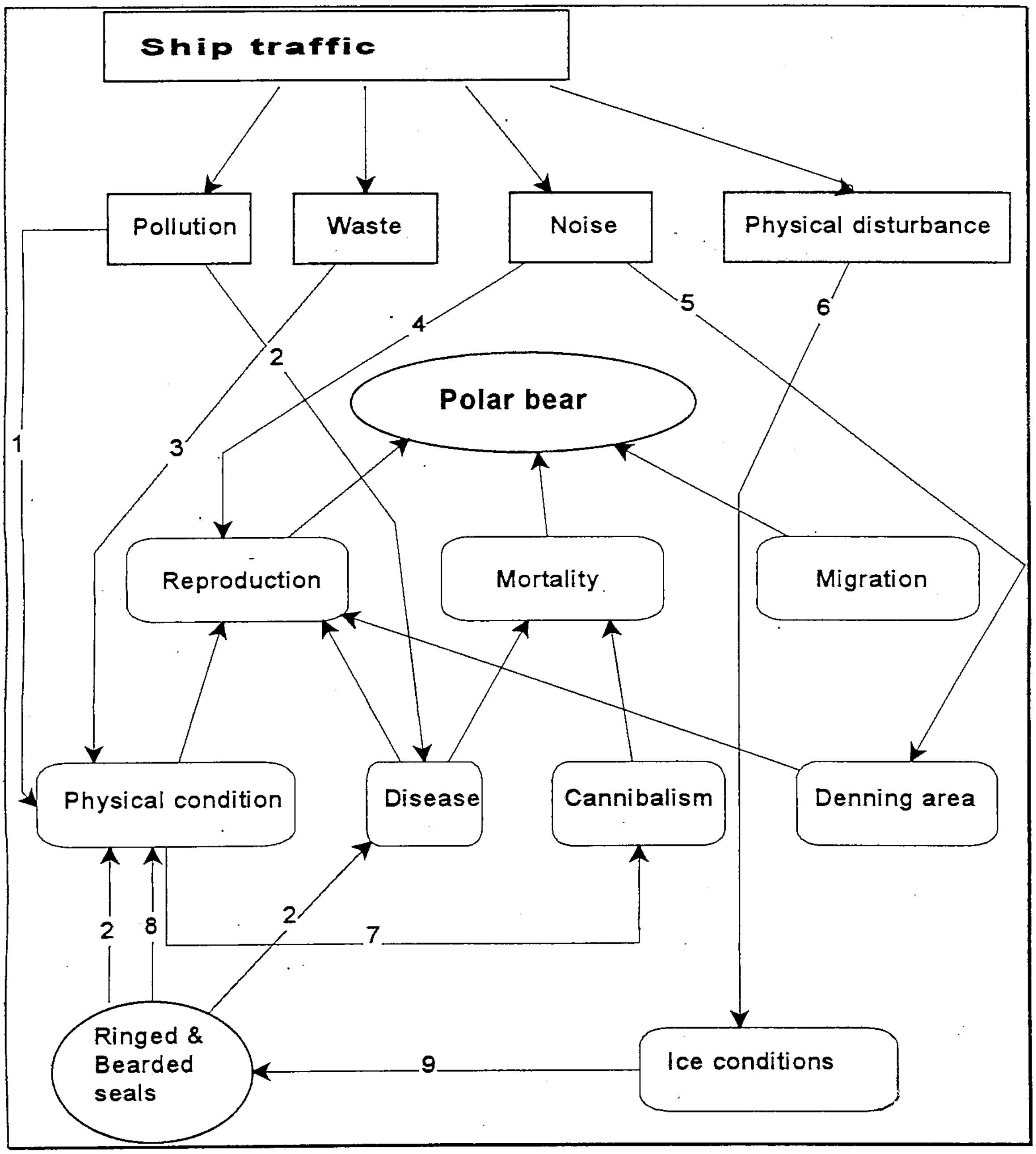
3.1. VEC C1: Polar bear
3.1.1 Flow chart



3.1.2. Linkages

1. Pollution of ice and water can have a negative effect on the physical condition of polar bears.
2. Pollution of ice and water can cause disease directly or indirectly through accumulation in the food chain.
3. Edible waste from ships can have a positive effect on the physical condition of polar bears. Disturbance from active installations can have a negative effect on polar bears by reducing the local prey population.

4-5. Disturbances from noise in the mating period or when pregnant females enter the dens can negatively affect reproduction.

6. Physical disturbance of ice conditions may have an effect on the migration of polar bears.
7. The extent of cannibalism is probably affected by the physical condition of the population.
8. The physical condition is mainly contingent on seal availability.
9. Sea ice conditions affect food supply.

3.1.3. Impact hypotheses

Six hypotheses concerning potential impacts of NSR activities on polar bears were evaluated. Two hypotheses (C1-IH3 and C1-IH6) were considered to be potentially valid but not worth testing for scientific, practical or economic reasons. The validity of two hypotheses (C1-IH1 and C1-IH2) has been documented through previous research. Two hypotheses (C1-IH4 and C1-IH5) were considered to be valid and deserving of continued research and monitoring. The impact hypotheses have been listed in classified priorities (A - C).

A.

C1-IH1
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.

Oil spills reaching drift ice or ice-covered areas can potentially damage large areas. It is probable that the oil will be concentrated in ice leads and between ice floes, as well as trapped in pockets under the ice, gradually spreading upwards to the surface to end up as a snow-oil-water mixture on the ice. Due to low temperatures and ice-cover during parts of the year and calm sea, it is assumed that oil will be more slowly degraded and maintain light, toxic components for a longer period of time than would be the case in ice-free waters. It is nearly impossible to remove oil from ice with known methods. It can accordingly be spread over large areas and inflict damage for several years (Martin and Campbell 1974, Atlas *et al.* 1978, Griffiths *et al.* 1987).

The effect of oil on polar bears has been studied by Øritsland (1976), Øritsland *et al.* (1981) and Hurst and 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.

B.

C1-IH4
Installations and traffic in or near denning areas will cause reduced reproduction in the polar bear population.

Polar bears by nature have low reproduction, and cub mortality is high (Larsen 1985). It seems reasonable to assume that impacts further causing these factors to shift in a negative direction can harmfully affect the population.

Pregnant females enter the den in late fall, give birth in late December and abandon the den with their cubs in late March. In the denning period they do not eat and in spring their weight may be nearly halved since the previous fall (Ramsay and Stirling 1982). When breaking out of the den the female is probably approaching a critical energy situation, while the cubs, being still very small, are very vulnerable (Hansson and Thomassen 1982). At this time females with cubs are quite easily frightened, which is probably due to the fact that males take cubs if they find the opportunity (Taylor *et al.* 1986).

There is a tendency for pregnant females to seek "traditional" denning areas, in which there is a high density of dens annually (Larsen 1985). The reason for this pattern is probably that females initially resort to the place where they themselves were born, and gradually to places in which they have experienced high reproductive success. This will naturally coincide with areas which in normal years are easily accessible in the fall, and which have ready access to seal habitats in the spring, while at the same time not being too close to areas in which there are a great number of males (Larsen 1985, Stirling *et al.* 1980).

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 unfavorable 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.

Some investigations have been made concerning the impact on polar bears of disturbances and industrial activities in denning areas. Blix and Lentfer (1992), who has measured sound and vibration levels in an artificial den, concluded that bears in such dens hardly will be affected by any kind of petroleum-related activity unless this activity takes place less than 100 m from the den. This applies to the period before den break.

Amstrup (1994) found that perturbations resulting from capture, marking, and radiotracking maternal bears did not affect litter sizes or stature of cub production. He further found that polar bears tolerated exposure to exceptional levels of human activity but concluded that spatial and temporal restrictions of human activity could prevent the potential for many disruptions of dens from being realized. The effect of ship traffic was, however, not discussed.

Belikov (1973) assumed that female polar bears left the den due to disturbance, which resulted in mortality of cubs.

Experience from activities carried out in the spring in the Svalbard denning areas (Hansson and 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 and Stirling 1986b).

C.

C1-IH3
Reduced seal occurrence resulting from disturbance and pollution from activity will cause a decrease in the polar bear population in the area.

Polar bears live on seals and will, within their habitats, visit areas where seals are abundant. If seals are displaced from their traditional habitats, the occurrence of polar bears in the affected areas must be expected to decrease. Should the displacement of seals result in a reduction in seal carrying capacity, polar bear carrying capacity will be correspondingly reduced.

Access to seals may be a delimiting factor, which implies that some local seal occurrences may be of relatively great importance. If such occurrences are reduced or eliminated, the local, and possibly also the total, polar bear carrying capacity can be reduced (Stirling and Smith 1975). However, such potential effects will be very difficult to prove.

C1-IH5
Disturbances and obstacles caused by traffic in polar bear migration and feeding areas will result in a reduced population.

Most polar bears will keep a distance from noisy installations and other human activities and traffic (Born 1982). What that distance is, is not known, and there would probably be great individual variations. Stirling (1988) found that many bears were attracted to human installations in the ice because of their curious nature and because open water made by installations in the ice make seals more abundant and/or more accessible. Generally it can be assumed that females with cubs are the most fearful, young males the least. Experience from Hudson Bay in Canada (Stirling *et al.* 1977) indicates that in migration areas in which there is ample space for the polar bear to avoid frightening stimuli, such stimuli will not affect the main characteristic of the migration.

C1-IH6
Activity in the ice creating artificial leads will cause a local increase in polar bear prey and accordingly a local increase in the occurrence of polar bears.

Polynyas, or naturally permanent leads in the ice, can form biological "oases" in which reproduction is higher and the fauna is richer than in areas entirely covered with ice. Such areas are also known to have a high density of polar bears. Leads artificially produced by technical installations may create the same effect (Stirling 1988).

Polynyas, and the rich production found in some of them, are largely created by currents. Artificial leads may lack this factor and may therefore become less productive than polynyas. Installations may also cause animals to avoid such areas.

3.1.4. Recommended research, monitoring and/or surveys
The following studies can be implemented in connection with developments potentially resulting in the impacts described above. The studies have been listed in classified priorities (I - III).

I. (To be implemented in connection with all C1-IHs).
Surveys of polar bears in the total NSR area. 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.

Objective: Finding distribution, migration routes and areas that are important/vulnerable to the population throughout the year, in order for developments to be adapted to minimize harmful effects.

Method: Processing of raw data on distribution already collected. Mark/recapture and satellite telemetry from various points. Possibly aerial/ship counts. Such studies are currently performed.

II. (To be implemented in connection with all C1-IHs)
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.

Objective: Find the effect on the polar bear's general use of the area by the current type of development.

Method: Record the number of bears, length of stay and behavior in the area before, during (and possibly after the development). If possible, conduct a parallel study in a corresponding, unaffected area of reference.

III. (To be implemented in connection with C1-IH2 and C1-IH3).
Impact study on polar bear disturbance.

Objective: Measure physiological and behavioral response to relevant types of disturbances.

Method: Physiological telemetry and behavior observations compared to available physiological data from laboratory conditions. Record response to quantified stimuli. Possibly new laboratory tests.

