ASSESSMENT SYSTEM FOR THE ENVIRONMENT AND INDUSTRIAL ACTIVITIES IN SVALBARD

Rapport nr. 68
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FOREWORD TO THE ENGLISH VERSION

Tourism and commercial activities, where petroleum exploration is a major part, have increased significantly on Svalbard during the last ten years and will probably continue to increase in the years to come. Monitoring this development and recognizing the potential for environmental deterioration of the archipelago the Norwegian Ministry of the Environment in 1986 instructed the Norwegian Polar Research Institute to develop a new programme for environmental impact assessment and management advice.

We found that the Beaufort Environmental Monitoring Project (BEMP) and other projects utilizing the Adaptive Environmental Assessment and Management methods (Holling 1978) provided a good basis for a programme for Svalbard. The programme was named MUPS ("Miljøundersøkelser på Svalbard" which translates to "environmental impact studies on Svalbard") and included development of a system for environmental consequence analysis (MUPS analysis system). Two versions of the MUPS analysis system have been produced until now.

The basis for the MUPS analysis system deviates from that of BEMP in several ways:

- We had, and partly still have, little detailed knowledge of the human activities that the programme might have to handle. It was primarily set up in response to petroleum activities, but had to be useful for tourism, coal mining etc. as well. Even the petroleum sector was unable to provide detailed scenarios.

- No administrative framework is yet established for the implementation of MUPS.

- Environmental Impact study projects imposed on companies must generally be geographically and temporally connected to each specific development or operation.

Compared to that of BEMP the MUPS analysis system is characterised by:

- A relatively high number of Impact Hypotheses. Due to the lack of specified scenarios the screening of Impact Hypotheses was relatively 'mild', but under each VEC the hypotheses are ranked by priority.

- A relatively high number of suggested projects. For the reasons mentioned above the projects are not described in detail. Under each VEC they are ranked by priority.

The MUPS system has generally been well received by the scientific and industrial communities in Norway. From an environmental management point of view a major benefit of the system is that the Environmental Authorities have for once been able to stay ahead of the commercial development.

The Norwegian Polar Research Institute will initiate a third revision of the MUPS system during the spring of 1990. All VECs, IH's and project suggestions will be screened. Activities like coal mining, tourism and establishment of new settlements may be taken into account to a greater extent. Establishment of an administrative framework for running MUPS and updating the analysis system is on the agenda.

Far too often the processing of environmental management decisions is hampered by frustrating repetitions of verbal ecological arguments. Also we are not aware of any numerical ecosystem model that may be used operationally in practical management. Attempting to alleviate this situation a subproject named DAKON is conducted under MUPS. DAKON (computer assisted consequence analysis) have elements of expert system development. Attempts are made to set up a system for both text retrieval and linking of numerical models to verbal rules by means of logic processing.

The present English translation of the MUPS system may both serve as an aid for foreign companies wanting to start activities on Svalbard and as general information. Comments and criticism from interested environmentalists are welcomed.

We thank David P. Stone (Dept. of Indian and Northern Affairs, Canada), Nic Sonntag (Environment and Social Analyses Systems Analysts Ltd.) and other BEMP participants for valuable advice to the development of the MUPS system. We also thank Inger Lovise Tvede and Lynda White Petterson for translation work, and Torbjørn Severinsen for the final editing of the English version of the system.

Rolfstangen, 15 January 1990

Rasmus Hansson Pål Prestrud Nils Are Øritsland (editors)

FOREWORD

This report contains Version 2 of the "Assessment System for the Environment and Industrial Activities in Svalbard". The assessment system is a sub-project under the MUPS programme (environmental studies in Svalbard associated with petroleum activities), for which the Norwegian Polar Research Institute is responsible. MUPS has been developed as a guide to conducting environmental studies and impact assessments in Svalbard.

The assessment system is modelled on the Beaufort Environmental Monitoring Project (BEMP) from Canada. Our objective has been to create a system for swift selection of environmental projects providing the most relevant data for an impact assessment based on constraints imposed by practical, temporal and economic realities. The advantage of the model lies in the fact that it is systematic and demands a rationale for the choices made. Its drawback lies in being to some extent unscientific in the respect that its basic elements, the "valued ecosystem components", inter alia are selected on the basis of political criteria. The method also tends to give priority to short-term approaches directed towards administrative requirements, which is criticised in baseline research quarters. The objections raised against the method and its implementation that are presumed to be most severe will be referred to in chapter 7. It is a prerequisite in order to develop the system further that this discussion be continued. The assessment system will only be beneficial if it is subjected to continual adaptation and further development. The knowledge available to us as well as the character of the industrial activity is undergoing a process of change. Accordingly the assessment system should be altered in keeping with these changes.

The assessment system also discusses some groups of animals that come under the responsibility of the fishing authorities. It has been natural to include these since we have been trying to assess the entire ecosystem and the entire problem complex in a context. We hope the fishing authorities will study the results and the assessment system more closely, to consider whether it can be used in the fisheries management.

Version 2 of the assessment system is the result of a long development process. Version 1 was prepared by a total of approximately 40 researchers, administrators, people from industry, and others, after three expert workshops (approximately 10 participants for one day) and two working group meetings (approximately 40 participants for two days). It was available in October 1987. Version 2 is a continuation mainly prepared in the course of a three day working group meeting with approximately 35 participants in January 1988.

Version 1 of the assessment system was funded by Statoil, British Petroleum and Store Norske Spitsbergen Coal Company/Norsk Hydro. The present version is funded solely by Tundra A/S (with funds from Polargass A/B). Representatives from Tundra, Polargass, Statoil, BP and Store Norske Spitsbergen Coal Company/Norsk Hydro have taken part in the preparation of Version 2.

The present assessment system is the result of joint efforts by all those who have participated in preparations, meetings and discussions, written VEC reviews or contributed in other ways. Many have made a considerable effort, far exceeding their professional obligations. We would like to extend our thanks to everybody who has participated in the development of the assessment system.

We also wish to acknowledge the helpful contributions of Per Espen Fjeld, Ian Gjertz, Elsa Hammer, Rigmor Hjorth, Lars Øyvind Knutsen, Torbjørn Severinsen and Morten Skaugen.

Rolfstangen, 30 December 1988

Rasmus Hansson Pål Prestrud Nils Are Øritsland (editors)

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1.1 Background

The issue of petroleum exploration activities has once more become relevant in Svalbard. The first exploration phase was terminated more than ten years ago, with no indications of profitable finds being made. In 1985 the petroleum companies again began to take a greater interest in Svalbard, and this time the activity is likely to be more extensive. Careful surveying is being carried out in the form of seismic and geological investigations before drilling is begun. In the course of the last couple of years a small number of drillings have been carried out, and more are expected in the near future. Personnel and equipment investments by far surpass preceding years. New geological theories have made the companies seriously consider the possibility of oil/gas finds in Svalbard. Moreover, knowledge of the geology of Svalbard will facilitate the finding of gas/oil in the Barents Sea, which is now being opened up for exploratory drilling.

One of the main objectives of the Norwegian Svalbard policy is to maintain the natural wilderness character of the archipelago. This implies that, in principle, human activity resulting in considerable changes in the environment cannot be accepted. Besides, the natural environment of Svalbard is vulnerable to human influence.

The environmental authorities will meet the development by studying the impacts of various encroachments on the natural environment. This research will provide a better basis for assessing the impacts involved and also for initiating mitigative measures to prevent unnecessary damage to the environment. Before the implementation of industrial activities in a specific area, this area will generally be subjected to environmental surveying and to studies concerning potential impacts. Pursuant to the Svalbard Conservation Regulations, the Ministry of the Environment has decided that the environmental studies required in connection with such developments shall be paid by the companies wishing to operate in Svalbard. To ensure a maximum level of precision in impact assessments of this kind, the Ministry of the Environment has assigned the coordination and administration of this work to the Norwegian Polar Research Institute. The Institute's primary task will be to prepare proposals for potential Government assigned projects to be conducted by the companies, and to evaluate the results of these projects. The Institute will simultaneously undertake the implementation of some of the projects on contract for the companies involved.

To assume this task the Polar Research Institute has established the programme "Environmental Studies in Svalbard" (Miljøundersøkelser på Svalbard ⇒ MUPS). The first projects were implemented in 1986 (Prestrud & Øritsland 1987). As a MUPS subproject the Institute has coordinated the compilation of an "Assessment System for the Environment and Industrial Activities in Svalbard" (Hansson et al. 1987 editors). The assessment system is an attempt at systematic examination of the entire range of the problem connected with "the impact of industrial activities on the natural environment of Svalbard." It is intended to become an overall coordinated plan for assigning priority to environmental studies associated with petroleum activities in Svalbard. The current report contains version 2 of this assessment system.

1.2 Literature

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2. EXPERIENCE FROM OTHER COUNTRIES

In Canada and in the U.S. Environmental Impact Assessments (EIA) have in the course of the last 10 - 15 years increasingly been incorporated in the decision making process of industrial developmental planning. Several extensive impact assessments have been carried out in these countries, including the Arctic regions. The experience gained has however not been entirely favourable, and the work carried out has been met with harsh criticism from several quarters.

Generally the main problem has been that biologists and environmental authorities have been trying to cover the entire ecosystem in their studies. There has been a reluctance to give priority to the most relevant and realistic approaches at the expense of more peripheral and theoretical issues. Admittedly, the relevance of environmental data and the choice of approaches to be focussed upon are by no means evident. Such choices are dependent upon scientific, administrative and political priorities that environmental authorities in particular, and possibly other employers, should be conscious of. Such issues have however tended to be left unclarified. Besides, often the knowledge of industrial development planning has been insufficient. Project selection has been left to the researchers; no general plan based on systematic problem examination being required. Many environmental studies have accordingly been based on the interests of the individual researcher, and not on the maximum relevance to the impact assessments. In many cases this has resulted in resource intensive environmental studies and voluminous reports still forming an insufficient basis for assessing the impact of the industrial development in case.

In Canada a project was started in 1982 to examine the experience gained from a number of impact assessments. The objective of the project was to point out common problems associated with the conducted assessments and arrive at a framework for impact assessments to the satisfaction of all parties involved. The result is printed in the report "An ecological framework for environmental impact assessment in Canada" (Beanlands & Duinker 1983). The report concludes that the problems are caused by the following relationships:

— Participating groups have lacked a common perspective. Means and objectives have not been agreed upon.

— A central objective, as well as an analytical basis for data collection, has been lacking.

— Inadequate application of ecological knowledge and methodology.

— The industries themselves have made an inadequate contribution to the design and implementation of impact assessments.

Several measures to get out of this deadlock are proposed in the report, such as:

— Which ecosystem components to focus on, and which to exclude must be ranked by priorities. The introduction of the concept of "Valued Ecosystem Component", or VEC, is being proposed. A VEC is a component in the system selected for special examination.

— Use of the AEAM method (Adaptive Environmental Monitoring and Assessment).

AEAM (Holling 1978) is a method evolved to enable speedy evaluation of the implementation of environmental encroachments or administrative measures. AEAM connects ecological knowledge and systems analysis with problems related to the management of the environment. A central element in the method is the development of a computer simulation model to describe, as carefully as possible, all relevant linkages connected with a specific industrial activity. The model is developed at meetings in which all relevant disciplines, as well as representatives of environmental management, industry and other interested parties take part. The aim is to represent the range of likely problems. The model is to be further developed at new meetings with the appearance of new knowledge, conditions and approaches. The entire process will be one in which research and investigations will continually be followed by workshops to adjust the course when required.

In the Beaufort Environmental Monitoring Project (BEMP 1985) the Canadians have tried to take into account the experience gained and the recommendations provided in the Beanlands and Duinker Report (1983). The aim of the BEMP was to prepare a workable and comprehensive environmental research programme connected with expected petroleum activity in the Arctic Beaufort Sea. The BEMP model as such was developed at two major workshops and several minor technical meetings. A VEC was in BEMP defined as "an ecological component which is important to local human populations, has a national or international profile or is important to the evaluation of impacts of development". The model as such consists of a schematic flow chart indicating possible interactions between the VECs and the relevant industrial developments. One or several linkages in the flow chart constitute the basis for so-called "impact hypotheses" (IHs). All the hypotheses were critically evaluated and in the BEMP the number of VECs was reduced to 20 hypotheses considered to be valid and important enough to test. Research and monitoring programmes were prepared for each of these hypotheses.

This method of approach involves the assignment of different levels of priorities. Firstly between the various ecosystem components, subsequently between the various hypotheses produced concerning the possible interactions between industrial developments and the high priority VECs, and finally between the various research and monitoring programmes associated with different IHs. The entire process is systematically carried out in order to establish the projects found by the participants to be most relevant and most profitable.

There are many similarities between the Canadian problems and those met with in Svalbard. Accordingly we found it natural to study Canadian experience with the use of impact assessments in the Canadian Arctic. On the whole the Canadians have been satisfied with BEMP's problem solving, and gradually the method has been adopted in many contexts. BEMP appeared to offer a sensible solution to dealing with our problems because:

— It is obviously necessary to have a scientifically based general plan when selecting research and monitoring projects, in this way facilitating the coordination of problem solving approaches.

— There is a need for a strategic ranking of priorities between the various ecosystem components and the relevant research projects to avoid ending up with too many and too large projects, and with a disintegration into individual components that are unconnected to, or irrelevant to, the development in case.

— Several research communities, the relevant management, industry and others concerned must be included when evaluations are made and priorities decided upon.

— It is essential to have a dynamic system, which can be adjusted with the acquisition of new knowledge and with industry's changing plans.

Literature

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3. DESCRIPTION OF THE ASSESSMENT SYSTEM

3.1 Objective

The Svalbard follow-up of BEMP is called "Assessment system for the environment and industrial activities in Svalbard". When drawing up this assessment system we have, as far as possible, tried to utilize the BEMP design and concepts, adapted to conditions in Svalbard. However, the bases of the Canadian and the Norwegian models clearly differ in certain aspects. From the onset BEMP aimed at making a computer simulation model, as prescribed by the AEAM method. This turned out to be a difficult task, and eventually a verbal model was chosen instead. Moreover, BEMP focused on a marine environment, and the interests of the aboriginal population are a main concern in its assessment of harmful impacts. The MUPS assessment system primarily focuses on land areas, and even if the interests of the residents of Svalbard are essential, they do not, in a legal sense and with respect to international law, have the same relationship to the natural resources as do the aboriginals of Canada. Thus in some aspects the MUPS assessment system differs from the BEMP, even if the main features are the same. We decided to start up by making a verbal system. A computer simulation model is planned at a later stage.

The first version of the assessment system was compiled during three expert workshops, each of one day's duration, and at two working group meetings, each lasting two days. The main task of the expert committee was to state some basic terms (including the selection of VECs) and to prepare the meetings for the working groups. Version 2 is a continuation of Version 1. The basis for this version was established at a working group meeting in the course of three days in January 1988. The group of experts was made up of specialists within the relevant fields, and of proponents of environmental management and industry. About 10 persons took part in these meetings. The working groups consisted of a total of approx. 30-40 persons. The groups were, if possible, to be made up by professionals within the relevant fields, by persons with a general understanding of ecology, by persons connected with the Svalbard management, by persons with a general administrative background, by proponents of industry and by persons representing the local residents of Svalbard. The aim was a representation of all groups having legitimate claims associated with industrial development in Svalbard (See list of participants).

The objective of the assessment system is:

— to provide the environmental authorities with an overview of the major questions concerning the environment raised by the industrial activity.
— to provide them with a tool for planning and implementing the necessary research and monitoring, and for systematically applying the results in the administration and design of continued research and monitoring, and
— to limit imposed research and monitoring to approaches and tasks that may lead to concrete and serviceable results.

Specifically the assessment system is meant to:

— indicate the environmental impacts of potentially greatest significance,
— be based on scenarios for industrial development and the best available understanding of ecological processes,
— be able to respond to/assimilate the alterations in scenarios for industrial development, and to new knowledge concerning ecological conditions in the specific area; and
— represent the views of a broad range of specialists with the experience required from industrial activities, research and environmental management in Svalbard.

The management authorities desire a swift initiation of relevant environmental studies associated with possible new industrial activities, to avoid having to plan investigations at short notice, without the necessary coordination and preparatory work. This can be attained through a plan based on estimated trends of development for industrial activities in Svalbard (scenarios), seen in relation to selected Valued Ecosystem Components (VECs). This approach will also ensure equality of treatment of the companies, as instructions to conduct individual and arbitrary studies will be avoided. Moreover, it will ensure professional benefits, and lead to the development of a professional community with knowledge of the impacts of environmental encroachments in Svalbard, which can be of assistance to the companies as well as the management.

The assessment system has mainly been prepared for Svalbard and its territorial waters (4 nautical miles). Accordingly, conditions of an entirely marine biological character have been given less emphasis.

Below follows an examination of three concepts of importance to the assessment system.

3.2 Valued Ecosystem Component (VEC)

A VEC is defined as a resource or environmental feature that:

a) is important (not only economically) to a local human population, or

b) has a national or international profile, or

c) if altered from its existing status, will be important for:
- the evaluation of environmental impacts of industrial developments, and
- the focussing of administrative efforts.

Re. a): This item in principle equates everything from traditionally economic resources, to people's experience of nature or even people's delight at e.g. knowing that Edgeøya remains intact, even if they themselves will never have the opportunity to visit it.

Re. b): This item points to the fact that the value of a resource or feature has to be evaluated in a wider than local perspective; its value can first of all appear in a national or international context.

Re. c): Listed under this item we primarily find resources (e.g. species) and features (e.g. balances or energy flows) of an ordinary biological/ecological character.

According to a simplified definition "a VEC is something that gives a politician a headache if something happens to it". The latter definition stresses the scientific as well as the social/political/economic character of the VEC concept. Moreover, it implies that there is only room for a small number of VECs, and that, accordingly, there must be a disciplined ranking of priorities. Even if e.g. polar cod (Boreogadus saida) constitutes an important component in the Svalbard marine system, it is hardly of sufficient interest to the general public, nor sufficiently researchable to warrant a position as a VEC.

This can be problematic to scientists and conservationists, used to working within the tradition of Norwegian ecology and conservation plans. One objection will be that ranking the components of natural systems as "important" or "unimportant" is dubious; it would imply making too large concessions to the development lobby already from the onset. Another objection might be that the criteria for selection are unscientific, thus implying that there is a possibility of ending up with the "wrong" VECs: Viewed from a food chain perspective, the polar cod may be far more important than the polar bear or the walrus. Regarding the first argument it must be said that the assessment system is only developed to handle specific cases of environmental encroachment, and shall accordingly almost by definition function on the terms of the encroachment. The system as well as the proposed investigations shall mainly be funded by the developer. However, it is of course a prerequisite that the traditional, more comprehensive and ecologically based environmental management is to operate parallel with and set the terms for the assessment system.

The other objective is to a great extent compensated for by the fact that the system at all times assumes an optimal scientific description of the physical, biological and human contexts in which any VEC is placed (socalled "schematic flow charts", see 3.4). Thus in practice the most important but "anonymous" components will be described in the system. To the extent these components are affected by the development, and this impact assumes general importance, the system will necessarily have to consider the impact in case.

The VECs in MUPS were selected at the meetings of the group of experts. Much time was devoted to ensuring that all potential VECs were considered before a final list was agreed upon. Accordingly the first proposals for a VEC list were very comprehensive, covering most vertebrate species and main groups of invertebrates, most plant communities and types of terrain plus activities like fisheries, hunting and recreation. It soon became evident that the list was too comprehensive and too unspecific. It was pointed out by the Sysselmann (Governor of Svalbard) as well as by representatives of the Ministry of the Environment that it was of little use to the management, as it scarcely distinguished between the relative importance of priorities. Besides, the proposed VECs only to a small degree agreed with the social/political aspects of the definition. To compromise, an attempt was made to form "collective VECs", without coming up with anything significantly better. The group therefore ended up with a list of rather "selfevident " peaks in the food chain. A complete report of the VEC discussion will not be rendered here. The reasons for selecting the various VECs will only be provided by the way of key words.

Among "potential" VECs the following were excluded:

White whales (Delphinapterus leucas) and bearded seals (Erignathus barbatus) were neither considered to be of sufficient significance to the general public nor to the ecosystem. These species were however bordering on being included in the system. Minke whale (Balaenoptera acutorostrata), humpback whale (Megaptera novaeangliae) and harp seals (Phoca groenlandica) are insignificant in coastal areas. Common seals (Phoca vitulina) are too few in number, have a distribution limited to Forlandet National Park and are therefore looked after in the parks regulations. Glaucous gull (Larus hyperboreus), snow bunting (Phlectrophenax nivalis) and wading birds are only marginally vulnerable, and the last two are relatively unimportant to the system.

The work done by the expert group, and the conclusion arrived at, indicated the tendency for the selection of VECs to become too "scientific". To be functional, the VECs must primarily mirror the public interest attached to the specific area. There are many indications that VECs to a greater degree than is the case today ought to be determined by administrators, although in consultance with professionals.

3.3 VECs in the MUPS assessment system version 2

The following Valued Ecosystem Components have been adopted for the MUPS Assessment System (a summary argument accompanies each VEC):

SVALBARD REINDEER (Chapt. 6.2)
Endemic race, sole herbivorous terrestrial mammal.Importance to: Vegetation, fox, research, aesthetic and recreational value, hunting, identity, internationally.

ARCTIC FOX (Chapt. 6.3)
Sole terrestrial carnivore. Importance to: Seabirds, reindeer, eiders/geese, ptarmigan, hunting, research, rabies, aesthetic and recreational value, identity.

POLAR BEAR (Chapt. 6.4)
Marine top predator. Importance to: Ringed seal, bearded seal, research, aesthetic and recreational value, identity, internationally.

WALRUS (Chapt. 6.5)
Has nearly been exterminated in Svalbard. On the increase, but still vulnerable. Importance to: Research, aesthetic and recreational value, identity, internationally.

RINGED SEAL (Chapt. 6.6)
Most common marine mammal. Importance to: Polar bear,research, hunting, aesthetic and recreational value.

EIDERS AND GEESE (Chapt. 6.7)
Relatively similar in terms of biology and vulnerability. The group comprises important (common eider, pinkfooted goose), distinctive (barnacle goose) and rare/endangered (brent goose) species. Importance to: Fox, glaucous gull, hunting, research, aesthetic and recreational value, identity, internationally.

SEABIRDS (Chapt. 6.8)
Quite similar in terms of biology and vulnerability. Transfer nutrients from sea to land. Very numerous species. Importance to: Small fish and crustaceans, vegetation, fox, glaucous gull, research, hunting, aesthetic and recreational value, identity, internationally.

SVALBARD PTARMIGAN (Chapt. 6.9)
Endemic race. Sole bird wintering on land. Importance to: Fox, hunting, research, aesthetic and recreational value.

MARINE BIOLOGICAL RESOURCES (Chapt. 6.10)
Main components are scallop beds, breeding habitat for Greenland halibut and prawn. Gathered in one group as it constitutes a large complex system, not lending itself easily to research, and lying only peripherally within the MUPS framework.

SVALBARD CHAR (Chapt. 6.11)
Sole freshwater fish. Endemic race. Importance to: Angling, research, possibly interesting in an aquaculture context.

VEGETATION AND SOIL (Chapt. 6.12)
Have been combined, as vulnerability to wear etc. is particularly associated with the quality of the soil; plant communities greatly reflect these qualities.

THE "LITTORAL ZONE" (Chapt. 6.13)
Transitional zone between marine and terrestrial systems. Particularly exposed to wear and pollution. Many connected species.

OUTDOOR RECREATION (Chapt. 6.14)
Importance: Aesthetic and recreational value, health, identity, understanding, disturbances, wear.

PROTECTED AREAS (Chapt. 6.15)
Particularly low tolerance to encroachments. Importance to aesthetic and recreational value, identity, reference, research and internationally.

3.4 Schematic flow chart

A schematic flow chart, i.e. a diagram of boxes and arrows indicating the context in which the VEC appears, was made up for each VEC. The expert group prepared proposals for some of the flow charts, while the working groups prepared the final version of all the VECs. In the flow chart are included the main categories of the physical, biological and possibly also social and political factors influencing the VEC, socalled system components, and industrial impacts, called developments. In the flow chart for ringed seals, e.g., ice conditions, marine biological resources and polar bears are system components, while ringed seal is an important system component in the polar flow chart. In both flow charts active offshore structures and disturbances are included as developments.

The relationships between the components are called linkages. In most cases we cannot yet quantify the extent, importance, biomass or energy flow represented by the linkage. In the longer term we do however aim to build a model which, to the greatest extent feasible, is based on quantifications. The symbols in the flow chart are explained in the introduction to chapter 6.

Each linkage has been explained in a brief text following the flow chart. To facilitate a general survey each flow chart on the whole only comprises the components that are in direct interaction with the VEC. Thus in the polar bear diagram, ringed seal is included, because it constitutes the diet of the polar bear, while marine biological resources, which form the diet of the ringed seal, have been excluded. To illustrate the relationships between the marine food chains and the mammals and birds living on top of them, a separate flow chart, with a description of the marine food web has been included together with the flow chart of the VEC for Marine Biological Resources in chapter 6.

3.5 The impact hypotheses (IHs)

The linkages in the flow chart indicate which developments will influence the VEC directly, or indirectly, via system components. A series of impact hypotheses (IHs), that is hypotheses for the impacts of the relevant developments on the VEC, can be set up by means of these links. These IHs were the basis for the final recommendation for research, monitoring, mapping and mitigating measures presented in this version of the assessment system. To avoid leaving out hypotheses, efforts were made, when preparing the first set of hypotheses, to cover all impacts that could reasonably be imagined from the very onset. Following a special screening procedure, only those hypotheses that were sufficiently probable, important or researchable for the assessment system to recommend the initiation of mapping, monitoring or research in the field remained. When revising the assessment system in the future, impact hypotheses that have now been downgraded can be upgraded and conversely. Such changes have already been made during the revision of version 1 of the system. All hypotheses, including the ones that have not been given priority in this version, have been listed on a standard diagram (chapter 8) with the following categories:

1. The hypothesis.
2. Description of the hypothesis based on a flow chart (i.e. an explanation of the hypothesis).
3. The placing of the hypothesis in one of the following categories, accompanied by argumentation for the placing:
   - **A.** The hypothesis is not assumed to be valid.
   - **B.** The hypothesis is valid and is already verified. Research to validate or invalidate the hypothesis is not required. Surveying, monitoring and/or administrative measures can possibly be recommended.
   - **C.** The hypothesis is assumed to be valid. Research, monitoring or surveying is recommended to validate or invalidate the hypothesis. Administrative efforts to mitigate negative effects on the environment may be recommended if the hypothesis is valid.
   - **D.** The hypothesis may be valid, but is not worth testing for professional, practical, economic or ethical reasons, or because it is assumed to have minor environmental repercussions. Monitoring, surveillance, and environmental enterprises are recommended to mitigate negative environmental effects.

4. Management.
   Measures, procedures etc. associated with the development to prevent or reduce harmful effects on the environment.
5. Surveying.
   The occurrence of relevant resources/features (VECs) at the relevant times/sites are surveyed, to prevent/mitigate and/or predict possible harmful effects.
6. Monitoring.
   Investigations measuring the extent of impact, or assessing the cause-effect relationship connected with a development affecting a VEC, or associated system components, in which the VEC impact as such is not under discussion.
7. Research.
   Test of a system process hypothesis, i.e. the impact of a development on a VEC or its associated components, or investigations to find the baseline measurements required for further research concerning the problems in case.

On the whole only IHs placed in categories 3B or 3C have been given priority in the active assessment system. Documentation for these IHs has been compiled, represented together with the documentation of the relevant VEC. A brief note on each of the remaining hypotheses discussed has also been included (Chapter 8) on the flow chart. In some instances management, surveying, monitoring or research potentially relevant to the hypothesis if given priority in the future has also been mentioned. These projects have, however, not been given priority within this version of the assessment system.

4. SCENARIOS FOR PETROLEUM ACTIVITIES IN SVALBARD

4.1 Summary

This description is limited to a discussion of the current plans and development for petroleum exploration activities in Svalbard.

Onshore seismic exploration activities will most probably be in progress for a period of 1-2 years. Drilling will possibly be started to the south of Svea and in the central areas of Spitsbergen - i.e. Nordenskiøld Land, Van Mijenfjorden and Isfjorden, by 1995. The Trust Arktikugol drilling in Vassdalen will proceed for some years. The drillings at Haketangen were concluded in 1988. The same interests are preparing a new drilling at Kvalvågen to the north of Haketangen in 1989. When selecting methodology and equipment, finding lightweight equipment and the simplest solutions possible will be decisive, for obvious technical, economic and practical reasons.

Correspondingly, each operation will be optimally implemented at specific periods of the year. An activity consisting of several separate operations may accordingly be more timeconsuming than is normally the case.

The exploratory strategy will to a great extent be determined by the geographical area to be explored. In eastern parts of Nordenskiøld Land existing infrastructure is not far away, thus the economic conditions required for finds to be operable are more favourable than e.g. on the east coast or further south. Drilling in campaigns, and with a quick start of small field production can therefore be of interest, while in other areas more timeconsuming assessments will be made in each exploratory and developmental phase.

4.2 Introduction

The objective of this juxtaposition is to provide an overview of petroleum activities in Svalbard, and of potential developmental trends in the coming decade. The information used is taken from documents that the management authorities have received from the companies, from the press, from contacts with company employees, and from replies received after applying by letter to the companies concerned in September 1986, asking for information on future activities and on the companies' evaluation of Svalbard in a petroleum context. The proponents of industry have taken an active part in preparing the statement.

The development of the assessment system coincides with a difficult situation on the petroleum market. Accordingly all descriptions of future developments in Svalbard will remain uncertain. Most of the companies contacted pointed to the uncertainty caused by low petroleum prices. The plans and visions of the companies have changed considerably in the course of the last couple of years. Svalbard still appears to be interesting in a petroleum context, but the companies are biding their time. On the other hand, current exploration activities represent the companies' investments for the future. A certain amount of exploration activity is likely to be in progress in Svalbard, even in periods of low petroleum prices.

The description of future petroleum activities must partially have to be based on the companies' longterm strategies.

In this description of future petroleum activities in Svalbard the following factors form the basis of the evaluation of possible scenarios:

- Activities in Svalbard have till now been seasonal, i.e. each operation is optimally carried out at a certain time of the year. Onshore transport is considerably simpler and cheaper on frozen snowcovered ground than on bare ground. Marine seismic surveys must be effected in late summer or early fall, with minimal sea ice. Bringing equipment ashore is cheapest and easiest in the spring or late fall by maximally utilizing the fjord ice. Even in the event of finds there will in most cases be a long preproduction period (several years) before the field is fully developed for production.
- The development is difficult, and even the planning and implementation of a minor development will be timeconsuming. The preparatory phase will increase with the size of the project.
- The environmental impact is contingent on the vulnerability of the specific area, the type of development concerned and the scope of the development.
- The assessment system will have to take into account the considerable length of time expected between the notification of the first exploration well and the possible initiation of the development.

Below follows first a description of the arguments in favour of petroleum activities in Svalbard, then the known technical and logistic factors, relevant geographical areas, the companies' activity up to the present, and finally potential trends of development.

4.3 Why exploration and drilling in Svalbard?

When the first exploration phase was finished in the early 1970s, petroleum geologists considered it unlikely that interesting finds would be made in the sedimentary rocks in Svalbard.

At the same time profitable finds were made elsewhere, e.g. in the North Sea, and those areas became the focus of interest.

However, as petroleum activities have been moving north and as geological knowledge has increased, Svalbard once again has begun to attract interest.

It is the aim of the Ministry of Petroleum and Energy to open up the Barents Sea North up to and including Bjørnøya for exploratory drilling in 1990. Detailed knowledge of the geology of Svalbard may then become very important in order to make a detailed ranking of priorities in the exploration fields. Large sums may be saved by optimum utilization of all available geological information.

Development and production of a field in Barents Sea North may involve construction of major bases on shore. The land areas of Svalbard will be well suited for this purpose.

In petroleum/gas quarters Svalbard is interesting for the following reasons:

- Possible hydrocarbon finds.
- "Laboratory" for the companies' geologists.
- Land area available for bases and shore installations for the Barents Sea developments.
- Svalbard has easy access. Accordingly research activities of a more technical character, testing of new equipment and methodology is a possibility. Such activities will presumably necessitate a degree of support provided by previously established infrastructure.

As the petroleum industry rates the prospects of economic finds to be good, they will probably find Svalbard to be interesting for a long period to come.

During the exploration phase the operations in Svalbard may be divided into separate activities:

a) Field work - sampling - securing of rights.

   The activity will be limited in scope, using portable equipment and a small number of personnel working over a large area. Apart from helicopter noise and possibly boat traffic, field work normally will not affect the environment.

b) Seismic surveys, documentation of rights, determination of drilling site.

   The seismic surveys carried out in Svalbard may be divided into:

1. Marine seismic surveys:

Marine seismic surveys have been undertaken in most fjords and nearshore coastal waters around Svalbard. The seismic surveys are carried out via special vessels and up to the present there has been no obligation to give notification to the authorities pursuant to the Environmental Protection Regulations. Accordingly the question of assigning environmental investigations has not yet arisen. If new information should indicate a greater impact on the marine environment than previously supposed, these findings may have an effect on MUPS. Unless significant finds are made, major marine seismic surveys are not expected within the Svalbard territorial waters (the 4 mile zone) in the future.

2. Onshore seismic surveys:

In the course of spring 1986, 425 km of seismic surveys were shot in Svalbard, including a total of 390 km on glaciers. Seismic surveys were also shot outside the glaciers, partly to refine the methods used, partly for research purposes.

1) On glaciers: Holes, 15-20 m deep, were drilled in the ice by means of simple drilling machines. Dynamite charges of 200-800 grams were detonated at a distance of 25-50 m. The reflected sound waves were detected by geophones and subsequently read into a computer.
2) A socalled "detonating fuse" has now replaced drilling. This methodology is ordinarily applied by drawing the fuse on the glacier surface, to be subsequently detonated in charges of 1-4 kg distributed over a distance of 50 m. Data collection and processing correspond to method 1.

Up to the present seismic surveys have only been shot in winter conditions. Experience gained in Alaska indicates that seismic surveys on frozen ground do not have a permanent effect, while work performed in the summer season may result in longlasting damage (e.g. wheel tracks).

3. Tundra seismic surveys:

The traditional method involves drilling with and detonating 200-1000 gram charges. As on glaciers, a detonating fuse may also be employed. A socalled snow streamer, i.e. a cable with built-in geophones, which is pulled after a belted vehicle, has been developed to replace some geophones.

To-date seismic surveys have been shot on tundra in Berzeliusdalen in 1986 and in Adventdalen, in the direction of Sassendalen, in 1985 and 1987. In Berzeliusdalen a detonating fuse in coils with wiring from 15-100 kg was discharged on top of the snow. A sound level of 80 dB was measured at a distance of 30 km from the detonation point. However, this methodology is not normally applied, and future onshore seismic surveys will probably employ the method described under item 2 above.

Onshore seismic surveys are characteristically carried out daily within a limited area and are based on the use of lightweight, mobile equipment. The extent of the impacted area will however be contingent on the distance between main base and study area.

The surveys carried out so far, have had their headquarters in the permanent settlements or on board ships, with temporary camps in the study area. The activity is continually on the move and has so far been based on helicopter support, in addition to heavier as well as lighter ground transport. The tables below provide an overview of the activity potentially involved in seismic shooting.

At the present the perspective on seismic surveys for the next years can be indicated as follows:

Agardh	-	approx. 100 km
Nordenskiøld Land	-	approx. 300 km
Edgeøya	-	cursory plans have been presented for seismic mapping of the claims around Tjuvfjorden

Seismic data in most cases provide necessary background information before possible drilling. Seismic surveys may however also be relevant after the completion of test drilling, in which case it assumes the character of a detailed study.

a)

	Number of persons	Number of detonations	Number of kg explosives	Km total prod
STATOIL	40-50	3,400	4,400	85
BP	100	8,000	8,600	310
ADC	5	660	11,500	30
SNSK/HYDRO	12	800	3,200	40

b)

	Number of persons	Number of detonations	Number of kg explosives	Km total prod
SNSK/HYDRO	24	8,000	24,000	300

Table 1.
Table detailing experience from seismic surveys 1986 and 1987 (a).
Project figures for 1988 (b).

	Snow scooter		Helicopter		Belted vehicles	
	no.	km	no.	flight hours	no.	km
STATOIL	15	18,000	3	316	3	3,500
BP	40	210,000	2	345	4	8,000
ADC	15	15,600		40	1	5,000
SNSK/HYDRO	12	12,000	1	10	1	500

Table 2.
Transport carried out in connection with seismic surveys spring 1986 and 1987.

c) Exploration drilling, possibly deviated drilling:

Drilling activities can also be divided into several categories:

1. Onshore drilling; heavy or lightweight drilling rig.

Drilling equipment is heavy and will demand considerable logistic support in the form of transportation, installation, maintenance, utilization and eventually dismantling. The objective of the drilling is to determine the geological formations at certain depths and locations. Ideally the drilling site is situated vertically above the desired location, but deviated drilling enables selection of the drilling site. At the most relevant drilling depths in Svalbard (2,500-3,000 m) the drilling rig may be located several hundred meters to the side of the ideal location.

In Svalbard drilling can take place in four entirely different types of terrain:

- On the shore and right behind.
- In the valleys.
- In the more elevated mountain areas.
- On glaciers.

Each type of terrain has its particular characteristics. Common to all types is the need to carry out a maximum of equipment transport on frozen ground. The choice of equipment will depend on the means of transport available and to some extent on expected geological strata. A big rig will involve a greater need for transport, higher operation costs and greater manning than smaller rigs. A small rig (micro drill) will be preferred in so far as it satisfies the requirements of drilling engineering. Regardless of location, exploration drilling will comprise the following:

i. Choice of drilling site
ii. Determination of access road
iii. Arranging of drilling site
iv. Equipment transport
v. Installation
vi. Drilling
vii. Dismantling
viii. Rehabilitation

i. The choice of drilling site is made on the basis of geological surveying but consideration is also given to the type of local terrain and the possibility of deviated drilling.

ii. and iii. Access roads and preparations vary with different types of terrain.

iv., v., vi. and vii. The equipment required and the drilling operation as such are on the whole not dependent upon the various types of terrain. In addition to the drilling rig the equipment also includes drilling pipes, lining pipes, drilling mud, fuel etc. Store rooms, offices, recreation rooms and accommodation etc. are also necessary on site. Daily fuel consumption will be 5-6,000 litre, and water consumption for technical purposes 7-9,000 litres. A total of about 40 persons will be working at the drilling site. The activities will, in addition to the traffic involved with the replacement of personnel, also include other types of traffic while the actual drilling operation is taking place. All equipment for the entire drilling operation will be in place at start-up. For an ordinary drilling rig approx. 100 loads of equipment, each weighing about 40 tons, will be carried to the drilling site. When using a micro drill the demand for personnel and equipment will be considerably lower. Distance to the coast, type of terrain etc. will determine the mode of transport chosen (helicopter, sleigh etc.)

viii. Rehabilitation - dependent on terrain and local conditions.

Normally the actual drilling operation will go on for 3-4 months. Due to seasonal variations in conditions the entire operation may, from deciding upon drilling site till rehabilitation, last more than two years.

It is assumed that drilling crews will have little time for recreational activities.

Drilling will normally involve some pollution, and several waste products will have to be dealt with.

Pollution:

- Into air - diesel exhaust and other types of engine exhaust.
- Into water - some drilling mud and drilling fluid.

Waste:

- Sewage and waste discharge from a camp for 40 persons.
- Solid waste and garbage, wornout engine components.
- Lubricating oil.
- Drill cuttings, 200-250 m^3 for a 3,000 m deep well.
- At completed drilling - approx. 100 m^3 of used drilling mud.

Waste products that may pollute if burnt or deposited will be removed.
All food storage etc. must be specially protected against fox, birds and polar bear.