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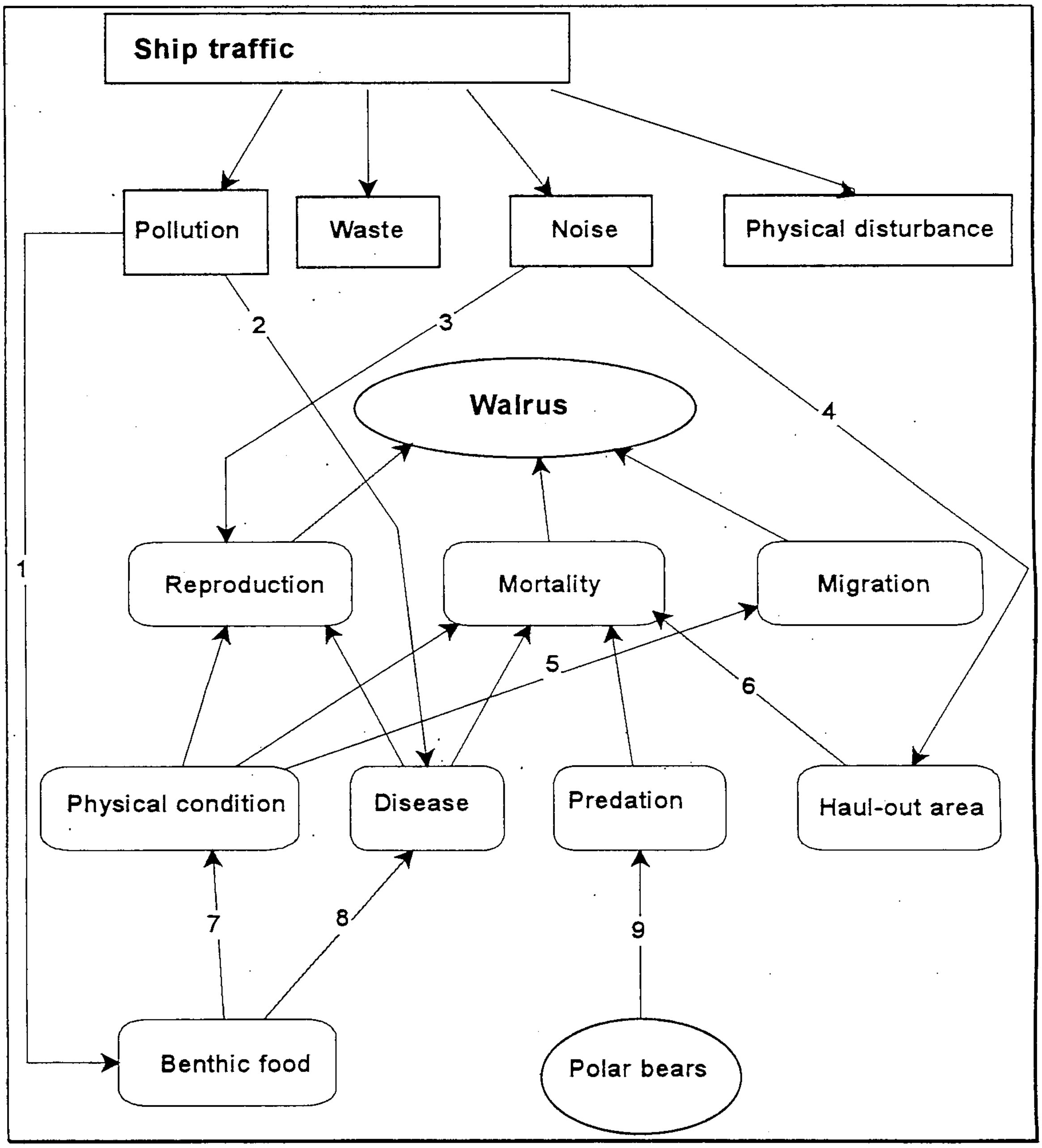
3.2. VEC C2: Walrus
3.2.1. Schematic flow chart



3.2.2. Linkages

1. Toxic substances can be accumulated in benthic fauna.
2. Ingestion of toxic substances can cause disease.
3. Disturbances during mating can cause reduced reproduction; underwater noise can interfere with the mating vocalization of the walrus.
4. Disturbances can make the walrus avoid traditional haul-out sites on shore and in the ice.
5. An impaired physical condition resulting from inferior food supply can initiate migration.
6. Disturbance on haul-out sites can result in calves being crushed to death by adults fleeing in panic.
7. The physical condition is mainly contingent on access to benthic fauna.
8. Toxic substances accumulated in benthic fauna can cause disease.
9. Polar bears can be predators.
10. Ice conditions will determine walrus habitats.

3.2.3. Impact hypotheses

Two hypotheses concerning the potential impact of NSR activities on the walrus were evaluated. Both hypotheses (C2-IH1 and C2-IH2) were considered to be valid and important to test with surveys, monitoring and research. The impact hypotheses have been listed in classified priorities (A - B):

A.

C2-IH1
Disturbances resulting from traffic will reduce the walrus population.

Loughrey (1959), Salter (1979), Cowles *et al.* (1981) and Fay *et al.* (1984) have documented that human and industrial activities, permanent bases etc. can displace local walrus populations. Several different factors may influence the population.

1) Disturbances to haul-out sites. Noise, smells and visual impressions from ships, planes and other traffic or activity can result in:

— Panicky flight to the sea, with the result that suckling young are separated from their mother (Fay *et al.* 1984), that young are crushed by adult animals (Loughrey 1959), that pregnant cows will abort, or that adult animals are injured (Fay and Kelly 1980, Fay *et al.* 1984).

— Frequent flight to the sea resulting in increased energy expenditure, among other things affecting the survival of the young.

— Reduced resting periods on land or ice haul-out sites, which may disturb natural molting and wound-healing processes (Salter 1979).

Salter (1979) found that walruses reacted when a Bell 206 helicopter was 8 km off and fled to the sea when it was at a distance of 1.3 km, while Orr *et al.* (1986) found a greater degree of tolerance to the same type of helicopter. Fay *et al.* (1984) found that adult walruses reacted to an ice-going ship at a distance of 2 km but did not flee to the sea until it was 100-300 m away. Cows with calf did however flee when the ship was at a range of 0.5 - 1 km. In several cases calves were abandoned. Observations would indicate that walruses may retreat if exposed to strong olfactory stimuli, such as exhaust and other waste gases (Lounghrey 1959, Fay et al. 1984).

The effect of disturbances will vary from one area to the other, depending on the relative shyness of the walrus. Walrus populations that are subjected to hunting, like those in the Thule area in Northeastern Greenland, are supposed to be more shy than un-hunted populations in e.g. Northern Canada and Svalbard. Presumably the walrus in general, in common with other species, will to some degree adapt to a particular type of noise over a period of time, and it may also be presumed that regular noise is less disturbing than noise occurring at longer, relatively irregular intervals (Griffiths et al. 1987). The speed of aircraft, ships etc. can be decisive to the extent of disturbance involved (Fay et al. 1984).

2) Aquatic disturbance: Turf (1982) makes the assumption that underwater noise from petroleum activities can disturb marine mammals. Noise from ships and other activities transmitted in water can possibly have a negative effect on reproduction:

— by being so loud as to drown the walrus's own sounds and thereby prevent the animals from locating each other, or
— by having the same frequency as important parts of the mating sounds and thereby diverting the walrus from the ritual and preventing mating.
— Underwater noise can also be imagined to scare away walrus from important areas, such as is registered with the hooded seal (Fay *et al.* 1984).

B.

C2-IH2
Oil spills caused by traffic and installations will reduce the walrus population.

No studies are available on the effect of oil spills on walruses, and the hypothesis is accordingly based on studies of other species (see discussion under corresponding hypotheses for ringed seal and polar bear).

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.

If walruses, like other marine mammals (see Loughlin 1994) do not avoid oil spills, they may quite easily suffer if their habitats are affected by oil. Studies carried out on other mammals would indicate that short-term as well as long-term crude oil exposure can be harmful, in certain cases fatal (Griffiths *et al.* 1987, St. Aubin and Geraci 1994). For the walrus such exposure will possibly have a milder effect than it would upon thicker-coated species, where the oil would not wash or wear away so easily. Long-term exposure and severe contamination can however cause irritation and inflammations, which will involve increased blood supply to the skin, increased heat loss and energy expenditure, and reduced survival. Griffiths *et al.* (1987) also assumed that the volatile and most toxic components may diffuse into the blood stream and cause damage to the central nervous system. This did happen in several species during the Exxon Valdez oil spill (see Loughlin 1994). Direct uptake (eating) of oil can also, in accordance with experience with other species, result in damage to intestines, stomach, liver, kidneys and lungs, which may be fatal.

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.

3.2.4. Recommended research, monitoring and/or surveys

The following studies can be implemented in connection with NSR activities that may cause the effects discussed above. The studies have been listed in classified priorities (I - III).

I. (To be carried out in connection with both IHs):
Surveys of the incidence and of area use throughout the year in the NSR area.

Objective: To find number and sex/age groups of walrus that may be affected by a potential activity. Find possible resting, feeding or mating areas and times in which activities may disturb or damage walrus.

Method: Prior to, during and after the activity surveys should be implemented in late winter, spring, summer and fall by helicopter (aircraft), possibly using photography techniques.

II. (To be implemented in connection with both IHs):
Surveys of the migrations, distribution and population affiliation.

Objective: Surveying potential conflict areas throughout the year, to find delineation between populations.

Method: Telemetry in combination with estimates and detailed recordings in selected areas. A project along these lines has been performed in the Bering Sea area.

III. (To be implemented in connection with both IHs):
Detailed monitoring of local incidence.

Objective: Provide detailed data on behavior and area use throughout the year in walrus habitats that are important/relevant for future developments.

Method: Direct behavior observations combined with photographic techniques.

3.2.5. Literature cited

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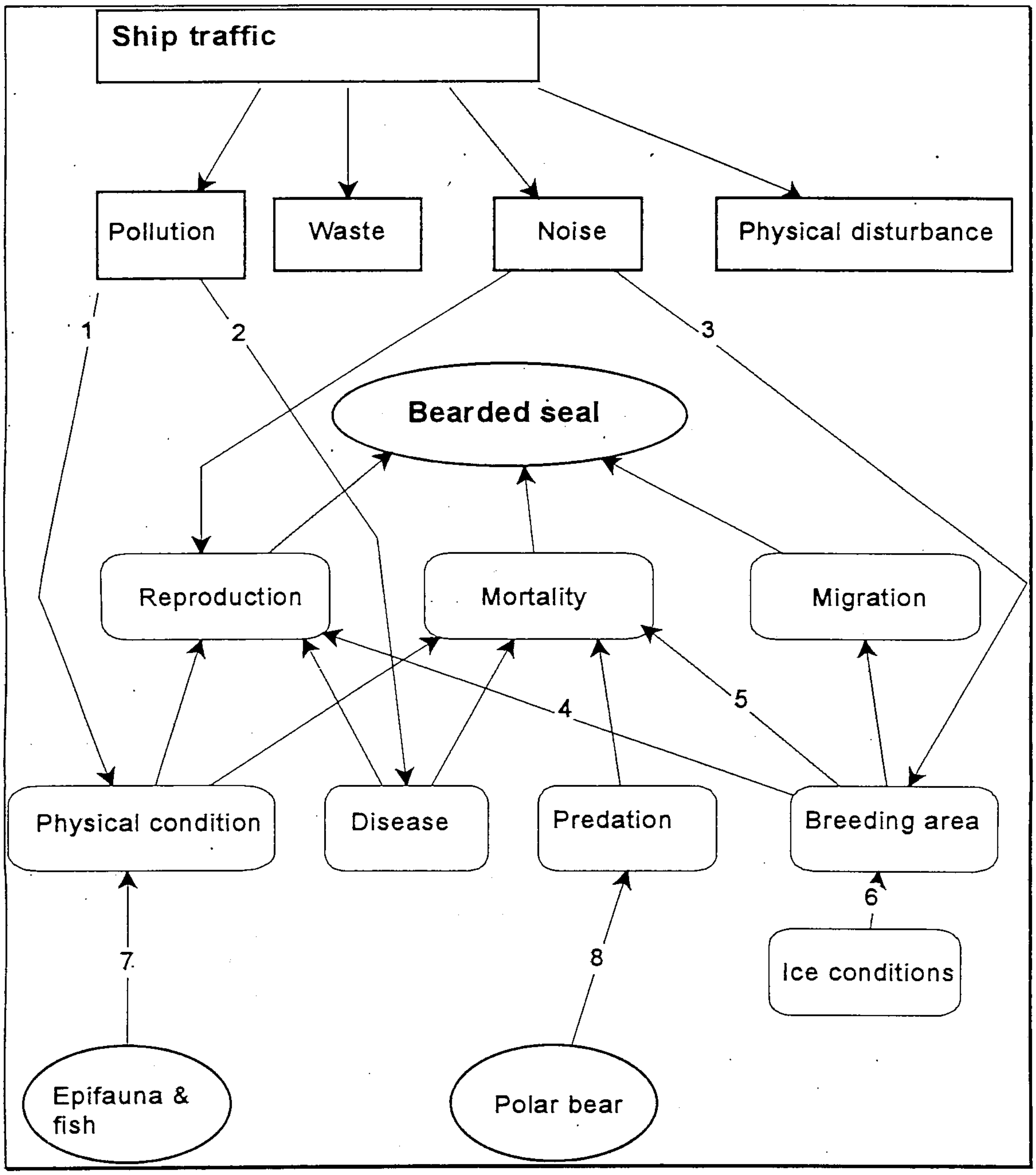
3.3. VEC C3: Bearded Seal
3.3.1. Flow chart