If finds are made, deviated drilling will be required to determine total volume, extraction etc. The need for this type of drilling will be the same as with exploration drilling even if deviated wells may also serve as future production wells. The question of more permanent installations may be brought up, even if no guarantees of production have yet been given.

Usually seismic surveys will be shot to determine drilling site. Onshore seismic surveys are however very expensive, and it may therefore be an alternative to start drilling directly.

Drilling with untraditional equipment and smalldiameter wells is being deliberated by the companies, and if costs can be cut, lightweight exploration drilling in campaigns will be preferred to conducting advance seismic surveys. This type of campaign may e.g. last for 1.5 to 2.5 years, in which period 10 - 15 wells could be drilled. Crews estimates are reduced to 10 - 15 persons at each drilling site at all times.

2. Offshore drilling; platform, drill ship, artificial island.

Offshore drilling can be carried out from a floating platform, jack-up platform, drilling ship or artificial island. Platforms and drilling ships have equipment on board and all required supplies for consumption will be provided from an onshore base. Most likely this kind of base will be located at an existing installation.

Due to the risk of such things as sea ice, drilling ships with dynamic positioning will be preferred. Constructing artificial islands for drilling can only be an alternative in very shallow parts of the fjord. In such cases drilling will have to comply with the same requirements as drilling on the shore.

All drilling activities will be regulated through permits, contingency plans etc. provided by the Ministry of the Environment. It will also be vitally important to ensure that drilling personnel are well trained and motivated to comply with the regulations currently in force.

4.4 Area relevant for petroleum drilling in Svalbard

Four areas have till now seemed to indicate particular relevance for petroleum activity:

1. Isfjorden and Van Mijenfjorden, land areas to the east in the direction of Storfjorden. The first drilling in Svalbard was carried out by Van Mijenfjorden (1965). The greater part of this land area, as well as Van Mijenfjorden, has already been claimed and continuous exploration activity in this area during the next decade seems likely. Drilling is in process at one site. No claims have yet been allocated in Isfjorden, and accordingly there is hardly likely to be any expansion of the activity in the course of the 3 - 4 years to come. On shore an increase is expected in 1989 in the western areas, and further east in 1990.

2. The areas to the east and west of Van Mijenfjorden. Claims have not yet been allocated in the relevant areas. Continued exploration activity will not be in question until 3 - 4 years hence.
3. Edgeøya and the areas to the east. Several exploration wells were drilled in the early 70s, but parts of the claimed areas have later been abandoned, which presumably reflects a negative total evaluation. It is assumed that drilling on the claims left may provide valuable geological information. At the present stage it is hard to judge the possibilities of making finds.
4. Spitsbergen south. In a petroleum context this area is a "classic". Two wells have been drilled; the drilling of the latter was finished in 1988.

Edgeøya, along with the Hornsund area, is situated within the protected areas but the claims are not covered by the conservation regulations.

Seismic surveys have been carried out in Woodfjorden. The locations of discovery that have been notified in this area are however invalid, which should indicate that the area is considered to be of minor interest.

4.5 Recent petroleum activity and concrete plans

The activity during the last couple of years can be divided into three:

1. Regional prospecting and seismic surveys for the location of discoveries, possibly documentation of claims.
2. Concrete mapping (seismic surveys) on previously claimed structures.
3. Drillings.

The following companies have given notification of drilling start-up, or been involved in petroleum activities in Svalbard during the last two years:

Statoil has carried out regional marine seismic surveys in a great many of the fjords and coastal waters of Svalbard, and has been engaged in onshore seismic surveys on claimed structures at Grimfjellet in the Hornsund area in spring 1986. The company has given notification of regional seismic surveys in the area near Agardhbukta, and on drilling in Isfjorden, but these operations have been postponed.

BP carried out extensive regional seismic surveys in the mountain areas to the south and east of Rindersbukta at the head of Van Mijenfjorden in spring 1985 and 1986. In their original exploration programme BP had planned drilling if justified by the results of the seismic surveys. For the present it is uncertain whether these plans will be realized, and if so, when.

SNSK/Norsk Hydro have been carrying out regional seismic surveys in several of the fjords on the west coast of Spitsbergen and in Storfjorden. In spring 1986 these companies gave notification of extensive onshore seismic surveys in central parts of Nordenskiøld Land, but these were postponed. SNSK/Norsk Hydro have carried out seismic surveys in 1987-89.

Trust Arktikugol are presently drilling for petroleum in Vassdalen by Van Mijenfjorden. Further plans are not known.

Arctic Development Corporation has been carrying out marine seismic surveys in Van Mijenfjorden and onshore seismic surveys in Berzeliusdalen to the north of Van Mijenfjorden in spring 1986. The company notified on drilling in Berzeliusdalen in the summer of 1987. The claims in that area belong to Norwegian Polar Navigation. The drilling has not been effected.

All the above companies have made geological expeditions to Svalbard, of varying extent. Statoil has put in the greatest effort, with big ship and helicopter expeditions to Svalbard. BP and Nordisk Polarinvest have during the last two-three summers been carrying out geological field work.

In addition to these companies, ELF, Shell, ESSO, Saga and many minor companies have been employing geologists. NOPEC (a Norwegian firm of oil consultants) and IKU have in recent years been arranging excursions to Svalbard for the oil company geologists.

The oil companies will continue their geological field activity in the years to come.

4.6 Petroleum activity towards 1995?

Predicting future petroleum activity in Svalbard is difficult. The development is contingent on petroleum prices and of the potential discovery of economic finds. With increased prices or economic finds the activity will assume an entirely different character. The exploration activity will become far more intensive, and there will be large permanent installations with a great number of employees in the operation period, which may extend over several decades.

When evaluating the future development it is natural to start from the available plans for petroleum activities in Svalbard. In addition we will have to include the activities in the Barents Sea that may affect the archipelago.

Estimated activities ahead:

1988: Drilling near Haketangen (Tromsøbreen 3) and continued drilling in Vassdalen. Regional seismic surveys in the eastern parts of Nordenskiøld Land.

1989: Termination Tromsøbreen 3. Possible drilling on Nordenskiøld Land with lightweight equipment. Detailed seismic surveys on Nordenskiøld Land. Continued drilling in Vassdalen. Claims have been requested on Heer Land.

1990: If results are positive: Deviated drilling on Nordenskiøld Land and designing of production strategies. Seismic surveys near Haketangen, Kvalvågen and Agardh. If results are negative in 88/89 the activity may be spread, e.g. to Heer Land. Claims are requested in Agardh and Isfjorden.

1991/92: If claims are allocated, drilling may be relevant in the area to the east of Nordenskiøld Land and/or in the western fjord areas. Later in the period: possible start of production if finds are made near existing infrastructure.

1993/94: Deviated drilling if a positive result is reached in '92. Possible mobilization of equipment for extended drilling in other areas.

1995: Exploration drilling to the north of Bjørnøya. (Cf. the plans of the Ministry of Petroleum and Energy (OED) as to opening these areas). These plans may be advanced.

Possibly continued drillings in Isfjorden, Storfjorden, probably also on Edgeøya. The decision concerning the construction of production installations will be made pending a positive result in '93. Possible starting up of production in the south if there is a positive outcome in '88/'89.

1998: Production startup if finds are made in 1992/93.

The seismic surveying activities in Svalbard are likely to be concluded in the course of a period of 3-5 years. If the implemented drillings do not yield results, the petroleum activities in Svalbard will be terminated in the course of 8 years.

Most likely the permanent settlements, hutted camps or ships will serve as bases during the exploration phase. Production may however involve large permanent installations, petroleum/gas line(s) or roads for tank trucks over land to the coast. The construction of pier installations and terminals along the coast will be determined by the location of the finds. It is assumed that existing settlements (Longyearbyen, Svea) will, if possible, be used for such development. A productiondirected development may involve major road construction, production towers, roads, lines, petroleum/gas storage installations, pier installations etc. and accordingly be very spaceconsuming.

For gas as well as for oil finds, building pipelines in tunnels, and possibly parts of the processing/storage installations in rock, may turn out to be viable alternatives. If existing settlements are found to be unsuitable, the building of minor settlements might reasonably be expected. During the construction phase the maritime traffic will be relatively frequent. During the operational period there will be a smaller number of ship arrivals per season, obviously depending on the duration of the season, storage capacity, port conditions and the size of the find. Extensive use of helicopters and terrain vehicles is expected on development.

No public evaluation is available concerning a minimum development concept. Based on a number of factors, including port conditions, extension of glaciers, topography and sea ice, it seems evident that the area of Isfjorden - Nordenskiøld Land will be far easier to develop than other areas. Thus less will be required in terms of resource basis as well as technical solutions.

With the use of seagoing icebreakers and modern ice forecasting Hornsund, Van Mijenfjorden and Isfjorden should all be suited as year-round-operating ports. It is however not granted that shipping will be on a year-round basis.

In the event of exploration drilling to the far north of the Barents Sea South, the location of a base area on Bjørnøya may be considered. But floating bases in the sea to the north of Finnmark will probably be preferred, both for safety and for logistic reasons.

Floating bases will probably also be preferred for exploration drilling on the continental shelf still further north. If finds are made, and the activity becomes more permanent, the issue of bases may be assessed differently. Among the advantages of floating bases is a shorter and more direct transport to the mainland and a better utilization of investments if the exploration activity should not bring about the expected result. A primary drawback is the sensitivity to drift ice, but this problem will be even greater for other aspects of the activity.

4.7 Activities in the Barents Sea

The Ministry of Petroleum and Energy aims at opening the Barents Sea north to, and including, Bjørnøya (the area is termed the "Barents Sea South") for petroleum activity in 1989. The areas further north will possibly be opened towards year 2000. Extensive exploration activity is expected in this area in the course of the next 20 years. To maintain continued activity based in the northernmost areas of our country the authorities will open up the areas to the north of Finnmark as soon as possible.

Petroleum activity in the area of "Barents Sea South" will potentially affect Bjørnøya to a great extent. The remainder of Svalbard may be affected by oil spills from the south, but probably only to a small extent. An element of uncertainty is the drift ice, which may carry oil into the waters around Spitsbergen and Edgeøya.

5. USER GUIDE TO THE ASSESSMENT SYSTEM

5.1 Background

According to the environmental conservation regulations, companies wishing to operate in Svalbard must notify the Sysselmann (Governor) at least one year before desired production start-up. This notification should state potential environmental impacts, which implies that the companies should make an impact assessment already at the planning stage of a new development.

The companies' impact assessments will be preliminary: It is the responsibility of the authorities to ensure that the expected impact of proposed activities are subjected to professional assessment. Ideally the companies should be able to carry out impact assessments that are sound enough to meet the requirements when the authorities are notified.

The system presented here provides an important basis for preparing impact assessments concerning industrial activity in Svalbard. Instructions in its use follow below.

5.2 User guide in key word form

1. Describe the development (details, location, number, quantities etc.)
2. Find, by means of ecological charts or relevant literature,which VECs will, in one way or another, be affected by the development.
3. Use the schematic flow charts to find out how each VEC is affected. This must include the seasonal variations of the VEC incidences.
4. Use the VEC documentation to inventory the impact hypotheses (IHs) to be selected as the most relevant, based on the flow charts.
5. In addition, inventory the projects (all priorities) connected with the impact hypotheses. These are projects to which the companies may have to contribute. The Ministry of the Environment will make the final decision as to which investigations should be made.

5.3 Details of the procedure

The activities outlined above may be carried out in various ways. Below is a proposal for a mainly "manual" method which may also give an indication of the accuracy required. Notice that months are used as the unit of time, and that a commenced month is considered as a full month.

1. Describe the development.

The developments are defined as:

a) Occupying space (houses/installations, roads and levelled areas).
b) Traffic (helicopters, aircraft, terrain vehicles/tractors, cars, pedestrians, small boats, ships).
c) Disturbances (sounds, visual impressions, smells).
d) Pollution (gases, fluids and solid substances (chemical composition to be declared)).
e) Dumping of waste (household waste and nontoxic waste).

Localize the activities (developments) on maps on the scale of 1:100,000:

a) Trace the location of houses, roads, installations etc. State the period when built.
b) Trace trafficked areas, i.e. transport routes and areas in which people and vehicles will move. State the period of traffic/transport activity.
c) Trace areas that will contain polluting substances (gases, solutions and solid substances).
d) Prepare a report to be enclosed with the maps. The report should describe the quantities connected with items a) - c) above.

2. Map the VEC incidence for all areas delimited under item 1.

This mapping primarily involves research of literature, and it is important that the data references are specified for each VEC. If no usable values are found in the relevant literature, field studies must be initiated. The incidence of each VEC is to be stated for each month.

3. Make an impact assessment (by using the schematic flow charts) for each VEC recorded under item 2.

This work involves intensive use of the schematic flow charts in the assessment system. A reasonable "manual" way of doing it is to make use of a table (calculation sheet/spreadsheet) with e.g. the VECs listed on top and the specified developments vertically, so that each VEC will represent one column and each development will represent one line of the table. 12 copies are made of the table, i.e. one for each month. Conclusions are reached by tracing the relationships between development and VEC (use the schematic flow charts) and by using the accompanying documentation for evaluating the impacts. This process also implies an "activation" or inventory of impact hypotheses (IHs).

4. Make a separate list of impact hypotheses.

It may be sensible to sum up the conclusions for each month in a table (no. 13) and provide a short statement for the result in each place in the table. The statement will naturally contain a list of all relevant impact hypotheses, and must include literature notes and specifications of missing data or information.

For the mammal and bird VECs the conclusions in table no. 13 should include the results of a prognosis for the development of the relevant populations. It is of course essential to provide a proper description of the calculation method as well as the basic material used.

5. Describe the need for projects (mapping, monitoring and research) connected with the activity.

This description follows naturally after the work carried out under item 4 and will accordingly not be further referred to here.

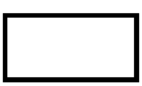
6. MUPS ASSESSMENT SYSTEM VERSION 2

6.1 Summary

The assessment system consists of 14 Valued Ecosystem Components (VECs). A schema flow chart indicating the influence of abiotic, biotic and human factors has been prepared f each VEC. A more detailed description of the VEC is also found in a backgrou documentation. A total of 76 Impact Hypotheses (IHs), i.e. hypotheses indicating t potential impact on the VECs of oil and related activities in Svalbard, have been selected the basis of the flow charts. Ten of the IHs were considered to be invalid, 22 we considered to be potentially valid, but of minor significance, 19 have already be documented to be valid, while 25 were considered to be probably valid. Out of the 76 IH 37 were regarded to be important enough to be included in the assessment system. The will be more specifically referred to in this chapter, together with their respective VECs, a mutually ranked by priority, merely 18 being given top priority. Fiftysix projects have be proposed in connection with the IHs included in the assessment system, some of whi overlap and some are mutually exclusive. Within each VEC mainly one IH and one proje have been given top priority.

Concerning the VEC of Protected Areas, nothing has been prepared in the form of imp hypotheses or project proposals, as encroachments upon this VEC will be covered throu other VECs. In connection with the VEC of Marine Biological Resources a chart has be drawn of the positions of all the marine VECs in the marine food chain.

Four different symbols are used in the schematic flow charts:



IMPACT OF ENCROACHMENT

VALUED ECOSYSTEM COMPONENT - VEC

SYSTEM COMPONENT
Natural factor of importance to the VEC

LINKAGE
Indicating the direction of the impact

6.2 VEC 1

SVALBARD REINDEER

LINKAGES

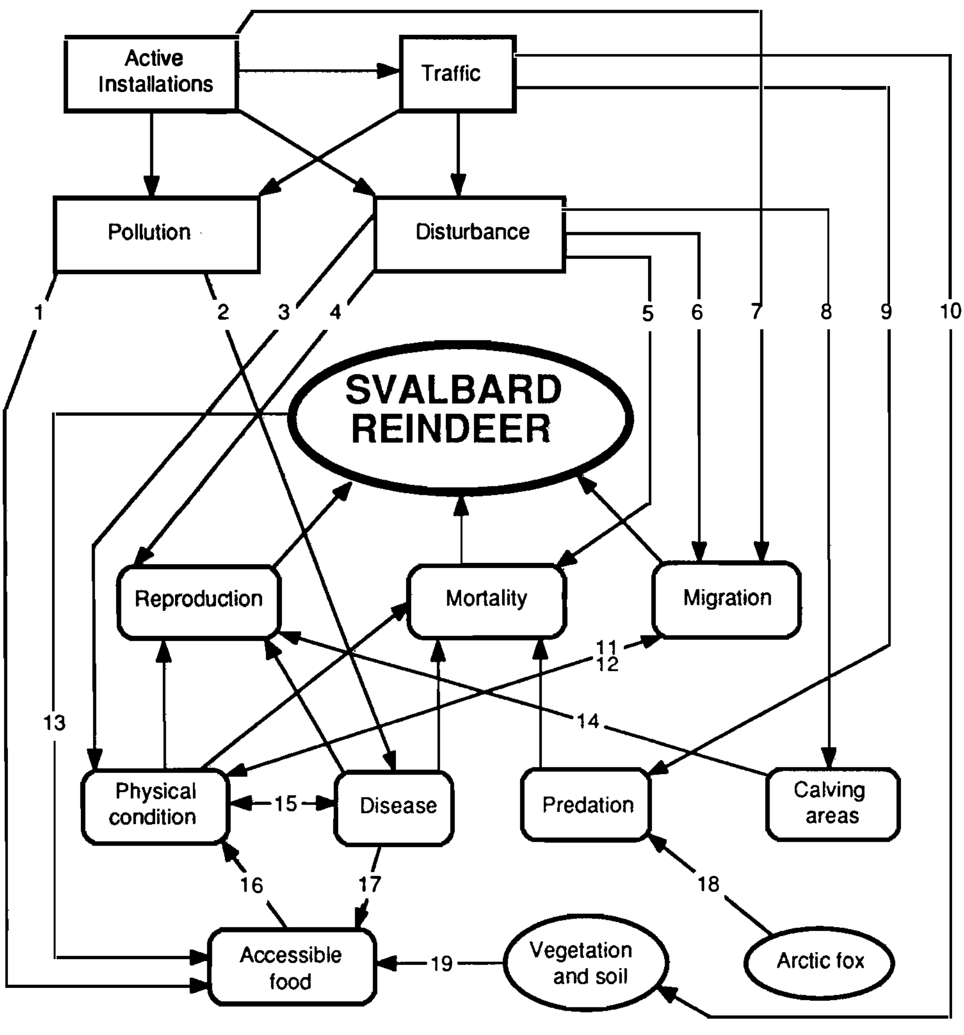
Self-explanatory linkages have not been described

VEC 1 SVALBARD REINDEER

1. Pollution can affect the quality of grazing ranges.
2. Direct uptake of toxic pollutants can cause disease.
3. Disturbances will cause an increase in flightinduced energy expenditure, and accordingly impaired condition.
4. Disturbances can cause reduced reproduction because of abortions or resorption.
5. Disturbances can directly cause increased mortality, by estranging female and calf, and by subjecting starving animals to stress during the spring months.
6. Disturbances result in migrations.
7. Installations like pipeline corridors, roads etc. can affect the migration pattern of the reindeer.
8. Disturbances in calving habitats during the calving period can cause reduced calf survival, and, in the long term, reduced use of the area.
9. Traffic can lead to increased mortality due to hunting.
10. Traffic will influence the productivity of the grazing range by wear, erosion etc., and the availability by an altered melting/packing of the snow layer.
11. Migration requires energy and will impair the physical condition.
12. An impaired physical condition resulting from insufficient food availability can result in migration to new living areas.
13. The grazing pressure will affect available vegetation.
14. The number of calving areas and their size will affect reproductive success.
15. Impaired physical condition will increase susceptibility to disease. Disease will impair physical condition.
16. The physical condition is mainly contingent on the availability of vegetation.
17. Disease will reduce food intake capacity.
18. Fox will hunt for young calves.
19. Weather conditions and topography will determine what fraction of the potential grazing range is available grazing range.

SCHEMATIC FLOW CHART

VEC 1 SVALBARD REINDEER



6.2.1. Background

The Svalbard reindeer (Rangifer tarandus platyrhynchus) holds a unique position, being the only plant-eating mammal on the archipelago. Presumably through a long period of isolation it has developed into a separate race, to be found nowhere else (Staaland & Røed 1985). The population differs from continental reindeer by the display of special adjustments to a High Arctic environment mainly without predators. Its fur has excellent insulative properties, it is especially adapted for fat deposition, has short legs and a small relative body surface, it is a food generalist, and has a sedentary lifestyle.

Thanks to the preservation regulations the population of reindeer has risen from a minimum of about 1,000 animals around 1925 to the present number of 10-12,000. The Svalbard reindeer occur in more or less discrete local populations, about half of which are found on Nordenskiøld Land, around 3,000 on Edgeøya, Barentsøya and Nordaustlandet, and probably around 1,000 on Northwestern Spitsbergen (Øritsland & Alendal 1985).

In transplantation experiments reindeer have proved to thrive in new areas (Øritsland in prep.), but apparently they seldom migrate. There still are areas in Svalbard with apparently good grazing range and which should be accessible to reindeer, but where there are None. (Øritsland & Alendal 1985). On the other hand, reindeer are found on Svenskøya, nearly 100 kms across the sea to the east of Edgeøya.

The reindeer lives in open valleys, on covered beaches and plateaus. It eats most plants, and differs from e.g. the continental reindeer by feeding a great deal on moss (Staaland 1985). It is assumed that available grazing range rather than the total potential grazing range is the nutritional minimum factor. In seasons with a great deal of icecovered grazing range the mortality of yearlings can approach 100%, few new calves are born and survive, and there is also a great mortality in the adult population (Tyler 1987a).

In the summer season the animals graze in the bottom of lush valleys and on beaches, males and females/calves normally occurring in separate flocks (Tyler 1987a). In the autumn, towards the mating season, the males seek the female flocks to form harems, which are dissolved in the winter when the mating season is over.

As the bottom of the valleys are being covered by snow the animals migrate to higher altitudes, and in late winter particularly the males may be seen on exposed ridges and plateaus. Calving time (May-June) approaching, pregnant females, and later on barren females and males, will migrate down to the lowlands again. The females are less inclined to gather in common calving habitats than is the case with continental reindeer (Tyler 1987a).

In the course of the summer season the Svalbard reindeer accumulates layers of fat constituting up to 30% of its total body weight (Nilssen et al. 1984a). Throughout the winter it consumes this fat, after which it survives on its muscle mass and digestive system. Total weight loss may reach 41-55% (Reimers & Ringberg 1983). All the same about 3/5 of the animals' maintenance energy throughout this period has to be supplied by grazing. Towards the end of the winter many animals are close to starvation, and in addition 70-80% of the foetal growth of pregnant females takes place during these months.

Insulation against cold seldom represents a problem to the Svalbard reindeer. Decisive to the energy expenditure is the degree of motion (Nilssen et al. 1984b). The Svalbard reindeer normally only runs 5 - 6% of the time (Kastnes 1979), but the running makes up 20 - 25% of its total energy expenditure (Nilssen et al. 1984b)

The vulnerability of the Svalbard reindeer is primarily connected with:

— disturbances, particularly in late winter and in the calving season
— reduced access to grazing range
— closing of migration routes
— pollution of grazing ranges

6.2.2 The impact hypotheses

Six hypotheses concerning the potential impact of development activities on the Svalbard reindeer population were evaluated. Four hypotheses (IHs 3, 4, 5 and 6 - see chapter 8) were considered to be potentially valid, and a number of possible measures and studies were discussed. However, None. of these have been given priority in this version of the assessment system. Two hypotheses, (IHs 1 and 2) were however considered to be valid and more deserving of follow-up in the form of studies, monitoring and/or research. The impact hypotheses have been listed in classified priorities (A, B).

A.

IH 1
Disturbances and traffic will cause increased energy expenditure and reduced grazing time, and accordingly reduced survival and calf production in the affected local populations of Svalbard reindeer.

Petroleum related and other industrial activities will directly and indirectly imply a substantial amount of motorized traffic. In addition to the Soviet drilling operations, some seismic surveys have been shot on Nordenskiøld Land, and more is being planned (Tyler 1987a). This involves a relatively great amount of traffic consisting of snow scooters and helicopters in the spring months (Prestrud & Øritsland 1987). This activity adds to the already heavy and increasing motorized traffic of the local population, authorities and researchers in the same area and during the same period of time (Persen 1986).

In Alaska and Arctic Canada a number of studies have been made on the impact of disturbances and motorized traffic on caribou. The results varied in different studies. While Surrendi & deBock (1976), Tracy (1977) and Russel & Martell (1985) found that little or no impact was caused, Dau & Miller (1985) and Smith et al. (1985) have shown that, since the building of the Dempster Highway, caribou no longer crossed to get to less insectinfested areas, which they had done before the road was built. Surrendi & deBock (1976), Gunn & Miller (1980), Horjesi (1981) and Russel & Martell (1985) have demonstrated that caribou often flee from the disturbance caused by motorized traffic, and that females with calf are the most easily disturbed.

Seasons, races and environmental conditions will however determine the relative significance of the reaction. Many North American studies have been made in the summer and conclude that the disturbances only affect the animals minimally. Meanwhile, such conclusions cannot, however, be directly transferred to the Svalbard reindeer; the caribou is far better adapted to running, and the summer is a season of food and energy abundance.

Late winter and the calving season are the periods in which the Svalbard reindeer presumably is most sensitive to disturbance. In late winter (April-May) most animals are starving, and only a small increase in energy expenditure may probably be fatal or cause abortion (Nilssen et al. 1984 b). Around the calving season the females are shy, and disturbances in this period may have a negative effect on calf survival (Skogland 1978).

Conditions in Longyearbyen, Adventdalen and the areas around Svea would indicate that Svalbard reindeer can, to a great degree, adapt to motorized traffic. In areas in which the reindeer is unused to traffic, its reactions appear to be more pronounced. No scientific studies have been made on these effects, and for the time being we cannot exclude that animals with seemingly minimal reactions may experience negative effects, such as loss of grazing time, stress etc.

B.

IH 2 Physical encroachments and installations will obstruct the movements of the Svalbard reindeer and may accordingly impede access to grazing and calving areas.

Seismic explorations have been, and still are, the dominating form of industrial activity in the reindeer habitats in Svalbard. In addition, the Soviets terminated a drilling operation at the mouth of Vassdalen in 1987, and have started another at the same site. In connection with this operation there are winter driving routes to Barentsburg and to ponds at the mouth of Reindalen. Norwegian and other seismic surveys and drilling operations are being carried out at other sites on Nordenskiøld Land, with thereto extended transport routes. Commercial finds will entail a demand for roads, larger installations and possibly pipelines.

Seismic exploration activities take place without permanent installations, in the course of a short period of time and usually in areas with only few reindeer (Tyler 1987a). On test drilling the rig site will be an acre or two. Winter routes for other types of transport will also most often pass through areas with few reindeer at this time of the year, but may possibly cut off migration routes in the spring. Conflicts may also be imagined in the polar night, before the reindeer start their migration to higher altitudes (Tyler 1987a). Roads will most likely be located in lowlying areas, i.e. in areas in which the bulk of the reindeer will stay in the summer. In the event of production, rig sites, roads, pipelines and shipping ports will probably occupy areas of considerable size locally, and form a long, consecutive linear extension that may act as a barrier against reindeer.

In his literature study, Klein (1980) concludes that roads, railways, pipelines and similar installations can block or alter the migration routes of reindeer/caribou. He points to the importance of such factors as the location chosen for the installation, and in addition he stresses such factors as connected traffic and period of use. Different reactions may also be expected in the various sex and age groupings, and behavioural differences have been recorded between the different subspecies. Reindeer/caribou appear to adapt more easily to installations in areas in which they stay a lot, than is the case in areas they seldom pass through.

In a study of the impact of the Trans Alaska Pipeline corridor on the distribution of caribou, Cameron & Whitten (1980) found that particularly females with calf, but also other caribou, generally avoided the areas close to the pipeline.

Except during the production phase, the physical area potentially occupied by the production facilities will hardly be significant for the access to feeding areas. The effect of occupying areas has not been studied in Svalbard, but the situation in Longyearbyen would indicate that reindeer can adapt to installations of considerable size. It must however be added that we do not know what the situation would have been like without today's installations, nor do we know how long it took for the reindeer to adapt to the conditions. In calving areas sought by many females, like the outer part of Reindalen (Skogland 1985) and the inner part of Adventdalen (Tyler 1987a), the occupation of areas may however possibly have a directly negative effect.

6.2.3 Recommended measures and studies

The following studies should be carried out in connection with developments potentially having the impacts referred to in IHs 1 and 2. The investigations are listed in classified priorities (I-III etc.).

The implementation of new investigations and literature studies, in part initiated on account of the MUPS programme (Tyler 1987 a and b), now make II and III somewhat less relevant than was the case when this version of the assessment system was under preparation.

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

Mapping of seasonal habitats and migratory patterns in areas relevant for development projects with a view to age, sex, physical condition and season. The mapping should be carried out before development activities are started. The project area, as well as an unaffected control site, should be monitored for the same parameters during the implementation of the development project.

Objective: Check whether certain segments of the relevant local population, certain areas and/or certain periods are vulnerable to disturbance from the development, in order to minimize projectinduced impacts.

Method: Live capture. Determination of age and condition. Telemetry. Recording of area use and migratory pattern, in the project area and the control site.

II. (To be implemented in connection with IH 1)

The effect of disturbance on reindeer, when considering age, sex, physical condition and season, and with a view to long-term effects.

Objective: Decide whether/to what extent Svalbard reindeer are affected by measurable impacts of disturbance.

Method: Behaviour should be recorded and heart and breathing frequency (physiological telemetry) measured in field and laboratory by known (quantified) stimuli.

III. (To be implemented in connection with IH 2)

The impact of physical obstacles on reindeer, with a view to age, sex, physical condition and season, and with a view to long-term area use.

Objective: Decide whether/to what extent physical obstacles alter reindeer area use.

Method:

a) Experimentally or in connection with existing or new installation (potential obstacles) record behaviour near the obstacle. Telemetry and observation.
b) Record area use before and after the building of the obstacle. Telemetry and observation/counting.

6.2.4 Literature

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6.3 VEC 2

ARCTIC FOX

LINKAGES

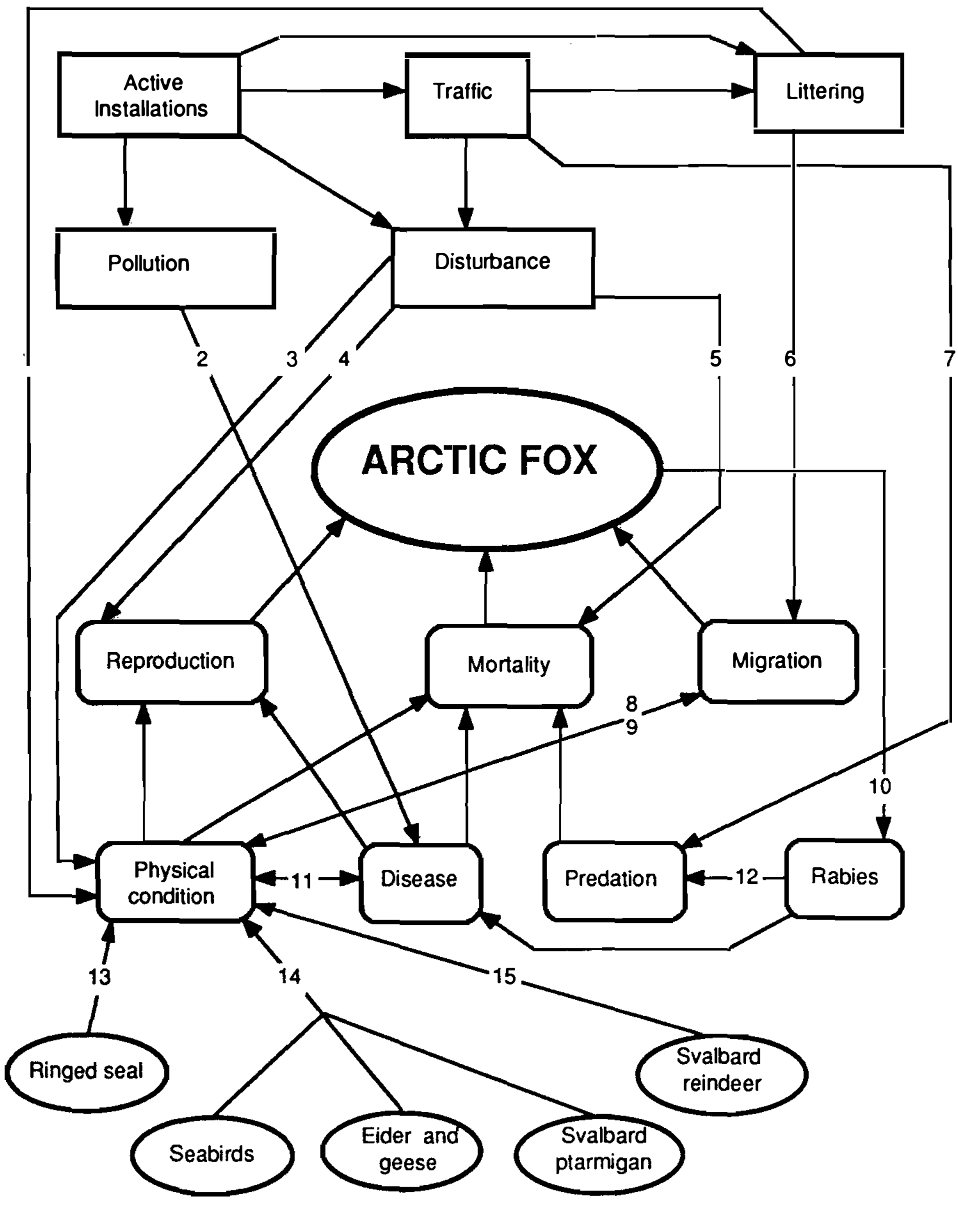
Self-explanatory linkages have not been described

VEC 2 ARCTIC FOX

1. Increased food availability due to waste can improve physical condition.
2. Pollution can cause disease by foxes taking oil-injured birds or otherwise ingesting toxic waste.
3. Disturbances can increase energy expenditure and thereby reduce physical condition.
4. Disturbances can cause spontaneous abortions and thereby affect reproduction.
5. Disturbances can result in mortality in the form of whelp killing.
6. Food waste can attract fox from other areas.
7. Increased human traffic can result in an increase in hunting pressure.
8. Impaired physical condition resulting from reduced food availability can result in migration to other areas.
9. Migrations demand energy and will therefore affect physical condition negatively.
10. Increased population density can cause an increased rate of rabies infection.
11. Impaired physical condition will increase disease susceptibility. Disease impairs physical condition.
12. Fear of rabies can result in an increased number of fox killings.
13. Seal is an important source of food. Ringed seal pups are caught in lairs in the spring. Remainders of seal caught by polar bear are a source of food throughout the year.
14. Eggs and chicks of sea-birds, eiders, and to some extent geese, are the most important food source in the summer. Ptarmigan is a year-round prey.
15. Reindeer carcasses are an important food source in winter and spring. Young reindeer calves can be a source of food in spring/early summer.

SCHEMATIC FLOW CHART

VEC 2 ARTIC FOX



6.3.1 Background

The arctic fox (Alopex lagopus), along with the Svalbard reindeer, is the only indigenous terrestrial mammal in Svalbard. Its distribution covers the entire archipelago but it is probably most abundant along the west coast of Spitsbergen. Food availability is decisive to its choice of habitat, and to density. No population estimates have been carried out, but there is every indication that the population is numerous. In an area covering 600 square kilometres on Nordenskiøld Land there are for instance around 10-15 maternity dens each summer. The late summer/autumn population in this area is estimated at 100-150 individuals (Prestrud unpublished data). About 10 active hunters in Svalbard catch around 200 fox per year.

The arctic fox is normally a solitary territorial species (Hersteinson & Macdonald 1982, Eberhardt et al. 1982). A male can have one or several bitches within his territory but will normally only mate with one. This social system is likely to be found with the Svalbard population as well, but whether it is maintained throughout the year is uncertain. In Svalbard the dens are often made in screes near bird cliffs or up on the hillsides. A few lairs have been excavated in sediment. Sediment lairs appear to be predominant in other parts of the arctic fox distribution area (Macpherson 1969, Chesemore 1969, Garrott & Hanson 1983).

With regard to diet, the arctic fox is a typical opportunist and generalist (Macpherson 1969, Speller 1972) - taking what is available. In Svalbard its summer diet is mainly sea birds and eiders/geese. Throughout the autumn food availability will decrease drastically, and in the winter the arctic fox will only prey on reindeer and ptarmigan. Some fox follow polar bears and live on seal kills left by them, but the significance of this food source to the fox population in Svalbard is uncertain. In the winter there are few bears on the west coast of Svalbard. In the course of spring the availability of prey is once more on the increase; for instance ringed seal pups are important animals of prey (Smith 1976). The Svalbard arctic fox has adapted to this extreme variation in food availability by an extensive degree of hoarding, body fat deposition and probably also reduced activity/metabolism in the winter season (Prestrud 1982).

The quantity of food available is normally the factor determining population size. More cubs survive the den period when food is abundant than when it is scarce. Besides, more bitches have cubs in years of food abundance (i.e. the territories become smaller) (Macpherson 1969). The winter food supply determines the number of individuals surviving till the next reproductive season. The reproductive potential of the arctic fox is very high. The average number of scars produced by foetus in the uterus of foxes caught in Canada was e.g. 10.6 (Macpherson 1969). This implies that the population may increase swiftly with favourable factors regulating cub survival and the number of reproductive bitches. This is clearly seen in areas in which small rodents make up a substantial part of the diet of the arctic fox. The variations of the regular populations are here closely connected to the well-known small rodent cycle (Braestrup 1941, Smirnov 1967, Macpherson 1969, Speller 1972, Østby et al. 1978).

It is reasonable to expect that the food supply is decisive to the size of the Svalbard arctic fox population as well. Even if small rodents are scarcely found here, there are indications of irregular variations in density that must be attributed to varying food supply. One single food factor is hardly the cause of these variations in density, as is seen with populations living on small rodents. We do however not know about the relative significance of the food factors.

The arctic fox is a both a carrion eater and a top predator in the Svalbard ecosystem. An opportunist and a generalist, it probably has local effects on several of the bird and mammal populations in Svalbard. In particular this applies to geese, eiders, sea birds and ringed seals (see Smith 1976). The other mammals may also be affected, as the arctic fox is the main carrier of the rabies virus (in Svalbard rabies has been proven in both ringed seals and reindeer). This fact also makes the arctic fox a potential threat to the local residents. In addition, the arctic fox is an important species to people hunting in Svalbard, and it is essential to the small number of hunters that still make a living from nature on the archipelago.

6.3.2 The impact hypotheses

Seven hypotheses concerning the potential impact of development activities on the Svalbard arctic fox were evaluated. One hypothesis (IH 13) was considered to be valid. Two hypotheses (IHs 11 and 12) were considered as potentially valid, while one hypothesis (IH 10) is documented as valid. Some management and monitoring measures have been discussed for these hypotheses (chapter 8), but None. of them have been given priority in the assessment system. Three hypotheses (IHs 7, 8 and 9) were considered to be valid and important to study with surveying, monitoring and research. The hypotheses have been listed in classified priorities (A-C).

A.

IH 7 Waste resulting from traffic and installations causes increased immigration and reproduction, and thus increased local population of arctic fox.

The arctic fox is a food opportunist and will feed on waste from human activity. Edible waste is particularly important in the winter, as the food available at this time of year will decide what number will survive and reproduce during the next summer. An area with plenty of edible waste may also be visited by fox from nearby areas, and the result will accordingly be an increase in the local fox population.