3.3.2. Linkages

1. Oil spills can reduce insulating property, cause skin irritations and hence increase metabolism, thereby impairing physical condition.
2. Pollution can result in poisoning and intestinal/stomach injuries.
3. Traffic can scare bearded seals away from breeding areas.
4. Disturbance of breeding areas will decrease reproduction.
5. Disturbance of breeding areas will increase pup mortality.
6. Ice conditions affect the suitability and location of breeding areas.
7. The bearded seal feeds upon marine biological resources, especially epifauna.
8. Polar bears prey upon pups and adult animals.

3.3.3. Impact hypotheses

Two hypotheses concerning the potential impact of NSR activities on the bearded seal population were evaluated. One hypothesis (C3-IH1) was considered to be valid but very difficult to verify or test. The other hypothesis (C3-IH2) was considered to be valid and important to study with surveys, research and monitoring. The impact hypotheses have been listed in classified priorities (A-B).

A.

C3-IH2
Oil spills in the sea will cause suffering and death for affected bearded seals and reduction in local ringed seal populations.

An oil spill in a typical bearded seal habitat will, particularly during the seasons when the areas are covered by ice, cause a situation about which very little is known. Almost all documented cases in which seals have been fouled by oil have taken place in temperate waters except for the Exxon Valdez (see papers in Loughlin 1994). In ice-covered waters oil spills will probably more or less be caught in/under the ice. Together with the low temperature the decomposition may be slower (Atlas *et al.* 1978), and the oil will retain volatile and more toxic components for a relatively long period (Griffiths *et al.* 1987). A bearded seal in an oil contaminated ice area will risk coming into contact with oil every time it enters or leaves the water. In the event of spills in the breeding period, the pup will also be fouled.

The bearded seal's fur consists of short wiry hairs with low insulating properties - the seal's insulation is primarily made up by a thick layer of subcutaneous fat. It has been demonstrated experimentally that the ringed seal does not actively avoid oil spills, and accordingly it will soon be fouled by oil (Geraci and Smith 1976). That was also the lesson learned at Valdez (St.Aubin and Geraci 1994). This is probably also the situation for bearded seals. van Haaften (1973) and Griffiths *et al.* (1987) assume that long-term contact with oil can cause inflammations of the seals' skin. From their experiment, Smith and Geraci (1975) concluded, however, that crude oil had no such effect. This conclusion is discussed by Griffiths *et al.* (1987), who claim that the experiment did <u>not</u> simulate natural conditions, as the seals here were exposed to a lighter grade of crude oil for only 24 hours. Inflammations in the skin resulting from oil spills have been described for a number of other seal species (van Haaften 1973, Muller-Willie 1974, Kooyman *et* al. 1976, Costa and Kooyman 1979), but a pathological study has not been undertaken.

This type of effect has also been observed in many other mammalian species. If crude oil exposure will cause such skin damage, these changes may in turn cause increased blood supply to the skin and increased energy loss and energy expenditure. The result may be impaired physical condition, which in turn will influence survival and reproduction. The effect of such heat stress on the seal's energy balance in water temperatures below 0°C has not been studied.

In ringed seals exposed to crude oils it has been demonstrated that hydrocarbons are speedily absorbed into body tissues and fluids (Engelhardt *et al.* 1977). The excretory pathways of the hydrocarbons were indicated by small but significant quantities of oil metabolites being found in tissue, blood and plasma, with particularly high concentrations in urine and gall. Three ringed seals that were experimentally exposed to oil spills in captivity at the University of Guelph (Smith and Geraci 1975) died between 21-71 minutes after exposure. The authors claim that stress in connection with capture was the main reason. Their description of the seals' behavior before dying, and results of blood investigations of the animals, have made Griffiths *et al.* (1988) conclude that the animals were not killed by stress, but rather by the effect on the central nervous system of the volatile components of the oil (acute poisoning).

Geraci and Smith (1976) found that feeding seals with crude oil (together with fish) did not result in serious poisoning. Duguy and Babin (1975, 1976) and Prieur and Duguy (1979) report, however, that grey seals (Halichoerus gryphus) and common seals can swallow oil in fatal quantities. Autopsies on stranded dead seals of these species revealed oil metabolites and damaged tissue in a number of organs. The most serious damage was caused to the microvilli of the small intestine, but damage to the liver, kidney and lungs was also indicated.

Frost *et al.* (1994a) concluded that it was likely that at least 302 harbor seals died as a result of the Exxon Valdez oil spill. Indications were also found that pup production and pup survival were decreased due to the spill. Lowry *et al.* (1994) found that shoreline treatment before the pupping season about one month after the spill did not prevent harbor seal pups from getting contaminated by oil. No external oiling of seals was seen the year after the spill. It was not clear from the study how oiled pelage and skin may have contributed to the overall damage to seals from the spill. Spraker *et al.* (1994) found that skin irritation, conjunctivitis, and liver lesions occurred more frequently in oiled seals than in those not oiled. In addition Frost *et al.* (1994b) found that harbor seals in the spill area were exposed to high concentrations to petroleum-related hydrocarbons. The implications of this for the health of the seals were, however, unknown.

One of the most important lessons from the studies in relation to the Exxon Valdez oil spill was that good baseline data are very important in order to evaluate the effects of oil spills on marine mammals (St.Aubin and Geraci 1994).

B.

C3-IH1
Disturbance (traffic, ice breaking) will result in a reduction of the local bearded seal populations.

Studies of the caustic and non-caustic effects of intensive ice breaker traffic do not seem to have been conducted (Dietz 1992). Nothing is known about the effects of noise from traffic on bearded seals. Kelly *et al.* (1988) conclude that short-term local disturbances causing ringed seals to leave their breeding lairs presumably have a slight negative effect, while long-term disturbances over larger areas may have unknown consequences and that disturbances of this kind will be most harmful in the breeding period in March and April.

Bearded seals are largely solitary animals which are usually widely dispersed and do not occur in large aggregations in any habitat. They are known to be highly vocal particularly during breeding season probably in order to attract females and exclude males from their territory (Stirling *et al.* 1983). Noise from ships could mask this and result in reduced mating success and pregnancy rates.

The shear zone is the preferred pupping habitat for bearded seals (Stirling *et al.* 1982). This zone will probably also be a preferred shipping zone during NSR activity. Such activity will probably lead to increased pup mortality particularly during the period of maximum vulnerability of seal pups.

The bearded seal is distributed over very large areas in the NSR area. It is doubtful if the effect on the total population of NSR activity would be significant. It is even more doubtful if the effect will be detectable.

3.3.4. Recommended research, monitoring and/or surveys

The following studies should be implemented in connection with the impacts discussed. The studies are listed in classified priorities (I-III).

I. (To be implemented in connection with C3-IH1 and C3-IH2):
Surveys of local bearded seal population with respect to seasonal variations in selected areas.

Objective: To provide basic data for the evaluation of potential impact of activity.

Method: Observations of the time budget on ice/in water, combined with transect/photographic surveys from aircraft/helicopters and registrations of breeding areas.

II. (To be implemented in connection with C3-IH2):
Experimental testing of the effect of oil spills on bearded seal skin.

Objective: To determine whether oil spills are harmful to the skin of the bearded seal. To examine behavioral and physiological reactions, effect mechanisms and extent of damage.

Method: Record behavior, skin temperature, possible inflammation reaction under corresponding natural conditions (air and water temperatures, ice, food supply etc.), dead seal autopsies.

3.3.5. Literature cited

Atlas, R.M., Horowitz, A. and Busdosh, M. 1978. Prudhoe crude oil in Arctic marine ice, water and sediment ecosystems: degradation and interactions with microbal and benthic communities. J. Fish. Res. Bd Can. 35: 585-590.

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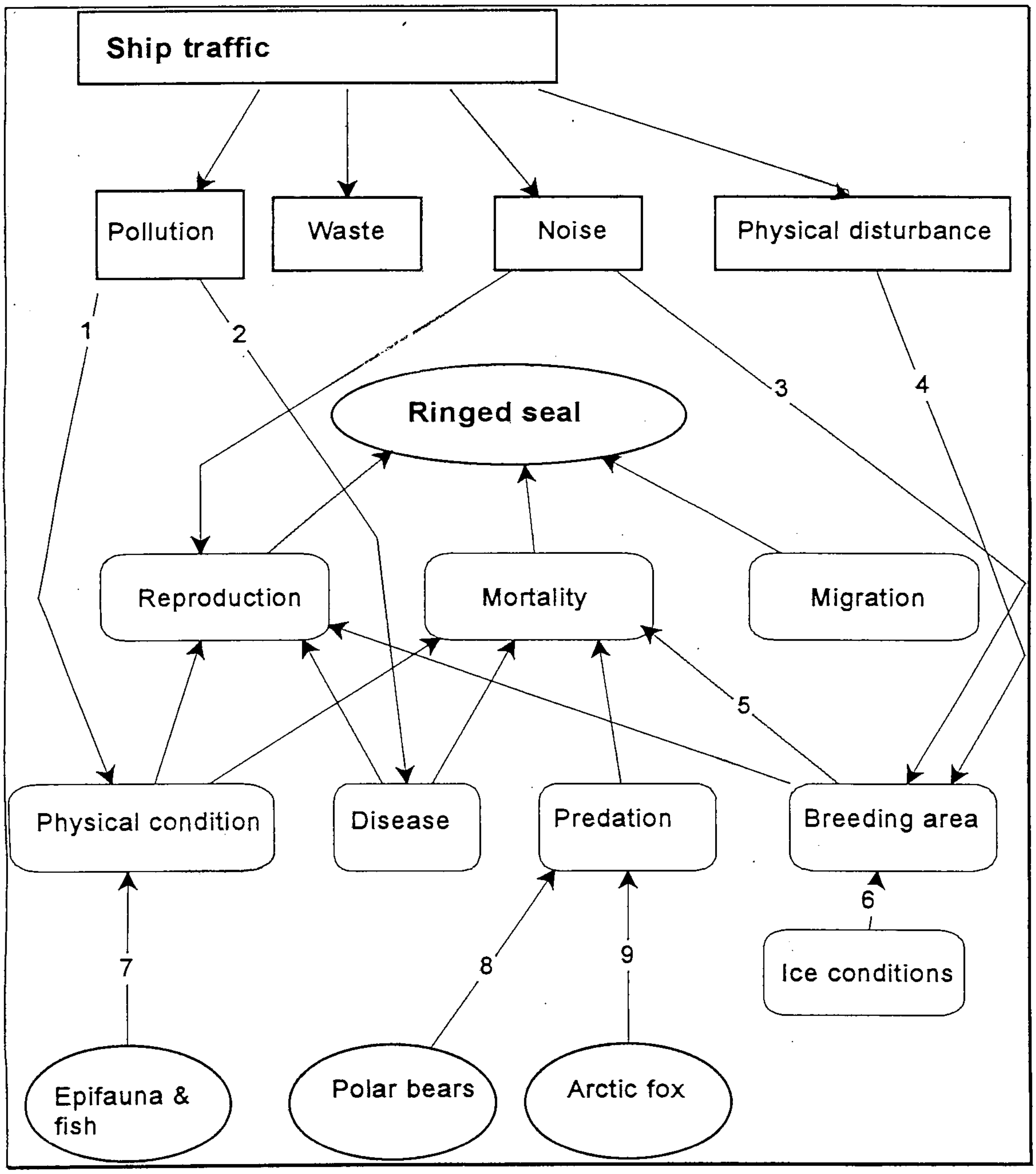
3.4. VEC C4: Ringed Seal