In connection with the development of the Prudhoe Bay petroleum fields, impact studies were carried out on the arctic fox population. Eberhardt et al. (1982) and Eberhardt et al. (1983) concluded that edible waste from these installations sustained a large population in the winter. There was also a greater number of dens, and the litters were bigger in the Prudhoe Bay area than in the adjoining areas. Neither were population variations resulting from the small rodent cycle as pronounced in Prudhoe Bay as in other areas, the food supply being far more constant.

In the same manner, extra food from the permanent settlements on Nordenskiøld Land probably sustains a larger population of foxes in this area than is the case elsewhere in Svalbard (Prestrud unpublished data).

An increased arctic fox population in Svalbard may locally have serious effects on geese and eiders, in certain cases also on sea birds and ringed seal. An essential increase in the population may shift the balance in parts of the ecosystem in Svalbard. There is incidentally a similar situation on the mainland, where the common fox (Vulpes vulpes) has profited by an increase of food in the form of household waste, with subsequent negative effects on the common fox's traditional populations of prey.

B.

IH 8
Increased population of arctic fox as a result of industrial activities will increase the risk of transference of the rabies virus.

Rabies has been indicated in the arctic fox population in Svalbard. The documentation of IH 7 shows a real possibility of an increase in arctic fox population should the supply of edible waste from human activities increase. Rausch (1958), Crandell (1975) and Wamberg (1960) demonstrated that rabies outbreaks in Arctic regions have coincided with peaks in the fox population. Syuzyumova (1967) collected rabies samples from more that 2000 foxes in the course of several years and demonstrated a far higher incidence of rabies virus (75%) in the year when the population peaked than in the year when it reached the bottom low (6%). These data indicate a connection between the number of rabies cases and a large fox population.

An increase in the fox population in Svalbard resulting from an increased supply of edible waste may accordingly provide an increased possibility of contact between humans and rabies contaminated foxes because:

— the rabies frequency may increase,
— the numbers of foxes in populated areas are increasing.

C.

IH 9
Pollution resulting from oil spills can cause increased mortality in local arctic fox populations as a result of poisoning and reduced insulation against cold.

The biological production of the marine environment contributes to a substantial degree to sustaining a high arctic fox population in Svalbard. Several authors have stressed the importance of the marine production to fox with coastal habitats

(Braestrup 1941, Murie 1959, West & Rudd 1983). In the summer sea birds are probably the most important prey of the arctic fox. It is assumed that large quantities of sea birds are hoarded, to be eaten throughout the autumn and winter. All through the year it is common for the fox to patrol the shore searching for food.

It is unlikely that an onshore oil spill will have a serious impact on the arctic fox in Svalbard. An oil spill affecting the coast may however be assumed to have effect on local fox populations as:

— the fox may be poisoned when eating oil-injured birds or seals,
— fouling by oil of the fur may reduce its insulating properties, cause skin irritation and thus cause increased energy expenditure.

We know of no studies directly demonstrating that arctic foxes are injured by oil spills, but all studies on other arctic mammals conclude that oil is very harmful both if ingested or if fouling of fur/skin occurs. Pending further research on this aspect, there is accordingly reason to believe that this applies to arctic fox as well.

An oil spill will hardly have lasting effects on the Svalbard fox population, the restitution period being short because of the high reproduction potential, and because only relatively limited areas can be affected by oil spills.

6.3.3 Recommended measures and studies

The following studies can be implemented in connection with developments potentially having the effects described in IHs 7, 8 and 9. The studies have been listed in classified priorities (I III).

Ia. (To be implemented in connection with IH 7):

Study concerning density variations in the arctic fox population in an area under development. The development project should be relatively extensive in character and last for a minimum of 2 years.

Objective: Find out whether activities will affect the fox population locally, to be able to predict corresponding impacts in other development projects and model the activity in order to minimize the impact.

Method: Lair counts, registration of litter size and territories, tagging and radio telemetry before, during and after development. Corresponding investigations will probably have to be made in a control site.

Ib. (To be implemented in connection with IH 7):

Recording of the frequency of fox visits to the relevant locations of development, before, during and after the implementation of a development project. (May be carried out as part of a pre-project).

Objective: To find out whether foxes will change their area in connection with developments.

Method: Counting by observations and/or automatic counters.

II. (To be implemented in connection with IH 8):

As for Ia, the aim is to find whether the fox population is increasing in connection with human activity. Check the potential connection between rabies outbreaks and variations in the fox population.

Objective: Gain more information on the relationship between rabies outbreaks and the density of the fox population.

Method: Routine rabies analyses (examination of brain tissue) from all foxes killed by trapping etc., combined with population data. Recording of life cycle and modes of infection of the rabies virus in arctic fox.

IIIa. (To be implemented in connection with IH 9):

Registration of oil damage to fox fur in areas affected by oil spills.

Objective: To find the extent to which foxes actually are exposed to oil spills occurring in their environment.

Method: Routine examination of all furs from foxes caught by hunters or in separate hunting programmes in the relevant area.

IIIb. (To be implemented in connection with IH 9):

Study of fox behaviour in relation to oil spills and food soiled by oil.

Objective: To find out whether foxes actively avoid oil spills and food contaminated by oil.

Method: Observations of fox behaviour when exposed to oil spills and food contaminated by oil, experimentally and possibly under natural conditions.

IIIc. (To be implemented in connection with IH 9):

If the previous research project should indicate that foxes will not avoid contaminated food and oil spills, the effect of soiled fur and ingested oil must be examined.

Objective: To find out whether oil on fur and ingested oil will have a negative effect on fox.

Method: Physiological measurements and autopsies should be undertaken on foxes experimentally exposed to oil spills.

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6.4 VEC 3
POLAR BEAR

LINKAGES

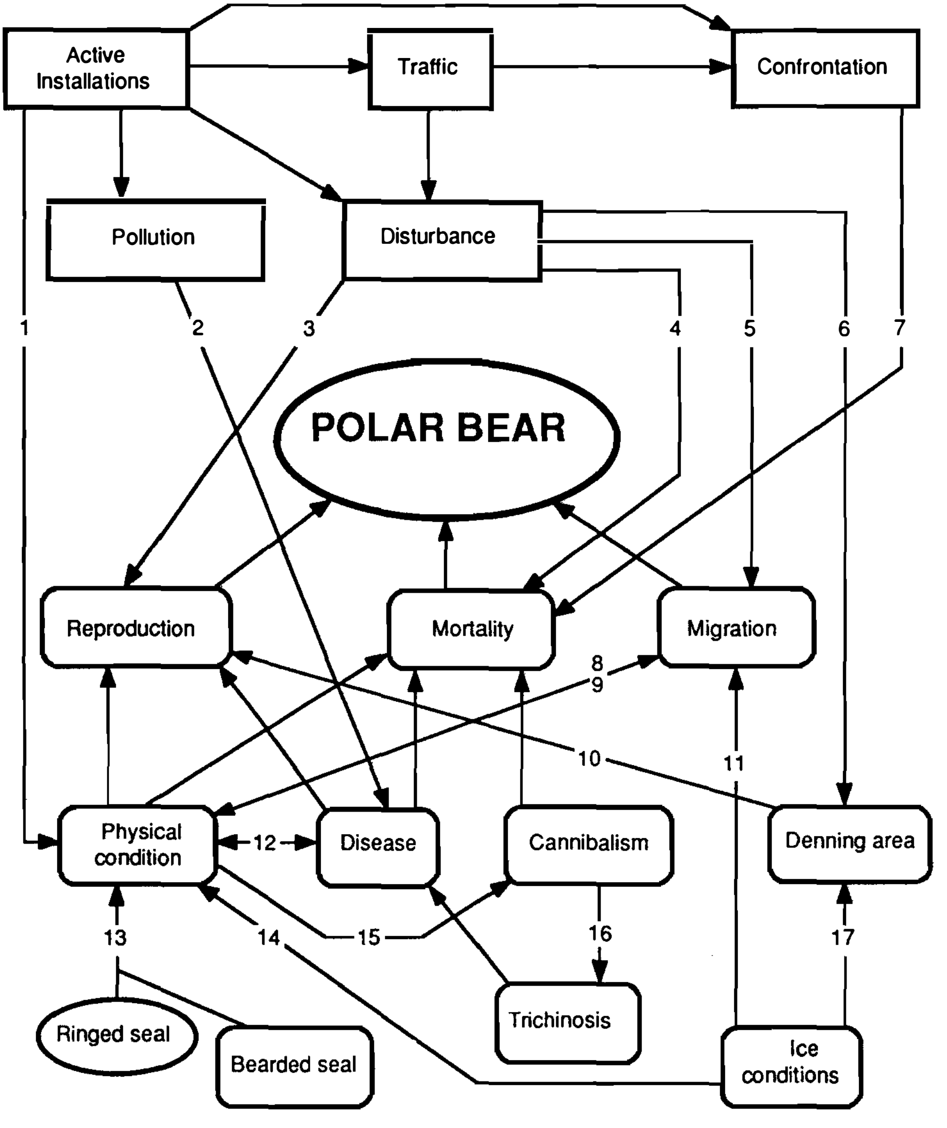
Self-explanatory linkages have not been described

VEC 3 POLAR BEAR

1. Edible waste from active installations 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.
2. Pollution can indirectly cause disease by accumulation in the food chain, or directly, by oil spills (often fatal).
3. Disturbances in the mating period or when pregnant females enter the dens can affect reproduction negatively.
4. Disturbing females with yearlings can result in mortality through the young losing contact with their mother.
5. Disturbances can lead to changing of migration routes.
6. Disturbances can result in reduced use of traditional denning areas.
7. Confrontations between bear and human can result in the destruction of bears.
8. Migrations require energy, and that aspect alone may cause an impaired physical condition.
9. Impaired physical condition resulting from poor food supply can result in increased migration or changed migratory pattern.
10. Access to good denning areas is important to reproduction.
11. Sea ice conditions are essential to the choice of migration routes.
12. Impaired physical condition will increase disease susceptibility. Disease will impair the physical condition.
13. Physical condition is mainly contingent on seal availability.
14. Sea ice conditions affect food supply.
15. The extent of cannibalism is probably affected by the physical condition of the population.
16. Cannibalism is a vector for tricinosis.
17. Sea ice conditions will affect the female's ability to reach a good denning site, and her arrival time.

SCHEMATIC FLOW CHART

VEC 3 POLAR BEAR



6.4.1 Background

The Svalbard polar bear (Ursus maritimus) belongs to a population extending from Eastern Greenland to the western Soviet Arctic. (Uspensky & Belikov 1988). According to the estimates of Larsen (1986) the total population in 1980 - 1983 was 3-5,000 animals, of which the population of the Svalbard area was estimated at 1,500 - 2,000 animals. The population has presumably risen since then. Throughout the summer season the Svalbard bears mainly stay in the drift ice to the east and north of the archipelago. Some are also found along the east coast and on the eastern islands. The winter distribution is less known, but the concentration of the population probably have their habitats in the drift ice areas to the south and east of Spitsbergen - Storfjorden - Hopen and further east. In the late winter/early spring there is a movement towards the east and north. This migration is to some extent concentrated through Hornsund, turning northward through Storfjorden or north-east past Edgeøya (Larsen 1986, Hansson et al. 1988). Satellite telemetry marking of females in Hornsund carried out under the direction of MUPS in the spring of 1988 does however indicate large individual variations in migratory routes. Pregnant females tend to concentrate in traditional denning sites particularly in Kong Karls Land, Edgeøya, Barentsøya, and probably also on and around Nordaustlandet (Larsen 1985).

The polar bear lives mainly on ringed seals, and partly on bearded seals (Lønø 1970). However, it also feeds on whatever it may find, such as carcasses, waste etc. The polar bear's seal-catching technique generally involves lying or sitting at the ice edge or by a seal's breathing hole, catching the surfacing seal, or, in the spring, breaking into seal breeding lairs on the fjord ice (Stirling 1974). Individual bears are continually moving over great distances, both in connection with hunting and with seasonal changes in ice conditions (Larsen et al. 1983).

Polar bears usually reach about 20 years of age. Females are sexually mature at the age of 4 - 5, males somewhat earlier. Mating takes place in April - May (Ramsay & Stirling 1986a). As the young stay with their mother for 2 1/2 years, only about one third of the female population is available for mating each year. Accordingly the females are objects of strife, and it is probably common for successful males to mate several females (polygyny), and for females to mate several males (polyandry), in the course of spring. Each male can stay with the female for at least one week, mating her several times (Hansson et al. 1988). The fertilized egg does not start growing until around September (Ramsay & Stirling 1982). In late fall the pregnant female digs a snow den, in which she normally gives birth to 2 cubs (1-4) around Christmas (Lønø 1970). The cubs weigh about 0.5 kg and are poorly developed at birth (Ramsay & Dunbrack 1986). The female does not open the den until early March. From then on the family stays in the denning area for a period lasting from a few days to several weeks before moving out on the ice (Hansson & Thomassen 1982). The female has not eaten since the previous spring, living solely on her fat reserves for 4 - 7 months

(Ramsay & Stirling 1982). In Svalbard the cubs do not leave their mother until the spring of their third year of life (Larsen 1985).

From sexual maturity till the age of about 20 a female probably seldom has more than 6 litters. Larsen (1986) has estimated cub survival rate from birth to weaning in Svalbard to 0.41, and annual growth rate to maximum 5% (in practice it is normally lower).

The Svalbard polar bear was totally protected through an international agreement in 1973. The species is seen by many as the symbol of the arctic environment, and is subjected to great interest from permanent residents, tourists, the press and the authorities. Potential harmful effects on polar bears caused by human activities must be expected to cause considerable attention.

The polar bear's vulnerability to human activities has connection with the fact that it:

— is curious by nature and to some extent unafraid,
— is potentially dangerous,
— can occur in relatively large numbers in some potential development areas,
— has a low reproduction potential, which implies that the population can be hit by long-term effects if a substantial number of adult animals (particularly females) die,
— has a low tolerance to oil pollution and has its habitat in an environment (drift ice) in which oil would probably be concentrated and slowly degraded,
— has low tolerance to disturbances in the period in which it takes care of its cubs.

6.4.2 The impact hypotheses

Ten hypotheses concerning potential impacts of development activities on the Svalbard polar bear population were evaluated. Five hypotheses (IHs 19, 20, 21, 22 and 23 were considered to be potentially valid but not worth testing for scientific, practical or economic reasons. The validity of 3 hypotheses (IHs 14, 17 and 18) have been documented through previous research. A number of possible measures and projects (see chapter 8) are discussed in connection with IHs 17 and 18 but None. of them have yet been recommended for implementation within the MUPS system. Two hypotheses (IHs 15 and 16) were considered to be valid and deserving of continued research and monitoring. The impact hypotheses have been listed in classified priorities (A - B):

A.

IH 14 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, 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 & Campbell 1974, Atlas et al. 1978, Griffiths et al. 1987).

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 Svalbard area or in the north/east of the Barents Sea, it is accordingly most likely for a relatively great number of polar bears of the Svalbard population to be fouled by oil (Hansson et al. 1988).

The effect of oil on polar bears has been studied by Øritsland (1976), Øritsland et al. (1981) and Hurst & Øritsland (1982). Three research animals were swimming in oil-covered water for respectively 15, 30 and 53 minutes. The animals absorbed great quantities of oil in their pelts and gradually ingested a lot of oil while trying to lick themselves clean. The oil accumulated in the pelt resulted in reduced insulation, skin irritations and a severe loss of hair. The ingestion of oil resulted in vomiting, kidney failure, dehydration, reduction of blood volume, inflammations of the digestive system and kidney and brain damage. Two of the animals died, the third one would under natural conditions also have died. Based on this experiment, Griffiths et al. (1987) conclude that even a single, short-term oil spill will, under natural conditions, kill a great number of the affected polar bears.

A.

IH 15 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. This fact was conducive to the decision in establishing the Nordaust-Svalbard and Søraust- Svalbard nature reserves, in which the greater share of the Svalbard maternity dens are found.

Pregnant females enter the den in late fall, give birth around Christmas and abandon the den with their cubs in March. In the denning period they do not eat and in spring their weight may be nearly halved since the previous fall (Ramsay & 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 & 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).

Each spring there are maternity dens scattered throughout Eastern Svalbard; Kong Karls Land, Edgeøya and Barentsøya being the most well-known areas. This exemplifies the tendency for pregnant females to seek "traditional" 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 or industrial activities 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) (but see Blix 1987), in both cases resulting either in abortion or delivery of the cubs under unfavourable conditions. In the spring she may leave the area too early with the cubs (but see Blix 1987) 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 Svalbard population.

No investigations have been made concerning the impact on polar bears of disturbances and industrial activities in denning areas, whether in fall, winter or spring. Blix (1987), who has measured sound and vibration levels in an artificial den, concludes 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. Experience from activities carried out in the spring in the Svalbard denning areas (Hansson & Thomassen, unpublished data) would indicate that during/after den break, industrial activities and disturbances such as physical installations and extensive motorized traffic within sight of the den, and otherwise about 1 km from the denning area, can disturb females with cubs. Canadian researchers have, however, for several years caught and marked pregnant females (fall) and females with cubs (spring) from helicopters near the denning area close to Churchill, Hudson Bay, without being able to prove any reduction in the number of yearlings or the size of the litter (Ramsay & Stirling 1986b).

Seismic surveys and petroleum exploration during the last couple of years have taken place in Eastern and Southern Spitsbergen, where few maternity dens have been found, and where it is unlikely that polar bears have been disturbed by any activities till the present (Hansson 1987). In the case of possible long-term activities in the areas claimed in inner Hornsund - Grimfjellet - Hambergbukta - Haketangen and northward along the east coast to Agardh-, Duner- and Mohnbukta one cannot discount that a minor number of dens may be negatively affected. Of greater importance are the claims of Kvalpynten and Dyrkongen/Dianadalen (Norwegian Polar Navigation) and Kapp Heuglin (Trust Artikugol) on Edgeøya, of which the last-mentioned two are situated in the areas with the highest incidence of recorded dens on Edgeøya (Larsen 1985 and Hansson unpublished data). The claims on Svenskøya (the Fina Group) and Kongsøya (the Fina Group and Norwegian Polar Navigation) cover the densest denning areas in Svalbard and probably in the world as a whole. The status of these claims is uncertain but Norwegian Polar Navigation has notified activities in their claim on Dyrkongen/Dianadalen.

B.

IH 16
Disturbances and obstacles caused by installations and traffic in polar bear migration and feeding areas will result in a reduced population.

The spring migrations through Hornsund follow the shortest and probably easiest route across South Spitsbergen (Hansson et al. 1988). Because of the ice conditions in Hornsund the animals mainly follow along the northern, or possibly the southern side of the fjord, to gather on the permanent ice in the innermost bays before crossing one of the 3 - 4 alternative glaciers on their way to the east coast. The nearest alternative routes across Spitsbergen are through Van Mijenfjorden or Van Keulenfjorden, or around Sørkapp. For bears on the west coast of Spitsbergen, these are longer and partly more hilly routes, and the food supply along these routes is probably poorer (Gjertz & Lydersen 1983). Other possible migratory routes in the Svalbard area are assumed to offer corresponding advantages when compared to alternative routes.

Areas relevant to petroleum installations in Svalbard (Hornsund, Haketangen, Edgeøya South) are located close to, in some cases right in the spring migration route. In the event of petroleum activities in Hornsund the topography is such that passing polar bears will necessarily have to get close to the activity. Along the east coast of Spitsbergen and near Edgeøya South passing an installation at some distance would be easier, provided there is still ice.

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. 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. In the event of petroleum activities in a narrow fjord like Hornsund there is a risk that polar bears will not pass, and choose other, presumably less favourable routes.

6.4.3 Recommended measures and studies

The following studies can be implemented in connection with developments potentially resulting in the impacts described in IHs 14, 15 and 16. The studies have been listed in classified priorities (I - III).

I. (To be implemented in connection with IHs 14, 15 and 16).

Surveys of migrations and habitats. The surveying should run as a long-term project to provide accurate data. In connection with developments in specific areas detailed studies should possibly be carried out here. There is little knowledge of the incidence of polar bears on the ice edge zones throughout the year, and this group of bears requires particular attention.

A MUPS study of the local situation in Hornsund/Storfjorden has already been carried out (Hansson et al. 1988), and a continuation of this work, a satellite telemetry study of long-term migrations, was begun in 1988-89.

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

Method: Mark/recapture and telemetry (satellite and conventional) from various points. Possibly aerial/ship counts.

IIa. (To be implemented in connection with IHs 15 and 16)

If it is decided to locate activities near an area that is vital to the polar bear's migration, food or denning; study the incidence of bears and their use of the area before, during (and possibly after) the development.

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 behaviour in the area before, during (and possibly after the development). If possible, conduct a parallel study in a corresponding, unaffected area of reference.

IIb. (To be implemented in connection with IH 14 together with ringed seal, sea birds and eider/geese IHs):

Study the fate of an oil spill in ice-filled waters in the Barents Sea/Svalbard area.

Objective: Clarify local movement, physical and chemical change/degeneration and longevity during winter and summer from the drift ice edge and inwards for the most likely types of oil pollution, and provide the basis for assessing possible counter measures.

Method: Experimental oil spills under natural conditions in the relevant areas during summer and winter, monitoring and sampling throughout. If necessary, make supplementary experiments under controlled conditions.

IIc. (To be implemented in connection with IH 14 together with Ringed Seals, Sea Birds, Eider/Geese and Marine Biological Resource IHs):

Oil spill drift trajectories.

Objective: To be able to predict, with sufficient accuracy, the movements of an oil spill from Svalbard or the Barents Sea, to be able to initiate counter measures of maximal efficiency.

Method: Refining available simulation models.

IId. (To be implemented in connection with IH 15):

Denning surveys in poorly recorded development areas.

Objective: Provide an overview of polar bear maternity dens in areas where development is being planned, and where information on the incidence of dens is insufficient.

Method: Helicopter, snow scooter or ski recordings.

III. (To be implemented in connection with IHs 15 and 16).

Impact study on polar bear disturbance.

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

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

6.4.4 Literature

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6.5 VEC 4
WALRUS

LINKAGES

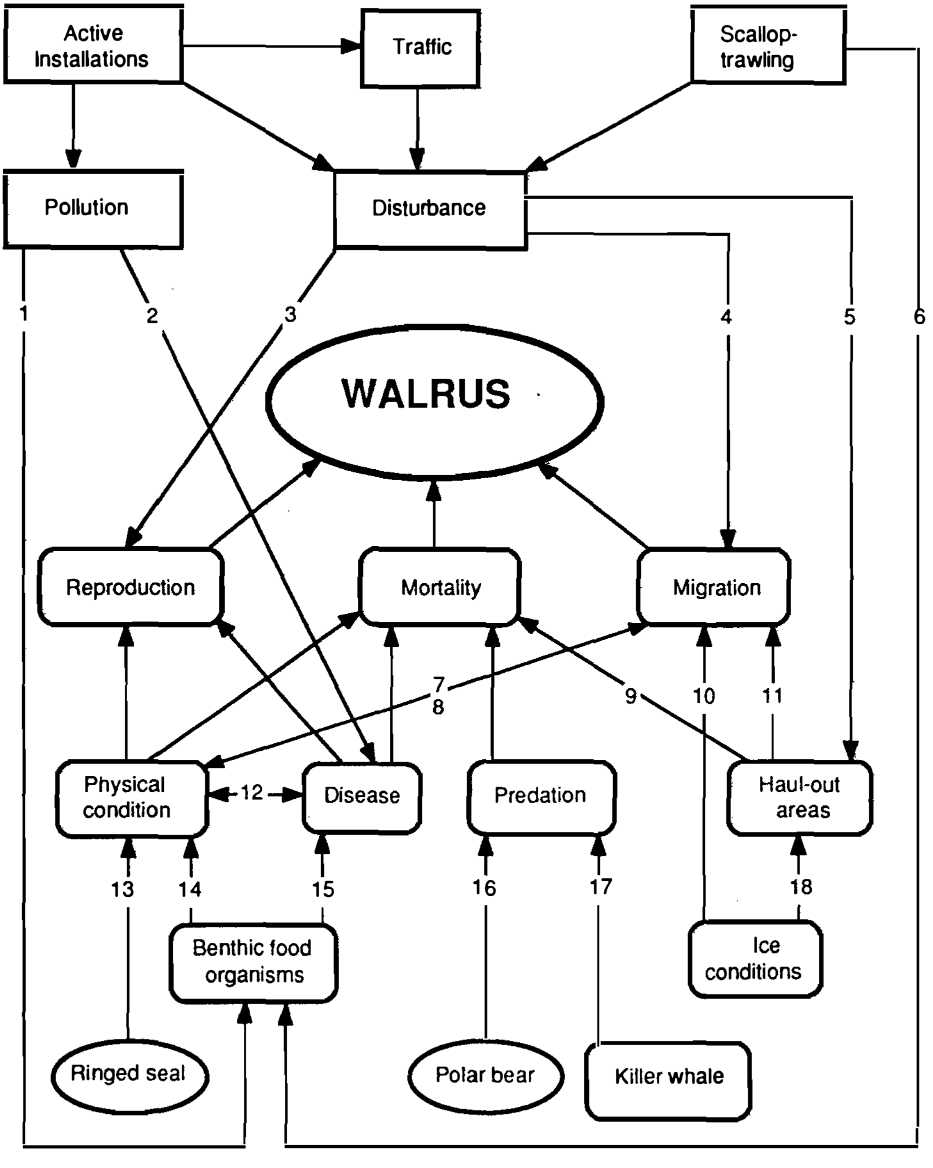
Self-explanatory linkages have not been described

VEC 4 WALRUS

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 habitats.
5. Disturbances can make the walrus avoid traditional haul-out sites on shore and in the ice.
6. Dredging of scallop beds can affect areas in which walrus search for food.
7. Migrations require energy and will therefore impair physical condition.
8. An impaired physical condition resulting from inferior food supply can initiate emigration.
9. Disturbance on haul-out sites can result in calves being crushed to death by adults fleeing in panic.
10. Ice conditions will determine walrus habitats.
11. The access to haul-out sites will influence possible emigration to new habitats.
12. Impaired physical condition will increase disease susceptibility. Disease will impair physical condition.
13. Ringed seals can periodically serve as an alternative diet.
14. The physical condition is mainly contingent on access to benthic fauna.
15. Toxic substances accumulated in benthic fauna (filter feeders) can cause disease.
16. Polar bears can be predators (calves).
17. Killer whales (Orca orca) can be predators (all age groups).
18. Ice conditions can determine the access to haul-out sites on shore. Moreover, walrus prefer specific types of ice for their haul-out sites.

SCHEMATIC FLOW CHART

VEC 4 WALRUS



6.5.1. Background

The population of Atlantic walrus (Odobenus rosmarus rosmarus) in the Svalbard region originally consisted of many thousands (Lønø 1972). Intensive hunting in the 1800s, with some yearly catches of more than 1,000 animals, resulted in a drastic reduction of the population. The Svalbard walrus was protected in 1952, but from World War I till the 1970s it was only sporadically seen on the archipelago (Lønø 1972). On the western side of Spitsbergen, which previously had a large population, only 9 individuals were seen between 1960 and 1968, while on the northern and eastern side small herds were observed in the summer season (Lønø 1972). An increasing number of observations in the 1970s would indicate a slight increase in the population. Born (1984) assumed that more than 100 individuals were living on Eastern Svalbard in the summer. However, he pointed out that an under-representation of females and calves in the observations would indicate that these herds belonged to a population distributed over a larger area than Svalbard. He supposed that such an area also might include Franz Josef Land and Novaya Zemlja (see also Reeves 1978).

No status report on the Svalbard walrus after 1982 is available. In recent years a comparatively large number of individuals has been recorded in the summer season (the Norwegian Polar Research Institute, unpublished data). The main haul-out sites in use are found on Lågøya, Moffen, Storøya, Murchinsonfjorden, Kvitøya, Andretangen and Tusenøyane (Lønø 1972, Nyholm 1977, Born 1984, the Norwegian Polar Research Institute, unpublished data). In 1984 a herd of about 500 animals, among these many females and calves, was seen near Kvitøya (Thor Larsen, personal communication). In the autumn of 1987 a considerable number of females and calves were seen in this area (Christian Lydersen, personal communication). Whether these animals originated from eastern breeding areas, or whether there is now a separate population breeding in Svalbard, is still uncertain.

The walrus is a typical herd animal. In the winter it stays close to the ice edge and drift ice areas in shallow waters, using ice floes as haul-out sites (Fay 1982). It may however also winter in open, permanent leads (polynyas) to the north of the ice edge. Onshore haul-out sites are mainly used in the moulting period in July and August (Mansfield 1958). Large herds of walrus will then lie on shore for extended periods, which is assumed to be necessary to maintain the high, stable body temperature required to produce new hair and heal wounds (Salter 1979). Such haul out behaviour will vary in duration and frequency and appears partly to be controlled by air temperature, precipitation, wind and time of day (Mansfield 1958, Fay & Ray 1968, Miller 1976, Fay 1982). A great deal of evidence would indicate that, when choosing onshore haul-out sites, the walrus is exacting in terms of topography and geography, and the number of suitable haul-out sites is accordingly limited. The haul-out sites are generally found on slightly inclined shores well protected against the weather, and they are also located near good feeding grounds.

Walrus principally feed on scallops (Mansfield 1958, Fay 1982), found and consumed down to depths reaching 80 m (Vibe 1950). Excluding some seal-hunting walruses (Lowry & Fay 1984), the walrus will utilize a lower trophic level than other species of seals. This may indicate that the walrus is less exposed to the accumulation of environmental toxins found in body tissue (Born et al. 1981). Killer whale, and to some extent polar bear, are probably the only species besides man that can be predators on walrus but little importance is attached to this kind of predation (Fay 1982). Killer whale is generally not found in the Svalbard area (Nyholm 1977).

The walrus generally calves on ice, and at most it has 1 calf every second year (normally every third year). The gestation period is 15 - 16 months, including 4 months of delayed implantation of the blastocyst (Fay 1982). This results in a low reproduction rate (DeMaster 1984), which can partly explain the apparently low population growth in Svalbard after the protection was enforced in 1952. Walrus in the northern Pacific and Northwest Atlantic will mate in January - February, while the calves are born from the middle of May till the end of June (Mansfield 1958, 1973). Information from the Soviet Union would indicate that walrus in this area will give birth as early as January (Lukin 1978). We have no information on the reproduction biology of the walrus in Svalbard. The species is generally regarded to be polygynous (males surround themselves with a harem) (Fay 1982). The mating ritual often takes place in the pack-ice, and airborne sounds as well as underwater vocalization is essential (Schevill et al. 1966, Stirling et al. 1983, Fay 1982, Miller 1985). The mating ritual as such is assumed to take place in the water. It is not known whether underwater vocalization is used in contexts other than mating.

The low reproduction rate of the walrus; its narrow feeding niche, its specific requirements concerning haul-out sites and the fact that it is a herd animal, are all factors which contribute towards its vulnerability to encroachments and disturbances. If one of the permanent habitats of the Svalbard walrus is damaged, this may have negative impacts on the entire local population.

6.5.2 The impact hypotheses

Six hypotheses concerning the potential impact of development activities on the Svalbard walrus population were evaluated. Three hypotheses (IHs 27, 28 and 29), were considered to be invalid. One hypothesis (IH 26) was considered to be potentially valid, and some possible measures and studies were discussed, see chapter 8). It was however not given priority in this version of the system. Two hypotheses (IHs 24 and 25) 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.

IH 24 Disturbances resulting from traffic and installations 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 sucking 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 & 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 the land or ice haul-out sites, which may disturb natural moulting and wound healing processes (Salter 1979).

   Salter (1979) found that walrus 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 walrus 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 walrus may retreat if exposed to strong olfactory stimuli, such as exhaust and other waste gases (Loughrey 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: Turl (1982) makes the presumption 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.

IH 25 Oil spills caused by traffic and installations will reduce the walrus population.

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

Walrus 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. These locations are also areas where oil spills would be likely to accumulate (Griffiths et al. 1987). 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 walrus found around Svalbard 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.

If walrus, like ringed seal (Geraci & Smith 1976), are not able to 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). For 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. 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 hard 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 animals of prey, and reduce the walrus's food supply locally.

6.5.3 Recommended measures and studies

The following studies can be implemented in connection with development activities that may cause the effects discussed in IHs 24 and 25. The studies have been listed in classified priorities (I - IV).

I. (To be carried out in connection with both IHs 24 and 25):

Surveys of the incidence and of area use throughout the year in potential development areas.

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

Method: Prior to the development an rough survey should be implemented over two years in late winter, spring, summer and fall by helicopter (aircraft), possibly using photographing techniques. Detailed surveying from a dinghy. Possibly in combination with projects II and IV.

II. (To be implemented in connection with IHs 24 and 25):

Surveys of the migrations of the Svalbard walrus, distribution and population affiliation.

Objective: Surveying potential conflict areas throughout the year, find whether the Svalbard walrus is a separate population or part of a larger common population.

Method: Telemetry (possibly satellite telemetry), in combination with estimates and detailed recordings in selected areas. Duration minimum 3 years. Pilot project for method extraction may be necessary. A project along these lines has been initiated by the Norwegian Polar Research Institute, jointly financed with the Norwegian Fishery Research Foundation, with a pilot project in 1989.

III. (To be implemented in connection with IH 24):

Monitoring of local incidence before/during/after development.

Objective: Record possible impact on walrus in the development area, so that current and later developments can be adapted with the view of minimizing the impact.

Method: Aircraft/helicopter surveys according to determined pattern in late winter, spring, summer and fall. Counts should be undertaken on sites in which the incidence is known, possibly by using photographing techniques, possibly in combination with project IV. At least 1 year before development and at least 3 years during/after development has been terminated.

IV. (To be implemented in connection with IH 24):

Detailed monitoring of local incidence.

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

Method: Automatic interval photography on haul-out sites etc. over a long period of time, minimum 2 years. Direct behaviour observations.

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6.6 VEC 5

RINGED SEAL

LINKAGES

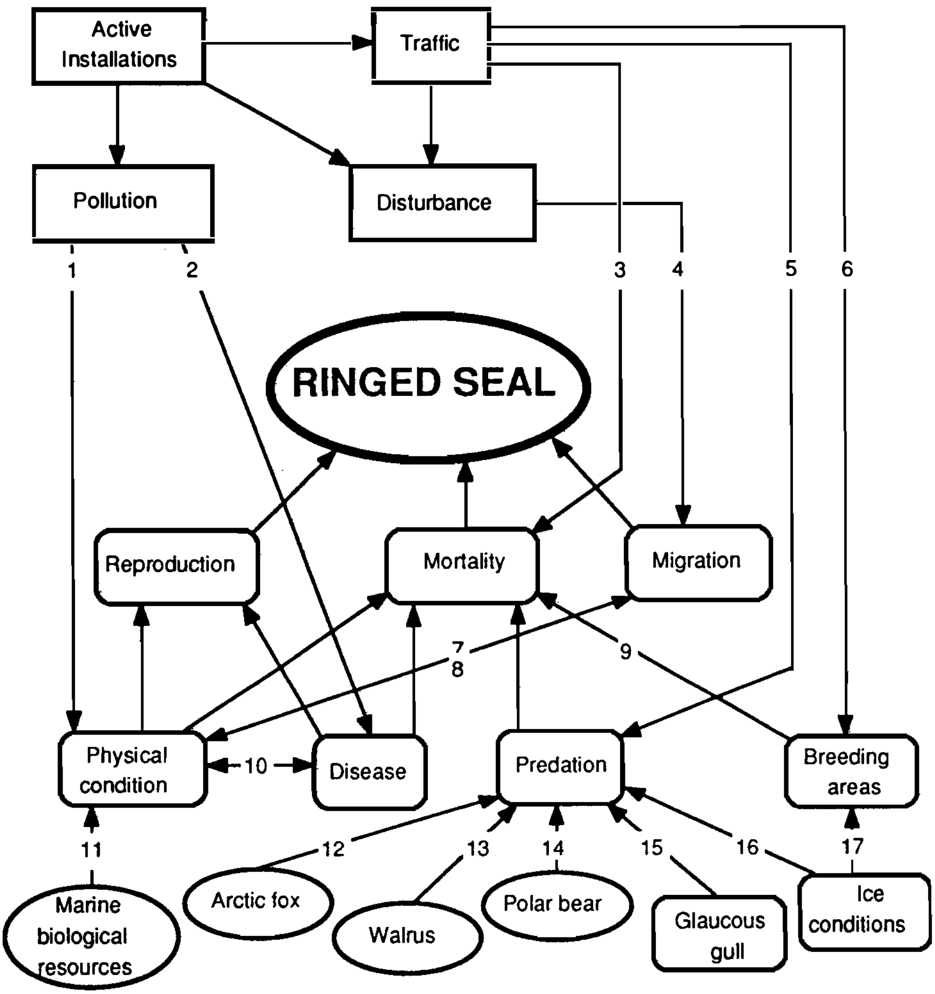
Self-explanatory linkages have not been described

VEC 5 RINGED SEAL

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 (ice breakers) can cause mortality by damaging breeding lairs.
4. Disturbance can cause migrations.
5. Traffic can cause increased hunting.
6. Traffic can scare ringed seals away from breeding areas.
7. Migrations require energy and will therefore cause impaired physical condition.
8. Impaired physical condition resulting from poor food availability can cause migrations.
9. The quality of breeding areas is important to pup mortality.
10. Impaired physical condition will cause ringed seals to be more susceptible to disease. Disease will impair physical condition.
11. The ringed seal feeds upon marine biological resources, especially polar cod.
12. Foxes will take pups in breeding lairs and on the ice when there is a lack of snow.
13. Walrus can in certain instances prey upon ringed seals.
14. Polar bears prey upon pups and adult animals.
15. When there is a lack of snow, glaucous gull will prey upon pups.
16. Snow and ice conditions affect the degree of predation and which species will become predators.
17. Snow and ice conditions affect the suitability and location of breeding areas.

SCHEMATIC FLOW CHART

VEC 5 RINGED SEAL



6.6.1. Background

No studies have yet been made to clarify the size of the ringed seal (Phoca hispida) population in Svalbard, but no doubt this species is the most abundant mammal in the area. Adult animals will reach around 130 cm in length and weigh (varying with season) about 60 kg (Lydersen & Gjertz 1987). In Svalbard the females will reach sexual maturity at the age of 3-5 years, the males at the age of 5-7 years, with the maximal recorded age in the area being 45 years (Lydersen & Gjertz 1987). The ringed seal has a key function as top predator in the purely marine food chain, and as the polar bear's most important prey in the area (Lønø 1970), and in periods as arctic fox prey (Lydersen & Gjertz 1986). Polar cod (Boreogadus saida), decapods and large amphipods constitute the ringed seal's most important prey in this area (Gjertz & Lydersen 1986). From winter till early summer sexually mature ringed seals in Svalbard stay in icecovered fjords, where the females give birth to their one pup in March/April, usually in breeding lairs dug out in the snow above a breathing hole in the ice (Smith & Stirling 1975). In June/July large numbers of moulting ringed seals are gathered on the remains of the winter ice. After the moulting, large parts of the ringed seal population disappear from the fjords of Svalbard, presumably searching for food in near-shore waters. When the fjords freeze up again in the winter the adult ringed seals are back to maintain breathing holes and claim territories in these areas.

6.6.2 The impact hypotheses

Four hypotheses concerning the potential impact of development activities on the Svalbard ringed seal population were evaluated. One hypothesis (IH 33) was considered to be invalid. Three hypotheses (IH 30, 31 and 32) were considered to be valid and important to study with surveys, research (see chapter 8) and monitoring. The impact hypotheses have been listed in classified priorities (A-C).

A.

IH 30 Disturbance (traffic, seismic surveys, ice breaking) 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 & 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 & Ronald 1976), and the upper limit was found to be 60 KHz.

Kelly et al. (in press) 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.

Burns & Harbo (1972) carried out aerial censuses of ringed seals in areas with and without seismic activity. Even in areas with intensive seismic activity the density of animals was found to be the same as in unaffected areas. This may indicate that ringed seals are not affected by such activities, or that potential effects cannot be proved on the population level because local variations in the abundance of ringed seals are great as a result of variations in available ice, type of ice, snow conditions etc. Kelly et al. (in press) did however find indications of ringed seals leaving their dens twice as often within a zone of 150 m from a seismic line as outside of this zone.

By immersing sheep, dogs, monkeys and ducks in water, Yelverton et al. (1973) made estimates of safe distances for these species to underwater explosions of various force. Applying their results, Geraci & St.Aubin (1980) estimated that safe distance from a 5 kg charge for a common seal (Phoca vitulina), is 360 m at 25 m depth.

This distance is almost certainly much too great, as marine mammals are better adapted to enduring pressure than the research animals of Yelverton et al. The number of marine mammals documented killed as a result of seismic activity is remarkably low, particularly when viewed in relation to the extent of such activities, e.g. in North American waters. One of the few documented cases reports that 3 sea lions were killed, Fitch & Young (1948). It would therefore appear to be unlikely that seismic activity may directly hurt large numbers of ringed seals. Besides, the use of explosives in marine seismic surveys is increasingly being replaced by other techniques.

B.

IH 31
Oil spills in the sea will cause suffering and death for affected ringed seals and reduction in local ringed seal populations.

An oil spill in a typical ringed 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. In icecovered waters oil spills will probably more or less be caught in/under the ice. Together with the low temperature this fact may involve that the decomposition will be slower (Atlas et al. 1978), and that the oil will retain volatile and more toxic components for a relatively long period (Griffiths et al. 1987). A ringed seal in an oilcontaminated 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 breeding lair and pup will also be fouled.

The ringed seal's fur as such consists of short wiry hairs with small 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 & Smith 1976). 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 & 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 not 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 & 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 in ringed seals, 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 ringed seal's energy balance in water temperatures below 0°C has not been studied. The lowest temperatures that ringed seals have been exposed to in oil spills is 7°C (Geraci & Smith 1976).

In ringed seals exposed to crude oils it has been demonstrated that hydro carbons 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 & 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' behaviour before dying, and results of blood investigations of the animals, have made Griffiths et al. 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 & Smith (1976) found that feeding research seals with crude oil (together with fish) did not result in serious poisoning. Duguy & Babin (1975, 1976) and Prieur & Duguy (1979) report, however, that at least 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.

C.

> IH 32
> Installations 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 & 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. In Svalbard no cases have been documented of foxes, at this time weighing 3-3.5 kg, having caught seals of this size (P. Prestrud, unpublished data). The number of seals taken by an individual fox is unknown.

6.6.3 Recommended measures and studies

The following studies should be implemented in connection with the impacts discussed in IHs 30-32. The studies are listed in classified priorities (I-III).

I. (To be implemented in connection with IHs 30, 31 and 32):

Surveys of local ringed seal population with respect to seasonal variations in areas potentially exposed to/currently exposed to development activities.

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. A pilot project is a prerequisite to deciding whether the investigation can be implemented with an applicable result.

II. (To be implemented in connection with IH 31):

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 behavioural and physiological reactions, effect mechanisms and extent of damage.

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

III. (To be implemented in connection with IH 30):

Study of the effect of seismic activities on the ringed seal's main food organisms (primarily polar cod).

Objective: To record possible effects of seismic activities on the ringed seal's main food organisms.

Method: Experimental field studies: Polar cod collected under ice exposed to seismic activities at various distances.

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6.7 VEC 6

EIDERS AND GEESE

LINKAGES

Self-explanatory linkages have not been described

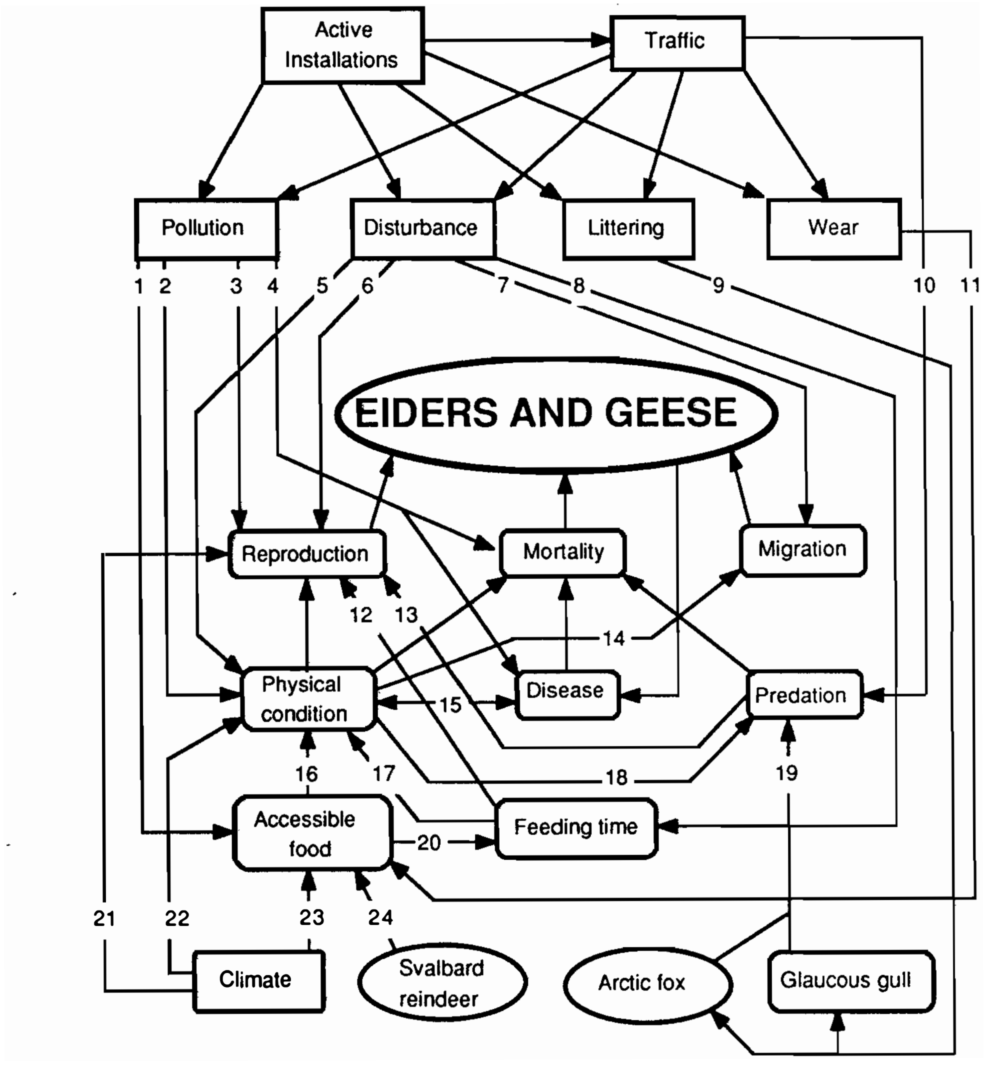
VEC 6 EIDERS AND GEESE

Eiders and geese are affected by human encroachments on nesting colonies on islets (breeding areas) and moulting/rearing areas and resting areas throughout the migration. Food organisms have not been specified, but are treated on a separate schematic flow chart, see VEC 9 "Marine Biological Resources".

1. Pollution can kill food organisms and thus reduce access to food.
2. Oil spills will result in increased energy expenditure by the reduction of feather insulation.
3. Pollution can result in reduced reproduction by adult fouled birds soiling eggs and chicks.
4. Pollution can cause disease or mortality.
5. Disturbances can increase energy expenditure and result in impaired physical condition.
6. Disturbances can cause females to leave the nest for shorter or longer intervals, with an ensuing increase in egg and chick mortality.
7. Disturbances can cause birds to withdraw from the affected area.
8. Disturbances can reduce grazing time.
9. The dumping of waste can affect the glaucous gull and arctic fox populations.
10. Traffic is likely to result in hunting.
11. Wear can cause a reduction of accessible grazing land for pink-footed goose and barnacle goose.
12. Predation is the limiting factor for reproduction.
13. Increased grazing time will involve less protection and warming of eggs and chicks and accordingly reduced reproduction.
14. Impaired physical condition because of inadequate food supply can result in migration. Migrations require energy and will therefore impair the physical condition.
15. Impaired physical condition will increase disease susceptibility. Disease will impair the physical condition.
16. Available food (or the quality of the food) will to a great extent determine the physical condition when available grazing land is limited (during the breeding period).
17. Reduced grazing efficiency will result in increased energy expenditure, and accordingly in impaired physical condition.
18. Impaired physical condition will increase exposure to predation.
19. Increase in the populations of glaucous gull and arctic fox can result in increased predation.
20. Less grazing land available will imply increased grazing time.
21. The climate affects egg and chick survival and accordingly reproduction.
22. The climate affects energy expenditure, and accordingly the physical condition.
23. The climate affects production of, and access, to food.
24. The reindeer can be a grazing competitor.

SCHEMATIC FLOW CHART

VEC 6 EIDERS AND GEESE



6.7.1 Background

Eiders (king eider and common eider) and geese (barnacle goose, brent goose and pink-footed goose) have been grouped in one VEC because their biologies are identical on many points. All of them are strongly attached to the littoral zone during the greater part of the time they spend in Svalbard. The most important breeding areas are also common among some of the species. Accordingly their vulnerability to human development activities is relatively similar, and the impact hypotheses put forward will to a great extent apply to all species within this group.

Svalbard has considerable breeding populations of eiders and geese (Ebbinge et al. 1984, Madsen 1984 a, Owen 1984, Prestrud & Børset 1984, Prestrud & Mehlum, unpublished data). There are two eider species in the area, common eider (Somateria mollissima) and king eider (Somateria spectabilis). The former, which is the most numerous, mainly breeds in colonies on skerries along the coasts of Svalbard, the concentration of the population being along the west coast. The nests of the king eider occur more scattered, generally beside small freshwater ponds along the west coast of Spitsbergen. Before the start of the breeding season the eiders lie grazing in flocks along the coast, waiting for the breeding areas to become free from ice and snow. Since the eider breeds in colonies, human disturbance can easily become a negative factor to population development. After breeding the eiders once more gather in flocks when, for a period of some weeks, they are unable to fly while changing their plumage. The largest congregations of females and young birds are in this period found in shallow waters along the west coast where there is a good supply of food. Throughout the fall the largest flocks are found from Bellsund and southwards towards Sørkapp (Knutsen et al. 1988). In this area, in the summer and fall, there are also large flocks of king eiders. The male eiders spend summer and early fall in separate flocks, and Agardhbukta and areas to the west of Barentsøya are important male flock sites (Knutsen et al. 1988). During these periods they are also more vulnerable to human disturbance and pollution, primarily oil spills. The eider migrates from Svalbard in late fall.

Svalbard has three populations of goose species, all arriving in Svalbard at the end of May from wintering areas mainly in Denmark, the Netherlands and the British Isles. In the course of September the majority of the birds leave Svalbard. The pink-footed goose (Anser brachyrynchus) is the most numerous, with a fall population of about 25,000 individuals (Ebbinge et al. 1984). The species is common in most of the archipelago and it usually breeds in minor, scattered colonies near bird cliffs. The barnacle goose (Branta leucopsis) is the second most numerous species, with a fall population of about 11,000. It mainly breeds on islets in the western and southern parts of Svalbard. An essential part of the population breeds within bird sanctuaries (Prestrud & Børset 1984). Finally, the brent goose (Branta bernicla), has a population numbering approximately 3,000 (Madsen 1984a). Its present distribution is scattered throughout islands in the eastern parts of Svalbard but a small number can also be found on some of the islands along the west coast of Spitsbergen. The brent goose is not such a typical colony breeder as the barnacle goose. All three species gather in socalled "moulting flocks" after breeding. They are unable to fly during this period because of moulting. The flocks generally stay in the littoral zone or by freshwater ponds near the sea. Beaches along the west coast are the most important moulting and rearing areas for the barnacle goose due to the good grazing conditions in this area. In common with the eider, they are vulnerable to oil contamination and disturbance during this period. Pink-footed geese and brent geese are particularly shy and will react to human activity at some distance, and will, if sufficiently disturbed, leave an area altogether (Madsen 1984b). The pink-footed goose is the only one among the species in this group for which permission for regular hunting is given. The hunting is not likely to represent any population regulating factor to any of the species. Predation from arctic fox, glaucous gull and arctic skua can however be considerable (see argument for IH 35 for a closer explanation).

6.7.2. The impact hypotheses

Nine hypotheses concerning the potential impact of development activities and disturbances upon the Svalbard eider population were evaluated. One hypothesis (IH 42) was considered to be invalid. One hypothesis (IH 41) was considered to be potentially valid, while at the time not worth following up with studies. Three hypotheses (IHs 36, 39 and 40) have been documented as valid, and measures were recommended only in the case of IH 36. Four hypotheses (IHs 34, 35, 37 and 38) were presumed to be valid and important to examine more closely with surveys, monitoring and/or research. The impact hypotheses have been listed in classified priorities (A - B).

A.

IH 34
Disturbances near breeding areas can result in reduced reproduction of eiders and geese through both increased predation and reduced egg and chick survival, and may lead to abandonment of breeding areas.

Eiders and geese are very vulnerable to disturbance from traffic or noise. To avoid predation and the cooling of eggs and chicks, these birds normally have a high incubation constancy, i.e. the eggs are left only seldom, and for short periods. Incubating birds are however easily scared from the nest when disturbed, which makes eggs or chicks an easy prey for predators like glaucous gull, arctic skua and arctic fox. Moreover, eggs and chicks may die from cold if the adults, due to disturbance, are unable to keep them warm for prolonged periods. A study carried out in Kongsfjorden in Svalbard indicated that the glaucous gull would take eggs in 12.5 % of the cases when incubating female eiders left their nests (Mehlum, unpublished data). Pink-footed geese and brent geese may flee the nest even if the disturbance is several hundred meters away. Another possible effect of disturbance of the breeding area is that the species are forced to leave the area and must try to settle in areas free from disturbance. Preliminary studies carried out by the Norwegian Polar Research Institute would indicate that the breeding areas are subject to competition, between goose and bird species, as well as within the various species. The number of available breeding areas may in many cases be a factor delimiting the size of the local breeding population. There is a great deal of evidence indicating direct competition for breeding areas, between barnacle geese and brent geese (Owen & Norderhaug 1977), and between eiders and barnacle geese, the barnacle geese in both instances being the strongest. The barnacle goose evidently fares better against the glaucous gull than does the eider, which enables it to oust the eider in colonies with a large population of glaucous gulls. When birds are forced to search for new breeding areas because of disturbance, the reproductive success is reduced, as suitable breeding areas are a limited resource. Moreover, competition for suitable breeding areas in the areas free from disturbance will be greater, within as well as between the species, in turn resulting in reduced reproduction and possibly population decrease with the weaker species.

A.

IH 35
Disturbances in resting, moulting and feeding areas will result in increased energy expenditure, less time for food intake and accordingly increased mortality with adult eiders and geese.

Geese also react to disturbances outside the breeding areas and may show a reaction to human activity and helicopter traffic at a distance of up to several kilometres (Madsen 1982). When reacting actively to disturbances the geese will use extra energy to flee from the danger and will in addition have less time for grazing. This will in both cases result in a shift in the energy balance (impaired physical condition). Studies of tundra geese (Anser albifrons) in Greenland (Belman 1981) and pink-footed geese in Svalbard (Owen & Ogilvie 1979) have indicated that moulting geese that are disturbed and flee from an area can lose several hundred grams of body weight in the course of a few days.

It is essential for arctic geese to have sufficient fat deposits for the southward migration in the fall. Considerably impaired physical condition can lead to increased mortality. The location of active installations and an increase of traffic in the vicinity of the traditional resting areas of the migration (e.g. on Bjørnøya) may result in reduced food uptake and impaired physical condition.

B.

IH 36
Oil spills affecting concentrations of eiders and geese will cause increased mortality.

Oil will float on the sea for a certain period and foul the plumage of the swimming birds that are exposed to it. The insulating properties of the birds' feathers will be damaged and they will have to spend more energy on maintaining their body temperature, besides losing their ability to fly. This will easily result in exhaustion and death. Moreover, the toxic effect of the oil may result in disease and death (see VEC 7 Seabirds).

Being the most marine of the relevant species, the eiders will be the ones that are most likely to come in contact with oil on the sea. Females fouled by oil may also transfer this oil to the eggs and thus cause a reduction in breeding success. Eventually this will result in reduced reproduction. The geese will be particularly vulnerable in the chick and moulting periods, when they stay a great deal in the littoral zone.

B.

IH 37
Toxic substances released into the sea may be accumulated in, and possibly kill, organisms that are normally preyed upon by eiders, so that eiders are poisoned or their food supply is reduced, which in turn will cause reduced reproduction and possibly increased mortality.

The eider mainly feeds on benthos organisms, primarily molluscs. Toxic components from oil spills and dispersants can be accumulated in or kill benthos. The female eider is particularly dependent upon a good supply of benthos before the onset of the breeding season, to be able to accumulate a layer of body fat to live off throughout the incubation period, throughout which it does not feed. In the event of a decimation of the prey organisms in the area because of pollution, the female eider may not be able to accumulate sufficient fat reserves. She will then either interrupt the breeding before the hatching, or her physical condition may be so gravely impaired that she is likely to die. If toxic substances are accumulated in the eider's prey organisms, these substances may reach high concentrations in the eider's body tissues or organs, possibly with resulting impaired physical condition/disease/death. After the hatching, the female eider and the chicks mainly feed on crustaceans in the littoral zone. Correspondingly, if these animals accumulate or are killed by toxic substances (such as oil components or dispersants), eiders may suffer reduced reproduction and increased mortality.

C.

IH 38 An increase in glaucous gull and arctic fox populations resulting from increased dumping of waste will cause increased predation on eiders and their eggs and chicks.

Eggs and chicks of eiders and geese are important prey for glaucous gull and arctic fox (cf. documentation for VEC 7 Arctic Fox). An increase in the populations of these predators can represent a danger to the local eider and geese populations, if such are found within the relevant area. Industrial activities can cause increased dumping of food waste, which may attract glaucous gull and arctic fox. Such an example are the garbage dumps near the settlements in Svalbard, where concentrations of glaucous gull can be found. A good food supply may result in increased reproduction, lower mortality, and accordingly a population increase among these predators.

6.7.3 Recommended measures and studies

The following studies should be implemented in connection with development activities potentially involving the impacts referred to in IHs 34, 35, 36, 37 and 38. The studies have been listed in classified priorities (I - III).

<u>Ia. (To be implemented in connection with IHs 34, 35, 36)</u>:

These assignments generally come under the responsibilities of governmental administration. On the implementation of development activities the relevant area(s) should however be surveyed before and possibly during/after the development phase

— for pink-footed geese and eiders: Moulting areas and breeding areas
— for barnacle geese and brent geese: Moulting areas and resting areas
— for king eiders: Breeding areas and breeding populations.

To be carried out before and possibly during/after development activities.

<u>Objective</u>: To find whether the development activity involves the risk of affecting eiders/geese in their most vulnerable periods, and, in the case of king eider, the number of individuals potentially affected, so that a possible development can be adapted in order to minimize harmful impacts. Find possible effects of implemented developments.

<u>Method</u>: Traditional inventories, telemetry after pilot project testing.

Ib. (To be carried out in connection with IHs 34, 35 and 36):

Field study of the pink-footed goose's reaction to disturbances during breeding and moulting. The pink-footed goose has been selected, as it is the shyest among the goose species. This study will require a pilot project.

Objective: To measure the effect of disturbances from human activities on pink-footed goose during breeding and moulting.

Method: Recording of behavioural reactions in the field by the use of known, quantified stimuli. If possible, use of conventional and heart beat telemetry (possibly coordinated with II).

II. (To be carried out in connection with IHs 34, 35 and 36):

Experimental, physiological study of the reaction to disturbance in breeding pink-footed goose (possibly brent goose).

Objective: To provide a quantified basis for determining tolerance limits to disturbance for geese.

Method: Pilot study to estimate the feasibility will be connected to pilot study under Ib). Physiological telemetry studies will be carried out on individuals.

III. (To be implemented in connection with IHs 34, 35, 36, 37 and 38:

Monitoring of the number of breeding/moulting birds in an affected area (including oil spill area).

Objective: Record changes in connection with developments/impact.

Method: To be coordinated in long-term public registrations (counts every 3-5 years). Moulting flocks with juveniles, or nests in breeding colonies, will be counted. Can be compared with existing winter counts (e.g. in Great Britain and Denmark for geese).

6.7.4 Literature

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6.8 VEC 7

SEABIRDS

LINKAGES

Self-explanatory linkages have not been described

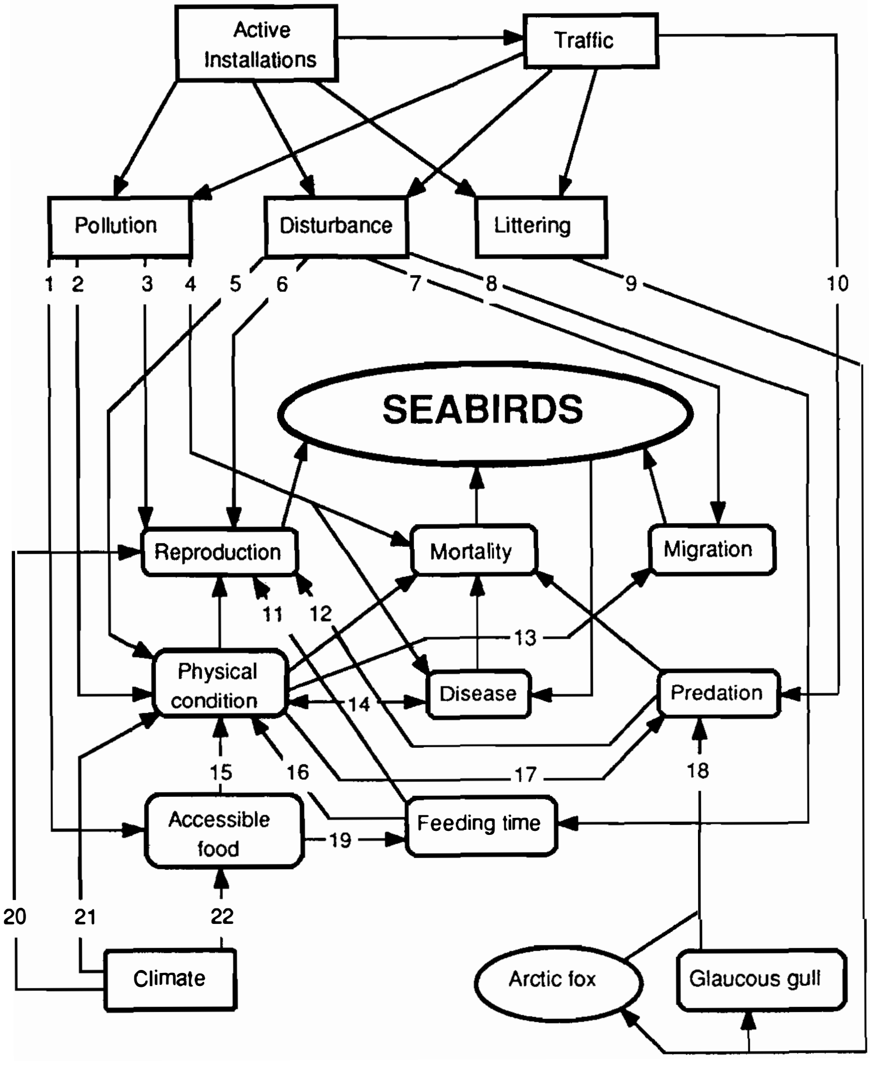
VEC 7 SEABIRDS

Seabirds have been treated as an ornithological VEC. The bird cliff vegetation and the birds' contribution to its formation have not been included. The sea-birds are affected by encroachments both in the breeding and feeding areas. The types of food available have not been specified. This will vary among species and is treated in a separate flow chart (see VEC 9 Marine Biological Resources).

1. Pollution may lead to reduced access to food by causing the destruction of food organisms.
2. Oil fouling causes increased energy expenditure, by impairing the insulating properties of the plumage.
3. Pollution can cause reduced reproduction, as eggs and chicks will be soiled by adult birds fouled by oil.
4. Pollution can cause disease or direct mortality.
5. Disturbance can increase energy expenditure and thereby impair physical condition.
6. Disturbance can cause females to leave the nest for a shorter or longer period, with a resulting increase in egg and chick mortality.
7. Disturbance can cause birds to withdraw from an affected area.
8. Disturbance can reduce foraging time.
9. Edible waste can affect the glaucous gull and arctic fox populations.
10. Traffic may result in hunting.
11. Predation is the limiting factor for reproduction.
12. Increased foraging time will result in less time for the protection and warming of eggs and chicks and accordingly in reduced reproduction.
13. An inadequate food supply leading to impaired physical condition can cause birds to migrate. Migration requires energy and will therefore impair the physical condition.
14. Impaired physical condition increases disease susceptibility. Disease will impair the physical condition.
15. The quantity of food available (or the quality of the food) to a great extent determines physical condition when available foraging time is limited (during the breeding period).
16. Reduced foraging efficiency causes increased energy expenditure and accordingly impaired physical condition.
17. Impaired physical condition increases exposure to predation.
18. An increase in the populations of glaucous gull and arctic fox may imply increased predation.
19. Reduced available foraging area may imply that increased foraging time is needed.
20. The climate affects egg and chick survival and accordingly reproduction.
21. The climate affects energy expenditure and accordingly physical condition.
22. The climate affects food production and access.

SCHEMATIC FLOW CHART

VEC 7 SEABIRDS



6.8.1 Background

Being at the top of the food chains, sea-birds have a central function in the Barents Sea ecosystem. A large part of the system's energy flow runs via these species. The sea-birds also link the marine and terrestrial ecosystems. This is particularly important to the High Arctic land areas in the northern Barents Sea. The primary production is here hampered by lack of important nutrients, as the system does not contain sufficient micro organisms to break down organic material to release nutrients for new production. Besides the decomposition is slow due to low temperatures. Seabirds do however supply considerable quantities of essential nutrients to the vegetation, thus stimulating primary production. In Svalbard this fertilizing effect is evident; the incidence of sea-birds has a direct influence on much of the terrestrial biotop. The sea-birds accordingly have been given a high priority in the assessment system.

VEC 8 "Seabirds" consists of the little auk, Brünnich's guillemot, kittiwake and fulmar, the predominant sea-bird species in Svalbard. The problems relevant to these species are however to a great extent valid to the other sea-birds in the area as well. The species have been dealt with collectively, as their biology and vulnerability to human interference are relatively similar. They are found in enormous numbers, and they probably carry hundreds of tons of nutrients ashore each year. As for quantitative data on sea-birds in this area, very little is available. Norderhaug et al. (1977) have produced a compilation of the available information on the incidence of species in the Barents Sea. Mehlum and Fjeld (1987) have made a catalogue of the bird cliffs in Svalbard containing present quantitative data.

The little auk (Alle alle), the most numerous bird in Svalbard, is found on most of the archipelago. Norderhaug (1968) estimates the number to be a couple of million merely in the Hornsund area. The population winters in the Greenland and the Barents Sea area, partly in open waters right up to Svalbard. The little auk breeds in small and large colonies in steep screes on the coast and on nunataks in the interior. It arrives in the colonies in April and lays one egg in late June. The little auk dives for pelagic crustaceans and fish larvae.

Next to the little auk, Brünnich's guillemot (Uria lomvia) is probably the most common bird in Svalbard, with roughly 600,000 couples in the breeding colonies. The total number is larger. The population winters in the Greenland and Barents seas, partly in ice-filled waters near Svalbard. Brünnich's guillemot breeds on the coast in steep bird cliffs in colonies numbering from a few to more than 100,000 couples. They arrive in the colonies in April and lay one egg in early June. The species is a good diver, feeding on polar cod, sea scorpions, capelin, squids, crustaceans etc.

The fulmar (Fulmarus glacialis) is difficult to count but is regarded to be one of the most common sea-birds in Svalbard. This species, which belongs to the procellariforms, is a very competent soaring bird living over open sea areas and lead systems without the breeding season. It breeds high up on bird cliffs along the coast and on nunataks, and arrives in the colonies in late winter/early spring, to lay one egg in May-June. Many individuals reach the age of about 50 years. The fulmar feeds on squids, polychaets, small fish, crustaceans etc. which it takes from the water surface.

The kittiwake (Rissa tridactyla) is Svalbard's most common seagull. The species winters on both sides of the North Atlantic southwards to the western Mediterranean. The kittiwake breeds in small to large colonies on the coast, often together with Brünnich's guillemot and other species. It arrives in the colony in March-April and lays 1-2 eggs in early June. The kittiwake feeds on polar cod, capelin and crustaceans which it takes from the water surface.

Impact studies must always be seen in relation to the natural condition of the relevant species, the natural fluctuations in physical condition, climate, food availability etc., and accordingly to the stress level. Identical effects (e.g. a 5% additional loss of eggs and chicks, or 10% of the feeding areas made inaccessible) may have just a slight effect on breeding success one year but the following year it may be "the straw that broke the camel's back". Similarly, serious acute impacts (one or two unsuccessful breeding seasons) can have entirely different effects on a population that is already in decline, than on one that is not.

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

6.8.2 The impact hypotheses

Eight hypotheses concerning the potential impact of development activities on the sea-bird population of Svalbard were evaluated. Two hypotheses (IHs 49 and 50 - see chapter 8) were considered to be invalid. Two hypotheses (IHs 47 and 48) were considered to be potentially valid, but for the present not worth testing for scientific, practical/economic or other reasons. Two hypotheses (IHs 43 and 46) have been documented as valid, making research for their verification unnecessary. IH 46 is considered to be so unimportant that it has not been given priority in the assessment system. Administrative measures, surveys and/or monitoring should be carried out in connection with IH 43. Two hypotheses (IHs 44 and 45) were considered to be valid and important to test with research, surveys and monitoring. The impact hypotheses have been listed in classified priorities (A - C):

A.

IH 43 Oil spills occurring near of sea-bird concentrations will cause increased mortality and reduced reproduction of the population.

Seabirds are the most visible victims of oil pollution at sea, and a considerable amount of literature documenting the effect of oil on sea-birds and sea-bird populations is available (see Folkestad 1980, Stowe 1982, Evans & Nettleship 1985).

Oil floats on the sea for a while and will foul the plumage of swimming birds. Hence the waterproofing and the heat insulating properties of the feathers will be reduced, and the birds will sink deeper into the water and lose body heat. Increased energy expenditure to keep up body temperature will reduce fat deposits and gradually also muscle tissue. Besides, the birds will generally suffer internal injuries, as they will ingest oil in their attempts to cleanse themselves (see Folkestad 1980, Levy 1980, Evans & Nettleship 1985, Fry & Lowenstine 1985, Leighton et al. 1986 for further references). The passing on of oil from the plumage of adult birds to eggs and nestlings, with an ensuing reduction in survival rate, has been observed with several sea-bird species (Albers 1980, 1983). Fry et al. (1986) have recently demonstrated that even small doses of oil will cause a considerable and prolonged increase in mortality and lower breeding success during the succeeding year among the surviving birds. The same effects have been demonstrated in sea-birds that have been washed and rehabilitated after oil-injuries (Swennen 1977, Morant et al. 1981).

Thus, there is no doubt that oil contamination can kill large numbers of sea-birds. Whether oil also represents a great threat to sea-bird populations is contingent upon many factors, such as reproduction strategy, site tenacity and the population development (see Baillie & Mead 1982). Various models have been developed (Ford et al. 1982, Wiens et al. 1984, Hudson 1985), but at present the biological input data is generally not sufficient to provide useful results. An oil vulnerability index for sea-birds is being developed in Norway (Rikardsen et al. 1987; Anker-Nilssen 1987; Anker-Nilssen & Vader; in press, Anker-Nilssen et al. 1988).

B.

IH 44 Disturbances in nesting colonies and feeding areas resulting from human activity will cause reduced reproduction and/or the abandoning of areas.

All studies of the breeding biology of sea-birds in temperate and arctic regions indicate that these species are exposed to egg and chick predation (sometimes predation on adult sea-birds as well). The main predators are seagulls and corvids, mink and fox, while the sea eagle and the eagle owl take some adult sea-birds. Among these, only seagulls (including skuas) and fox are found in Svalbard. Under normal conditions such predation is not assumed to have much effect on the seabird populations. According to the estimates of Williams (1975), there was about 2% of predation of common guillemot when the chicks jumped directly into the sea, increasing, however, to 17% when the chicks had to negotiate a stretch of beach before reaching the sea. In such cases the arctic fox represents an important predator (Daan & Tinbergen 1979). Predation on eggs and chicks by seagulls (and ravens in other areas) constitutes an even greater problem in declining bird cliff populations, as the predators will then be able to land on the sparsely covered shelves. Under such circumstances the auks are not able to defend eggs and chicks (Birkhead 1977, Tschanz & Barth 1978).

Many studies document the negative effect of "disturbance" (often the activities of the researchers themselves) on the breeding population and the reproductive success of sea-bird colonies. Johnson (1938) quotes several incidents in which seagull predation on common guillemot eggs became particularly extensive after common guillemots had been frightened away from their eggs. Several observations have been made of eggs and chicks that have been "raining down" from bird cliffs when the adult birds are fleeing in panic (W. Vader, pers. obs.). Similar negative effects have also been recorded with puffins, where the chicks are well protected (Manuwal 1978). A colony was abandoned in British Columbia after a helicopter landed in the breeding period (Vermeer 1978). Among other negative effects resulting from disturbances it can be mentioned that eggs are kicked into cracks etc. where the parent birds are unable to incubate them (Johnson 1938, W. Vader pers. obs.), and that unhatched and recently hatched chicks freeze to death, as they can only withstand short-term exposure to low temperatures. It is also an important factor that many unprotected eggs and chicks are taken by predators (in the Arctic primarily glaucous gulls) in the panic following a disturbance (see e.g. Gillet et al. 1975, Kury & Gochfeld 1975, Robert & Ralph 1975, Ellison & Cleary 1978, Anderson & Keith 1980, Cairns 1980). There is reason to believe that the effects in Svalbard will produce the same outcome, particularly if the area's carrying capacity for glaucous gull and arctic fox will increase due to increasing quantities of available food (via edible waste) in critical periods.

Few studies are available regarding the effect on sea-birds of oil installations and traffic. Dunnet (1977) could not prove any reduction in the number of birds present at the nests on Scottish bird cliffs because of the disturbing effect of passing helicopters and small aircraft, but his results cannot without reservation be transferred to other locations. In Arctic Canada Barry and Spencer (1976) carried out a preliminary study of the effect of a shore-based oil rig on birds breeding on tundra and found that only about half of 20 species breeding within 30 km of the rig were unaffected by traffic activities (helicopter, aircraft and boat). In this instance as well, the disturbances caused increased egg loss due to increased predation. Most likely, all traffic near breeding sea-birds, regardless of objective, has measurable effects on reproductive success (Wilkes 1977).

From Alaska it is known that air traffic near breeding sea-bird colonies can result in increased egg and chick mortality (Hunt 1987). In 1986 an experimental project, based on IH 45 of MUPS, was therefore carried out in Svalbard to discover whether helicopter disturbance would cause a negative effect on egg and chick survival in seabird colonies during the breeding period (Fjeld et al. 1988). Primarily the common guillemot was studied, this being the species assumed to be most exposed to such disturbances. A Bell 212 helicopter was used for these tests, and noise frequencies and noise intensities were quantified by means of advanced sound registration equipment. The work carried out during this first season must be regarded as a pilot project with emphasis on the testing of methodology. This was also decisive to the choice of research area, a colony at the head of Kongsfjorden. The results from this area indicated that breeding birds were not frightened from the breeding ledges, and no loss of eggs or chicks could be registered as a result of the helicopter flights. On the other hand, non-breeding birds were frightened from the colony for a shorter period when the total noise level exceeded 70-75 dB. The distance to the helicopter might then be as much as 6 km. Since the Kongsfjorden colony is relatively small, and since the frequent helicopter traffic to Ny Ålesund may to some extent have made the birds in this area accustomed to helicopter noise, it is not possible to draw any general conclusions from this first study. In the summer of 1989 the experiment was repeated in a remote, normally undisturbed colony in Storfjorden, East Spitsbergen.

As far as is known, no studies are available concerning the general effect of seismic activity on sea-birds, neither on or off shore. The effect of onshore seismic explosions (e.g. Geoflex) on the colonies may possibly be compared to the effect of the horn of tourist vessels blown near bird cliffs in Norway, which has caused many egg and chick losses due to adult birds fleeing the colony in panic (Brun 1979, W. Vader pers. obs.). From South Africa it has been documented that small underwater explosions can kill penguins and other sea-birds in the sea within a radius of approximately 20 m (Cooper 1982, Brown & Adams 1983). Possible seismic underwater explosions must therefore be expected to scare sea-birds away from affected areas for a period of time. Such "barring" of important feeding areas can influence nesting success in years when food availability is insufficient.

C.

IH 45
An increase in the glaucous gull population resulting from the dumping of edible waste will cause increased predation on sea-birds and their eggs and chicks.

(See also under VEC 2 "Arctic Fox" and VEC 6 "Eiders and Geese").

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

There is little documentation to indicate whether these conditions also apply in the Arctic and the Antarctic, but in Svalbard e.g. the populations of glaucous gull are clearly denser around the population centres (Løvenskiold 1964), and corresponding conditions are known from the antarctic bases.

No population studies have been carried out on glaucous gulls that indicate seasonal and age-class distribution of mortality, whether in natural or commensal populations (populations adapted to human environments). But there may be reason to monitor the glaucous gull population if greater industrial activity should cause an increase in the population.

There is probably a connection between the extent of traffic and access to new areas, and the harvest of sea-birds by hunting and egg gathering. At the present level this does not constitute a problem, and will not do so, even with a considerable increase in traffic. The prospect of an increase in public interest in hunting and egg gathering would however indicate that the extent of such activities should be submitted to a measure of control.

6.8.3 Recommended measures and studies

The following surveys, monitoring and research assignments should be implemented in connection with new developments potentially affecting sea-birds in Svalbard. The projects have been listed in classified priorities (I - VI).

I. (To be implemented in connection with IHs 43 and 44):

Mapping of breeding colonies, moulting, foraging and resting habitats and swimming migrations. Updating of existing maps.

Objective: To provide an overview of the geographical areas in which sea-birds are particularly vulnerable throughout the seasons in Svalbard, so that the timing and localization of potential developments can be adapted in order to minimize the effect on sea-birds, and so that damage potential and the necessary clean-up measures can be speedily determined in the event of oil spills.

Method: Will vary with the species and item to be surveyed. General: Observations made from small boats, helicopters and, to some extent, from the shore for the sighting of species in coastal waters and ashore, from ships and helicopters in more open waters. Aerial photography and satellite imagery may in future be included as supplementary methodology.

II. (To be implemented in connection with IHs 43, 44 and 45):

Monitoring of development in selected populations near installations/development activities and in unaffected areas (control populations).

Objective: To record possible effects on sea-birds resulting from local development activities and from diffuse environmental changes of a general character.

Method: Frequent counts in permanent test fields (possibly total count of minor occurrences) before, during and possibly after the implementation of development activities.

III. (To be implemented in connection with IHs 43, 44 and 45):

Studies of the population dynamics of the four bird species of priority.

Objective: To provide insight that enables the administration of the populations, considering both natural and man-made environmental factors.

Method: Mark/recapture, individual studies.

IV. (To be implemented in connection with IHs 44 and 45):

On the basis of this recommendation a study has been carried out under the direction of MUPS concerning the reaction of Brünnich's guillemot to the noise and passing of helicopters (Fjeld et al. 1988, see comment under IH 44).

Study the effect of various activities (traffic, noise etc.) on breeding colonies, particularly with a view to changes in predation pressure and foraging.

Objective: To provide a basis for adapting development activities/traffic in order to minimize the effect on sea-birds.