3.4.1. Flow chart



3.4.2. Linkages

1. Oil spills can reduce insulating property, cause skin irritations and hence increase metabolism, thereby impairing physical condition.
2. Pollution can result in poisoning and intestinal/stomach injuries.
3. Traffic can scare ringed seals away from breeding areas.
4. Traffic (ice breakers) can cause mortality by damaging breeding lairs and decrease reproduction.
5. The quality of breeding areas is important to pup mortality.
6. Ice conditions affect the suitability and location of breeding areas.
7. The ringed seal feeds upon marine biological resources, especially polar cod.
8. Polar bears prey upon pups and adult animals.
9. Arctic foxes prey upon pups.

3.4.3. Impact hypotheses

Three hypotheses concerning the potential impact of NSR activities on the ringed seal population were evaluated. One hypothesis (C4-IH3) was considered to be valid but very difficult to verify or test. The other hypotheses C4-IH1 and C4-IH2 were considered to be valid and important to study with surveys, research and monitoring. The impact hypotheses have been listed in classified priorities (A-B).

A.

C4-IH2 Oil spills in the sea will cause suffering and death for affected ringed seals and reduction in local ringed seal populations.

See discussion under C3-IH2.

B.

C4-IH1 Disturbance will cause a reduction in local ringed seal populations.

Some basic research has been carried out on the underwater hearing sensitivity of the ringed seal. Underwater audiogrammes in the area of 1-90 KHz have been made for two ringed seals (Terhune and Ronald 1975a and 1975b). These indicated a uniform sensitivity in the area of 1-45 KHz. Sensitivity to frequencies over 45 KHz showed a steep decrease with increasing frequency. The ringed seal's ability to distinguish between constant frequencies versus frequency modulated pulses has also been tested (Terhune and Ronald 1976), and the upper limit was found to be 60 KHz.

Kelly *et al.* (1988) have tested the reactions to various disturbances on radio-marked ringed seals in breeding lairs in the spring. They found that the seals went into the water in 73% of the cases when snow machines came within a distance of 3 km. Corresponding distances for the sound of humans on foot or on skis on the ice was 600 m and 300 m respectively. The seals also left their lairs when helicopters landed or took off at a distance of 3 km. Kelly *et al.* conclude that short-term local disturbances causing seals to leave their dens presumably have a slight negative effect, while long-term disturbances over larger areas may have unknown consequences and that disturbances of this kind will be most harmful in the breeding period in March and April.

C.

C4-IH3
Activity causing changes in local predator populations will affect the ringed seal population of the area.

Both in the Canadian Arctic and in Svalbard the arctic fox is an efficient predator of ringed seal pups in breeding lairs (Smith 1976, Lydersen and Gjertz 1986). The arctic fox represents a far greater threat for this age group of ringed seals than does the polar bear. In some of the fjords in Svalbard, particularly in years with little snow, some ringed seals will give birth directly onto the ice without having dug a protective den. The mortality rates for these pups are almost equal to 1, which is primarily due to fox predation.

According to the estimates of Smith (1976), a newborn ringed seal pup may cover the maintenance energy requirements of an average arctic fox for 30-45 days, while a pup soon to be weaned might cover the maintenance energy requirements of the same fox for 227-341 days. It should be mentioned in this context that, when leaving its mother, the ringed seal weighs around 25 kg. and a fox about 3-3.5 kg.

3.4.4. Recommended research, monitoring and/or surveys

The following studies should be implemented in connection with the impacts discussed. The studies are listed in classified priorities (I-III).

I. (To be implemented in connection with all IHs):
Surveys of local ringed seal population with respect to seasonal variations in selected areas.

Objective: To provide basic data for the evaluation of potential impact of development.

Method: Observations of the time budget on ice/in water, combined with transect/photographic surveys from aircraft/helicopters and registrations of breeding lairs.

II. (To be implemented in connection with C4-IH2):
Experimental testing of the effect of oil spills on ringed seal skin.

Objective: To determine whether oil spills are harmful to the skin of the ringed seal. To examine behavioral and physiological reactions, effect mechanisms and extent of damage.

Method: Record behavior, skin temperature, possible inflammation reaction under corresponding natural conditions (air and water temperatures, ice, food supply etc.), dead seal autopsies.

3.4.5. Literature cited

Atlas, R.M., Horowitz, A. and Busdosh, M. 1978. Prudhoe crude oil in Arctic marine ice, water and sediment ecosystems: degradation and interactions with microbal and benthic communities. J. Fish. Res. Bd Can. 35: 585-590.

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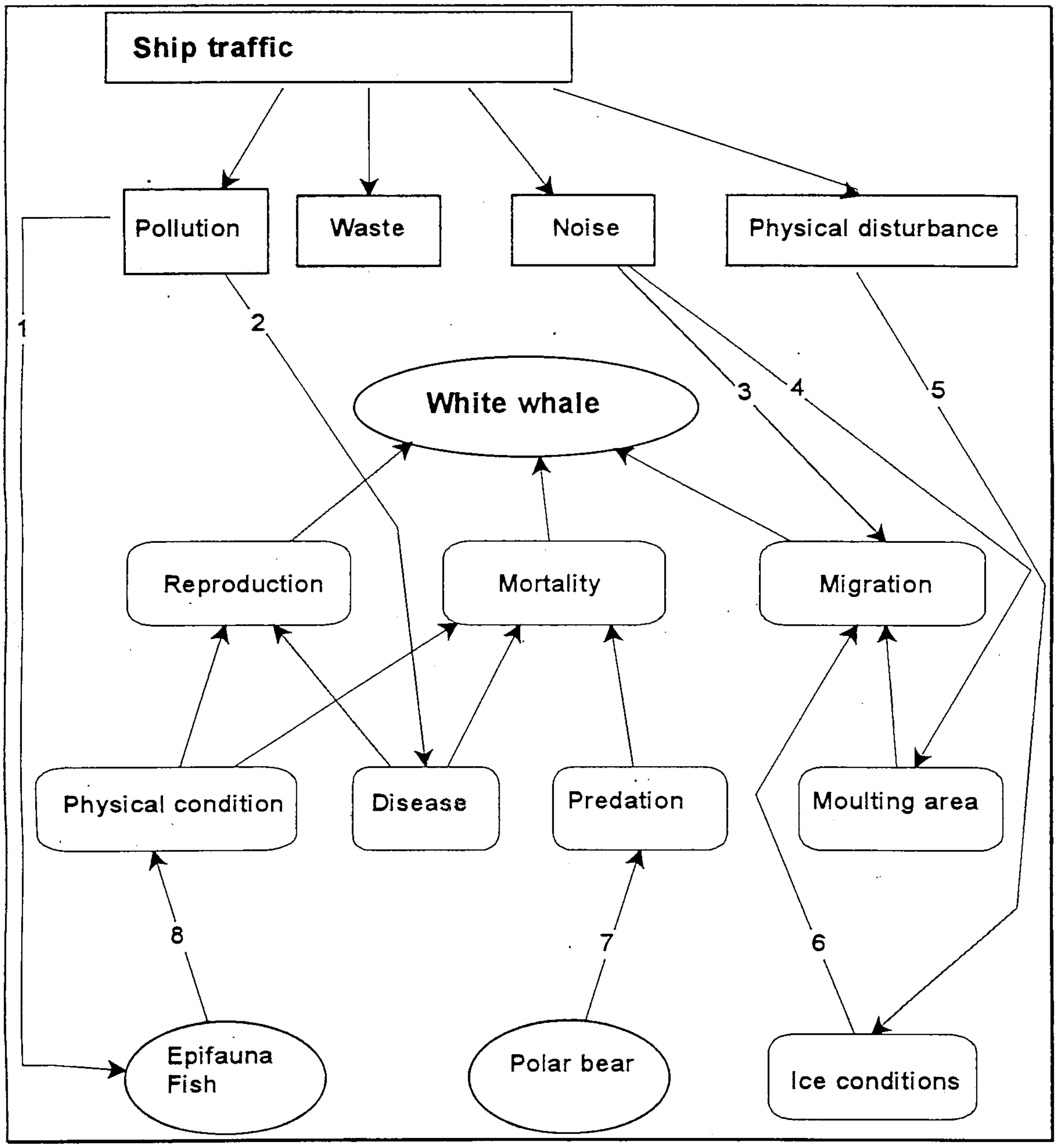
3.5. VEC 5: White whale
3.5.1. Flow chart



3.5.2. Linkages

1. Toxic substances can be accumulated in benthic fauna.
2. Ingestion of toxic substances can cause disease.
3. Disturbances can make the white whale avoid traditional habitats.
4. Disturbances can make the white whale avoid traditional molting sites in estuaries and rivers.
5. Ship traffic has an effect on the ice conditions.
6. Ice conditions affect migration.
7. Polar bears prey on white whales.
8. White whales prey on epifauna and fish.

3.5.3. Impact hypotheses

Two hypotheses (C5-IH1 and C5-IH2) concerning the potential impact of NSR activity on the white whales were evaluated. They were both considered to be valid and important to test with surveys, monitoring and research. The impact hypothesis have been listed in classified priorities (A-B).

A.

C5-IH1
Oil spills caused by traffic will reduce the white whale population.

The effect of oil on white whales has not been examined. The effects of oil on several other marine mammals can be severe. Because of physiological and behavioral 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 will be less harmful in cetaceans then for other marine mammals.

Caldwell and Caldwell (1982) fed dolphins on fish containing capsules with hydraulic oil. The dolphins accepted the contaminated prey. It is unknown whether white whales can detect contaminated prey. However, white whales seem to feed on fish that are wide-ranging and which probably thus would be less affected by oil spills.

There are no data concerning the effects of inhalation of petroleum vapor in cetaceans (Richardson et al. 1983). Geraci (1990) concluded, however, that for the short time they persist, vapors are one feature of an oil spill that can threaten the health of a cetacean.

After the Exxon Valdez oil spill 14 individually known killer whales were documented as missing. Although there was a temporal and spatial correlation between the missing whales and the oil spill, no clear cause-and-effect relationship could be documented (Dalheim and Matkin 1994). Similarly, von Ziegesar *et al.* (1994) could not document any effects of the oil spill on humpback whales. It was clear, however, that in no case did cetaceans alter their behavior when they came into an area with oil (Harvey and Dahlheim 1994).

Oiling in estuaries and at the ice edge might be especially risky for white whales due to their gregarious behavior.

B

C5-IH2
Disturbance (traffic, ice breaking) will result in a reduction in the local white whale populations.

Toothed whales show considerable tolerance to vessel traffic in some circumstances, but they sometimes react at considerable distances. The "behavior" of the sound source seems to determine whale response to some degree. White whales often approach within a few kilometers of drilling operations on artificial islands (Fraker 1979). The reaction of white whales to vessels has been observed in more detail and has shown that the animals can be habituated to such disturbance (Fraker 1983). White whales along the ice edge have been noted to move away from an icebreaker 40 km away and did not resume their original distribution for several days (Finley *et al.* 1983). Ship noise was first detected when the vessel was 105 km away. The white whales began to emit "alarm" calls at that time. The animals returned to the ice edge and resumed normal activity about 48 hours after the ship had passed. Disturbance of whales in the Chukchi Sea may be of particular concern because their options to avoiding the sources are restricted (Hazard 1988). White whales in leads seem to be especially sensitive to introduced sound (Fraker and Fraker 1982).

There is no clear evidence that white whales have abandoned significant parts of their range as a result of vessel traffic (Dietz 1992). The effects of displacement are unknown. It must be assumed, however, that places where whales have gathered for centuries are "best" and that displacement means movement to less suitable areas. Increased stress might in turn result in greater sensitivity to food shortages, cold or diseases. Such changes could result in long-term changes in productivity, survival, and abundance (Seaman *et al.* 1985).

3.5.4. Recommended research, monitoring and/or surveys
The following studies should be implemented in connection with the impacts discussed. The studies are listed in classified priorities (I-II).

I. (To be implemented in connection with C5-IH1 and C5-IH2):
Surveys of local populations with respect to seasonal variation in selected areas.

Objective: To provide basic data for the evaluation of potential impact of development.

Method: Evaluation of earlier collected data. Aerial surveys in selected areas.

II. (To be implemented in connection with C5-IH1 and C5-IH2):
Surveys of the migration of white whales, distribution and population affiliation.

Objective: To survey potential conflict areas throughout the year.

Method: Telemetry in combination with estimates and detailed recording in selected areas.

III. (To be implemented in connection with C5-IH1):
Effects of oil pollution on white whales.

Objective: In case of an oil spill, investigate possible effect on individual whales.

Method: Necropsy of fouled individuals.

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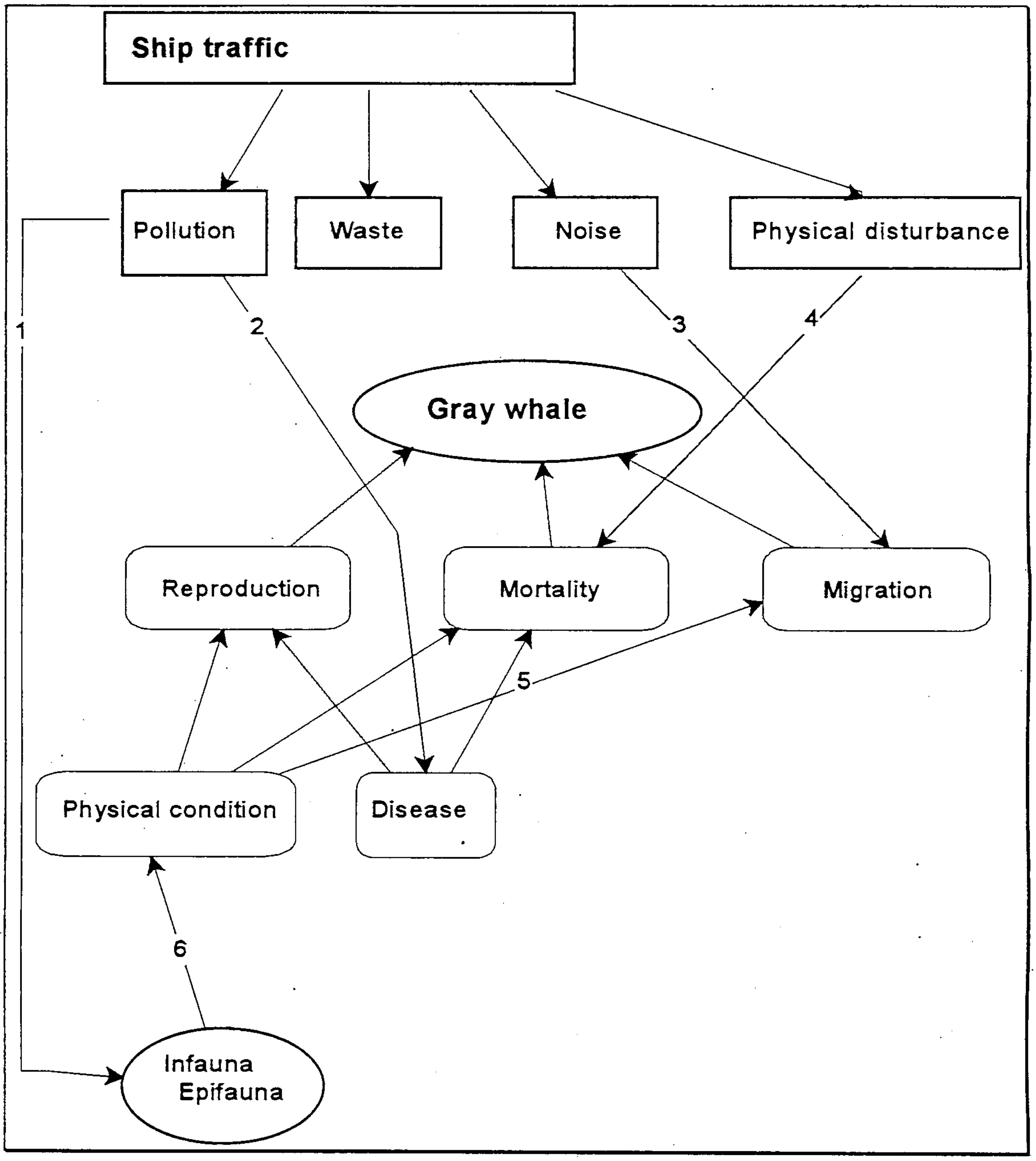
3.6. VEC 6: Gray whale
3.6.1. Flow chart



3.6.2. Linkages

1. Toxic substances can be accumulated in benthic fauna.
2. Ingestion of toxic substances can cause disease.
3. Disturbances can make the Gray whale avoid traditional habitats.
4. Increased ship traffic will increase the number of collisions between ships and Gray whales and increase the mortality.
5. Impaired physical condition resulting from poor food availability can affect migrations.
6. Gray whales prey upon infauna and epifauna.

3.6.3. Impact hypotheses

Two hypotheses (C5-IH1 and C5-IH2) concerning the potential impact of NSR activity on the Gray whales were evaluated. They were both assumed to be valid and important to test with surveys, monitoring and research. The impact hypotheses have been listed in classified priorities (A-B).

A.

C6-IH2
Disturbance (traffic, ice breaking) will result in a reduction in the Gray whale populations

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 and Swartz 1984, 1986). 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 and Guess 1979). According to Bogolovskaya *et al.* (1981) Gray whales off Chukotka reacted to ships at a distance of about 350-550 meters.

B.

C6-IH1
Oil spills caused by traffic will reduce the Gray whale population.

The effect of oil on Gray whales has not been examined. Geraci (1990) concluded that bottlenosed dolphins were able to detect and avoid oil on the sea and that contact with oil will be less harmful in cetaceans then for other marine mammals. If Gray whales will detect and avoid oil on the sea is not known. Geraci (1990) assumed that baleen whales would have to ingest enormous amounts of oil during a spill in order for mortality to occur, sublethal effects are also not likely. The effect of oil exposure through the food chain is not known.

There are no data concerning the effects of inhalation of petroleum vapor in cetaceans (Richardson *et al.* 1983). Geraci (1990) concluded, however, that for the short time they persist, vapors are one feature of an oil spill that can threaten the health of a cetacean.

It is therefore believed that an oil spill will have minor influence on the populations in relation to the effects of noise.

3.6.4. Recommended research, monitoring and/or surveys
The following studies should be implemented in connection with the impacts discussed. The studies are listed in classified priorities (I-II).

I. (To be implemented in connection with C6-IH1 and C6-IH2):
Surveys of the population with respect to seasonal variation.

Objective: To provide basic data for the evaluation of potential impact of development.

Method: Aerial and acoustic surveys.

II. (To be implemented in connection with C6-IH2):
Surveys of the reaction of individual whales to disturbance.

Objective: To provide basic data for the evaluation of potential impact of ship traffic on behavior.

Method: Observation, telemetry and photo-identification.

III. (To be implemented in connection with C5-IH1):
Effects of oil pollution on bowhead whales.

Objective: In case of an oil spill, investigate possible effect on individual whales.

Method: Observation of behavior and necropsy of fouled individuals.

3.6.5. Literature cited
Bogoslovskaya, L. S., Votrogov, L. M., and Semenova, T. N. 1981. Feeding habits of the gray whale off Chukotka. Rep. Int. Whal. Comm. 31:507-510.
Cowles, C. J., Hansen, D. J. and Hubbard, J. D. 1981. Types of potential effects of offshore oil and gas development om marine mammals and endangered species of the northern Bering, Chukchi, and Beaufort Seas. Tech. Pap. No. 9, Alaska Outer Cont. Shelf Office, U.S. Bureau of Land Management, Anchorage.
Dohl, T. P. and Guess, R. 1979. Evidence for increasing offshore migration of the California gray whale Eschrichtius robustus in soutehrn California, 1975 through 1978. Abstr. 3rd. Bien. Conf. Biol. Mar. Mammals, 7-11 Oct 1979, Seattle.