Method: Behaviour observation of birds in test fields exposed to controlled, quantified stimuli.

V. (To be implemented in connection with IHs 43 and 44):

Genetic studies of the sea-bird populations in Svalbard.

Objective: To find whether populations are genetically, and accordingly reproductively, discrete, and therefore necessitating separate management.

Method: Standard comparative genetic studies.

VI. (To be implemented in connection with IH 45 - cf. VEC 6 Eiders and Geese):

Monitoring of the glaucous gull population.

Objective: To provide an opportunity for regulating the relevant seagull populations before they become so numerous as to cause a reduction in the populations of the seabirds of priority (plus eiders and geese).

Method: Standard yearly counts in relevant (commensal) areas.

6.8.4 Literature

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6.9 VEC 8

SVALBARD PTARMIGAN

LINKAGES

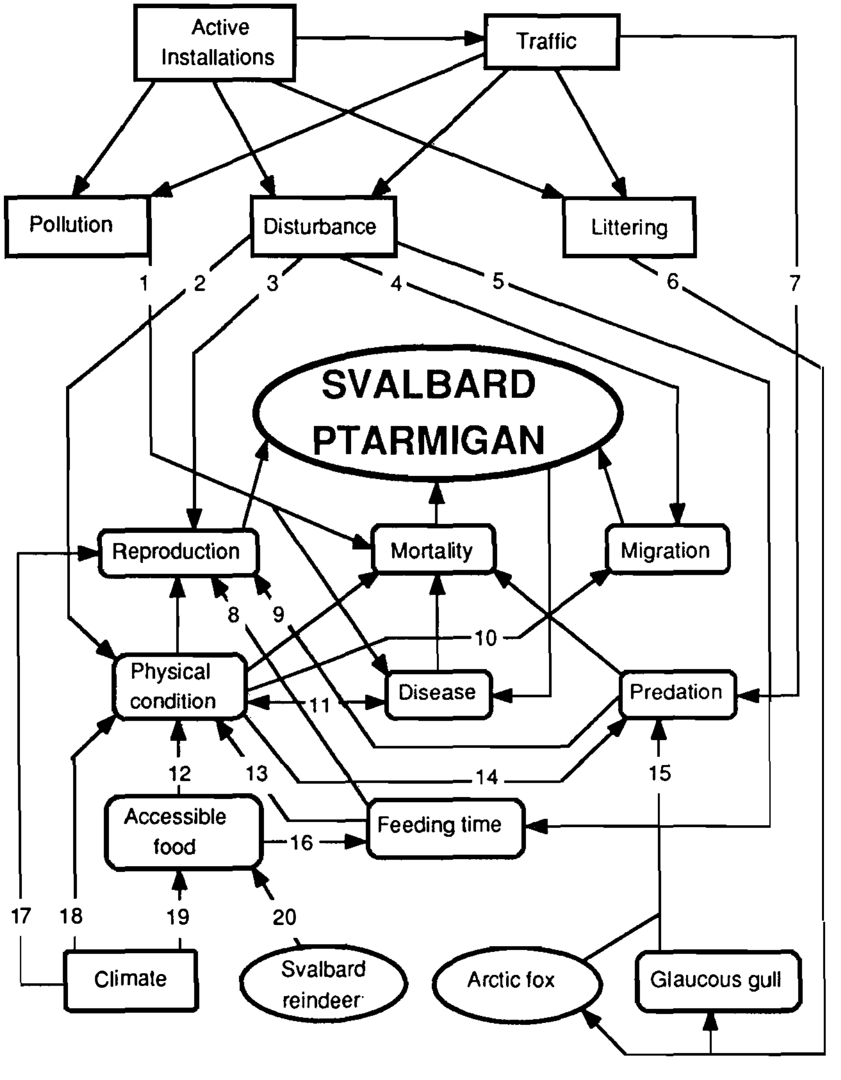
Self-explanatory linkages have not been described

VEC 8 SVALBARD PTARMIGAN

1. Pollution can cause disease or direct mortality.
2. Disturbance can increase energy expenditure and impair physical condition.
3. Disturbance can cause females to leave their nests for shorter or longer periods, with a resulting increase in egg and chick mortality.
4. Disturbance can cause birds to withdraw from an affected area.
5. Disturbances can reduce foraging time.
6. Edible waste can affect the glaucous gull and arctic fox populations.
7. Increased traffic can cause an increase in hunting.
8. Predation is a limiting factor for reproduction.
9. Increased feeding time will result in less time for the protection and warming of eggs and chicks and accordingly in reduced reproduction.
10. An inadequate food supply leading to impaired physical condition can force birds to migrate. Migrations require energy and will therefore impair the physical condition.
11. Impaired physical condition will increase disease susceptibility. Disease will impair the physical condition.
12. The quantity or quality of food available will to a great extent determine physical condition when available foraging time is limited (during the breeding season).
13. Reduced feeding efficiency will cause increased energy expenditure, and accordingly impaired physical condition.
14. Impaired physical condition will increase predation vulnerability.
15. Increase in glaucous gull and arctic fox populations can cause increased predation.
16. A reduction in available grazing areas implies that more time is required for feeding.
17. The climate affects egg and chick survival and accordingly the reproduction.
18. The climate affects energy expenditure and accordingly physical condition.
19. The climate affects food production and access to feeding.
20. The reindeer can be a grazing competitor.

SCHEMATIC FLOW CHART

VEC 8 SVALBARD PTARMIGAN



6.9.1. Background

The Svalbard ptarmigan (Lagopus mutus hyperboreus) is the sole wintering herbivorous bird in Svalbard. It is distributed over the whole of Svalbard, excepting Kvitøya. The Svalbard ptarmigan is particularly well adapted to the extreme climatic conditions in Svalbard. A low rate of activity and its ability to live on accumulated fat reserves are important factors for the ptarmigan's winter survival (Mortensen 1985). The Svalbard ptarmigans are migratory and alternate between summer and winter habitats. Mark-recapture studies carried out in Kongsfjorden indicate that the ptarmigans will leave their breeding areas in October/November, to return in February/March. The ptarmigans' winter habitat is unknown but large flocks of migrating ptarmigans have been observed in the fall and spring, particularly on the west coast of Svalbard (Løvenskiold 1964; Unander & Steen 1985). The Svalbard ptarmigans have been described as tame because they will not flee at the sight of humans. Unlike the mainland ptarmigan, the Svalbard ptarmigan has few natural enemies. Its principal enemies are the arctic fox, the glaucous gull and the snowy owl (Nyctea scandiaca). The biology and behaviour of the Svalbard ptarmigan make this a species special interest with regard to the expected activities in Svalbard. The Svalbard ptarmigan is moreover the most important of the small game species on the archipelago.

The breeding areas of the Svalbard ptarmigans are found in high-lying places, often on plateaus and on steep mountain slopes. The cock arrives in his area on the advent of daylight in February. Here he will claim territories (15-20 hectares) well before the arrival of the hens in April/May. Generally each cock has one hen in his territory, but experiments have indicated that some cocks may have up to 5-6 hens in their territory if the neighbouring cock is removed and competition is decreasing (S. Unander, unpubl. data). Unlike the cock, the hen changes to brown feathering as early as May. Already after a year the hens are sexually mature. Normally they will lay 8-9 eggs, while older hens (2 years or more) will lay 9-11 eggs. The incubation period lasts for 21 days, and the hen and chicks will leave the breeding area soon afterwards. If some of the eggs are lost at an early stage of the incubation period, due to predation or adverse weather conditions, the hen will lay new eggs. She will then, however, not lay as many eggs as she did at the first laying. Cocks and hens both reach their lowest body weight in June/July due to the energy spent on the claiming of territories and on the laying and brooding. In the winter their body weight may be as high as 1100 grams, while in the summer it may be as low as 500 grams.

For the ptarmigan hen the breeding season and the first week after hatching is the most critical with a view to rearing the chicks. While eating very little, they must live on their body reserves. Owing to the low surrounding temperatures they must also keep up a constant heat supply for the eggs. Disturbances and repeated warming of the eggs will cause additional energy costs, which may imply that the hens may have to interrupt brooding to survive (Gabrielsen & Unander 1987). The chicks are hatched in July, when the plants are most nourishing. The chicks eat knotweed buds, and in the course of a week they manage to double their body weight. After 40 days the chicks will weigh 400 grams. A great increase in fat accumulation takes place throughout September/October. With some birds up to 300-350 grams of dissectable fat has been found (Mortensen et al. 1983). Knotweed is the most important summer food for the ptarmigans, while buds and twigs of the polar willow, capsules of purple saxifrage and tufted saxifrage are the most important winter nourishment (Unander 1987). While feeding at high altitudes in the summer, in the winter the ptarmigans find their food below bird cliffs, on windswept plateaus and on snow-bare patches along the sea/sea ice.

Not all ptarmigans leave their breeding areas in late autumn. A few stay on in the area, utilizing the snow's insulating properties by making a sheltering burrow in the snow. They now eat less nourishing food while using their fat reserves as an extra source of energy. The most important adaptations of the Svalbard ptarmigans, apart from their capacity for fat accumulation/consumption and for migration, is the reduction in activity level during the period when daylight is absent (Stokkan et al. 1986). By reducing their activity level during this period they can economize with stored energy and will accordingly increase their chance of surviving the winter. In February, with the reappearance of the light, the wintering ptarmigans will have used up their fat reserves and their weight will be low (Mortensen 1985). During this period they may be very exposed if their feeding areas are covered over with ice. This can in some cases cause starvation and death (Løvenskiold 1964). This being a local phenomenon, and most ptarmigans migrating over large areas, it is probably not a problem for the total population. Most likely the access to food (snow-bare areas) is more critical for the ptarmigans in the winter.

The quantity/quality of available food in the winter and in the egg laying period, as well as the possibility of obtaining a territory, are presumably the factors deciding the size of the breeding population. Removal experiments carried out on ptarmigans in the Kongsfjord area, have indicated that newly introduced ptarmigans will establish territories after the removal of the primary breeding population. In the year succeeding the experiment, the breeding population exceeded that of the control area. This results from the fact that younger birds claim smaller territories than older birds (Unander & Steen 1985; Steen & Unander 1985; Unander (unpublished data). If having access to a breeding area, the Svalbard ptarmigan's reproduction potential is large. The hens' reproductive success is determined by their weight/physical condition at the start of the egg laying. Hens with a high body weight lay their eggs earlier, have a higher number of eggs and produce more chicks (Unander & Steen 1985, Unander 1987).

Apart from reindeer and fox hunting, the ptarmigans are the only species for which hunting is allowed from the middle of August till 1 April. In spite of a severe harvest of the species in some areas, hunting does not appear to influence the population. A local reduction caused by hunting during any one year seems to be speedily replaced the following year. Studies carried out in the Kongsfjord area have indicated that the size of the breeding population has been very stable during the period between 1980 and 1986. Nest predation by polar fox has shown a marked increase during the last 2 .

3 years, and chick production has been significantly reduced. A decline in the recruitment of the breeding population as a result of predation is expected in the course of the next years. The hypothesis concerning a cyclical variation between predator (arctic fox) and (Svalbard) ptarmigan is interesting. Svalbard points itself out as probably the most suitable location for testing this hypothesis. The studies that have been carried out in the Kongsfjord area have been of too short a duration to be able to state anything with certainty about cyclicity of the Svalbard ptarmigans.

6.9.2 The impact hypotheses

Six hypotheses concerning the potential impact of development activities in Svalbard have been evaluated. Two hypotheses, IHs 55 and 56, were considered to be invalid. Three hypotheses (IHs 52, 53 and 54) were considered as potentially valid, but, with the exception of IH 52, not being worth following up with surveys and investigations. One hypothesis (IH 51) was considered as probably valid. For this hypothesis, and for IH 52, surveys, monitoring and research have been recommended. Generally the ptarmigan IHs must be given a relatively low priority in the present version of the assessment system. The impact hypotheses have been listed in classified priorities (A-B).

A.

IH 51
Edible waste from installations and traffic will increase the area's carrying capacity for arctic fox and glaucous gull and will cause increased predation pressure on the local ptarmigan population.

In this field, data from Svalbard is lacking. Studies carried out in the Kongsfjord area from 1980 to 1986 indicate a reduction in ptarmigan production during the last 2-3 years as a result of nest predation by arctic foxes. We have been unable to demonstrate such cyclicity in the ptarmigan production as is found on the mainland. Large-scale studies carried out in Northern Norway (Myrberget 1972, Parker 1978) indicate that the ptarmigan production is regulated by the predator population. Removal of predators in an area will probably result in an increase in ptarmigan production. As for the size of the breeding population, access to suitable breeding areas appears to be a delimiting factor, subject to yearly variations. The annual chick production is mainly regulated by the predation pressure on ptarmigan nests.

The arctic fox and glaucous gull populations may increase in areas where active installations are under construction. Available food waste will attract gulls and foxes from adjoining areas. Ptarmigan eggs are important nutrients for the polar fox. There is reason to believe that an increased polar fox population will reduce the production of ptarmigan chicks in an area, even if ptarmigans are able to lay a second time in the laying period. Glaucous gulls have not been found to prey upon ptarmigan eggs/chicks. In the winter, with reduced access to food, there is nevertheless reason to believe that both glaucous gulls and arctic foxes can be important predators upin Svalbard ptarmigans (see also documentation of VEC 2: Arctic Fox).

B.

IH 52 Disturbance resulting from increased transport/traffic (on the ground and in the air) will cause a reduction in the population of the Svalbard ptarmigan.

Studies of brooding Svalbard ptarmigans have demonstrated their great adaptability. They make no attempt to flee the nest when disturbed by humans. While mainland willow grouse will flee the nest when disturbed by humans, Svalbard ptarmigans will only reluctantly leave the nest (Gabrielsen et al. 1985, Gabrielsen 1987). When the ptarmigan hen is being disturbed to the extent that she must leave the nest, the chick production may be affected (Gabrielsen & Unander 1987). If she has to stay away from the nest for a prolonged period this may affect her physical condition because additional energy will be used for incubating the eggs. The fact that ptarmigans are migratory, that nests are widely distributed and often in inaccessible terrain, plus the fact their reproduction potential is great, should ensure that the population as a whole will not be threatened by increased traffic within a specific area.

As for the winter situation, we presently have little data on the Svalbard ptarmigans. The ptarmigans are known to migrate in flocks in the fall/spring on the west coast of Svalbard. Here they will feed below bird cliffs and on snow-bare patches near the sea/sea ice. If there is a shortage of this type of feeding area, increased activity in a potential ptarmigan feeding area may affect the ptarmigans' body condition and accordingly influence the population indirectly. This may be caused by an increase in the length of time spent searching for new feeding areas. More energy will also be required to provide the necessary food. The mainland rock grouse are migratory. They alternate between breeding and winter areas and will migrate up to 800 km. Besides, the rock grouse species will demonstrate great flexibility in the winter habitats by visiting the feeding areas at any time they are accessible throughout the winter.

6.9.3 Recommended measures and studies

The following studies should be implemented in connection with the potential impacts discussed in IHs 51 and 52. The studies have been listed in classified priorities (I - III). Studies connected to the VEC of lowest priority, IH 52, have been ranked higher than studies connected to IH 51, the latter being based on studies given priority under VEC 2 "Polar Fox".

I. (To be implemented in connection with IH 52):

Study of the effect of disturbance on the physical condition of brooding ptarmigan hens.

Objective: To find what tolerance limit brooding ptarmigan hens have to disturbances, i.e. what extent and type of disturbance will produce a measurable reduction in reproductive success as compared to natural conditions.

Method: A group of ptarmigan hens will be experimentally exposed to quantified stimuli typical of the expected disturbance. The weight, number of eggs, number of times the bird leaves the nest, and the temperatures of eggs and surroundings will be measured with these hens, and with a corresponding control group of birds unsubjected to disturbance.

II. (To be implemented in connection with IH 52):

Study of the behavioural response of brooding ptarmigan hens to disturbance. (Simplified version of study I).

Objective: Find the extent and type of disturbance that causes incubating ptarmigan hens to flee their nests.

Method: A group of 5-10 incubating ptarmigan hens are exposed to quantified stimuli typical of the expected disturbance. Record types and levels of stimuli that cause alertness, orientation response and flight.

III. (To be implemented in connection with IH 51):

Studies primarily implemented under Project Ia, VEC 2 Arctic Fox; recording of possible alterations in the fox population due to human activity. If an increase is recorded, it may be relevant to formulate a project concerning the change in fox predation on ptarmigan, and its effect on the ptarmigan population.

6.9.4 Literature

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6.10 VEC 9

MARINE BIOLOGICAL RESOURCES

Prawn, Iceland scallop and Greenland halibut

LINKAGES

Self-explanatory linkages have not been described

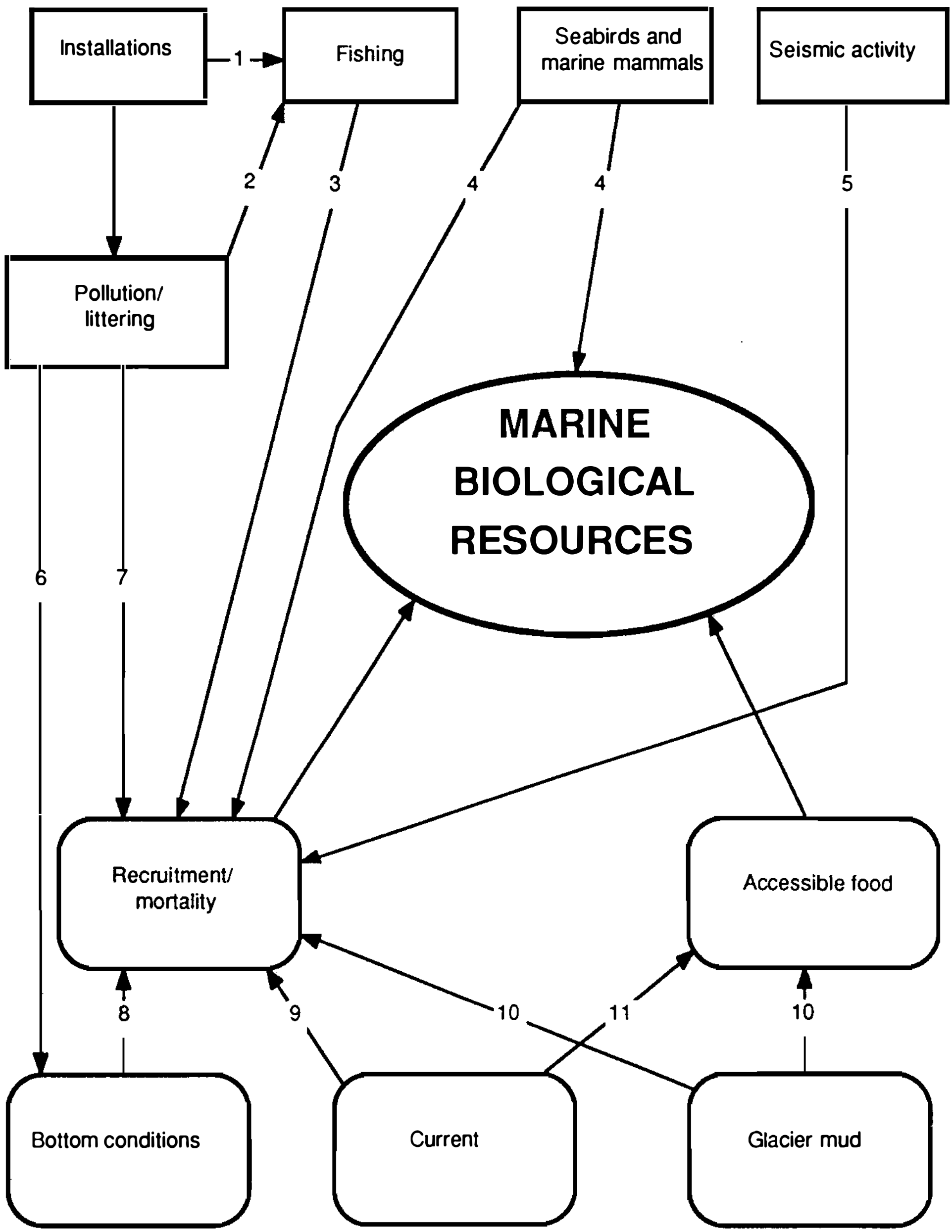
VEC 9 MARINE BIOLOGICAL RESOURCES

Reference should be made to the introductory discussion, which included pelagic fish. For several biological resources the 4 (nautical) mile limit was found to be inexpedient. In our further treatment of this VEC we have focussed on Iceland scallop beds, prawn fields and breeding grounds of Greenland halibut. It should be mentioned that the mapping of the occurrences of Iceland scallop and Greenland halibut is insufficient.

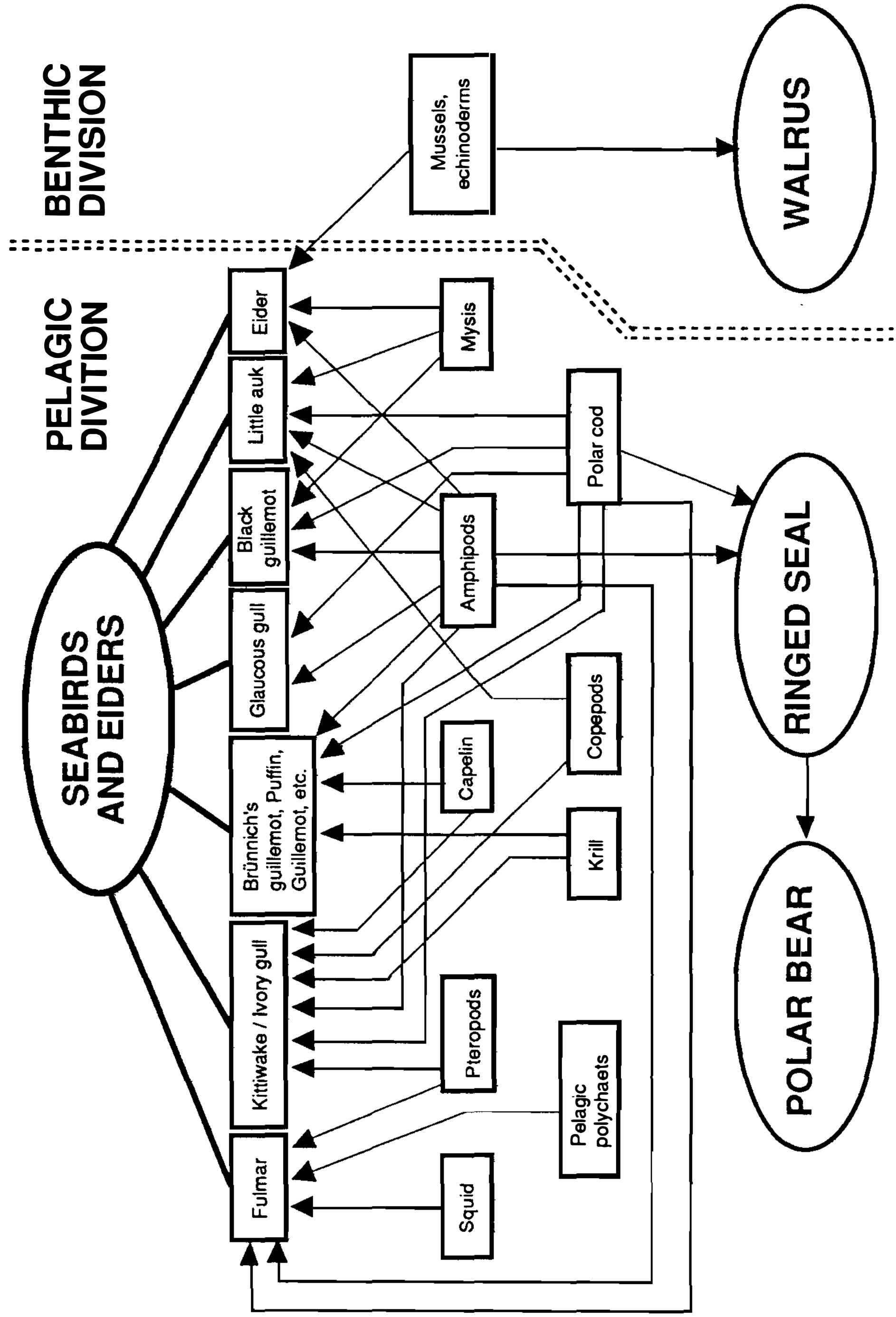
1. Installations in the fishing fields limit accessibility.
2. Mechanical waste left in the trawling fields limits fishing.
3. Fishing affects the spawning population, recruitment and mortality.
4. Sea birds and marine mammals prey on marine resources and affect the size of the population, mortality and recruitment.
5. Seismic activities can lead to increased mortality of the larval stages of Greenland halibut.
6. Mechanical waste and pollution (drilling mud) can alter sea floor conditions, and eventually affect recruitment and mortality.
7. Pollution can affect mortality and recruitment.
8. Conditions on the sea floor are decisive for distribution and recruitment.
9. Currents will affect recruitment, distribution and feeding conditions.
10. Glacial sedimentation can affect food availability and mortality. Glacial sediments particularly affect pelagic stages.
11. Currents affect food availability.

SCHEMATIC FLOW CHART

VEC 9 MARINE BIOLOGICAL RESOURCES



THE MARINE ASSOSIATED VEC'S POSITION IN THE MARINE FOODCHAIN



6.10.1 Background 170

The following criteria were taken as a basis for the delimitation of the VEC "Marine Biological Resources":

— The resources should be commercially viable.
— The resources should be of importance within the 4 mile limit.

Three marine organisms of economic significance to the Svalbard region were accordingly selected, namely deep-water prawn, Iceland scallop and Greenland halibut. Whether there are endemic marine resources in the Svalbard region worth preserving is not known, and therefore no such species are included in this VEC.

Capelin and cod can, at times, be important in the Svalbard marine ecosystem but have greater relevance outside the 4-mile limit. If the likely problems following an emergency situation are to be examined when the assessment system is subjected to adjustments later on, these species should be considered.

Seabirds and marine mammals are totally dependent upon the nutritional basis of marine biological resources. Natural fluctuations in marine populations are likely to cause fluctuations in the populations of sea-birds and marine mammals, and probably even in such species as arctic fox. To be able to distinguish between the effects of oil activities and those caused by natural fluctuations, knowledge is required of the natural fluctuations within the marine environments, physical as well as biological.

Several pelagic organisms, including polar cod, crustaceans (e.g. Parathemisto libellula, Thysanoessa inermis, calanoid copepods) and pteropods are important ecologically as food for sea-birds and marine mammals, but are most expediently dealt with as system components of other VECs. Neither does this VEC include vital food organisms for mammals that feed on the sea floor (walrus, bearded seal), as these will be most expediently dealt with as system components for other VECs.

Development activities affecting the marine environment may become important for the physical condition, mortality and reproduction of sea-birds and marine mammals. In the event of waste disposal, oil spills etc. the direct damage on these species is however likely to be more harmful than the indirect damage caused via marine food organisms.

Important food organisms such as polar cod, capelin and the pelagic amphipod libellula are abundant within Svalbard's territorial waters. The damage inflicted on these species, e.g. in the event of oil spills, will probably be smaller than the direct damage on sea-birds and marine mammals. Accordingly no specific VECs have been formulated concerning the effect of oil pollution on marine food organisms.

Deep-water prawn (Pandalus borealis) is a crustacean of great commercial importance to Norwegian fisheries. The most important fishing grounds utilized by Norwegian fishermen are the North Sea and Skagerak (Norwegian catch in 1985: 6,645 tons), Greenland (Norwegian quota 1987: 2,500 tons) and the Norwegian Sea, the Barents Sea and the areas around Svalbard. In 1986 a total of 46,000 tons of prawns was fished in the Svalbard zone, a decrease of 37 % from the previous year (Anon. 1988).

The prawn catches in the Svalbard zone may vary considerably from one year to the next. In recent years there have been comparatively large catches. The increase in the quantity of prawns caught can be ascribed to various causes: Fishing efforts have been enforced, new fields to the north of Svalbard have been taken into use and there have been years of favourable breeding conditions for prawns in this area.

The prawn's development is dependent on temperature, and the growth and development of prawns near Svalbard take longer than is the case further south. A male prawn on the Svalbard coast will e.g. need 3 years to reach about 85 mm, while the same length is reached after about 1 year on the coast of Southern Norway. The prawn is a protandric hermaphrodite. It functions as a male during the first years of its life. Growing older and bigger, it will change sex and become female. This change takes place at the age of 2-3 years in southern Norwegian waters, while the Spitsbergen prawn is 5-6 years old at the time of sex reversal. A Spitsbergen prawn between 120-130 mm is about 6-7 years old (Rasmussen 1942). On the Svalbard coast the prawn is near the northern limit of its distribution. In years when the water is particularly cold the female prawn does not develop spawn in the northern fjords. The population in northern fjords (e.g. Widjefjorden and Woodfjorden) is dominated by male prawns, as low temperatures will hamper growth and sex reversal (Nilssen et al. 1987). Under such conditions the prawn fields are dependent on immigration from areas further south.

The roe (the eggs) of the prawn is developed under the shield, i.e. "the head". Mating is effected by the male prawn placing a sperm under the forepart of the female's body. In the course of the spawning (on the Svalbard coast in August/September) the mature eggs move through two oviducts, pass the sperm, where the eggs are fertilized, continue further backwards and stick to the hind feet. The Svalbard prawn will carry the roe externally for about 9 months. When hatched, the larvae are about 5 mm long. In northern waters the larvae will probably live in the free water masses for five months before settling on the sea floor.

The trawling fields are relatively horizontal mud banks where a prawn trawl will not get stuck in. The prawns do not dig themselves into the bottom but live in the above-lying water layers. They may also wander upwards in the water column and these vertical movements are instrumental for the timing, day or night, of optimal prawn fishing.

A number of prawn fields have been mapped in the Svalbard zone. It is however not unlikely that new fields may be found, especially on the east coast of Svalbard. The biology of the Svalbard zone prawn (long period of growth, with some fields periodically needing immigration from other fields) implies that the prawn population may be subject to large fluctuations and also that it is very sensitive to an increased fishing pressure.

As indicated by its name, the Iceland scallop (Chlamys islandica) belongs to the scallop family. It is a circumpolar cold water species, and in Norway its main distribution is found to the north of Lofoten (Wiborg 1963). Most of our knowledge of the scallop's biology is based on a study of a field near Berg, Tromsø, and we know relatively little about the biology of the Iceland scallop in the Svalbard zone.

In the population near Tromsø, the Iceland scallop becomes sexually mature when the shell height measures 35 to 45 mm (3-5 years) (Vahl 1981). Males and females spawn eggs and milt into the water masses simultaneously (temperature induced?) in June/July (Skreslet 1973). In the Berg field approximately 75 million eggs are spawned per square meter. Eggs and larvae are pelagic, and the larvae settle after a couple of months. This strategy gives the Iceland scallop a large dispersal potential, and it is possible that the recruitment of one field originates from another. In the Svalbard zone the maximum age of Iceland scallops is approximately 25-30 years.

The Iceland scallops are filter feeders, of which the highest incidences are found in locations exposed to powerful currents. Their nutritional source consists of suspended organic material filtrated from the surrounding water by the gills.

Along the coast of Norway the main distribution of Iceland scallops is found at a depth interval of 20-60 m; near Bjørnøya the greatest scallop concentrations are found from 70-100 m, and on the Spitsbergen coast at 35-70 m. Since 1984 much interest has been attached to the Iceland scallop resources in the Barents Sea and around Svalbard (see 'Ottar' 1988). This is in part due to the fact that Norwegian fishermen have been forced to switch to alternative resources to keep the fishing fleet in operation. In 1987 about 15-20 Norwegian scallop factory trawlers were operating. During and after the 1988 season, however, the activity has been drastically reduced, mainly due to reduced prices on the scallops.

In 1986 six Iceland scallop fields were found on the west and north sides of Svalbard, and the catchable population was estimated at approximately 400,000 tons (Rubach & Sundet 1987). Little is known about the maximum sustained yield of the Svalbard populations, as e.g. data on growth is lacking. Nor do we know for certain whether the Svalbard fields are self-recruiting or being recruited from fields further south, but studies carried out in 1987 and 1988 would indicate that the populations are self-recruiting (Jan Sundet, personal notification). The densest populations have already been severely decimated due to fishing, and in addition the non-selective dredging technique has altered sea floor conditions radically (Jan Sundet, personal notification). Whether these changes will have long-term effects is unknown.

The Greenland halibut (Reinhardtius hippoglossoides) is an arctic boreal flatfish of a more pelagic character than the other flatfish species. The larvae lives pelagically till it is about 7-9 cm. At the size of 5 cm it is still symmetrical, and adult Greenland halibut have also been observed swimming "edgewise".

The Greenland halibut is high in fat content and is in some places appreciated as a very good edible fish, particularly when smoked. The male fish hardly reaches more than 80 cm in length (6-7 kg), while the female fish can reach more than one meter in length and obtain a weight of 15-20 kg or more. The Greenland halibut mainly lives on fish, crustaceans or echinoderms.

The Greenland halibut lives in the Pacific as well as the Atlantic Ocean. In the Atlantic Ocean it is found along the coast of North America, Greenland, and in areas near the Faroes and Iceland, along the coast of Norway and in the Barents Sea. There is a certain exchange between the Faroes/Iceland population and the Norwegian coast/Barents Sea population.

Before the mid 1960s, relatively little fishing was carried out on the population of this species on the coast of Norway and in the Barents Sea. However, the catches increased from 11,000 tons in 1963 to approximately 90,000 tons in 1970. In recent years the catches have been approximately 20,000 tons per year, half of which has been taken in the Barents Sea and in areas to the south and west of Bjørnøya (Anon. 1988).

The interest attached to Greenland halibut in connection with Svalbard is explained by the fact that the fjords of Svalbard are probably important breeding grounds for this species (Haug & Gulliksen 1982, Godø & Haug 1987 a,b,c). Eggs and larvae are carried northwards from the spawning grounds between 60°N and 75°N by the water current from the coast of Norway towards the coastal waters of Svalbard. The Greenland halibut found in the coastal and fjord areas of Svalbard are small (10-50 cm) and young (1-6 years). The Svalbard area is assumed to be the most important breeding ground and recruitment area of the adult population of Greenland halibut, as individuals of this size are seldom caught in other areas of the Barents Sea and along the coast of Norway. To a certain extent this has been confirmed by mark-recapture data. The data basis is however somewhat scanty, due to few marking experiments. Our knowledge of the distribution and migratory pattern of the Greenland halibut is therefore insufficient.

6.10.2 The impact hypotheses

In working out impact hypotheses, deep-water prawn, Iceland scallops and Greenland halibut have been dealt with separately. The factors of depth, sea floor conditions, water temperature and currents are essential to the size and distribution of the populations. In addition, there is fishing, which is the most important human activity influencing size and distribution. These factors will be central in the assessment of potential effects of the petroleum activity, while for the time being they are outside the scope of MUPS.

Six hypotheses concerning potential impacts of development activities on marine biological resources were evaluated. Two hypotheses (IHs 61 and 62, see chapter 8) were considered to be potentially valid, and some possible measures and investigations were discussed. However, None. of these hypotheses were given priority in this version of the assessment system. Three hypotheses (IHs 57, 58 and

59) have been documented as valid, and investigations in connection with them have been recommended. One hypothesis (IH 60) was considered as probably valid and relevant to follow up with surveys and monitoring. The impact hypotheses have been listed in classified priorities (A and B):

A.

> IH 57
> Dumping of mechanical waste in the sea will result in loss of and damage to fishing equipment and will reduce fishable areas.

Experience from the North Sea shows that petroleum activities may cause dumping of mechanical waste on the sea floor (discarded equipment, scrap from constructions) which is likely to become most extensive near platforms and in the sea lane of the petroleum traffic. Fishing and catching equipment used in Svalbard (prawn trawl, shellfish dredger) may become caught up in and possibly destroyed by such waste.

A.

> IH 58
> The presence of installations will reduce the area available for deep-water prawn trawling and Iceland scallop dredging.

If located in an area where fishing and catching is going on, a petroleum rig will make part of the area inaccessible for fishing. The practical size of this part will depend on type of equipment used, but in relation to the gear (trawl, dredger) mainly used on the Svalbard coast the area made inaccessible will be relatively large.

It is presently not possible to estimate the size of the areas potentially occupied in the waters around Svalbard, but, as an example, the areas to be occupied during the exploration phase (1986-95) of Troms II in the fishing banks of Sveinsgrunnen (line field) and Malangsgrunnen (line/net field) were estimated at approximately 250 km^2 and approximately 320 km^2 respectively (Troms County Municipality/the Troms Director of Fisheries 1985).

A.

> IH 59
> Oil spills, and possibly the use of oil spill dispersants, can cause reduced quality/increased mortality of the benthic resources.

Parts of an oil spill, possibly the dispersed oil, can be absorbed in the sea floor sediments. A number of experiments and field observations (Anderson et al. 1978, Law & Blackman 1981, Hartwick et al. 1982) have indicated that oil in sediments can have harmful effects on marine benthic organisms. The following threshold values have been estimated for oil in sediment: "crude oil": 200 - 700 ppm (parts per million); "no. 2 fuel oil": 50 - 100 ppm; "residual fuel oil" 600 ppm (Davies et al. 1984). To prevent harmful effects on marine benthic resources, oil spillage, and the use of oil dispersants, should be avoided.

B.

> IH 60
> Oil spills, chemicals and drill cuttings will reduce the populations of deep-water prawns, Iceland scallop and Greenland halibut.

Oil is regarded to be most harmful to fish and benthos organisms at the egg and larval stages (FOH 1979). (With fish the most critical period is generally from the spawning and fertilization of the egg until the fry's movements are sufficiently powerful to make it essentially independent of the movements of the water masses). Whether this is also the case for the larval and fry stages of prawn, Iceland scallop and Greenland halibut is not known, but there is good reason to believe so. If occurring in the spawning period, an oil spill may thus potentially cause great local damage in the Svalbard area. The hypothesis is however very difficult to test under natural conditions. Laboratory tests may provide some information on the validity of the hypothesis.

The size and distribution of the populations around Svalbard should be more accurately assessed. To be able to estimate the extent of the damage caused by spills of oil, chemicals and drill cuttings there must therefore be a thorough assessment. In addition to the effect of the spills (oil, chemicals and drill cuttings), the physical presence of an installation will have an effect on the fishability of the population.

6.10.3 Recommended measures and studies

The following studies should be implemented in connection with development activities potentially having the impacts discussed in the impact hypotheses. The studies have been listed in classified priorities (I - III).

I. (To be carried out in connection with all IHs):

Surveys of marine biological resources such as prawn fields, breeding grounds of Greenland halibut and the occurrence of Iceland scallops.

Objective:
1. To obtain an overview of the total resources in the Svalbard zone.
2. A detailed description of the areas potentially affected by projected developments.

Method: Standard surveying methods. The distribution of responsibility between the Ministry of Fisheries and the Ministry of the Environment concerning the scallop and fish resources within 4 nautical miles of Svalbard will have to be clarified.

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

Monitoring of marine biological resources at the drilling stage and after potential spills of oil and chemicals.

Objective: To clarify the immediate effect of the relevant development activity, including spills, and to get an increased understanding of the effect of the oil activity on the natural dynamics of the system.

Method: Depending on type and extent.

III. (To be implemented in connection with IH 60):

Research on the effects of oil, chemicals and drill cuttings on the younger stages (egg, larvae) of the three species. The most important aspect of the effect studies is to study/clarify the recruiting process of the three populations.

Objective: To provide a basis for evaluating long-term effects of oil spills on the populations.

Method: Laboratory and possibly field studies.

6.10.4 Literature

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6.11 VEC 10

SVALBARD CHAR

(Arctic char)

LINKAGES

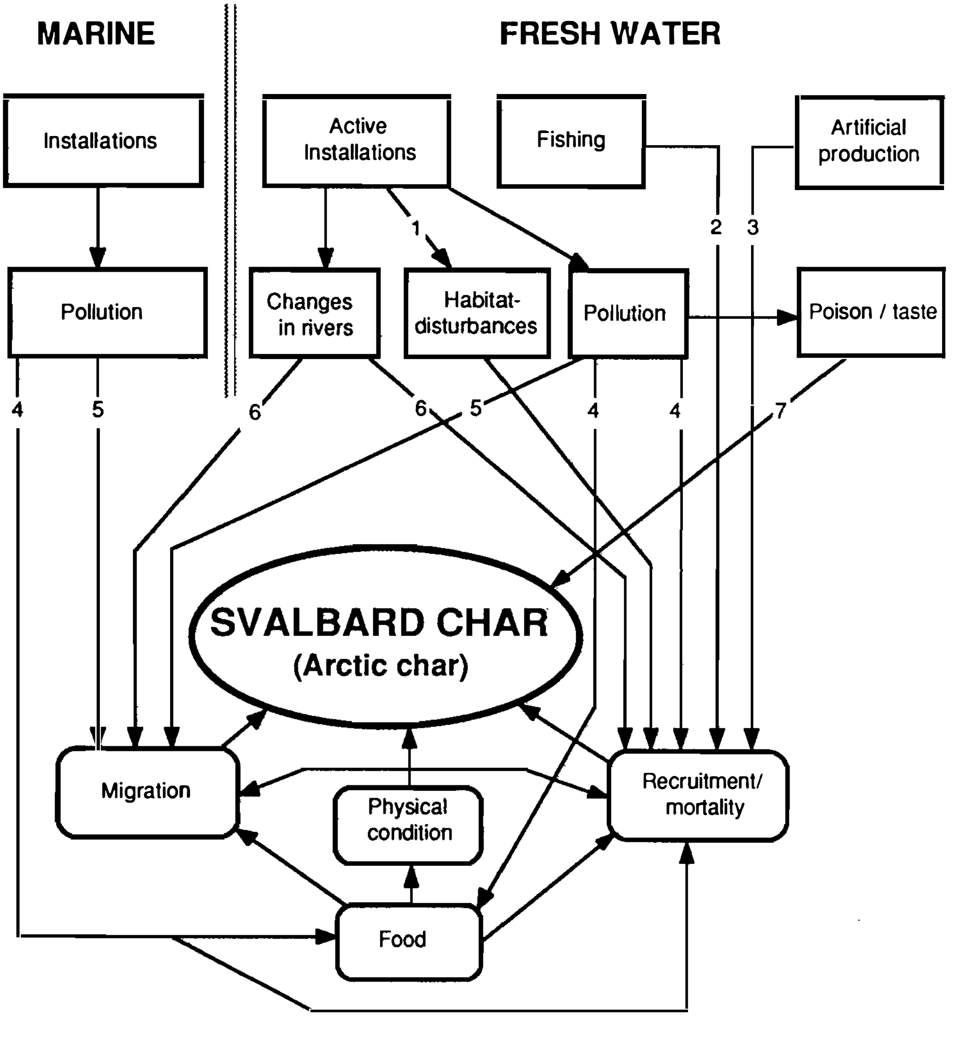
Self-explanatory linkages have not been described

VEC 10 SVALBARD CHAR (Arctic char)

1. Dams, gravel tips and quarries can cause disturbance in char habitats as well as reduced recruitment and increased mortality.
2. The fishing must be in accordance with the recruitment to the sexually mature population.
3. Transplantation of the char will increase the population (affecting outdoor recreation).
4. Pollution can result in increased mortality, reduced recruitment and food availability.
5. Pollution can impede upwards migration of spawning char.
6. The barring/changing of river beds can prevent immigration and emigration and recolonization of depleted lakes and will change the population composition and recruitment pattern.
7. Pollution can change the taste and may result in toxic components in char.

SCHEMATIC FLOW CHART

VEC 10 SVALBARD CHAR (Arctic char)



6.11.1 Background

The char family (Salvelinus) is distributed throughout the northern hemisphere and represents a branch of the salmon family (Salmonidae). The family includes three phylogenetic lines, of which two are each represented by one species, lake trout (S. namaycush) and brook trout (S. fontinalis). Both species have their natural origin and distribution in North America but have recently also been introduced to Scandinavia. The third line includes Dolly Varden (S. malma) and white-spotted char (S. leucomaensis), which are distributed along the edges of the Pacific Ocean and parts of Asia respectively, and our native char (S. alpinus). The char in Svalbard as well as in Norway belongs to this species. S. alpinus has a circumpolar distribution and is the freshwater species with the world's northernmost distribution. This char occurs in very different varieties. It is commonly divided into 3 groups: Small and stationary fish, plus anadromous fish. Stationary fish are the animals that live only in fresh water. The anadromous form is char (having reached a certain size) which each summer will migrate from fresh water to the sea, to return to the watercourse in the fall. Geographical conditions permitting, all these forms can exist together.

The issue of whether S. alpinus covers a variable (polymorph) species, or several closely related species, has been debated. This debate is referred to as the "char problem" (Reisinger 1953, Nordeng 1961). Based on breeding and mark/recapture experiments it has recently been demonstrated that offspring of the individual char form is split into all three types, and that the individual fish can transform from one form to another in the course of its life cycle (Nordeng 1983). The present scientific view is that all three varieties of char in reality belong to the same population/species.

In Svalbard the char is popularly called "Spitsbergen salmon". It is found everywhere in anadromous as well as stationary types. The anadromous char is found in water courses in which migration between fresh water and salt water is possible. The stationary char is probably found in most large inland lakes in Svalbard, also in waters in which there are anadromous individuals (Dahl 1926, Gullestad 1973, 1975, Hammar 1982). The Svalbard char is the only freshwater fish in the archepelago.

The anadromous char spawn lives its first years of life in fresh water, the number of years being dependent on its growth and accordingly on the food available in its habitat. In Svalbard the combination of a brief summer and low food production causes the fish to grow very slowly. In fact studies from Revvatnet near Hornsund would indicate that the spawn needs an average of 7 years before reaching a size of 17 cm (Gullestad 1973).

On reaching this size the char will migrate to the sea for the first time. This change of habitat is connected with outer morphological changes. The freshwater fish, which has a dark, colourless coating with markings resembling fingerprints along its body, appears in the sea with a dark back, shining sides and without the markings. It is assumed that these changes will contribute to providing a better camouflage against predators. This transfer implies a change from an environment with a lower salt concentration to an environment with a higher salt concentration than the char's body. To avoid dehydration the sea char accordingly has to readjust from removing a surplus of water to removing a surplus of salts. With salmon this adaptation to salt water involves a number of endocrine and biochemical changes which collectively are termed smoltification (Hoar 1976, Folmar & Dickhoff 1980). It is most likely that the anadromous char undergoes the same kind of process but this has not yet been documented. The time of this migration has however been documented and can vary with the age of the fish; it will usually take place immediately before or in connection with the disappearance of the ice in the watercourse.

Studies of the anadromous char in Norway indicate that it will stay 4 - 6 weeks in the sea before returning to fresh water life. In the course of this period it will seldom wander more than 10 -80 km from its river of origin (Mathiesen & Berg 1968). Corresponding data is not available for the Svalbard char. There is however reason to expect that its stay and the length of its migration are somewhat shorter than is the case with the char in Norway. The migration from salt water to fresh water takes place from the middle of July till the end of August. The migration of fish that are not yet sexually mature is distributed throughout this period while the spawners will migrate up the river during the last week of July and the first half of August. The periods of migration may vary from one year to the next, depending on the climate in the summer season (Gullestad 1973).

An abundance of food is available to the Svalbard char during its stay in the sea. An average growth of 5-7 cm/year has been recorded in the course of the first years after the establishment of its anadromous behaviour (Gullestad 1973). Spawning fish often have a tinge of pink on the silvery abdomen. The Svalbard char migrates to the sea at least 3 times before it starts spawning. The fish is 9-10 years old at this time and about 40 cm long. Following this they usually spawn each year after a period in the sea. The spawning, which takes place in fresh water (river or lake), will most likely occur in the course of September.

According to existing records, Svalbard char weighing 10 kg have been caught. The oldest recorded Svalbard char was 27 years (Hammar 1982).

As a whole, the Svalbard char does not appear to be particularly at risk by the extent of petroleum activities planned in Svalbard to date. The problem that is most likely to occur is an over-harvesting on some populations as a result of an increase in the human population and easier access. Locally there may be problems due to gravel quarrying, damming, changing the courses of rivers and pollution.

6.11.2 The Impact hypotheses

Three hypotheses concerning the potential impact of development activities on the Svalbard char population have been evaluated. Hypothesis 65 was considered to be potentially valid, but not worth following up with studies and measures. Hypothesis

64 was considered to be documented as valid, and hypothesis 63 was considered as probably valid. The hypotheses have been listed in classified priorities (A - B):

A.

IH 63
An increase in the human population and traffic resulting from industrial activities in Svalbard will cause a reduction in local char populations.

Today's sea char fishing in Svalbard takes place in late autumn, coursely meshed nets cast into the lakes are used. This implies that mainly fish aged 9-10 years and more will be harvested. The results of a shortage of spawners or limited spawning will be noticed 9-10 years later in the form of a lack of fish in certain age-classes.

The slow growth and turnover in a char population should actually indicate a careful harvesting. The anadromous char is very easy to catch because of its annual migrations to/from the sea. Barring the course of a river with nets may therefore cause a heavy impact on the area's spawning population. A few thoughtless people may damage the recruitment of the population. Several of the lakes of Svalbard are today being over-harvested. An increase in the population of Svalbard as a result of oil activities would therefore entail a risk of over-harvesting in several lakes. However, this problem ought to be solved by management measures.

Such measures are however contingent upon more information on the char's biology, the effect of net fishing on the populations, the char's distribution in Svalbard etc. and a monitoring of the most exposed lakes.

B.

IH 64
Impact on water courses by gravel quarrying, damming or pollution will result in a reduced recruitment and population of Svalbard char.

Changes in river courses, gravel quarrying or dam building can obviously affect the char population of a lake. This is however improbable with the present level of industrial development in Svalbard. Besides, such impacts will presumably only be local as it is unlikely that several lakes can be affected.

With regard to oil pollution, this is presently not considered to be a potential problem, as an oil spill hardly will affect the char population in Svalbard. Locally the problem may become relevant in a lake or at an estuary. Surveying is recommended for lakes with good fishing.

6.11.3 Recommended measures and studies

The following studies should be implemented in connection with development activities potentially causing the effects referred to in IHs 63 and 64. Further studies have been listed in classified priorities (I - III):

I. (To be implemented in connection with IHs 63 and 64):

Surveying of numbers of the char population in the water courses of Svalbard, primarily those exposed to human influence and harvesting.

Objective: To provide an overview of the localization and size of char populations potentially affected by human activities.

Method: Test fishing, mark/recapture studies.

II. (To be implemented in connection with IHs 63 and 64):

Monitoring of the char population in water courses exposed to human influence.

Objective: To record the effect of development activities and thereby enable the implementation of mitigatory measures and minimize the negative effects of new development projects.

Method: Test fishing, mark/recapture, studies of individual specimens.

III. (To be implemented in connection with IHs 63 and 64):

Studies on the biology of the Svalbard char (migrations and spawning population).

Objective: To provide a basis for determining a coordinated management policy.

Method: Standard methods (test fishing, mark/recapture, studies of individual specimens.

6.11.4 Literature

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6.12 VEC 11
VEGETATION AND SOIL

LINKAGES

Self-explanatory linkages have not been described

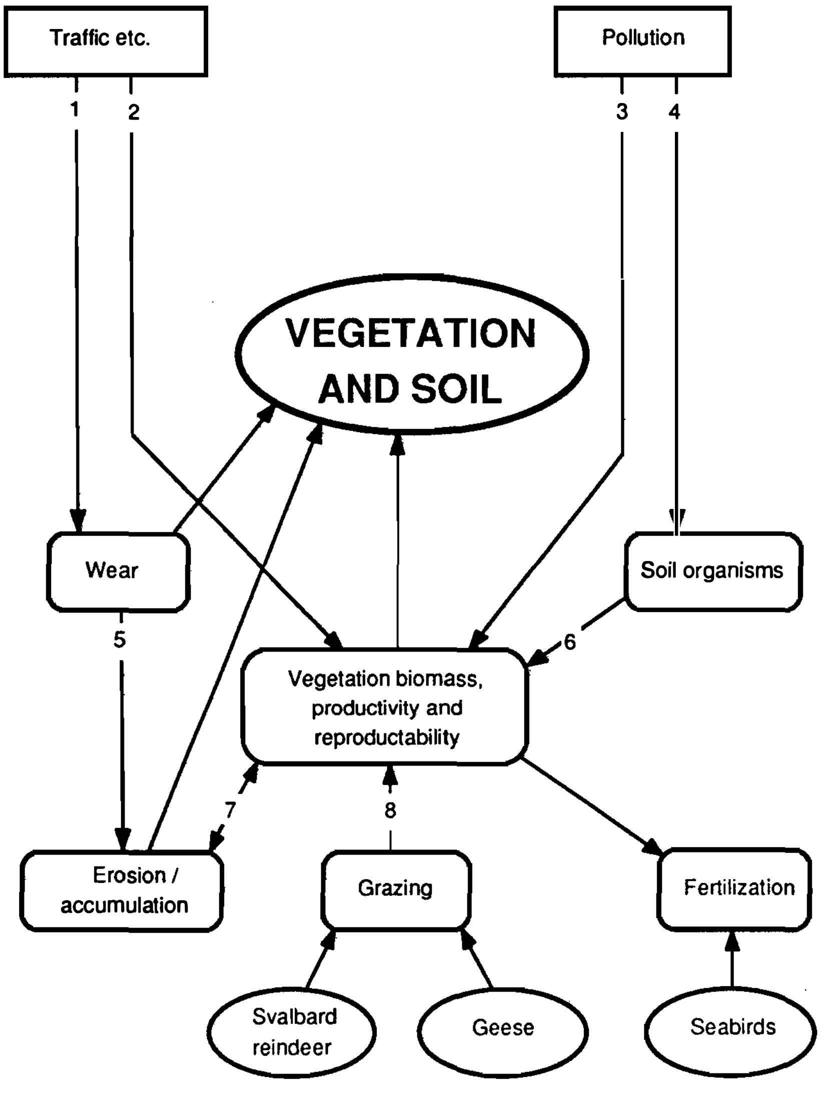
VEC 11 VEGETATION AND SOIL

1. Traffic causes soil wear. The sensitivity to wear is dependent upon geophysical conditions (including hydrology (water, snow, ice), texture, gradient) and vegetation.
2. Traffic causes vegetation wear. Traffic can also affect (positively or negatively) the reproduction and dispersal of plant species.
3. Pollution affects (positively or negatively) the vegetation cover.
4. Pollution affects soil organisms.
5. Wear initiates erosion/accumulation, contingent upon the same conditions as mentioned under item 1.
6. Soil organisms affect the conditions for the re-establishment of vegetation through mineralization of organic material, the effect on soil structure and dispersal of diaspores.
7. Erosion damages the vegetation cover. Destruction of vegetation leads to erosion.
8. Grazing can alter the vegetation's resistance to wear.

A further illustration of the most important system characteristics influencing vulnerability to vegetation damage are indicated in Fig. B.

SCHEMATIC FLOW CHART

VEC 11 VEGETATION OG SOIL



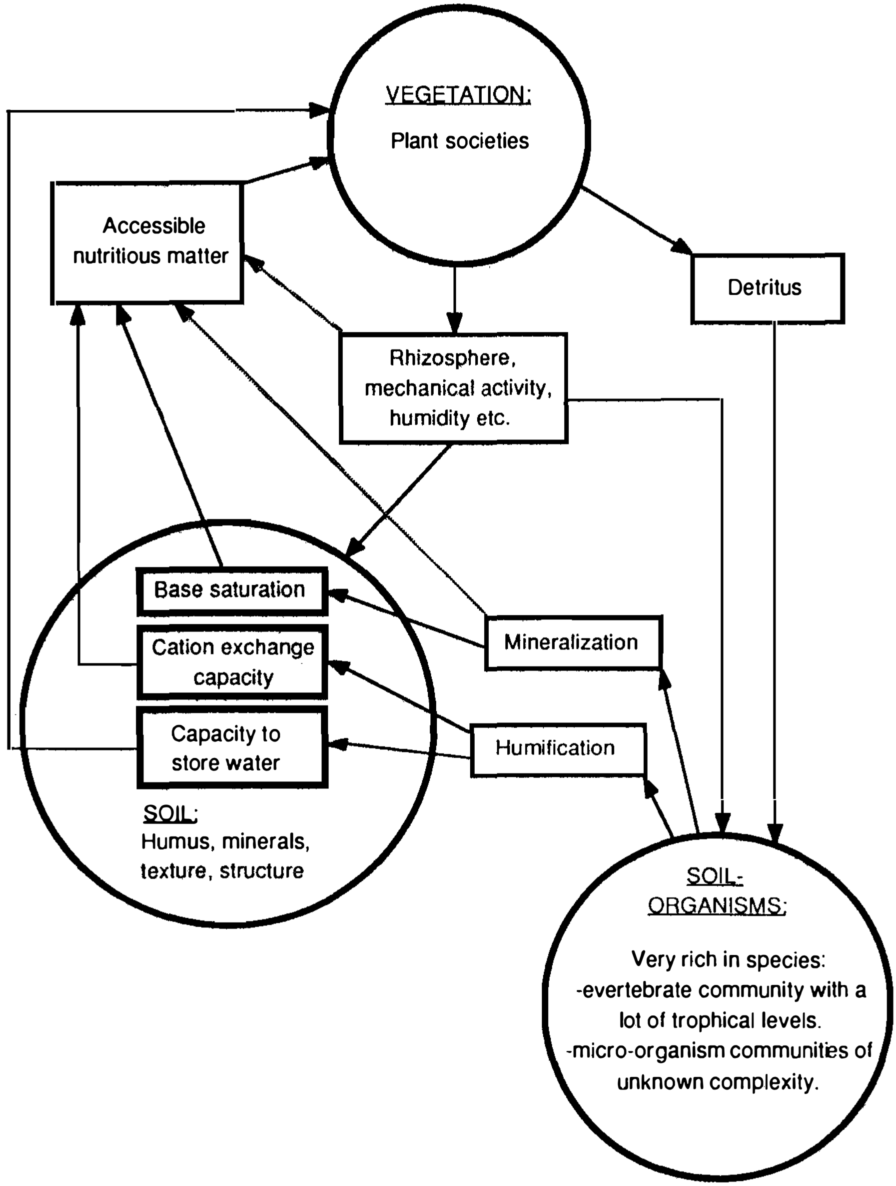


Fig. A
The links between vegetation, soil and soil-organisms.

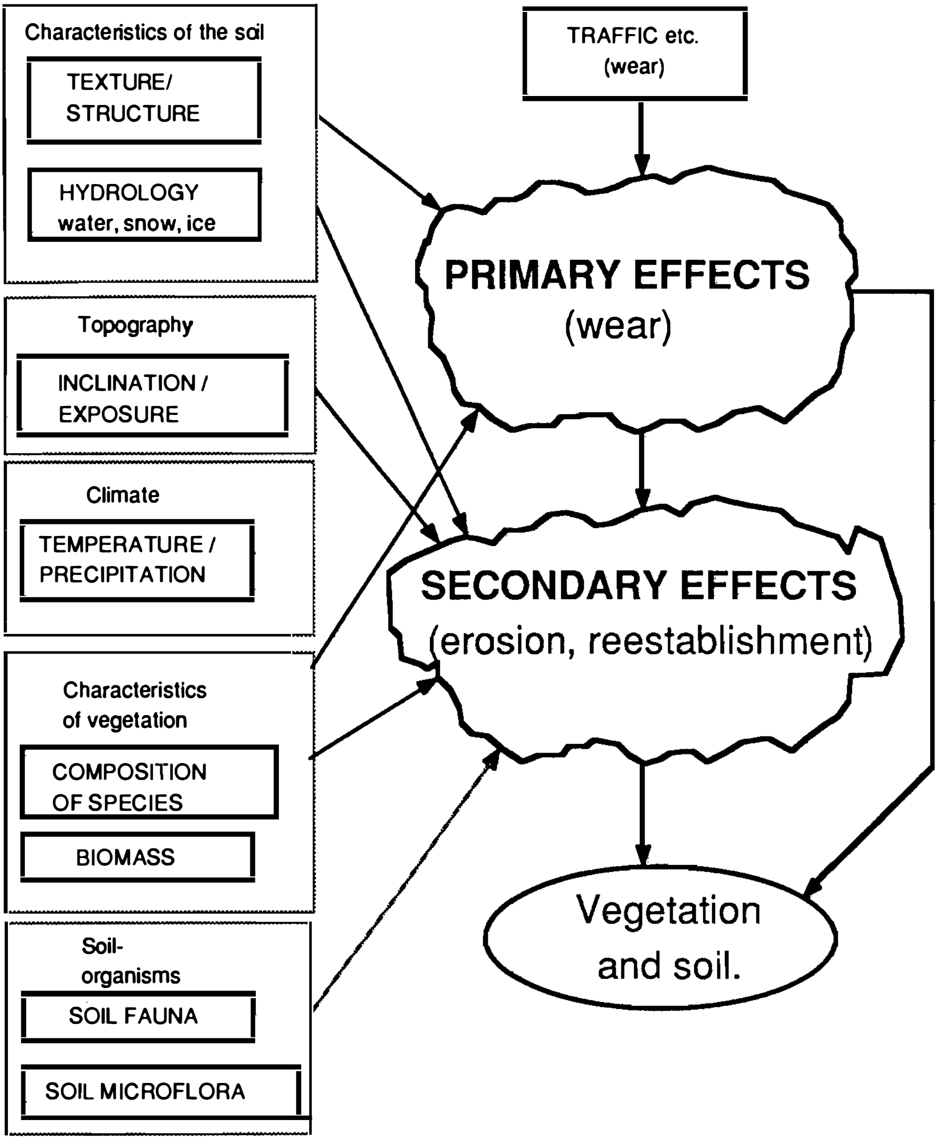


Fig. B
Characteristics of the system influencing the wear sensitivity of vegetation and soil.

6.12.1 Background

Vegetation destruction and the resultant soil exposure is the most conspicuous environmental impact of man's activity in Svalbard. Wherever industrial activities have taken place, there is track damage, erosion is in process and new tracks are continually made. Nevertheless we do not have sufficient knowledge on the localization, extent and development of vegetation damage in Svalbard.

The VEC "Vegetation and soil" was originally meant to consist of three main components: Vegetation, soil organisms and soil, which together constitute an open ecosystem (Fig. A). Soil and soil organisms were, in this context, to be viewed primarily for their importance concerning the formation of the plant cover and their effect on ground stability. After further discussion the soil organisms were left out of the VEC and instead regarded as "an essential ecological component" in the system (figs. A and B). Even if the soil organisms play a decisive part in the circulation of nutrients in terrestrial systems, our knowledge of their dynamics is still very fragmentary. Before soil organisms can be subjected to more thorough examination in impact assessments, considerable efforts are required in terms of basic research not naturally falling under the scope of the MUPS programme.

To a great extent damage of the ground surface is often due to erosion in deeper soil layers as well. The entire soil layer has therefore been included in the VEC.

Svalbard has in most areas a low, patchy vegetation, with the exception of low-land areas with favourable temperatures. There is a striking diversity in vegetation locally. This is due to variation in topography (surface relief), determining snow and water distribution, and in the courseness and stability of the soil. Different vegetation assemblages in this manner reflect the various environmental conditions. Svalbard has permafrost and only the upper meter will thaw in the course of the summer (the active layer). The vegetation cover has an insulating effect, and changes in the vegetation cover will influence the depth of the thawing. At sites with a great content of water the active layer can become unstable and might easily begin to move. Fine-grained soils normally have the greatest ice and water content and are accordingly more unstable than coarse-grained soils. In large parts of Svalbard the soils are determined by the underlying rock type.

Vehicle or pedestrian damage generally will not occur as long as the ground is snow-covered and frozen. Snow packing due to vehicles frequently running over the same track can result in uneven spring thawing and cause delays in plant growth and shifts in the soil layers as the top layers of the permafrost will become correspondingly uneven.

Wear of the plant cover and soil layers will have long-term effects. Due to poor insulation the melting will go deeper and water will gather where the plant cover has been pressed down. On slopes the melt water will cause soil erosion, and after some time a ditch will be formed. Plant and root density, the snow/water quantities in and above the tracks and the coarseness of the soil masses will determine the tendency for such ditch formation. Mainly fine-grained soil containing a lot of water and ice will be most sensitive (Lawson 1982). Fig. B gives a more detailed overview of the factors influencing the vegetation/soil sensitivity to such damage.

No completed system is yet available for judging the vulnerability of the vegetation/soil or for classification of the relevant areas. A preliminary suggestion has, however, been discussed by Sørbel and Tolgensbakk (1988) and may probably also be included in the MUPS assessment system. A division into four classes according to a vulnerability assessment is now employed - they range from scarcely vulnerable areas to high risk areas in which vehicular tracks will not be repaired by nature but will rather be opened further. A fifth class covers areas worthy of protection for aesthetic, educational or scientific reasons.

6.12.2 The impact hypotheses

Six hypotheses concerning the potential impact of development activities on the soil and vegetation of Svalbard were evaluated. One hypothesis (IH 71) was considered as potentially valid but not worth following up with investigations. Two hypotheses (IHs 66 and 70) have been documented as valid. Studies were only recommended in connection with IH 66. Three hypotheses (IHs 67, 68 and 69) were assumed to be valid and important to follow up with studies. The hypotheses have been listed in classified priorities (A-B):

A.

IH 66
Traffic and installations will result in vegetation and soil damage. The degree and type of wear can, to a great extent, be predicted on the basis of climate, soil geology and vegetation characteristics.

Pedestrian and vehicular traffic can involve wear on the plant cover and underlying soil and depends on such factors as thickness of plant cover, terrain gradient, composition of the soil layer and the area's exposure to snow, ice and water. Wear will often cause further erosion, i.e. the sediments are removed by mass movement, running water or wind with resulting scars in the terrain. Such traffic-induced erosion damage is, today, the most conspicuous effect of human activities in Svalbard and can be seen wherever industrial activities have taken place. Surveys of existing damage will provide information that may be useful in planning new activities, in order to avoid further damage.

Trampling and driving not involving direct wear may nevertheless involve the death of plants, and in the longer term alter the re-growth of the vegetation. The compression of the plant cover and soil also results in alteration of the composition of soil organisms, as the moisture and temperature conditions are changed.

After such an erosional event, when the soil is more or less bare, re-vegetation may start. The process will probably differ in the various vegetation types, depending on the degree of damage of the substratum. Knowledge of the various types of natural plant succession patterns is deficient. Such knowledge might form the basis of experimental trials, such as fertilizing and seeding, in order to accelerate the re-vegetation process with one or both of the following objectives:

a) to establish a plant cover to prevent further erosion
b) to re-establish a vegetation as close to the original vegetation as possible.

In some instances the plant cover will hardly reappear in the foreseeable future, as only dry layers of gravel are left. Very few erosion studies have been carried out in Svalbard (but see Kaltenborn 1986, Sørbel & Tolgensbakk 1988). With the death or removal of the plant cover, the soil layers might be exposed to further erosion. In locations with a high content of ground ice, deeper melting will create topographical depressions in the surface. In sloping terrain track damage may channel running water and accelerate erosion.

B.

IH 67
Pollution can result in erosion and damage to the vegetation.

Very little literature is available concerning the effects on vegetation and soils by such types of pollution that are relevant to industrial activity in Svalbard. Oil spills and other types of chemical contamination will presumably, in many cases, result in death and growth disturbances in affected plants. The effect will vary with the different species, depending on the type and amount of pollution, and the environmental requirements of the plants. Long-term effects can involve changes in the composition of species and plant cover. Where the plant cover is subjected to a certain level of destruction, resulting erosion damage may be hard to mitigate if soil contamination prevents re-vegetation. Wetlands below the emission sites will be the most at risk.

B.

IH 68
Soil organisms can be effective in breaking down oil spills.

The application of fertilizers and/or biological agents such as specialized bacteria may possibly form an alternative to mechanical clean-up operations. SINTEF (The Foundation for Scientific and Industrial Research at the University of Trondheim, Norway) has already started investigations within these latter two fields. New projects should await their results and be based on the work of SINTEF.

B.

IH 69 The soil fauna can be more vulnerable than the vegetation cover to certain pollutants. Impacts on this fauna may have secondary effects on the vegetation.

The soil organisms are vital to plant growth, by converting substances in dead plant material and thus providing nutrition for new growth. The soil organisms affect the structure and water content of the soil and also aid the dispersal of diaspores. If soil organisms are more vulnerable to a certain type of pollution than are the plants, this may cause secondary effects on vegetation that cannot be predicted by the reaction of the plants to the specific type of pollution.

The MUPS framework ought to offer an opportunity of gaining insight into this problem.

6.12.3 Recommended measures and studies

Studies recommended in connection with IHs 66, 67, 68 and 69 have been ranked by priority (I-II). They all involve surveying and monitoring assignments. To make such projects maximally efficient in terms of methodology, data basis and reference standard, several long-term research assignments of a more general character should be initiated. These have not been given priority within this version of the assessment system but, having general relevance, they have been included after the descriptions of the priority projects.

Ia. (To be implemented in connection with all IHs):

Surveying of vegetation and soil in the development area.

Objective: Provide a basis for recommendations that might minimize the effects of development activities.

Method: Test sites, aerial photography and possibly satellite (SPOT) imagery.

Ib. (To be implemented in connection with all IHs):

Surveys of "valuable objects" in the development area.

Objective: To provide an overview of geological formations that should not be affected by the development. May be implemented in connection with the general surveying.

Method: Field surveys.

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

Monitoring of possible industrial developments.

Objective: To record the effect of developments/pollution on vegetation and soil to enable the adaptation of relevant and possibly later developments, with a view to minimizing harmful effects.

Method: Field surveys, possibly use of unaffected control sites.

Basic research assignments which have not been given priority.

The following long-term, general research assignments have not been given priority within this version of the assessment system but have general reference to the projects of priority.

A. Studies for assessment/reduction of the effect of wear damage (ranked by priority).

1. Aerial photography of the central and southern parts of Spitsbergen at a suitable scale (1:20,000).

   Existing aerial photographs are frequently old and of a poor quality. Only black/white photographs are available. New aerial photography will enable the recording and surveying of all existing damage. The surveying of vegetation and soils will, to a great extent, be possible from aerial photographs. The need for field studies will be strongly reduced and the results will accordingly be produced more speedily and at a lower cost. Surveys based on new aerial photographs can be used as calibration data for satellite imagery.

2. Method testing for surveying.

   Testing of various survey methods for various purposes and for different levels of resolution/scales is important in order to produce a standard method for industrial plans. Key words in this context will be the assessment of satellite based surveying (LANDSAT 5-TM, SPOT) and colour/IR photography in contrast to traditional black-and-white aerial photographs. Modern technology no doubt enables a more integrated recording of botanical and geological objects, and a coordinated surveying, involving the professional challenges represented by this kind of cooperation, is made possible. In this context the relevant methods of data collection should be subjected to assessment, with an evaluation of population surveys versus vegetation assemblages. For these purposes, and also for other field studies, (e.g succession studies), an overview should be prepared of vegetation types/surveying units in Svalbard (as a parallel to the ØKOFORSK reports on the mainland) and supported by investigations of non-documented units (ØKOFORSK is now renamed NINA: Norwegian Institute for Nature Research, Trondheim).

This comprehensive project, which has already been initiated, will comprise 3-5 man-labour years per annum plus operation costs, yearly about 1-2 mill. NOK.

3. Succession studies along existing tracks.

   Surveys of vegetation and the extent of damage along existing tracks of different age and in different areas. These studies will cover the types of vegetation/geological formations through which the tracks pass. Such studies may explain the causality of the preceding modifications and be of great use in the preparation of criteria for vulnerability to erosion damage. A closer study of the re-colonization ability of plant species, distributed within the various types of vegetation and various types of damage modifications may provide the basis for active mitigative measures such as re-vegetation tests. The continuation of experimental studies can be considered anew when a survey on information of existing damage is available.

4. Surveying of "valuable objects".

   The surveying of "valuable objects" covers the distribution, status and ecology of rare plant species (vascular plants, cryptogams), vegetation population, "stationary" animals (e.g. invertebrates) and geological formations. This type of study ought to be undertaken over the whole of Svalbard, in order to assess the occurrences found in a minor development area in a larger context. This surveying will have to be performed as a follow-up of the MUPS funded project "List of Species recorded in Svalbard", and it will have to be coordinated as part of the data base construction. The long-term objective will be the maintenance of the present-day status of poorly known "objects": to put existing knowledge in the data base and to find a routine for continuously inputting future information into a data base for the relevant management agency, independent of the publishing cycle of researchers/observers. The project should not be cost intensive but should be of a considerable period of time: 0.3 - 0.5 man-labour years has been proposed. Investing in more concentrated efforts over a short period of time in order to finish the clarification of a specific organizing group for report/publishing may be considered later.

5. Establishing a geographical information system (GIS).

   The incorporation of all types of spatially referenced data connected to MUPS (survey information on geology and biology, protection areas, claims, terrain damage etc.) in a common data base. Thus information on a specific area can speedily be produced and connected to other information as desired. Such a system may greatly benefit research, management and industrial activities in Svalbard.

B. Studies concerning the evaluation/reduction of the effect of pollution:

With the start-up of drilling and possibly oil production, knowledge on the effects of pollution will be necessary (cf. IHs 67, 68 and 69). This information should be produced as early as possible. On the assumption that oil based drill cuttings will be properly taken care of, the most relevant types of pollution will be:

— accidents with diesel and other types of combustion fuel
— oil spills at test drilling/production sites
— spills of toxic wastes etc.

The following research assignments are recommended, ranked by priority:

1. Field experiments applying oil (possibly other pollutants) to different types of vegetation, in order to study the effects on vegetation and soil organisms.
2. Field experiment to study the decomposition of oil.
3. Field and laboratory experiments to study the effects of exhaust gases on vegetation and soil.

6.12.4 Literature

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6.13 VEC 12
LITTORAL ZONE

LINKAGES

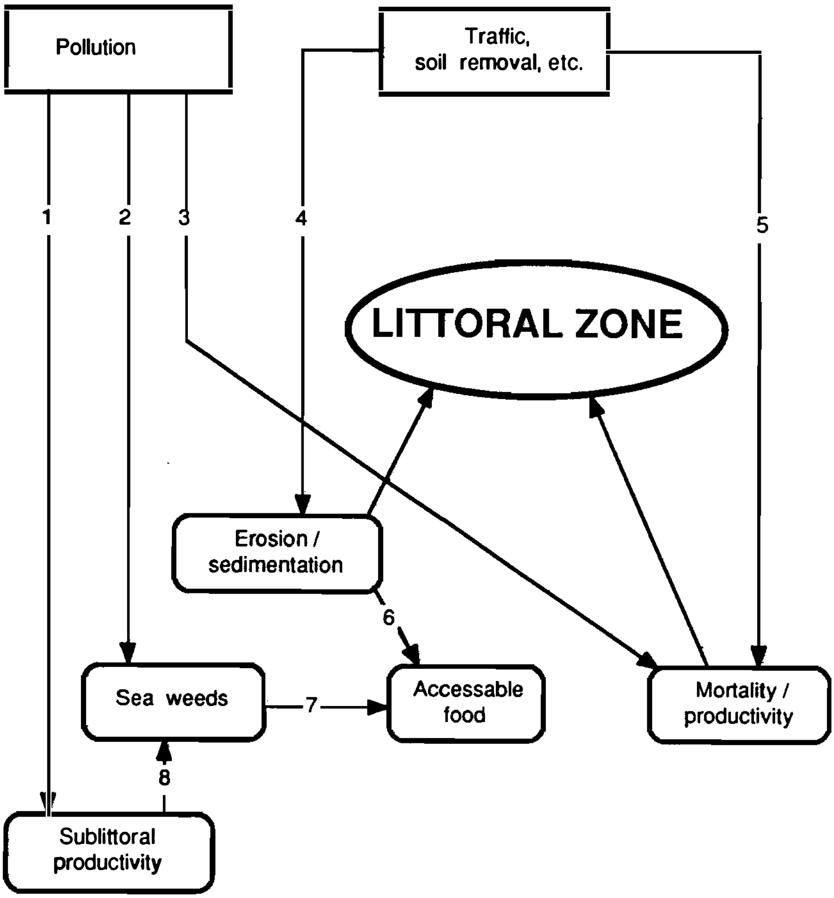
Self-explanatory linkages have not been described

VEC 12 LITTORAL ZONE

1. Pollution can affect sublittoral productivity both positively and negatively.
2. Pollution directly affects kelp banks both positively and negatively.
3. Pollution affects productivity/mortality by a toxic or fertilizing effect.
4. Traffic and gravel quarrying cause erosion and sedimentation.
5. Traffic and gravel quarrying generally cause increased mortality of "littoral zone" species.
6. Erosion and sedimentation affect the food availability positively or negatively.
7. The breakdown of kelp banks provides an important source of nutrition for plants and animals.
8. Sublittoral production supplies material for kelp banks.

SCHEMATIC FLOW CHART

VEC 12 LITTORAL ZONE



6.13.1 Background

This VEC covers the whole of Svalbard's "littoral zone", exclusive of glacier fronts. Its vertical distribution is in this context defined as the distance from the bottom low-water level to the upper limit of the spray zone (the littoral zone and the supralittoral zone). The VEC includes the entire ecosystem permanently connected to this zone. The VEC can in some instances share the qualities of, or overlap, the VECs 9 "Marine Biological Resources" and 11 "Vegetation and Soil".

The "littoral" zone has been made a separate VEC, as it is a part of the Svalbard environment which has specific qualities and importance, and which is relatively frequently exposed to such development activities as traffic, wear, installations and pollution.

VECs such as 3 "Arctic Fox", 4 "Polar Bear", 5 "Walrus", 7 "Eiders and Geese, 8 "Seabirds" are connected to, or use the "littoral zone", which is also of special value to recreationists, both aesthetically and as a traffic route (VEC 14). General traffic will also be impeded if parts of the coast are polluted or damaged.

A general map of Svalbard's coastline is under preparation and video recordings are available, supplemented with stills of the major part of the "littoral zone". The material is being organized in a data base (Department of Physical Geography, Institute of Geography, University of Oslo) which is not yet complete, as some areas have not been covered. Great importance should be attached to the follow-up of the production of a data base and a general map.

6.13.2 The impact hypotheses

Four hypotheses concerning the impact of potential development activities on the "littoral zone" of Svalbard have been evaluated. One hypothesis (IH 75) was considered to be potentially valid, but not sufficiently important to be given priority in the assessment system. One hypothesis (IH 74) has been documented as valid, and connected surveys and monitoring is recommended. Two hypotheses (IHs 72 and 73) were considered to be valid and important to follow up with studies. The impact hypotheses have been listed in classified priorities (A-B):

A.

IH 72
Oil contamination can cause considerable damage in the "littoral zone". The areas least exposed to waves are the most vulnerable.

Experience as well as research carried out on shores on more southerly latitudes have indicated that protected localities are vulnerable to oil spills. This is explained by their poor self-cleaning properties as well as the presence of a large element of stationary organisms unable to escape pollution. The same feature applies to lagoons. In arctic regions the oil may stay a considerable time (100 years) in fine-grained sediment (Domerachi & Thebean 1981). Rocky shores and wave-exposed sediment beaches, on the other hand, are scarcely vulnerable and have considerable self-cleaning properties (Teal & Howarth 1974). However, the more high-lying parts (the supralittoral) with their kelp banks and lagoons are vulnerable. Polluted kelp banks may possibly act as reservoirs for long-term pollution of adjoining areas. The yearly ice covering by e.g. freezing sea spray may have a preserving effect on oil absorbed in kelp banks and sediments. The long light period of summer must however, due to photo chemical processes, be assumed to contribute to a different course in the breakdown of oil spills in the "littoral zone" of Svalbard than is the case on the mainland.