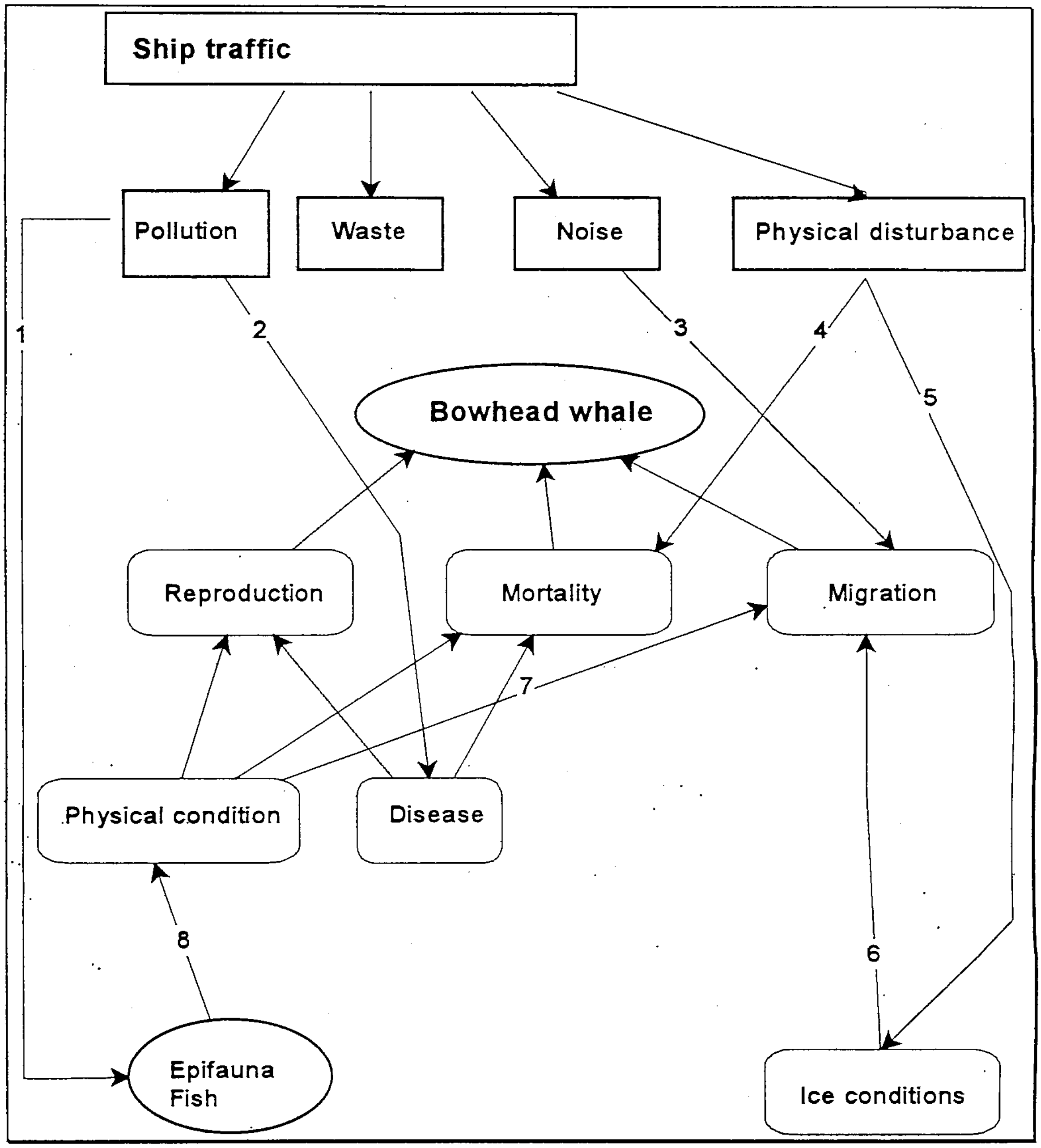
Geraci, J. R: 1990.Physiologic and toxic effects on Cetaceans. Pp. 167-197 In: Geraci, J. R. and St.Aubin, D. J. 1990. Sea mammals and oil: Confronting the risks. Academic Press Inc., New York.

Jones, M. L. and Swartz, S. L. 1984. Demography and phenology of gray whales and evaluation of whale-watching activities in Lagone San Ignacio, Baja California Sur, Mexico. Pp. 309-374 In: Jones, M. L. *et al.* (Eds.). The gray whale Eschrichtius robustus. Academic Press, Orlando.

Reeves, R. R. 1977. The problem of gray whale (Eschrichtius robustus) harassment: at the breeding lagoons and during migration. U.S. marine mammal Comm. Rep. MMC-76/06.

Richardson, W. J., and Green, C. R., Hickie, J. P. and Davis, R. A. 1983. Effects of offshore petroleum operations on cold water marine mammals: a literature review. American Petroleum Institute, Washington.

3.7. VEC 7: Bowhead whale
3.7.1. Flow chart



3.7.2. Linkages

1. Toxic substances can be accumulated in benthic fauna.
2. Ingestion of toxic substances directly or via food can cause diseases.
3. Disturbances can make the bowhead whale avoid traditional habitats.
4. Increased ship traffic will increase the number of collisions between ships and whales and increase the mortality.
5. Ship traffic has an effect on the ice conditions.
6. Ice conditions affect the migration.
7. Impaired physical condition resulting from poor food availability can affect migrations.
8. Gray whales prey upon infauna and epifauna.

3.7.3. Impact hypotheses

Two hypotheses (C7-IH1 and C7-IH2) concerning the potential impact of NSR activity on the bowhead whales were evaluated. They were both assumed to be valid and important to test with surveys, monitoring and research. The impact hypotheses have been listed in classified priorities (A-B).

A.

C7-IH2
Disturbance (traffic, ice breaking) will result in a reduction in the bowhead whale population.

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 behavioral responses have been documented although possible physiological responses and long term avoidance and population level effects have been hypothesized. 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 behavior 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 whals is unknown.

B.

C7-IH1
Oil spills caused by traffic will reduce the bowhead whale population.

The effect of oil on bowhead whales has not been examined. Geraci (1990) concluded that bottlenosed dolphins were able to detect and avoid oil on the sea and that contact with oil will be less harmful in cetaceans then for other marine mammals. WhetherIf bowheads will detect and avoid oil on the sea is not known. Geraci (1990) assumed that baleen whales would have to ingest enormous amounts of oil during a spill in order for mortality to occur sublethal effects are also not likely. The effect of oil exposure through the food chain is not known.

There are no data concerning the effects of inhalation of petroleum vapor in cetaceans (Richardson *et al.* 1983). Geraci (1990) concluded, however, that for the short time they persist, vapors are one feature of an oil spill that can threaten the health of a cetacean.

3.7.4. Recommended research, monitoring and/or surveys

The following studies should be implemented in connection with the impacts discussed. The studies are listed in classified priorities (I-II).

I. (To be implemented in connection with C7-IH1 and C7-IH2):
Surveys of the population with respect to seasonal variation.

Objective: To provide basic data for the evaluation of potential impact of development.

Method: Aerial and acoustic surveys.

II. (To be implemented in connection with C7-IH2):
Surveys of the reaction of individual whales to disturbance.

Objective: To provide basic data for the evaluation of potential impact of ship traffic on behavior.

Method: Observation, telemetry and photoidentification.

III. (To be implemented in connection with C5-IH1):
Effects of oil pollution on bowhead whales.

Objective: In case of an oil spill, investigate possible effect on individual whales.

Method: Observation of behavior and necropsy of fouled individuals.

3.7.5. Literature cited

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

Geraci, J. R. 1990.Physiologic and toxic effects on Cetaceans. Pp. 167-197 In: Geraci, J. R. and St.Aubin, D. J. 1990. Sea mammals and oil: Confronting the risks. Academic Press Inc., New York.

Philo, L. M., Shotts, E. B., and George, J. C. 1993. Morbidity and mortality. Pp. 275-312. In Burns, J. J., Montague, J. J. and Cowles, C. J. (Eds). The bowhead whale. Spec. Publ. No 2. The Society of Marine Mammalogy, Lawrence.

Richardson, W. J., and Green, C. R., Hickie, J. P. and Davis, R. A. 1983. Effects of offshore petroleum operations on cold water marine mammals: a literature review. American Petroleum Institute, Washington.

Richardson, W. S. and Malme C. I. 1993. Man-made noise and behavioral responses. Pp. 631-700 In Burns, J. J., Montague, J. J. and Cowles, C. J. (Eds). The bowhead whale. Spec. Publ. No 2. The Society of Marine Mammalogy, Lawrence.

3.8 VEC C1-C7: All marine mammals

3.8.1. Impact hypotheses

The accumulation of pollution from NSR activity in ice, water and the marine food chain is a problem related to most of the VECs described under this subprogram and could affect all marine mammal VECs. One impact hypothesis has been formulated which is assumed to be valid.

C1-C7-IH1
Pollution to ice and water can be accumulated through the marine food chain and reach such high concentrations in marine mammals as to have a toxic effect.

We know from the Norwegian coast that ship traffic will give at least some chronic pollution to the sea. There is at present a deficiency in the knowledge of whether chronic oil pollution in the sea actually results in an increased tissue level of oil in the animal species in the sea (Griffiths *et al.* 1987). It is further unknown if petroleum accumulates in tissues of top-predators. The lack of knowledge of long-term effects of oil on marine mammals is one of the most serious deficiencies in this field. The effect of a larger oil spill in this respect is also unknown. Surveys of tissue level of petroleum in marine mammals and their prey species in the NSR area is recommended. This will provide information concerning behavior of petroleum in the tissue of marine mammals after the activity has been established. This problem is also focused by the other project in INSROP Sub-program II: Environmental Factors (Larsen et al 1995, Bakken et al 1995).

3.8.2. Recommended research, monitoring and/or surveys

I. (To be implemented in connection with C1-C7-IH1).
Effect of oil in the marine food chain of the NSR area.

Objective: Document the amount of oil in the marine food chain before the NSR activity has started, and document the effect of the activity as it develops.

Method: Sampling tissue of different marine organisms for laboratory analyses.

3.8.3. Literature cited

Bakken, V.,

Griffiths, D., Øritsland, N.A. and Øritsland T. 1987. Marine mammals and petroleum activities in Norwegian waters. Fisken Hav. Serie B, no. 1, 179 pp.

Larsen, L. H., Evenset, A. and Sirenko, B. 1995. Linkages and impact hypotheses concerning Valued Ecosystem Components (VECs) Invertebrates, Fish, the Coastal Zone and Large Rivers Estuaries and Deltas. INSROP Working Paper No. 12.

4. VALUATED IMPACT HYPOTHESES

This section of the report contains a summary of all IHs that have been evaluated in the assessment system. Each IH has been listed in a separate form with a brief explanation of the hypothesis, a rationale for the evaluation of the hypothesis, the category in which it is placed and some key words concerning measures and studies relevant to carry out in the event of the impact referred to. The hypotheses are numbered consecutively from VEC 1. They have been included in this manner to clarify which potential impacts have been evaluated in the assessment system and which evaluations have been taken as a basis for the selection of hypotheses. And, finally, all relevant hypotheses shall be available at later revisions of the assessment system. The IHs have been placed in one of 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. Management measures to reduce environmental damage 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. Monitoring, surveys, research and/or management measures can be recommended.

VEC C1: POLAR BEAR	**C1-IH1**
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.	
Explanation: 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).	
Category: B	
Rational: Degree of harm and pathogenesis have been examined and need no further elaboration.	
Recommended research:	
Recommended monitoring or/and surveys: 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.	
Recommended management action: General measures against routine leaks and oil spills. Contingency plan to deter polar bears away from approaching less extensive oil spills. Contingency plan for capturing and cleaning of fouled bears where feasible, otherwise for destruction.	
Recommended mitigation measures:	
Literature cited: Stirling, I. 1990. Polar bears and oil: Ecological perspectives. Pp 223-234 In: Geraci, J. R. and St.Aubin, J. Sea mammals and oil: confronting the risks. Acad. Press, New York.	

VEC C1: POLAR BEARS	C1-IH 2
Hypothesis: Waste from installations and traffic will cause a local increase in the polar bear population.	
Explanation: Traffic and industrial activity can result in production of edible waste that, if made accessible, may increase the area's carrying capacity for polar bears.	
Category: B	
Rationale: This situation is known and well documented for populations of polar bears as well as for other bear species with access to waste (Lunn and Stirling 1985). The effect can be eliminated by preventing access to waste.	
Recommended management actions: A waste handling system must be developed in the NSR area.	
Recommended monitoring and/or surveys: None.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Lunn, N. J. and Stirling, I. 1985. The ecological significance of supplemental food to polar bears during the ice-free period of western Hudson Bay. Can. J. Zool. 63: 2291-2297.	

VEC C1: POLAR BEAR **C1-IH 3**

Hypothesis: Reduced seal occurrence resulting from disturbance and pollution from activity will cause a decrease in the polar bear population in the area.

Explanation: Polar bears live on seals and will, within their habitats, visit areas where seals are abundant. If seals are displaced from their traditional habitats, the occurrence of polar bears in the affected areas must be expected to decrease. Should the displacement of seals result in a reduction in seal carrying capacity, polar bear carrying capacity will be correspondingly reduced.

Category: D

Rationale: Access to seals may be a delimiting factor, which implies that some local seal occurrences may be of relatively great importance. If such occurrences are reduced or eliminated, the local, and possibly also the total, polar bear carrying capacity can be reduced (Stirling and Smith 1975). However, such potential effects will be very difficult to prove.