Oil on the types of shores which have poor self-cleaning properties can be removed by chemical treatment and/or washing, washing or biological decomposition. All of these methods can, in themselves, have environmental effects.

As it will be technically very complicated to use mechanical clean-up methods in Svalbard, chemical treatment/washing and biological decomposition are likely to be the most relevant measures.

Against this background it is desirable to learn more about the effectiveness and also the biological effects of the two latter methods under Svalbard conditions.

A.

IH 73
A. Remedial measures to treat oil spills accumulated in the "littoral zone" can be effective in arctic temperatures.
B. The effects of the remedial measures can be more harmful than the oil as such.

Some individual studies have been carried out concerning the microbic decomposition of oil on some types of shores (SINTEF reports). However, the type of study primarily needed is a comparison of the effectiveness, and the possible harmful effects, of all relevant cleaning methods. Only on such a basis will it be possible to agree on a standardized cleaning strategy. In that context it would be relevant to study the optimal effect of the individual cleaning methods under various conditions. Separate projects must be avoided; there should be a careful coordination of the efforts (resources) invested in the examination of the individual cleaning methods.

To be able to assess the impacts of oil spills (and accordingly the need for clean-up action) and also the effects of the clean-up measures, it is essential to provide more information on some natural fluctuations and processes in the ecosystem of "littoral zones".

B.

IH 74 Traffic and installations can cause wear in the "littoral zone".

Depending on the type of shore, installations and wear due to motorized and human traffic can cause erosion and sedimentation. The hypothesis is valid but gives little reason for concern. The most important aspect of this hypothesis is to avoid areas of special interest: particularly productive lagoons, stretches of beach (wave protected) and vulnerable types of shore meadows (on fine sediment beaches). Rocky shores are not subjected to wear, and wave exposed sediment beaches are scarcely vulnerable to mechanical wear. Likewise, beaches made up by fine-grained material, with a wave-protected location, will probably have a great self-repairing ability. The great yearly variations in frost and ice will take care of this, but these factors may at the same time cause oil spills to have very long-range effects (100 years?) (Domerachi & Thebean 1981).

6.13.3 Recommended measures and studies

The following studies should be implemented in connection with development activities potentially involving the impacts referred to in IHs 72-74. The studies have been listed in classified priorities (I-III).

I. (To be implemented in connection with IHs 72 - 74):

Geomorphological and biological surveys of the "littoral zone" in the relevant development areas.

Objective: To provide a basis for minimizing the harmful effects of developments.

Method: Field surveys (fauna, partly vegetation) aerial photography, satellite imagery (vegetation, geomorphology) to be coordinated with the surveys under the VEC "Vegetation and Soil".

II. (To be implemented in connection with IHs 72 - 74):

Recording/monitoring of impacts caused by development activities on the affected "littoral zone".

Objective: To document development impacts over a prolonged period, in order to minimize the harmful effects of the current, and later, of corresponding development activities.

III. (To be implemented in connection with IHs 72 and 73):

Studies of the biological and geological processes of the "littoral zone".

Objective: To identify the most vulnerable processes and provide a basis for evaluating the effects of development activities.

Method: Various.

6.13.4 Literature

Domerachi, D.D. & Thebean, L.C. 1981. Persistence of Metula oil in the Straits of Magellan six and a half years after the incident. OPP 1: 37-48.

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6.14 VEC 13
OUTDOOR RECREATION

LINKAGES

Self-explanatory linkages have not been described

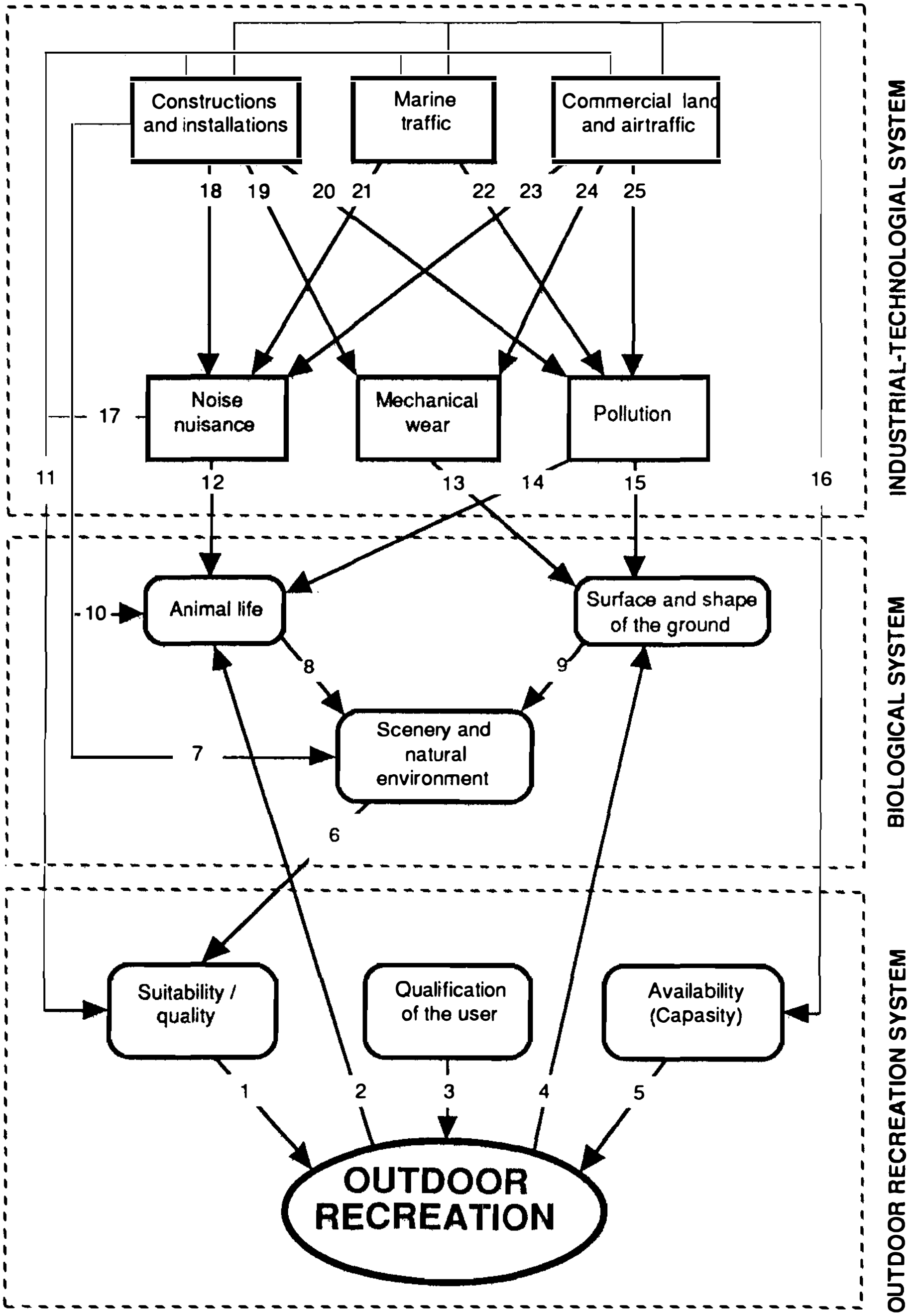
VEC 13 OUTDOOR RECREATION

1. The area's suitability/potential for outdoor recreation is of importance to practising outdoor recreation.
2. The practice of outdoor recreation may influence population size, survival and distribution of fauna.
3. The user's economic and personal qualifications, motivation, preferences, needs etc. are of importance to the practice of outdoor recreation.
4. The practice of outdoor recreation may affect ground surface and terrain form.
5. Organization and capacity, including physical accessibility and facilities (e.g. transport and overnight accommodation) are of importance to the practice of outdoor recreation.
6. The character of the landscape and the natural environment will be important factors when determining the area's suitability for outdoor recreation.
7. Industrial plants and installations, marine traffic and commercial traffic in the air and on the sea can have a direct effect on landscape configuration.
8. Disturbance/displacement of fauna will change the natural environment.
9. Modification of ground structure can result in a modification of the natural environment.
10. Industrial plants and installations may attract fauna.
11. Industrial plants and installations, marine traffic and commercial traffic in the air and on the land may affect the natural environment's suitability/quality for outdoor recreation.
12. Noise/disturbance can displace fauna.
13. Mechanical wear can have a negative effect on ground structure and in some instances cause (irreversible) erosion processes.
14. Chemical pollution can have a disturbing/degrading effect on fauna.
15. Chemical pollution and dumping of waste may cause modifications of the ground surface.
16. Industrial plants and installations, marine traffic and commercial traffic in the air and on the land can result in positive or negative changes in the accessibility of the outdoor recreation areas.
17. Noise/disturbance can have a direct effect on the area's suitability/quality for outdoor recreation.
18. Installations can cause noise.
19. Industrial plants and installations can result in mechanical wear of the ground surface.
20. Industrial plants and installations can cause chemical pollution of the sea, inland water, on land and in the air.
21. Marine traffic can cause noise.

22. Commercial traffic can result in chemical pollution of the sea, inland water, on land and in the air.
23. Commercial air and land traffic can involve noise.
24. Commercial air and land traffic can cause mechanical wear of the ground surface.
25. Commercial air and land traffic, can cause chemical pollution of the sea and inland water, both on the land and in the air.

SCHEMATIC FLOW CHART

VEC 13 OUTDOOR RECREATION



6.14.1 Background

The VEC "Outdoor Recreation" differs from the other VECs in a number of ways and will accordingly require a different angle of approach. Outdoor recreation as a VEC requires an integration of methods used in natural science as well as in social science. In the schematic flow chart, the system of outdoor recreation is seen in relation to natural environment and industrial impact. The flow chart does not, however, provide a total picture of outdoor recreation in relation to all types of effects. Factors other than nonindustrial activities have not been included.

The following system components will affect the VEC "Outdoor Recreation":

Suitability/quality: The physical suitability or quality of the landscape for practising outdoor recreation (recreational quality). The suitability is determined by the content of the landscape and the natural environment (mountains, woods, coast, cultural landscape etc.), variation (homogeneous or heterogeneous landscape; the extent of change between types of nature, human impact), character (unique or common type of landscape) and the degree of intactness (human impact, shaping of the landscape). In this component are also included administrative measures and regulations (rules concerning traffic, hunting and fishing, accessibility, organization in the form of accommodation, information).

User qualifications: A very complex system component. The motivation, preferences, skills, wishes, economy and recreational carrying capacity/behavioural carrying capacity. Recreational carrying capacity reflects acceptable user density within a certain area. The exceeding of recreational carrying capacity will result in a degrading of the user's experience when involved in outdoor recreation. Recreational carrying capacity has been defined in various ways:

"Tolerance to meetings between groups" (Stankey 1973; Badger 1975; Nielson & Shelby 1977). "Degree of acceptable social change" (Frissel & Stankey 1972) and "degree of sustain-able use over a defined period of time without causing unacceptable damage neither to the physical environment nor to the experience of the recreationist" (Lime & Stankey 1971). Several methods have been developed to be able to handle the concept; in practice using this expression has however proved to be difficult. American outdoor recreation research and management are now attempting to make a better quantification of the concept based on physically measurable and comparable sizes. The aim is to discover what users and management would consider to be "an acceptable degree of change" (Limits of Acceptable Change; Stankey et al. 1985).

Accessibility/(capacity): Determined by the infrastructure of the area and transport facilities to and from the area. Industrial activities can have a positive effect on accessibility (e.g. new roads) as well as a negative effect (e.g. occupying areas and traffic restrictions). Organization in the form of accommodation and other facilities will to a certain extent determine the physical capacity of the area, i.e. the maximal number of recreationists that can be received in the area, with indoor accommodation for all. Capacity is in this respect part of the concept of accessibility.

Due to the special conditions in Svalbard, where outdoor recreation, particularly in the winter, involves motorized traffic, defining the concept of recreation was difficult. However, the group decided to use the official definition of the Ministry of the Environment as a basis in Svalbard as well. The Ministry defines outdoor recreation as: "Outdoor and physical activity during leisure time aiming at giving a change of environment and experience of nature." The definition does not include motorized traffic, and accordingly not motor boat traffic, the use of terrain motorcycles or snow scooters. At the same time the group does acknowledge that these very activities play an essential part in outdoor recreation in Svalbard. We are therefore of the opinion that motorized means of transport used in an outdoor recreational context must be regarded as important system components. A snow scooter may for instance be an important means of getting into the wilderness to experience nature, while snow scooter driving as such in this context is not defined as an outdoor recreation.

The Svalbard environment offers varied opportunities for outdoor recreation activities. The cruise ship traffic must in this context be regarded as tourism and not as outdoor recreation. The remaining most important groups of activities are the following:

- hiking; carried out by permanent residents as well as visitors,
- hunting and fishing; big game hunting only by permanent residents, small game hunting by permanent residents and visitors,
- skiing; presumably mostly by visitors, but to some extent also by permanent residents,
- motorized traffic in the summer; terrain motorcycles and small boat traffic mainly used by permanent residents,
- motorized traffic in the winter; snow scooters driven by permanent residents and visitors.

Outdoor recreation is practised on an individual non-organized basis as well as via tour operators with guides, and is in several ways different from outdoor recreation on the mainland. A trip to Svalbard involves elements of risk which are only to a small degree met with on the mainland. The weather conditions, particularly in winter, can be capricious and extreme, demanding the use of good equipment and skills. A great deal of the recreational traffic takes place on fjord ice and glaciers. Considerable knowledge and experience are called for to be able to take proper safety precautions. The fauna constitutes an important attraction as well as an element of risk. Polar bears are found all over the archipelago, even if the chance of meeting one is greater in some areas than in others. Outdoor recreation to a great extent takes place far from centres of population. The wilderness character of the area implies that, in the event of an accident, help may be far away.

An increase of industrial activity in Svalbard may substantially affect the public's opportunity to practice and experience outdoor recreation. Outdoor recreation in

Svalbard today is to a great extent directed towards the experience of relatively untouched nature and is accordingly dependent on a low user density. The value of the experience in recreation will be reduced if the users of an area will encounter a relatively greater number of other users than expected (Hendee et al. 1978, Brockmann et al. 1979). Changes in user pattern density may be caused by an increase in the number of recreationists and an increase in other types of activities, such as oil/gas exploration/extraction, commercial traffic, government inspection etc. Warren (1986) has studied the experience satisfaction of a group of recreationists in an area of arctic Alaska. He found, among other things, that the delimiting social factor for hunters was a certain number of encounters with other groups of people, and that for hikers, the delimiting social factor was a certain number of helicopters or small aircraft.

To establish the potential disturbance of factors such as industrial activities it is essential to discover what the tolerance of outdoor recreation is to external impacts and also possible conflicts between the recreationists. There is a considerable potential for conflicts in outdoor recreation in Svalbard. It is a well-known fact that e.g. the noise of snow scooters will affect skiers a great deal more than vice versa, and that the tolerance of the snow scooter user accordingly will be higher than that of the skier (Hendee et al. 1978). The snow scooter user will probably also have a higher tolerance than the skier to changes such as increased helicopter traffic, traffic on the ground and installations in the terrain (Hendee et al. 1978). In Svalbard the recreational/behavioural carrying capacity must be expected to differ with the various groups of users, and, besides, it is a dynamic quantity. Recreational/behavioural carrying capacity will change with the development of an area and with the users' ability to adapt to change. It is also worth noting that the behavioural carrying capacity of the individual user will on occasions differ. Future conflicts within outdoor recreation will most likely take place between motorized and non-motorized activities. Or between what is sometimes called "urbanists" and "purists" (Warren 1986, Emmelin 1988, personal communication).

Industrial activities in an area can create more attractive conditions for some groups of users, by making the area easier of access, while other groups, seeking an experience which connects more with a wilderness-like character, will be "directed" to areas that are still unaffected. This is a well-known phenomenon within recreation management, e.g. in North America.

This condition will illustrate several important aspects of outdoor recreation in Svalbard:

— Outdoor recreation is a complex concept. In Svalbard it consists of different types of activities with different needs, tolerance limits and preferences. Outdoor recreation can hardly be referred to as one homogeneous group or type of activity.
— It is essential to understand the qualifications or "composition" of the users to a) ensure recreation management in accordance with the needs of the recreationists and b) to be able to evaluate the potential impact of industry on outdoor recreation in Svalbard. This will include knowledge concerning motivation, skills,

preferences, socio-economic background and expectations. A number of authors have pointed to the importance of recording these components, and of using this knowledge for evaluating the extent to which the needs of the users are met with. (Clark 1986, Hammit et al. 1986, Hendee et al. 1978). This type of information relating to Svalbard is today almost nonexistent.

— In addition to user qualifications studies it is also essential to carry out a classification of types of landscapes/regions and their suitability for the various types of outdoor recreation.
— Conditions and factors influencing outdoor recreation must be viewed in a context. Industrial activities affecting outdoor recreation will add to other conflicting interests and limitations already existing within outdoor recreation.
— The outdoor recreation management in Svalbard ought to be "stratified", as varying activities and needs have to be catered for. This can be done by preparing an outdoor recreation plan based on "Recreation Opportunity Spectrum" (ROS) (Driver & Brown 1978), providing opportunity for creating zones according to recreational needs and varying the degree of adaptation within the various zones.
— As the VEC of outdoor recreation consists of many types of activities, needs and interests, scenarios should be run for several potential developments in the event of a planned development. Scenarios may, until the completion of a ROS plan, give an indication of impacts upon outdoor recreation.

6.14.2 The impact hypotheses

Each main component of the industrial technological system (industrial plants and installations, marine traffic, commercial traffic in air and on land) was originally given its hypothesis concerning impacts on outdoor recreation. However, this division turned out to be inexpedient, the components representing three aspects of the same matter. A collective hypothesis, assumed to be valid and important to follow up with surveys/studies, has accordingly been formulated.

IH 76
Industrial activities will affect the practice and experience of outdoor recreation in Svalbard through industrial plants and installations, marine traffic and commercial transport on the ground and in the air.

The geographical location of resources used commercially will determine the extent of roads, routes, pipelines and other permanent installations, shipping fairways, and air traffic. For logistic and economic reasons, prospective installations are likely to be located as near Longyearbyen or Svea as possible. This may mean that central areas on Spitsbergen will become the most exposed part of Svalbard as outdoor recreation is concerned. This is currently also the part of Svalbard that is easiest of access and most used for outdoor recreation.

Increased industrial involvement on the archipelago will probably result in increased and possibly more widely spread building activity. This may be detrimental to the quality of the experience of outdoor recreation, but may also provide an attraction and a measure of safety in the event of accidents. There will be diverging views on this matter, according to the various interest groups.

Outdoor recreation may, also, disturb or cause problems for industrial activities.

A need for delimitations and traffic restrictions may occur because of this, possibly resulting in reduced access and an altered outdoor recreation user pattern.

Sea traffic may similarly limit the exercise of outdoor recreation. Possible commercial hydrocarbon finds may entail the building of storage and shipping installations and oil and gas tank transport. If tank traffic takes place on a year-round basis ice breakers will have to keep leads open in the fjord ice. The leads will be a hindrance to the snow scooter routes. Ship traffic will cause noise and disturbance. On the other hand, the use of ice breakers may result in an enrichment of the fauna in leads that are created, which in turn may have a positive effect on outdoor recreation.

6.14.3 Recommended measures and studies

The studies that should be implemented in connection with developments potentially involving the effects described in IH 76 have been listed in classified priorities (I-II):

I. Impact assessments concerning the impact of industrial development on outdoor recreation. The investigations are carried out within limited geographical areas around development sites. (To be implemented in connection with IH 76):

Objective: To provide an overview of the likely impact of developments and conflicting situations with outdoor recreation, with a view to minimizing harmful effects. When information on outdoor recreation in Svalbard eventually is built up, studies will no longer be needed regarding all new activities/developments.

Method: Examining area use (level prior to development). Assessing the area's suitability for outdoor recreation. Apply questionnaires to investigate user qualifications (motivation, preferences etc.).

II. Strategy of the Recreation Opportunity Spectrum (ROS) type. Results of the individual impact assessments will contribute to building up a satisfactory data base for an outdoor recreation plan of the ROS type. (To be implemented in connection with IH 76):

Objective: To prepare a plan for a stratified management plan for outdoor recreation in Svalbard. A ROS type plan will divide the relevant areas into zones suited for the various types of outdoor recreational activities. Different management measures or regulations can be attributed to the various zones. In Svalbard a somewhat smaller and modified edition of the original ROS will be relevant. In the event of planned developments, a plan of this type will to a great extent forecast expected impacts on outdoor recreation, which groups have been "directed" to other areas and to what extent "redirected" users can find comparable opportunities for experience elsewhere.

Method: To study user qualifications and terrain suitability for different types of outdoor recreation.

6.14.4 Literature

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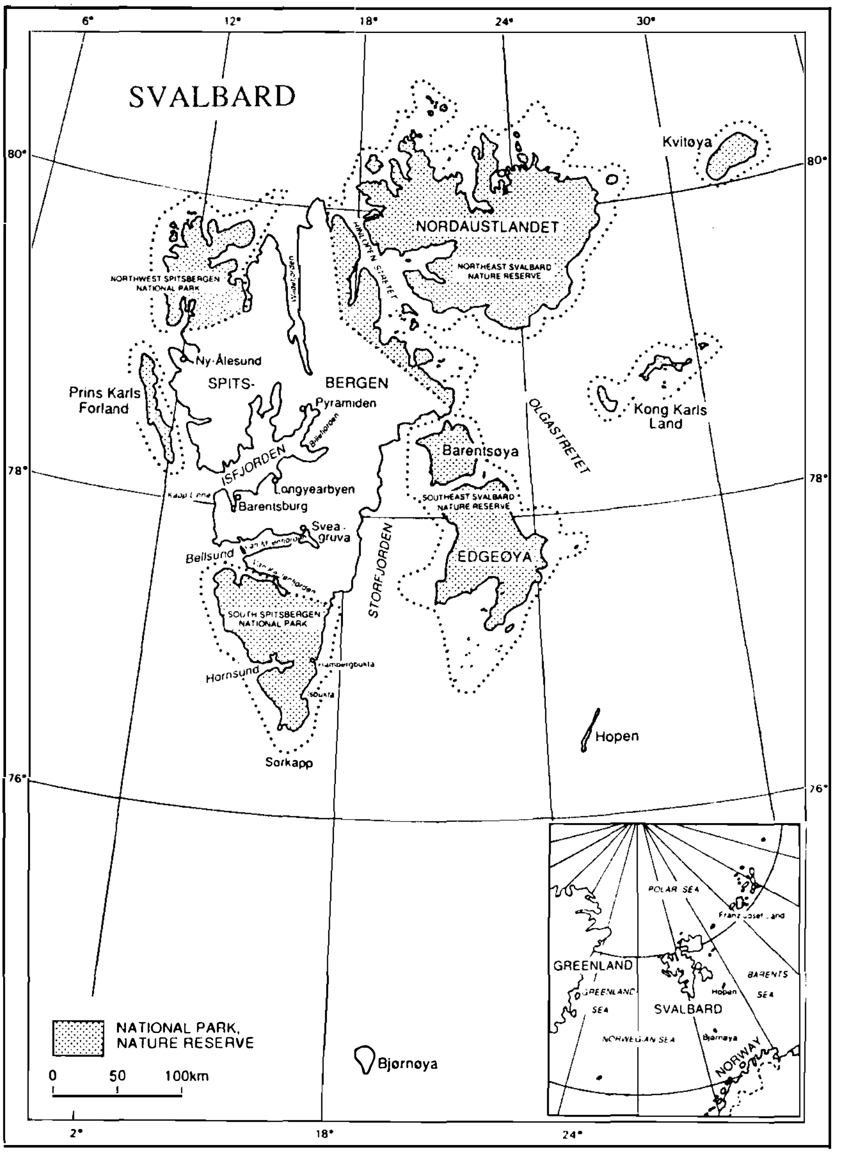
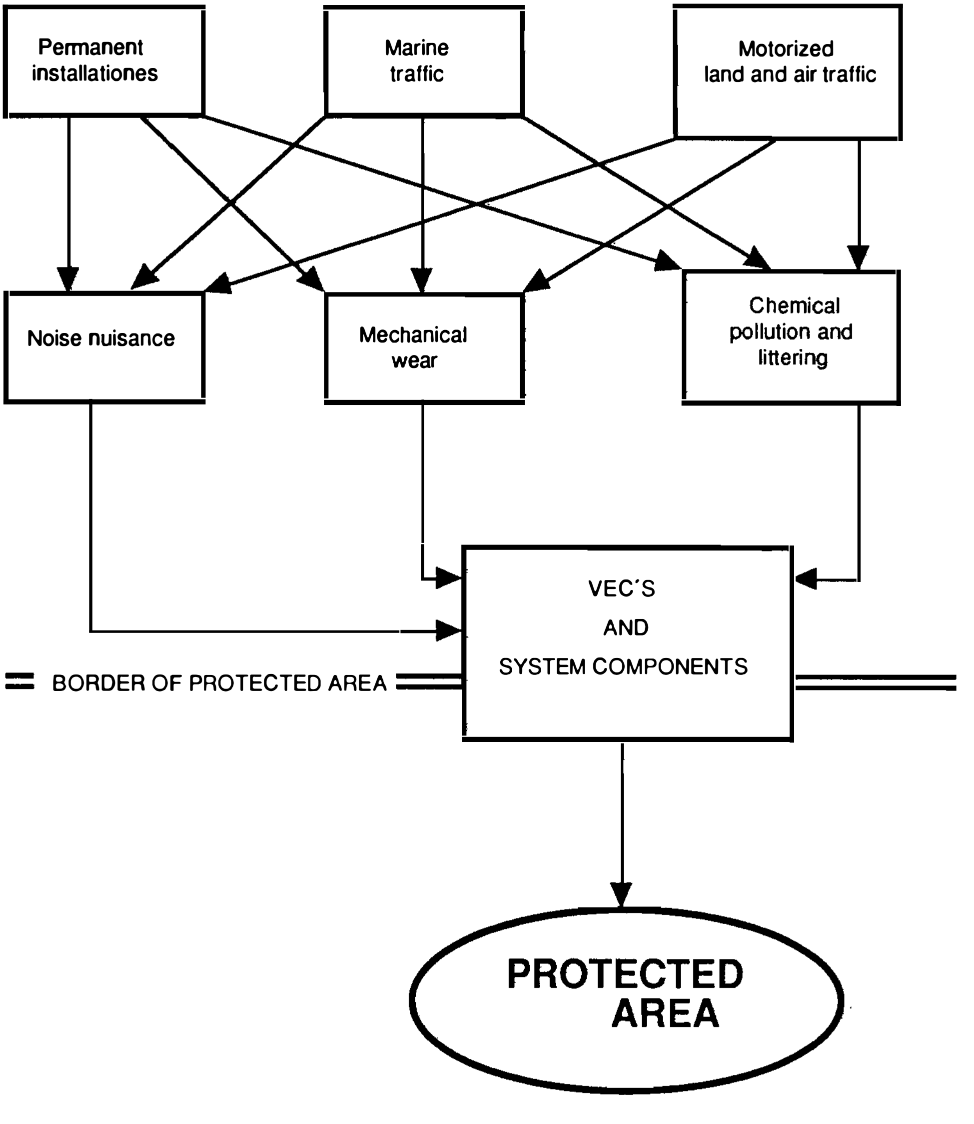
6.15 VEC 14
PROTECTED AREAS

6.15 PROTECTED AREAS



SCHEMATIC FLOW CHART

VEC 14 PROTECTED AREAS.



6.15.1 Background

According to Article 2, section 2 of the Treaty of Svalbard, it is due to Norway to maintain, take or decree suitable measures to ensure the preservation, and, if necessary, the reconstitution of fauna and flora in Svalbard.

Between 1925 and 1973 two plant protected areas were established in the Isfjorden area, in addition to a temporary nature reserve on Kong Karls Land.

In 1973 two major nature reserves were established in eastern Svalbard, three national parks in western Svalbard and 15 bird sanctuaries along the west coast of Spitsbergen. One of the nature reserves included the temporary Kong Karl's Land nature reserve. Areas that were situated within the boundaries of the recently established nature reserves and national parks that were registered as claims according to the Svalbard Mining Settlement, did not belong to the protected areas. If abandoned by the claimant, such a claim will automatically be included in the relevant protected area. In 1973 this applied to a total of 646 claims. For 22 claims in all, 18 on Kong Karls Land and 4 on Prins Karls Land, other rules applied. These were included in the protected area, but rights according to the Mining Settlement will be returned to the claimant if the protection is abolished within 20 years after its entry comes into force. As per today there are 217 claims left, out of which 20 have been included in the protected areas.

To provide extra protection status to the island of Moffen, which is situated within the Nordvest-Spitsbergen National Park, the island was given protection as a nature reserve.

The last protected area to be established in Svalbard to date was the Ossian Sars plant protected reserve in Kongsfjorden.

The following protected areas are found in Svalbard (cf. map no. in parenthesis refers to the map):

<u>Nature reserves:</u>

Nordaust-Svalbard Nature Reserve
Søraust-Svalbard Nature Reserve
Moffen Nature Reserve (16)

<u>National parks:</u>

Nordvest-Spitsbergen National Park
Forlandet National Park
Sør-Spitsbergen National Park

Bird sanctuaries:

Sørkapp Bird Sanctuary	(1)
Dunøyane Bird Sanctuary	(2)
Isøyane Bird Sanctuary	(3)
Olsholmen Bird Sanctuary	(4)
Kapp Linné Bird Sanctuary	(5)
Boheman Bird Sanctuary	(6)
Gåsøyane Bird Sanctuary	(7)
Plankeholmane Bird Sanctuary	(8)
Forlandsøyane Bird Sanctuary	(9)
Hermansenøya Bird Sanctuary	(10)
Kongsfjorden Bird Sanctuary	(11)
Blomstrandhamna Bird Sanctuary	(12)
Guissezholmen Bird Sanctuary	(13)
Skorpa Bird Sanctuary	(14)
Moseøya Bird Sanctuary	(15)

Plant protected reserves:

Area to the north and east of Dicksonfjorden and Sassenfjorden.
Area between Colesdalen and Adventdalen.
Ossian Sars plant protected reserve.

"The main objective of the protection resolutions of 1973 is to preserve the fauna and flora associated to them" (Government White Paper No. 39, 1974-75). National parks and nature reserves include some of the areas of Svalbard that are most magnificent, varied and least affected by man. The major difference between these two forms of protection status lies in the fact that the Sysselmann is entitled to prohibit traffic when considered necessary to preserve the flora and fauna of the area. Moreover, with the establishment of national parks it was decided that national parks are to serve recreational needs, while nature reserves have been established to preserve untouched nature where human activity is kept to a minimum. The large protected areas, national parks and nature reserves cover the indicated land areas with adjoining sea territories, i.e. out to the limit of territorial waters 4 nautical miles off land.

Bird sanctuaries are, with one exception, islands and islets along the west coast of Spitsbergen. These are among the most important breeding biotopes for geese and eiders in Svalbard. The bird sanctuaries include the island/islets as such with surrounding waters out to 300 m off land. Special regulations are applicable for the Kapp Linné Bird Sanctuary.

The plant protection areas are intended to preserve areas exceptionally rich in vegetation against damage and the decimation of rare plants. No particular regulations concerning fauna apply within the plant protection reserves, which only include the protected land area as such.

6.15.2 Protected areas as a VEC

The protected areas of Svalbard have been established to preserve areas of particularly great biological importance and/or areas considered to be unique in the sense that they are relatively unaffected by human developments. The protected areas meet with the requirements of the VEC definition, but differ somewhat from the remaining VECs. Apart from their biological and recreational importance the protected areas are also politically significant, signalling both to Norway and the rest of the world that great importance is attached to protection efforts.

It should in particular be noted that Nordaustlandet, forming part of Nordaust-Svalbard Nature Reserve, has been made a biosphere reserve by the United Nations (UNESCO), within the framework of the Man and Biosphere Programme (MAB). In the capacity of biosphere reserve, Nordaustlandet, with its genetic material, shall be preserved for the future, and will also provide reference and research material.

The protected area's value as a VEC is represented by its intrinsic value plus the sum of all the remaining VECs found within the protected area. As an example, Svalbard reindeer within Nordaust-Svalbard nature reserve will be of value as a the VEC "Svalbard Reindeer", while also being of value as part of the VEC "Protected Areas". Accordingly more emphasis will be given to developmental activities affecting VECs within protected areas than corresponding VECs outside the protected areas.

Since the protected areas are protected by law, the VECs within these areas must be assumed to enjoy a better protection than other areas in Svalbard, at least concerning the direct impact of human activity. Nevertheless, there will be a danger of direct effects on those areas having protected areas bordering on unprotected areas that are of actual or potential commercial value. Such boundary areas are found in cases in which claims are situated alongside or within protected areas, and also where the protected area is bordering on exploitable resources, such as scallop beds.

The danger of indirect effects on VECs in protected areas corresponds to effects outside the protected areas of Svalbard, but as mentioned above, the impact of developments, such as pollution, will be given more emphasis within a protected area. In the management of protected areas it is therefore important to consider the factors outside of the protected area, in case these by indirect impacts may become important to conditions within the protected area.

6.15.3 Impact hypotheses and recommendations

No impact hypotheses or recommendations for the VEC "Protected Areas" will be listed in this version of the assessment system. Such hypotheses and recommendations will be best attended to through the individual VECs, since no VEC is found exclusively within protected areas.

7. AN EVALUATION OF THE ASSESSMENT SYSTEM

7.1 Has our objective been reached?

"I hope this report will be hotly debated!" This wish, expressed at the end of our last working group meeting, underlines the fact that Version 2 of the assessment system has by no means gained unanimous approval. Primarily, however, this wish emphasizes that, in order to be improved, the assessment system must become an object of debate. The system represents an attempt to handle the conflicting interests of developers, researchers and conservationists, focusing upon what is important to all these groups without denying the basic conflict between them.

Nevertheless, after having completed Version 2, it is our overall impression that the involved parties are favourably inclined towards the assessment system. The system is structured, while being at the same time flexible. Certainly, this work has lead to an important review of our current knowledge of the natural environment of Svalbard. Version 2 has provided the management authorities with a well-thought-out and practical tool. We have already had requests from several quarters wishing to employ the "MUPS" method for impact assessments in other contexts.

7.2 Criticism raised against the assessment system and the methods employed

Admittedly, there have been many critical comments concerning the assessment system and the work carried out to develop it.

The MUPS assessment system is an attempt at employing the AEAM method with a problem related to environmental management in Norway. No objections of importance have been raised against the method as such. In some areas the MUPS work has, however, for various reasons deviated from the "original recipe", the most important divergence being that MUPS has not developed a computer simulation model of the assessment system. The decision not to develop a computer simulation model also applied to the BEMP project, the reason in both cases being that the data available would not suffice for the construction of anything resembling a functional model. Because of this, system-based decisions will all the same have to be left to judgement and political considerations to a greater-than-ideal extent.

In the AEAM method, great importance is attached to the function of the working group meetings. In principle, all important decisions should be made and all important material be prepared at these meetings. This material is to be recorded there and then, so that revised summaries can be made available at the end of the meeting. According to the Canadian experts behind the BEMP model, sufficient resources and competent personnel are the key to making such meetings work. The BEMP meetings would last up to one week and were headed by a relatively large group of advisers from consultancy firms specializing in this type of meeting. MUPS has neither had the personnel nor the resources for arranging such working group meetings. In spite of the participants' strenuous efforts, very little material has been completed at the meetings. Partly because of this, and partly because of delays and methodological problems, the full meetings did not perform the intended function of controlling the products of the expert groups. The final preparation of the report has also been protracted. However, as the resources earmarked for such meetings in Norway must be limited, MUPS will presumably also have to put up with somewhat amputated versions of the ideal working group meeting in the future. Considering our small professional communities we will hardly be able to avoid the situation that a few persons will gain a great deal of influence within their special field, i.e. within "their" VEC. The foundation now being laid, the individual VECs should, in the continued development of the assessment system, to a greater extent be reviewed in small, technical meetings, while possible large working group meetings should concentrate on the most important issues and priorities.

It is also an important principle in AEAM that scenarios for industrial development must be used actively as a basis for generating hypotheses. In MUPS it has proved difficult to provide scenarios of sufficiently specific and limited character to be used for the preparation of VECs. On the whole, the hypotheses were formed on the basis of a general assumption of how the activities were likely to develop, with possible correctives by proponents of industry. When making further amendments to the assessment system more importance should be attached to detailed use of scenarios.

It is a prerequisite of the AEAM method that the system to be developed is to be subjected to clear constraints in terms of time, space and types of development activities to be treated. This is to form the basis for the choice of hypotheses and priorities. The MUPS assessment system is mainly funded by oil companies and generally deals with oil activities. A consideration of fisheries, tourism and other types of human activities which may no doubt influence the VECs has frequently been requested. The system is therefore open to such activities in the future. Geographically the assessment system is basically confined to the Svalbard archipelago, including the waters within the 4-mile limit. However, as many of the VECs periodically will stay a long way from this limit, it has not been possible to insist on a rigourously defined geographical area. Based on this definition, Bjørnøya e.g. would be excluded from this system. But Bjørnøya has an important function in the ecosystem to which the rest of Svalbard also belongs, has important resting grounds for Svalbard geese and may be exposed to the same type of oil activities as Svalbard. Therefore it is reasonable that the assessment system "keeps an eye on" Bjørnøya as well. Nor have any clear temporal constraints been given concerning the effects to be considered by the system. Among other things, this is due to the fact that oil activity has not yet been established in the archipelago, and its future duration and extent are still matters of uncertainty.

The administrative position of the assessment system has not been clarified in detail and such things as a final management structure has not yet been established. This may for the time being make the system less efficient than it might have been. In addition, the Norwegian Polar Research Institute may easily end up in a "make the fox look after the goose" type of situation: NP has, as secretariat and administrator of the system stated many of the terms, they are the Ministry's advisers concerning the choice of projects, they will be consulted when terminated projects are to be evaluated, and, finally, they possess the competent expertise that is interested in carrying out MUPS projects. Since it is difficult to avoid such situations altogether, the professional community of Norwegian polar research being small, it is essential that the Ministry, as soon as possible, establishes an administrative structure for MUPS that is maximally objective and unbiased.

The VEC concept has been problematic to many researchers, as VECs frequently are selected on the basis of clearly unscientific criteria. The risk of ecologically important species being downgraded in favour of more "conspicuous" species/resources has attracted much attention. The political character of the VECs is consciously chosen to provide emphasis outside the research communities. The VEC selection is made on the understanding that experts in assisting the development of the system will identify all components of importance associated with the VECs. Effects on such components must be evaluated on a strictly scientific basis, and should, in principle, not be substantially damaged without a reaction in the system.

The impact hypotheses (the IHs) have been criticized because they do not have a sufficient scientific basis. They are not consistent when referring to effects such as "increased mortality", "reduced reproduction", "reduced local population" etc. Many hypotheses are, strictly speaking, untestable, as they postulate changes in conditions of which we have no baseline data. However, the most important aspect, from an administrative point of view, is the fact that the IHs identify approaches to problems that the management authorities need to solve, whether or not baseline data are missing.

The projects recommended by the assessment system should, as a starting-point, ideally be planned on the basis of scientific considerations and be described in sufficient detail to indicate the resources needed. Yet, compared for example to the BEMP project descriptions, the assessment system provides little information on the extent of the individual projects. The planning and realization of the selected projects will involve a great deal of work. In practice this will imply that the projects must to a large extent be planned in the light of the economic resources made available by the companies rather than from entirely professional considerations. The briefness of the project descriptions is mainly due to problems of capacity. However, the great uncertainty still attached to further oil exploration in Svalbard hardly makes it practical to bind the system up in rigid project descriptions.