Recommended management actions: See VECs Bearded seal and Ringed seal.

Recommended monitoring and/or surveys: A standard procedure should be prepared for the recording of polar bears in the affected area while the activity is in progress. See also recommendations concerning hypothesis on ringed seal disturbance.

Recommended research: None.

Recommended mitigating measures:

Literature cited: Stirling, I and Smith, T. 1975. Interrelationships of Arctic Ocean mammals in the sea ice habitat. Proc. Circumpolar Conf. North. Ecol. (Ottawa, Canada) 2: 129-136.

VEC C1: POLAR BEAR	C1-IH 4
Impact hypothesis: Traffic in or near denning areas will cause reduced reproduction in the polar bear population.	
Explanation: 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.	
Category: C	
Rationale: 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 and 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.	
Recommended management action: Traffic in the denning areas should be minimized throughout fall, winter and spring.	
Recommended monitoring or/and surveys: In connection with activity in and near denning areas: Recording of dens and production in the affected area should be monitored. Studies of female behavior and of choice of denning areas in the fall by means of telemetry and observations and den surveys in areas relevant for activity should be performed.	
Recommended research: Ethological and physiological study of the effect of disturbance on free-ranging polar bears. The implementation of such studies will require large sample size and high costs.	
Recommended mitigating measures:	
Literature cited: Amstrup, A. C. 1994. Human disturbances of denning polar bears in Alaska. Arctic 46: 246-250 Blix, A S and Lentfer, J. W. 1992. Noise and vibration levels in artificial polar bear dens as related to selected petroleum exploration and development activities. Arctic 45: 20-24.	

VEC C1: POLAR BEAR	**C1-IH 5**
Hypothesis: Disturbance and obstacles caused by ship traffic in polar bear migration and feeding areas will result in a reduced population.	
Explanation: Traditional migration and feeding areas may be shorter and easier to negotiate than alternative routes. The routes may be narrow, owing to terrain and ice conditions. Many bears find active installations and human activity frightening and will keep at a distance from them. Such installations/activities located in traditional migration routes may cause polar bears to take longer/more energy intensive and risky routes. Stirling (1988) found, however, that many bears were attracted to human installations in the ice because of their curious nature and because open water made by installations in the ice make seals more abundant and/or more accessible.	
Category: C	
Rationale: The NSR activity will go through migration and feeding areas for polar bears.	
Recommended management action: Installations, activity and traffic should be kept away from the migration areas.	
Recommended monitoring and/or surveys: Study of the migratory pattern of the population throughout the year by means of satellite telemetry. Study extending over several years. Such studies are taking place in parts of the area.	
Recommended research: Effect of disturbance on free-ranging polar bears.	
Literature cited: Stirling, I. 1988. Attraction of polar bears Ursus maritimus to off-shore drilling sites in the eastern Beaufort Sea. Polar Rec. 24: 1-8.	

VEC C1: POLAR BEAR	**C1-IH 6**
Hypothesis: Activity in the ice creating artificial leads will cause a local increase in polar bear prey and accordingly a local increase in the occurrence of polar bears.	
Explanation: Polynyas, or naturally permanent leads in the ice, can form biological "oases" in which reproduction is higher and the fauna is richer than in areas entirely covered with ice. Such areas are also known to have a high density of polar bears. Leads artificially produced by ships may create the same effect (Stirling 1988).	
Category: D	
Rationale: Polynyas, and the rich production found in some of them, are largely created by currents. Artificial leads may lack this factor and may therefore become less productive than polynyas. Traffic may also cause animals to avoid such areas.	
Recommended management actions: None.	
Recommended monitoring and/or surveys: Surveys of ice conditions and occurrence of polar bears in the relevant area before and during the activity.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Stirling, I. 1988. Attraction of polar bears Ursus maritimus to off-shore drilling sites in the eastern Beaufort Sea. Polar Rec. 24: 1-8.	

VEC C2: WALRUS	C2-IH 1
Hypothesis: Disturbances resulting from traffic and installations will reduce the walrus population.	
Explanation: 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.	
Category: C	
Rationale: 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.	
Recommended management actions: Regulation of activity in walrus habitats should take place 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.	
Recommended monitoring and/or surveys: Monitoring of local populations with respect to population size, sex and age composition and behavior. Surveys of occurrence and use of haul-out sites. Counts of possible local populations and studies of their seasonal distribution. Studies of the migrations and distribution of walruses.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Fay, F.H., Kelly, B.P., Gehnrich, P.H., Sease, J.L. and Hoover, A. 1984. Modern populations, Migrations, Demography, Trophics, and historical status of the Pacific walrus. Institute of Marine Science, University of Alaska, Fairbanks, Alaska 99701, 142pp.	

VEC C2: WALRUS	**C2-IH 2**
Hypothesis: Oil spills caused by traffic will reduce the walrus population.	
Explanation: Oil spills in haul-out sites and in open waters may cause the walrus to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Inhalation of vapor and ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction and survival.	
Category: C	
Rationale: 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 behavioral 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.	
Recommended management actions: Oil spill alert contingency plans should be initiated near walrus habitats. Protection zones should be established around haul-out sites and feeding areas to protect the walrus from routine oil spills.	
Recommended monitoring and/or surveys: Monitoring of walrus habitats and fouled individuals in the event of oil spills. Surveys of the walrus's seasonal habitats.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Griffiths, D.J., Øritland, N.A. and Øritsland, T. 1987: Marine mammals and petroleum activities in Norwegian waters. Fisken Hav. Serie B. no.1, 179 pp. Loughlin, T. R. 1994. Marine mammals and the Exxon Valdez. Accademic Press, San Diego.	

VEC C3: BEARDED SEAL	C3-IH 1
Hypothesis: Disturbance (traffic, ice breaking) will result in a reduction in the local bearded seal populations.	
Explanation: Increased traffic will lead to increased disturbance which can cause a reduction in local bearded seal populations. Disturbances can cause increased activity and energy expenditure in seals. Icebreaker traffic in breeding areas can cause an increase in cub mortality and reduced mating success (Kelly *et al.* 1988).	
Category: D	
Rationale: The hypothesis is assumed to be valid concerning ice breaking. The effects on the bearded seal population is assumed to be minor and very difficult to test.	
Recommended management actions: Traffic and other activities should be subjected to time and area control in bearded seal breeding areas.	
Recommended monitoring and/or surveys: Monitoring of the bearded seal population in areas with activity. Surveys of the size and distribution of the bearded seal population with particular emphasis on the localization of breeding areas.	
Recommended research:	
Recommended mitigating measures:	
Literature cited: Kelly, B.P., Burns, J.J. and Quakenbush, L.T. 1988. The significance of noise disturbance to ringed seals. Manus to POAC-87. Ninth international conference on port and ocean engineering under arctic conditions. 16-21 August 1987, University of Alaska, Fairbanks, Alaska USA.	

VEC C3: BEARDED SEAL	C3-IH2
Hypothesis: Oil spills in the sea will cause suffering and death for affected bearded seals and reduction in local bearded seal populations.	
Explanation: Physical contact with oil can cause increased heat loss and accordingly increased energy expenditure and food requirements. Inhalation of vapor and ingestion can cause poisoning. Mortality may accordingly increase and reproduction may be reduced in populations exposed to oil spills (Loughlin 1994).	
Category: C	
Rationale: It is likely, judging from experience with other species, that seals coming into contact with oil will be injured. In the event of a major oil spill, local bearded seal populations are likely to become affected.	
Recommended management actions: General measures concerning discharge constraints. Strict requirements concerning oil spill contingency plans. Activity in the breeding areas and during the breeding period should be subjected to restrictions.	
Recommended monitoring and/or surveys: In case of an oil spill situation: Continuous monitoring, recording of the number of seals fouled by oil. Surveys of number, distribution throughout the year and of breeding areas that may become affected by oil spills.	
Recommended research: Possible effects on skin after exposure to oil. Measuring of heat loss from the skin. With oil spills: Autopsies of dead animals collected. Toxic effects of oral oil intake.	
Recommended mitigating measures:	
Literature cited: Loughlin, T. R. 1994. Marine mammals and the Exxon Valdez. Academic Press. London.	

VEC C4: RINGED SEAL **C4-IH1**
Hypothesis: Disturbance (traffic, ice breaking) will result in a reduction in the local ringed seal populations.
Explanation: Increased traffic will lead to increased disturbance which can cause a reduction in local ringed seal populations. Disturbances can cause increased activity and energy expenditure in seals. Icebreaker traffic in breeding areas can cause an increase in cub mortality by the destruction of birth lairs and reduced mating success (Kelly *et al.* 1988).
Category: C
Rationale: The hypothesis is assumed to be valid concerning increased traffic, but more information/documentation is required for the preparation of monitoring and research programs. The effects on ringed seals should be investigated.
Recommended management actions: Traffic and other activities should be subjected to time and area control in ringed seal breeding and molting areas.
Recommended monitoring and/or surveys: Monitoring of the ringed seal population in areas with activity. Surveys of the size and distribution of the ringed seal population with particular emphasis on the localization of breeding and molting areas.
Recommended research:
Recommended mitigating measures:
Literature cited: Kelly, B.P., Burns, J.J. and Quakenbush, L.T. 1988. The significance of noise disturbance to ringed seals. Manus to POAC-87. Ninth international conference on port and ocean engineering under arctic conditions. 16-21 August 1987, University of Alaska, Fairbanks, Alaska USA.

VEC C4: RINGED SEAL	C4-IH2
Hypothesis: Oil spills in the sea will cause suffering and death for affected ringed seals and reduction in local ringed seal populations.	
Explanation: Physical contact with oil can cause increased heat loss and accordingly increased energy expenditure and food requirements. Inhalation of vapor and ingestion can cause poisoning. Mortality may accordingly increase and reproduction may be reduced in populations exposed to oil spills.	
Category: C	
Rationale: It is likely, judging from experience with other species, that seals coming into contact with oil will be injured. In the event of a major oil spill, local ringed seal populations are likely to become seriously affected (Loughlin 1994).	
Recommended management actions: General measures concerning discharge constraints. Strict requirements concerning oil spill contingency plans. Activity in the breeding areas and during the breeding period should be subjected to restrictions.	
Recommended monitoring and/or surveys: In case of an oil spill situation: Continuous monitoring, recording of the number of seals fouled by oil. Surveys of number, distribution throughout the year and of breeding areas that may become affected by oil spills.	
Recommended research: Possible effects on skin after exposure to oil. Measuring of heat loss from the skin. With oil spills: Autopsies of dead animals collected. Toxic effects of oral oil intake.	
Recommended mitigating measures:	
Literature cited: Loughlin, T. R. 1994. Marine mammals and the Exxon Valdez. Academic Press. London.	

VEC C4: RINGED SEAL	C4-IH3
Hypothesis: Activity causing changes in local predator populations will affect the ringed seal population of the area.	
Explanation: Polar bears, and to some extent arctic foxes, are ringed seal predators. An increase in these populations, e.g. as a result of increased dumping of (edible) waste from industrial activity can cause increased mortality and reduce ringed seal reproduction.	
Category: D	
Rationale: Increased food access due to waste dumping may cause a sharp increase in the arctic fox population. This may have a negative effect on the local ringed seal population, as the fox is one of the main predators of ringed seal pups. The hypothesis is therefore considered to be valid. An increase in the polar bear population due to human activity is considered to be less likely.	
Recommended management actions: See under polar bear.	
Recommended monitoring and/or surveys: Monitoring of the arctic fox population. Monitoring of local ringed seal populations. Surveys of local ringed seal population and breeding areas in areas of potential interest to developers.	
Recommended research: Study of fox predation pressure in ringed seal breeding areas as a function of fox number.	
Recommended mitigating measures:	
Literature cited: Richardson, W. J., Greene, C. R., Malme, C. I., and Thomson, D. H 1995. marine mammals and noise. Academic Press, London.	

VEC C5: WHITE WHALE	C5-IH1
Hypothesis: Oil spills caused by traffic will reduce the white whale population.	
Explanation: Oil spills in open water may cause white whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction capacity.	
Category: C	
Rationale: 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 behavioral 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 behavior. The effect on oil exposure through the food chain is not known.	
Recommended management actions: Oil spill alert contingency plans should be initiated in estuaries where white whales occur.	
Recommended monitoring and/or surveys: Monitoring of habitats and fouled individuals in the event of oil spills. Surveys of the seasonal habitats of white whales and oil exposure of the food chain.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Geraci, J. R: 1990. Physiologic and toxic effects on Cetaceans. Pp. 167-197 In: Geraci, J. R. and St.Aubin, D. J. 1990. Sea mammals and oil: Confronting the risks. Academic Press Inc., New York.	

VEC C5: WHITE WHALES	C5-IH2
Hypothesis: Disturbance (traffic,_ ice breaking) will result in a reduction in the local white whale populations.	
Explanation: Increased traffic will lead to increased disturbance which can cause a reduction in local white whale populations. Disturbances can cause increased activity and energy expenditure (Seaman *et al.* 1985). Icebreaker traffic in breeding and summering areas can cause an increased mortality.	
Category: C	
Rationale: The hypothesis is assumed to be valid concerning increased traffic, but more information/documentation is required for the preparation of monitoring and research programs.	
Recommended management actions: Traffic and other activities should be subjected to time and area control in white whale breeding and molting areas.	
Recommended monitoring and/or surveys: Monitoring of the white whale population in areas with activity. Surveys of the size and distribution of the populations with particular emphasis on the localization of breeding and molting areas.	
Recommended research: None	
Recommended mitigating measures:	
Literature cited: Seaman, G. A., Frost, K. J., and Lowry, L. F. 1985. Distribution, abundance, and movements of belukha whales in western and Northern Alaska. Draft final rep. prepared for U.S. Dep. Commer., NOAA, Natl. Ocean Serv., Anchorage, Alaske Dep. Fish and Game, Fairbanks.	

VEC C6: GRAY WHALE **C6-IH1**

Hypothesis: Oil spills caused by traffic will reduce the Gray whale population.

Explanation: Oil spills in open water may cause Gray whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction capacity.

Category: D

Rationale: The effect of oil on Gray whales has not been examined. The effects of oil on several other marine mammals are severe. Because of physiological and behavioral differences this tendency cannot without reservation be transferred to Gray whales. Geraci (1990) concluded that bottlenosed dolphines were able to detect and avoid oil on the sea and that contact with oil will be less harmful in cetaceans then for other marine mammals. Oiling in estuaries and at the ice edge might be a risk for Gray whales due to their gregarious behavior. The effect of oil exposure through the food chain is not known.

Recommended management actions: Oil spill alert contingency plans should be initiated in estuaries where Gray whales occur.

Recommended monitoring and/or surveys: Monitoring of habitats and fouled individuals in the event of oil spills. Surveys of the seasonal habitats of Gray whales and oil exposure of the food chain.

Recommended research: None.

Recommended mitigating measures:

Literature cited: Geraci, J. R: 1990. Physiologic and toxic effects on Cetaceans. Pp. 167-197 In: Geraci, J. R. and St.Aubin, D. J. 1990. Sea mammals and oil: Confronting the risks. Academic Press Inc., New York.

VEC C6: GRAY WHALE	C6-IH2
Hypothesis: Disturbance (traffic, ice breaking) will result in a reduction in the local Gray whale populations.	
Explanation: 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.	
Category: C	
Rationale: The hypothesis is assumed to be valid concerning increased traffic, but more information/documentation is required for the preparation of monitoring and research programs.	
Recommended management actions: Traffic and other activities should be subjected to time and area control in Gray whale breeding and molting areas.	
Recommended monitoring and/or surveys: Monitoring of the Gray whale population in areas with activity. Surveys of the size and distribution of the populations with particular emphasis on the localization of breeding and molting areas.	
Recommended research: None	
Recommended mitigating measures:	
Literature cited:	

VEC C7: BOWHEAD WHALE	C7-IH1
Hypothesis: Oil spills caused by traffic will reduce the bowhead whale population.	
Explanation: Oil spills in open water may cause bowhead whales to avoid an area. Oil spills on skin may cause increased energy expenditure and accordingly reduced chance of survival or direct death. Ingestion of oil may cause illness or lethal internal injuries. Accumulation of toxic substances in oil-exposed food organisms may reduce reproduction capacity.	
Category: D	
Rationale: The effect of oil on bowhead whales has not been examined. The effects of oil on several other marine mammals are severe. Because of physiological and behavioral differences this tendency cannot without reservation be transferred to bowhead whales. Geraci (1990) concluded that bottlenosed dolphins were able to detect and avoid oil on the sea and that contact with oil will be less harmful in cetaceans then for other marine mammals. Oiling in estuaries and at the ice edge might be risky for bowhead whales due to their gregarious behavior. The effect of oil exposure through the food chain is not known.	
Recommended management actions: Oil spill alert contingency plans should be initiated in estuaries where bowhead whales occur.	
Recommended monitoring and/or surveys: Monitoring of habitats and fouled individuals in the event of oil spills. Surveys of the seasonal habitats of bowhead whales and oil exposure of the food chain.	
Recommended research: None.	
Recommended mitigating measures:	
Literature cited: Geraci, J. R: 1990. Physiologic and toxic effects on Cetaceans. Pp.167-197 In: Geraci, J. R. and St.Aubin, D. J. 1990. Sea mammals and oil: Confronting the risks. Academic Press Inc., New York.	

VEC C7: BOWHEAD WHALE C7-IH2
Hypothesis: Disturbance (traffic, ice breaking) will result in a reduction in the local bowhead whale populations.
Explanation: Increased traffic will lead to increased disturbance which can cause a reduction in local bowhead 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.* 1993).
Category: C
Rationale: The hypothesis is assumed to be valid concerning increased traffic, but more information/documentation is required for the preparation of monitoring and research programs.
Recommended management actions: Traffic and other activities should be subjected to time and area control in bowhead whale feeding areas.
Recommended monitoring and/or surveys: Monitoring of the bowhead whale population in areas with activity. Surveys of the size, age composition and distribution of the populations.
Recommended research: None
Recommended mitigating measures:
Literature cited: Richardson, W. S. and Malme C. I. 1993. Man-made noise and behavioral responses. Pp. 631-700 In Burns, J. J., Montague, J. J. and Cowles, C. J. (Eds). The bowhead whale. Spec. Publ. No 2. The Society of Marine Mammalogy, Lawrence.

VEC C1-C7: ALL MARINE MAMMALS C1-C7-IH 1
Hypothesis: 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.
Explanation: Heavy metals, stable chlorides, breakdown products from oil or oil treated with dispersants, PCBs are relevant substances. Such bio-accumulation has in many areas been traced in fish and marine mammals.
Category: C
Rationale: 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).
Recommended management actions: None, beyond ordinary regulations concerning emissions.
Recommended monitoring and/or surveys: 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.
Recommended research: None.
Recommended mitigating measures:
Literature cited: Griffiths, D., Øritsland, N.A. and Øritsland T. 1987. Marine mammals and petroleum activities in Norwegian waters. Fisken Hav. Serie B, no. 1, 179 pp.

APPENDIX

REVIEW BY PROFESSOR YASUHIKO NAITO, NATIONAL INSTITUTE OF POLAR RESEARCH, TOKYO, JAPAN.

2. Selection of marine mammal VECs and description of impact hypotheses. By Oystein Wiig et al.

1. The above paper is well arranged with regard to purpose, process to select VEC, back ground information , general quality and so on. In the introduction chapter, I prefer to explain more detail on the concept of VEC as it is key issue of this paper.

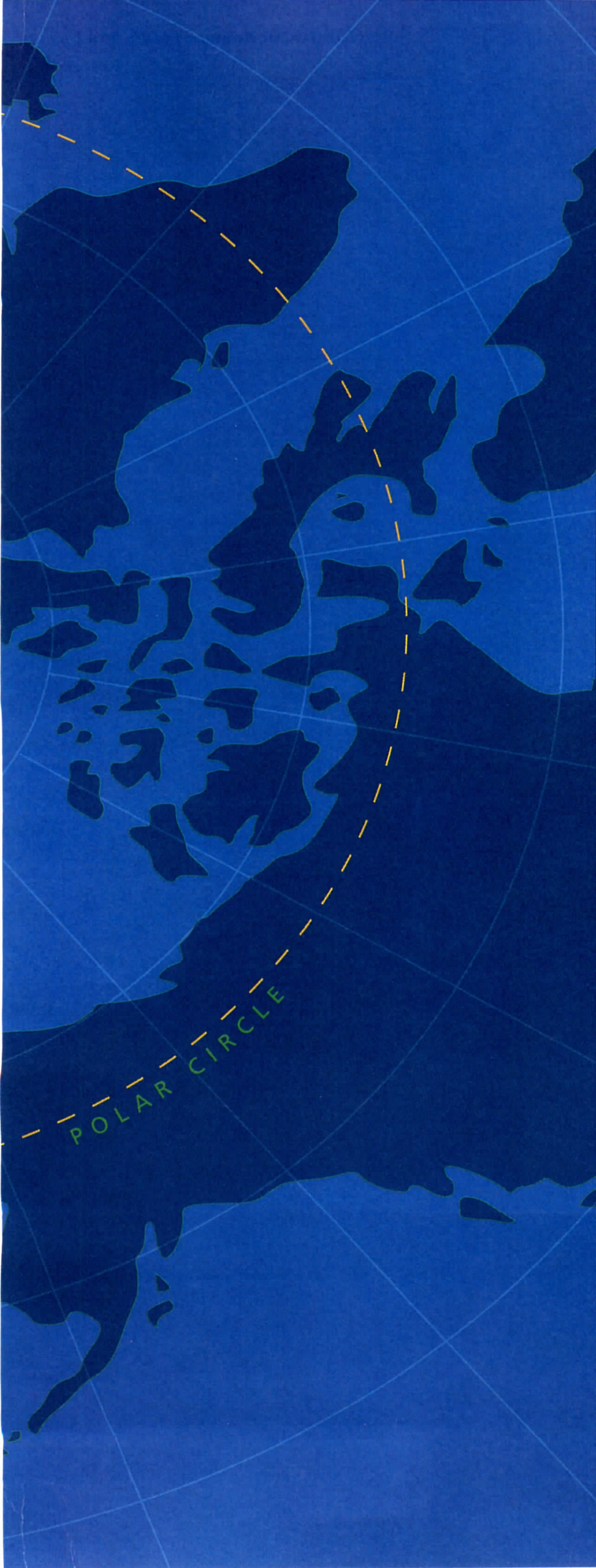
2. In the chapter 2.3. Evaluation of VEC candidates, authors set the priorities on scale 0-3. Is this relative saccade among the 10 species or absolute values according to the 5 parameters as mentioned in the chapter. I suppose it as relative scale. Then it is important to suggest it in the text.

3. The hypotheses seems to be appropriate. However, not only set up hypotheses but it also expected to investigate what kind effect was detected by the past experience in the Arctic region. I would like to give an example of oil well development in the North Slope in Alaska. This is not exactly the same example though, there may be good experience like happening by Vales ship wreck.

4. As conclusion I recommend to adopt this paper.

5. Small errors were indicated in the text. Please authors examine those.

Yasuhiko Naito



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 stockholding 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 multidisciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.