A main criticism raised against the system concerns its defensiveness. It accepts the condition that development activities will take place and it focuses on investigating effects and mitigating potential damage. The system may therefore be accused of legitimating, or providing a scientific alibi, for developments that may be unacceptable from scientific and environmental considerations. In principle this criticism is correct, from the point of view of researchers or environmentalists only, but such objections should be raised by other quarters than the MUPS administration. The assessment system has been developed precisely to be a non-ideological tool for finding pragmatical middle courses out of conflicts in which several parties have legitimate interests.

Researchers have also stressed that the assessment system scarcely contributes to baseline research and the building up of competence and seldom gives priority to experimental studies. In common with other applied impact studies, the assessment system is entirely dependent upon the data produced by baseline research while producing little essentially new knowledge itself. Some fear has been expressed that the assessment system, which at times will have quite considerable means at its disposal, will reach such a dominant position that it will directly replace baseline research in Svalbard. Arrangements securing a minimum of baseline research within the assessment system have therefore been proposed. One possibility would be to earmark a certain share of all MUPS funds for such research. Another possibility is the designation of all MUPS finances for a foundation to be managed by representatives of industry, research and management authorities. The foundation will distribute funds for current projects and at the same time have the opportunity of providing for relevant baseline research. Such a foundation has been established in connection with BEMP in Canada. The companies that have been involved in MUPS have been sceptical about such an arrangement. From their point of view, baseline research and general competence building is a public responsibility. The responsibilities of the companies are, strictly speaking, limited to the specific efforts of their own development activities. Nevertheless, the companies have taken a positive stand to support more general, long-term studies, not necessarily restricted to local developments.

7.3 Further work on the assessment system

As Version 2 of the assessment system is ready for the printers there are no plans for further adaptation. Such plans will be dependent upon the experience gained from practical application, and upon the future activity of the oil companies. It is however a prerequisite that the system, after a relatively short period, will be adapted to new information gained and to new conditions. No version of the system will represent the complete "truth". Therefore it has to be dynamic. The AEAM method was in fact developed because many systems were too rigid and unable to handle the new conditions turning up. Hence the word "adaptive" in the name of the method!

8. EVALUATED 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 "Svalbard Reindeer". 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: SVALBARD REINDEER	IH 1

HYPOTHESIS: Disturbances and traffic will cause increased energy expenditure and reduced grazing time, and accordingly reduced survival and calf production in the affected local populations of Svalbard reindeer.

EXPLANATION: Traffic affects population distribution and accordingly vegetation availability. This is decisive to physical condition and mortality. Disturbances occurring in late winter cause a sharp increase in energy expenditure during a period of negative energy balance. This will increase the danger of adult mortality and of females throwing their calves/aborting.

CATEGORY: C

RATIONALE: Little research has been carried out on the effect of disturbances in Svalbard reindeer. Experience indicates that reindeer that have not become habituated to traffic generally avoid areas of disturbance but can gradually become habituated to and ignore it. Reindeer that are unhabituated to traffic/noise can react with flight/panic when disturbed, sometimes far from the source of disturbance.

MANAGEMENT RECOMMENDATIONS: Traffic and other human activities should be located a distance from reindeer winter grazing ranges.

SURVEYS: Distribution and number are surveyed in areas relevant for development/activity. The surveys should be differentiated according to physical condition, sex and age.

MONITORING : Distribution, occurrence and area use are recorded in the affected area and in an unaffected control area throughout the period of development. The site tenacity of individual animals regarding seasonal habitats should be recorded from year to year.

RESEARCH: Effects of disturbance: Variations with respect to season, area and sex/age class. Long-term effects: telemetric measurements of heart and breathing frequency in the field and in experimental stress studies.

VEC: SVALBARD REINDEER	IH 2
HYPOTHESIS: Physical encroachments and installations will obstruct the movements of the Svalbard reindeer and may accordingly hinder its access to grazing and calving areas.	
EXPLANATION: Operational activities and installations will occupy areas and may accordingly reduce the access to grazing ranges and habitats and force animals to leave affected areas. They can also function as physical or psychological obstacles to migrations between seasonal habitats, e.g. calving areas, and accordingly affect reproduction.	
CATEGORY: C	
RATIONALE : The loss of grazing ranges is a likely outcome of physical encroachments but the loss will generally be minimal and the effect will be problematic to test. Installations are likely to become physical or mental migration barriers if unfavourably located. Such exclusion from important areas, e.g. calving areas, can be of importance to the population.	
MANAGEMENT RECOMMENDATIONS: The reindeer's habitat and migration areas, throughout the various seasons, must be considered when decisions are made concerning the location of installations and other developments.	
SURVEYS: Seasonal habitats and migratory patterns in relevant development areas should be surveyed. The surveys must be differentiated with respect to sex, age and variation in physical condition etc.	
MONITORING: The reindeer's migrations should be surveyed in relevant development areas and in unaffected control areas by means of tagging and telemetry. Feedback reactions concerning the relationship of animals to vegetation in the relevant areas should be monitored.	
RESEARCH: Effect in Svalbard reindeer of physical obstacles in traditional migratory routes should be studied experimentally.	

VEC: SVALBARD REINDEER	IH 3
HYPOTHESIS: Increased traffic resulting from industrial activity in formerly unaffected areas will lead to increased illegal reindeer hunting.	
RATIONALE: Some poaching of Svalbard reindeer is known to take place. Industrial activity in "new" areas will bring more people to places where poaching is easy and tempting.	
CATEGORY: D	
RATIONALE: The hypothesis may be valid but possible problems will have to be solved through management measures and government control. Biological research or monitoring projects are accordingly not recommended.	
MANAGEMENT RECOMMENDATIONS: Information, government control.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: SVALBARD REINDEER		IH 4

HYPOTHESIS: Pollution from industrial activity will be accumulated in grazing vegetation and will affect the health condition of local populations of Svalbard reindeer.

EXPLANATION: Emissions into air of heavy metals, sulphides and fluorides etc. will gradually be assimilated into the vegetation and be found in concentrations in the internal organs of reindeer feeding on these plants. High concentrations of toxins can cause illness and reduced fertility of these animals.

CATEGORY: D

RATIONALE: The effect is known and substantiated on various animal species exposed to high levels of pollution and there is reason to believe that general impairment may also occur at lower levels, even if the effect cannot be proven. To date there is no reason to expect emission levels to produce significant effects in Svalbard. The quantity of long-range air pollution must however be expected to increase and will in future necessitate the monitoring of heavy metal content in both vegetation and reindeer.

MANAGEMENT RECOMMENDATIONS: General measures against air pollution.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SVALBARD REINDEER	IH 5

HYPOTHESIS: Dust particles from coal production will result in more rapidly melting snow in spring and will accordingly affect vegetation and its availability for grazing and cause an altered grazing pattern, thereby affecting the physical condition and survival of local populations of Svalbard reindeer.

EXPLANATION: Self-explanatory.

CATEGORY: D

RATIONALE: The effect of dust emissions on snow melting is well known, cf. the situation in Longyearbyen. The situation in that location has been established and additional studies are not required. If the operations are considerably expanded, or if new operations are started in formerly unaffected reindeer grazing ranges, impact studies may become relevant.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SVALBARD REINDEER		**IH 6**

HYPOTHESIS: Dust from installations and roads will settle on vegetation and cause increased dental wear and accordingly reduced physical condition and life expectancy of Svalbard reindeer.

EXPLANATION: Dental wear in Svalbard reindeer is considerable under natural conditions and often leads to the starvation of older animals. Factors increasing wear will accelerate this effect.

CATEGORY: D

RATIONALE: Increased dust fallout on grazing range will, in principle, cause increased dental wear. The effect is however assumed to be quite marginal compared to wear caused by natural factors. Besides, the area potentially affected by dust fallout is assumed to be small.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: ARCTIC FOX	IH 7

HYPOTHESIS: Waste from traffic and installations causes an increase in immigration and reproduction, and thus increased local population of arctic fox.

EXPLANATION: Traffic and installations cause increased disposal of edible waste, which will attract foxes from surrounding areas. Extra food in the form of waste may lead to increased survival and reproduction of local arctic fox populations.

CATEGORY: C

RATIONALE: The arctic fox is a food opportunist and will no doubt be able to utilize edible waste. Its reproduction potential is high and the population may increase rapidly with increased food availability. A large arctic fox population will probably mean an increase in predation pressure on local populations of eiders/geese, sea birds, ptarmigans and ringed seal pups. The hypothesis is assumed to be relevant in Svalbard.

MANAGEMENT RECOMMENDATIONS: Measures against dumping of waste: All waste in containers. Waste treatment units. Clean-up procedures.

SURVEYS: Surveys of the fox population in a relevant area prior to operational activities.

MONITORING: Recording of fox visits to installations. Monitoring of lair density and reproduction prior to/during/after an encroachment. Monitoring of populations of prey and the predation of the arctic fox on these in an area with extensive activity.

RESEARCH: None.

VEC: ARCTIC FOX	**IH 8**

HYPOTHESIS: Increased population of arctic fox as a result of industrial activities will increase the risk of transference of the rabies virus.

EXPLANATION: The arctic fox population may rise as a result of increased access to edible waste. A large arctic fox population may increase the risk of transferring rabies to humans.

CATEGORY: C

RATIONALE: Other arctic areas with incidence of rabies in their arctic fox population have put forward the hypothesis that rabies outbreaks will occur in years of large arctic fox population. The connection between rabies outbreaks and a high arctic fox population has not been explained. In the event of a considerable increase in the arctic fox population in Svalbard, the number of rabies cases may be assumed to increase, and also the contact between humans and infected foxes. Taking precautions against infection is however relatively simple.

MANAGEMENT RECOMMENDATIONS: Control of the fox population in areas with industrial activity. Information on rabies. Measures against the spreading of edible waste.

SURVEYS: None.

MONITORING: See IH 7

RESEARCH: Study of postulated connection between rabies outbreaks and fluctuations in the arctic fox population.

VEC: ARCTIC FOX	IH 9

HYPOTHESIS: Pollution resulting from oil spills can cause increased mortality in local arctic fox populations as a result of poisoning and reduced insulation against cold.

EXPLANATION: Oil spills at sea can cause oil-injured sea-birds and marine mammals to drift ashore in Svalbard. As the arctic fox often roams along the shore searching for food, it is likely to be poisoned by ingesting fouled birds or seals, or the insulating properties of its fur may be reduced because of contact with oil.

CATEGORY C:

RATIONALE: No studies have been carried out on the poisoning effect of oil on arctic fox. There is however reason to believe that oil is harmful, since such an effect has been demonstrated in other arctic carnivores. The arctic fox population in exposed areas should be monitored, as an oil spill can have harmful effects on local populations.

MANAGEMENT RECOMMENDATIONS: Measures against routine oil spills. Preventative measures - the prevention of oil spills. Mitigative measures - oil spill contingency plans.

SURVEYS: None.

MONITORING: Routine examination of furs from relevant areas. If there are indications of frequent oil exposure: Carcass autopsies. Monitoring of the population in an area where oil slicks will drift ashore.

RESEARCH: Study fox behaviour in relation to oil spills and food soiled by oil. If the study indicates that fox will not avoid oil spills and food soiled by oil: Study of the effect on foxes of ingested oil and oil on fur/skin.

VEC: ARCTIC FOX	IH 10

HYPOTHESIS: Manned installations and traffic will cause increased hunting of arctic fox.

EXPLANATION: The hunting pressure on arctic fox will increase in connection with added traffic when new installations/plants are constructed in the open country.

CATEGORY: B

RATIONALE: An increase in the human population is likely to cause an increase in hunting. The Svalbard arctic fox population can, however, endure a great deal of hunting pressure, the reproduction potential and the population being large. Trapping can also be regulated by management measures, to avoid affecting the population. The fox population is only likely to be affected by hunting/trapping in the event of a considerable expansion of industrial activity.

MANAGEMENT RECOMMENDATIONS: Regulated trapping in areas under pressure. Reports on trapping in areas under pressure.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: ARCTIC FOX	**IH 11**

HYPOTHESIS: Helicopter disturbance causes abortions and infanticide in arctic fox.

EXPLANATION: Self-explanatory.

CATEGORY: D

RATIONALE: Evidence from fox farms has indicated that violent noise from aircraft/helicopters can frighten pregnant bitches and bitches that recently have given birth, with the result that they will abort/kill their whelps. Similar behaviour may be expected to occur under natural conditions, or dens may be abandoned in heavily trafficked areas, but there are no studies to validate/invalidate this assumption. To date, these problems are not considered to be significant in Svalbard.

MANAGEMENT RECOMMENDATIONS: Traffic/activity in denning areas should be avoided during the whelping period.

SURVEYS: Surveys of denning areas that will become heavily trafficked.

MONITORING: Monitoring of the population in denning areas with frequent overflights.

RESEARCH: Provocation of arctic foxes in dens by helicopters or possibly simulation of noise under controlled conditions to get information on reactions during the denning period.

VEC: ARCTIC FOX	IH 12
HYPOTHESIS: Dependence on a steady food supply from human settlements causes increased mortality in local arctic fox populations at the disappearance of the food source.	
EXPLANATION: Installations/industrial plants built up in connection with oil activities are likely to be of a transitory character. Possibly some foxes, having become dependent on easily available food (edible waste) will die when food access comes to a stop as the installations are removed.	
CATEGORY: D	
RATIONALE: The hypothesis is hardly testable for professional/logistic reasons. Although removal of an artificial food source may cause increased mortality (or emigration) in local fox populations, such an effect is expected to be environmentally insignificant.	
MANAGEMENT RECOMMENDATIONS: None.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: ARCTIC FOX	**IH 13**
HYPOTHESIS: The disturbance to other animal populations caused by industrial activity and traffic will lead to an increase in local arctic fox populations through greater access to prey.	
EXPLANATION: Traffic from helicopters, snow scooters and boats can scare birds away from bird cliffs, reindeer calves from the females, increase fox access to ringed seal pups and scare eiders/geese from nests/chicks, resulting in increased food availability for local arctic fox populations.	
CATEGORY: A	
RATIONALE: In the short term the described effect may be imagined. In the longer term the described effect of such disturbance may just as well turn out negatively for the arctic fox population.	
MANAGEMENT MEASURES: None.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: POLAR BEAR		IH 14

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.

CATEGORY: B

RATIONALE: Degree of harm and pathogenesis have been examined and need no further elaboration.

MANAGEMENT RECOMMENDATIONS: 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.

SURVEYS: Surveys of polar bear occurrence throughout the year in areas where oil spills may be likely, and of local and general migratory patterns. Oil spill drift trajectories (cf. Ringed Seal, Seabirds, Eiders, Walrus and Geese).

MONITORING: In the event of an oil spill, bears in the contaminated area should be monitored.

RESEARCH: Experimental study of the course of an oil spill in drift ice (cf. Ringed Seal, Seabirds, Eiders, Walrus and Geese).

VEC: POLAR BEAR	IH 15

HYPOTHESIS: Installations and 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 the optimal point of time. Disturbances in the denning area before delivery may cause the females to abort and 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 will reduce reproductive success. The effect of disturbances in the fall has not been studied but must be assumed to be negative. 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. 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.

MANAGEMENT RECOMMENDATIONS: Activity/traffic in the denning areas must be minimized throughout fall, winter and spring. Passing traffic and overflights should be kept at least 5 km from the boundaries of the area during fall and spring.

SURVEYS: Studies of female behaviour and of choice of denning areas in the fall by means of telemetry and observations. Den surveys in areas relevant for development.

MONITORING: In connection with activity in and near denning areas: Recording of dens and production in the affected area and possibly in a control area throughout the operational phase and for three seasons after the cessation of operational activities.

RESEARCH: Ethological and physiological study of the effect of disturbance on free-ranging polar bears. The implementation of such studies is difficult with current levels of technology and information.

POLAR BEAR:	**IH 16**

HYPOTHESIS: Disturbance and obstacles caused by installations and traffic in polar bear migration and feeding areas will result in a reduced population.

EXPLANATION: Traditional migration routes (e.g. Hornsund) may be shorter and easier to negotiate than alternative routes. The routes may be narrow, owing to terrain and ice conditions. Most 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.

CATEGORY: C

RATIONALE: The building of installations has been considered in Hornsund, on the Spitsbergen coast of Storfjord and at the south-eastern part of Edgeøya. These areas are located on a main migration route of the Svalbard polar bear population. The starting-point of this migration is not known, nor do we know its destination. No estimates concerning the importance of possible disturbances in the migration can be made until we understand its position in the annual cycle of the Svalbard population.

MANAGEMENT RECOMMENDATIONS: Installations, activity and traffic should be kept away from the migration areas, particularly from January till June.

SURVEYS: Study of the migratory pattern of the Svalbard population throughout the year by means of satellite telemetry. Study extending over several years.

MONITORING: Continuous recording of polar bears at the installations.

RESEARCH: Effect of disturbance on free-ranging polar bears. The implementation of such studies is difficult with current levels of technology and information.

VEC: POLAR BEAR	**IH 17**

HYPOTHESIS: Manned installations in the ice or near the coast will attract polar bears and result in increased mortality because animals will be destroyed in confrontations with humans.

EXPLANATION: The polar bear's curiosity regarding unknown objects, combined with the smell of food and waste, will encourage it to visit installations. Situations will arise in which polar bears will be destroyed because crews feel, or actually are, threatened.

CATEGORY: B

RATIONALE: There is a great deal of evidence, from Norway as well as from other countries, validating this hypothesis. There is, however, no reason to believe that the number of destroyed animals will become so high as to affect the size of the population. Since the species is protected, measures should be taken to minimize the number of confrontations and to record polar bear activity in the relevant areas.

MANAGEMENT RECOMMENDATIONS: Installations and activity should preferably be located outside of polar bear habitats and migration areas, and should not take place in periods of polar bear activity. Waste should be kept in closed containers and be treated in waste treatment units. Smells must be minimized. Installations must be provided with automatic warning systems, dogs and/or observation routines. Crews should be thoroughly briefed about polar bears.

SURVEYS: Surveys of polar bear denning areas, migration routes and hunting areas/habitats surrounding the planned installations. For year-round activity, particular emphasis should be given to the winter situation. For drilling operations in the ice or near the beach, ice drifts and currents should be recorded, and oil spill drift trajectories should be run.

MONITORING: Preparation of a standard procedure for the recording of polar bears at installations and transport routes, as well as standard regulations for conduct and for sampling when destroying polar bears.

RESEARCH: None.

VEC: POLAR BEAR	IH 18

HYPOTHESIS: Disturbance outside of the denning areas resulting from traffic and manned installations will cause increased mortality in the polar bear population.

EXPLANATION: For adult bears, disturbance and chasing cause increased energy expenditure and reduced time and area accessible for feeding. Disturbance and chasing of females with cubs also involve the risk that the female will abandon her cub(s), which is (are) then bound to die.

CATEGORY: D

RATIONALE: In the spring, installations/traffic in fjords can exclude polar bears from areas with ringed seal birth lairs. Disturbance/chasing involves a sharp increase in energy expenditure and a risk of hyperthermia. As the polar bear's most important hunting technique, still hunting, requires a long period of waiting for each successful catch, hunting bears may be sensitive to disturbances. Females with cubs of the year (coys) are very sensitive and will, when disturbed, easily start a panicky flight that coys can hardly keep up with. The female's physical condition is generally weak at this stage. Coys are unable to manage on their own. Effects on a population level will however hardly be measurable.

MANAGEMENT RECOMMENDATIONS: Avoid installations and traffic/transport in areas of ringed seal birth lairs in the spring and near/on ice floes that remain far into the summer. Information should be distributed concerning the harmful effects of chasing polar bears.

SURVEYS: Surveys of occurrences of polar bears in relevant development areas. Contribute to the surveying of distribution and migration (satellite telemetry) in the Svalbard area.

MONITORING: Standard recording procedure for the occurrence and behaviour of polar bears near installations and in connection with transport/traffic.

RESEARCH: Ethological and physiological study of the effect of disturbance on free-ranging polar bears. Difficult to carry out with current levels of technology and information.

VEC: POLAR BEARS		IH 19
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. The effect can be eliminated by preventing access to waste.		
MANAGEMENT RECOMMENDATIONS: Waste should be kept in closed, bear-proof containers and treated in waste treatment units.		
SURVEYS: None.		
MONITORING: None.		
RESEARCH: None.		

VEC: POLAR BEAR	IH 20

HYPOTHESIS: Reduced seal occurrence resulting from disturbance and pollution from installations and traffic will cause increased mortality in the polar bear population.

EXPLANATION: Polar bears live on seals and will, within their habitats in eastern Svalbard, 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 in Svalbard, polar bear carrying capacity will be correspondingly reduced.

CATEGORY: D

RATIONALE: The seal populations in Svalbard are probably so numerous that they do not delimit the polar bear population. Access to seals may however 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. However, such potential effects will be very difficult to prove for development activities of the order presently relevant in Svalbard.

MANAGEMENT RECOMMENDATIONS: See VEC 5 "Ringed Seal".

SURVEYS: Surveys of polar bear occurrence in relevant areas and periods. See also recommendations concerning hypothesis on the disturbance of ringed seals.

MONITORING: 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.

RESEARCH: None.

VEC: POLAR BEAR	**IH 21**

HYPOTHESIS: Installations 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 technical installations may create the same effect.

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. Installations may also cause animals to avoid such areas. Should this hypothesis turn out to be valid in principle, it will probably be of little importance. The available scenarios do not indicate that installations potentially causing artificial leads will be relevant in Svalbard in the near future.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: Surveys of ice conditions and occurrence of polar bears in the relevant area prior to the construction of the installation.

MONITORING: Monitoring of polar bear occurrence in the area while the installation is in operation.

RESEARCH: None.

VEC: POLAR BEAR	**IH 22**

HYPOTHESIS: Disturbances occurring in the polar bear's mating season and mating areas will cause a reduction in the polar bear population.

EXPLANATION: Females have several partners and will, throughout a prolonged period, mate each of them several times. Whether repeated matings are required for impregnation, or whether she is receptive for a short or long period, is not known. It cannot be excluded that disturbances during the mating season may result in fewer females being impregnated. The migration areas can also be mating areas and should, for the time being, be given the greatest attention.

CATEGORY: D

RATIONALE: Too little is known about the polar bear's reproductive biology to be able to carry out research concerning the effects of disturbance. Activity of the order relevant so far is not likely to have a significantly negative effect.

MANAGEMENT RECOMMENDATIONS: None. apart from general rules for traffic and installations.

SURVEYS: Satellite telemetry studies of polar bear migratory routes and habitat use, particularly the spring situation.

MONITORING: None.

RESEARCH: Study of mating behaviour in combination with studies of reproduction physiology. This type of study probably has too much of the character of baseline research to be assigned to petroleum companies etc.

VEC: POLAR BEAR	IH 23

HYPOTHESIS: Industry-related emissions, and breakdown products from such emissions, can be accumulated through the food chain and reach such high concentrations in the top predator, the polar bear, 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 seals. A circumpolar study of organochlorines in polar bear tissue will be initiated in 1990.

CATEGORY: D

RATIONALE: Apart from oil spills, the present scenarios give no reason to expect other emissions in Svalbard that may affect polar bears. Long-range air and sea pollution has however increasingly been demonstrated and may affect polar bears. The effect of oil on polar bears is known (cf. IH 14). The effect of the accumulation of breakdown products from oil/dispersants has not been studied. Whether the use of such chemicals may be relevant in Svalbard has not been clarified. In the event of oil spills the possible effects of such products are, however, assumed to be of secondary importance compared to the direct effect of the oil.

MANAGEMENT RECOMMENDATIONS: None. beyond ordinary regulations concerning emissions.

SURVEYS: None. (but see recommended oil drift trajectories in connection with IH 14).

MONITORING: A standard procedure should be established for the sampling of tissue, vital organs etc. from all bears that are killed or found dead in a state that makes it possible to handle them. Data will be incorporated in the Norwegian Polar Research Institute's fauna data base.

RESEARCH: None.

VEC: WALRUS	IH 24

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 walrus may avoid a specific area, and that mortality, especially with calves, may increase because of disturbances. Potential effects on the population level will be difficult to demonstrate, but, because the number of walrus in Svalbard is low, documented effects on individuals or small herds may also be significant.

MANAGEMENT RECOMMENDATIONS: Regulation of activity in walrus habitats should take place through a stipulation of the minimum permitted flying altitude, the establishment of protection zones, and the introduction of landing bans at well-known haul-out sites and feeding areas. Protection zones should also be established for oil and exhaust emissions.

SURVEYS: Surveys of occurrence and use of haul-out sites. Counts of possible local populations and studies of their seasonal distribution. Studies of the migrations, distribution and population affiliation of the Svalbard walrus.

MONITORING: Monitoring of local populations with respect to population size, sex and age composition and behaviour in exploration areas.

RESEARCH: None.

VEC: WALRUS	IH 25

HYPOTHESIS: Oil spills caused by traffic and installations will reduce the walrus population.

EXPLANATION: Oil spills in haul-out sites and in open waters may cause walrus 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 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. The effects of oil on several other marine mammals are severe. Observations of e.g. ringed seals indicate that the animals will not actively avoid oil spills. Because of physiological and behavioural differences this tendency cannot without reservation be transferred to walrus. The effect of oil on individual walruses does not easily lend itself to research.

MANAGEMENT RECOMMENDATIONS: Oil spill alert contingency plans should be initiated near to walrus habitats. Protection zones should be established around haul-out sites and feeding areas to protect the walrus from routine oil spills.

SURVEYS: Surveys of the walrus's seasonal habitats (cf. IH 24). Development of oil spill drift trajectories (cf. Polar Bear, Ringed Seal, Seabirds, Eiders and Geese).

MONITORING: Monitoring of walrus habitats and fouled individuals in the event of oil spills.

RESEARCH: None.

VEC: WALRUS	IH 26

HYPOTHESIS: Disturbance and pollution due to installations and traffic will prevent walrus from resettling in former habitats.

EXPLANATION: The Svalbard walrus population appears to be slowly on the increase and walrus have resettled in some former habitats. Most likely, some of the population increase is due to immigration from the east. Disturbances can deter these individuals from settling in otherwise good areas which have previously been in use.

CATEGORY: D

RATIONALE: The hypothesis is difficult to test, since determining why walrus will not settle in presumably good areas will be problematic. Indications concerning the possible validity of the hypothesis can be obtained through the monitoring and research measures proposed in connection with IH 24.

MANAGEMENT RECOMMENDATIONS: Regulation of the activity near walrus habitats. Stipulation of a minimum flying altitude, landing bans, stipulation of protection zones and protection of haul-out sites.

SURVEYS: Surveys of haul-out sites, feeding areas and general habitats. Surveys of old habitats, inter alia by the recording of old hunting sites, feeding areas (scallop beds) etc. Population surveys and identification by means of satellite telemetry (cf. IH 24).

MONITORING: As for IH 24.

RESEARCH: Population identification by means of satellite telemetry.

VEC: WALRUS	**IH 27**
HYPOTHESIS: Scallop dredging in walrus feeding areas will cause a reduction of the local walrus population.	
EXPLANATION: Scallop dredging can remove/destroy walrus food organisms or their substrate, and may cause a reduction in food availability in affected areas and accordingly reduced reproduction and survival.	
CATEGORY: A	
RATIONALE: Available documentation would indicate that Iceland scallops, the catch of the scallop dredgers, do not constitute an important element in the walrus diet. The Svalbard walrus population being very small, it is unlikely that lack of food will be a problem. If scallop dredging is taking place in walrus habitats possible conflicts should be examined.	
MANAGEMENT RECOMMENDATIONS: Scallop dreding should be restricted to areas which are presently not being used by walrus and which are not considered as primary areas for walrus expansion.	
SURVEYS: Surveys of scallop beds presently used by walrus and scallop beds that will potentially be good walrus food sites, should be compared with information concerning other relevant dredging areas. Areas described for IH 24 should be surveyed.	
MONITORING: Monitoring of currently dredged scallop beds in active walrus habitats. Effects on scallop occurrences and walrus habitats should be recorded. Studies should also be undertaken on scallop beds which are being dredged outside of active walrus habitats and the effect on the beds should be recorded.	
RESEARCH: None.	

VEC: WALRUS	**IH 28**

HYPOTHESIS: Changes in the ringed seal population due to industrial activity will result in a change in the walrus population.

EXPLANATION: Walrus can catch and eat ringed seal. If the ringed seal is an important walrus prey, changes in the ringed seal population may affect the walrus population.

CATEGORY: A

RATIONALE: Although walrus have been recorded preying on ringed seals, nothing indicates that the ringed seal is an important prey.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: WALRUS	IH 29

HYPOTHESIS: Changes in the predator population due to industrial activity will cause a change in the walrus population.

EXPLANATION: Killer whale and, to some extent polar bear, can be walrus predators. Changes in the predator populations can cause changes in the walrus population, if these species normally catch a great many walrus.

CATEGORY: A

RATIONALE: Killer whales rarely occur near Svalbard. Polar bear can only seldom take walrus, and then only calves. In Svalbard predation is therefore considered to be of minor importance to the walrus population. A general increase in the killer whale population due to industrial activity is not likely.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: RINGED SEAL	IH 30

HYPOTHESIS: Disturbance (traffic, seismic activity, ice breaking) will result in a reduction in the local ringed seal populations.

EXPLANATION: Increased traffic will lead to increased disturbance and increased hunting pressure, both of which can cause a reduction in local ringed seal populations. Disturbances can cause increased activity and energy expenditure in seals. Pressure waves caused by seismic explosions may scare away, and possibly kill, ringed seals. Icebreaker traffic in breeding areas can cause an increase in cub mortality by the destruction of birth lairs.

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 programmes. The pressure wave caused by seismic explosions can have a high impact and a long range in closed fjords. The effects on ringed seals should be investigated.

MANAGEMENT RECOMMENDATIONS: Traffic and other activities should be subjected to time and area control in ringed seal breeding and moulting areas. A reporting system should be developed for ringed seal hunting. Seismic activity should be limited to periods of minimal vulnerability and/or should employ techniques which cause a minimal pressure effect.

SURVEYS: Surveys of the size and distribution of the ringed seal population with particular emphasis on the localization of breeding and moulting areas.

MONITORING: Monitoring of the ringed seal population in areas with seismic activity.

RESEARCH: Effect of seismic activity on ringed seal hearing. Effect of seismic activity on ringed seal prey. Basic research on ringed seal hearing and on the use of underwater sounds.

VEC: RINGED SEAL	IH 31

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. Oil intake 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.

MANAGEMENT RECOMMENDATIONS: 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.

SURVEYS: Surveys of number, distribution throughout the year and of breeding areas that may become affected by oil spills.

MONITORING: In case of an oil spill situation: Continuous monitoring, recording of the number of seals fouled by oil.

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.

VEC: RINGED SEAL	IH 32

HYPOTHESIS: Installations causing changes in local predator populations will affect the ringed seal population of the area.

EXPLANATION: Polar bear, and to some extent arctic fox, 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: C

RATIONALE: Increased food access due to waste dumping may cause a sharp increase in the arctic fox population (see IH 7). 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 (see IH 19).

MANAGEMENT RECOMMENDATIONS: See under Arctic Fox - waste dumping IH 7. Also applies to polar bear.

SURVEYS: Surveys of local ringed seal population and breeding areas in areas of potential interest to developers.

MONITORING: Monitoring of the arctic fox population: See VEC 2 "Arctic Fox". Monitoring of local ringed seal populations.

RESEARCH: Study of fox predation pressure in ringed seal breeding areas as a function of fox number.

VEC: RINGED SEAL	IH 33

HYPOTHESIS: Active installations will cause changes in the ringed seal's access to food and will affect the local population.

EXPLANATION: Marine installations can prevent access to important feeding areas, or noise from such installations can frighten away ringed seals.

CATEGORY: A

RATIONALE: It is hardly likely that the installations will become so extensive as to cause essential changes in the availability of feeding areas.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: EIDERS/GEESE	IH 34

HYPOTHESIS: Disturbances near breeding areas can result in reduced reproduction of eiders and geese through both increased predation and reduced egg and chick survival, and may lead to abandonment of breeding areas.

EXPLANATION: Disturbance of breeding birds can result in the desertion of eggs and chicks. They will subsequently be exposed to cold and moisture, and, besides, they will easily fall prey to glaucous gulls and foxes. Lasting/heavy disturbances can deter birds from returning to the breeding area.

CATEGORY: C

RATIONALE: It has been documented that geese in particular are very prone to leaving the nest when disturbed, that heavy disturbances can deter them from returning, and that deserted eider and goose nests are frequently exposed to glaucous gull and fox predation. The hypothesis is accordingly considered to be valid and important.

MANAGEMENT RECOMMENDATIONS: Protection of the most important breeding areas, i.e. a re-assessment of existing regulations.

SURVEYS: For pink-footed geese and eiders: Moulting and breeding areas. For barnacle and brent geese: Moulting and resting areas. For king eiders: Breeding areas and populations. Updating of available maps.

MONITORING: Monitoring of the occurrence of breeding/moulting eiders and geese in development areas.

RESEARCH: Field study of the reaction of the pink-footed goose to disturbance. Experimental (laboratory) study of individuals.

VEC: EIDERS/GEESE	IH 35

HYPOTHESIS: Disturbances in resting, moulting and feeding areas will result in increased energy expenditure, less time for food intake and accordingly increased mortality of adult eiders and geese.

EXPLANATION: The birds will use more energy on flights, and at the same time absorb less energy from grazing. This can directly cause increased mortality, and will be in particular decisive in connection with the fall migration, since juvenile birds especially need to be in good physical condition in order to survive the migration.

CATEGORY: C

RATIONALE: The southward (fall) migration has been documented to be a critical period for the geese. They need to be left undisturbed to enable them to build up energy reserves prior to the migration. Disturbances during this period can particularly result in migration failure of juveniles of the year. Bjørnøya is of special importance as a resting area, and disturbances occurring in this area may have serious effects on the populations of barnacle geese as well as pink-footed geese. It is assumed that the hypothesis is valid and that the problem may become relevant in the Svalbard/Bjørnøya area.

MANAGEMENT RECOMMENDATIONS: Traffic encroachments must be regulated in relevant areas. Important resting/moulting/feeding areas should possibly be protected.

SURVEYS: As for IH 34.

MONITORING: Monitoring of eiders/geese in resting/moulting/feeding areas of potential interest to developers.

RESEARCH: As for IH 34.

VEC: EIDERS/GEESE	IH 36

HYPOTHESIS: Oil spills affecting concentrations of eiders and geese will cause increased mortality.

EXPLANATION: Self-explanatory.

CATEGORY: B

RATIONALE: The effect of oil spills on birds has been well documented. Eiders are vulnerable, but geese are also exposed, particularly in the moulting and chick period, when they remain mainly in the shore area. An oil spill in Svalbard in the summer season, particularly in the moulting period, may kill great numbers of eiders and geese and have serious effects on the populations. The hypothesis is valid.

MANAGEMENT RECOMMENDATIONS: Strict discharge control to avoid routine spills with harmful effects. Oil spill contingency plans.

SURVEYS: Updating and possible extension of existing maps of eider/goose concentrations at sea.

MONITORING: Monitoring of sea-based drilling near well-known eider/goose concentrations.

RESEARCH: Detail studies concerning the breaking down of oil in the "littoral zone" in Svalbard (re SINTEF studies).

VEC: EIDERS/GEESE	IH 37

HYPOTHESIS: Toxic substances discharged into the sea may be accumulated in and will possibly kill benthic fauna forming part of the eider's diet, resulting in the poisoning of eiders or in reduced access to food, and accordingly in reduced reproduction and possibly increased mortality.

EXPLANATION: Contamination of the eider's feeding organisms can cause a reduction in available basic nutrition and/or in ingestion of high concentrations of toxins. This may lead to weakened physical condition and thereby reduced reproduction and increased mortality, which will cause a reduction in the population.

CATEGORY: C

RATIONALE: Eiders live chiefly on benthos organisms, primarily molluscs and crustaceans in the sublittoral zone. Toxic substances and dispersants may destroy these food organisms. The female eider is particularly dependent upon adequate access to food before the breeding season, as she will live entirely on accumulated energy while incubating her eggs. Reduced access to food, or poisoned food, can therefore have negative effects. It is assumed that the hypothesis is valid and may become important in the event of oil spills.

MANAGEMENT RECOMMENDATIONS: Planning of contingency measures.

SURVEYS: Surveys of eiders immediately prior to egg laying and of chick habitats as well as of moulting areas.

MONITORING: Monitoring of breeding/moulting eiders in the event of a discharge.

RESEARCH: Studies of the effects of dispersants on benthos organisms.

VEC: EIDERS/GEESE	IH 38

HYPOTHESIS: An increase in glaucous gull and arctic fox populations resulting from increased dumping of waste will cause increased predation on eiders and their eggs and chicks.

EXPLANATION: Self-explanatory

CATEGORY: C

RATIONALE: Eider and goose species are exposed to considerable arctic fox and glaucous gull predation. Arctic fox and glaucous gull are both food opportunists, and local populations are most likely to increase in the event of waste resulting from human activity (cf. IH 7). An increased population of glaucous gull and arctic fox can cause increased predation on local eider and goose populations. The hypothesis is assumed to be valid.

MANAGEMENT RECOMMENDATIONS: Strict measures against dumping of waste.

SURVEYS: None.

MONITORING: Monitoring of population size of glaucous gull and arctic fox (cf. IH 7). A possible increase in predation pressure should be documented in areas of potential interest to developers.

RESEARCH: None.

VEC: EIDERS/GEESE	IH 39

HYPOTHESIS: Wear on tundra vegetation will result in a deterioration of grazing conditions for geese.

EXPLANATION: Bases, rigs, use of terrain vehicles etc. will damage vegetation and soil, with subsequent erosion damage. This may reduce available grazing range for geese and will accordingly have a negative effect on the populations.

CATEGORY: B

RATIONALE: Geese mainly live on tundra vegetation. Wear associated with industrial activity may reduce the productivity of the grazing range, which in turn will cause impaired physical condition and accordingly lower reproduction and possibly higher mortality. The industrial activity in Svalbard is however unlikely to become so extensive as to cause significant damage to vegetation and subsequently to the goose populations. The hypothesis is given a low priority.

MANAGEMENT RECOMMENDATIONS: Permission should not be granted for the use of the most important geese grazing areas for industrial purposes.

SURVEYS: Surveys of the most important geese grazing areas should be considered.

MONITORING: None.

RESEARCH: None.

VEC: EIDERS/GEESE	IH 40

HYPOTHESIS: Increased traffic will cause increased hunting pressure through legal and illegal hunting of eiders and geese.

EXPLANATION: Self-explanatory.

CATEGORY: B

RATIONALE: The hypothesis is valid but increased hunting pressure in the form of legal and illegal hunting can only become a problem in the event of a very great increase in traffic. The problem can however be regulated by inspection and other management measures.

MANAGEMENT RECOMMENDATIONS: Active regulation of the hunt. Possible introduction of quotas, reduced hunting season, protection of most of the areas under heaviest pressure etc. The extent of hunting pressure should be supervised.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: EIDERS/GEESE	IH 41
HYPOTHESIS: Disturbance in breeding areas will reduce the number of suitable breeding areas and accordingly lead to competition for breeding areas and increased migration and/or reduced reproduction with the least competitive species.	
EXPLANATION: Increased disturbance can cause migration. The competition for localities unaffected by disturbance will grow when the total number of nesting sites in an area decreases. Competition leads to lower reproduction with the losing species, and accordingly to a reduction in their populations.	
CATEGORY: D	
RATIONALE: The number of available nesting sites can in many cases be a factor delimiting the size of the breeding populations. There are many indications of direct competition between barnacle geese and brent geese, and also between eiders and barnacle geese. The hypothesis may be valid.	
MANAGEMENT RECOMMENDATIONS: Regulation of traffic near the nesting colonies, based on research findings.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: Behavioural studies on inter-specific competition for breeding areas.	

EIDERS/GEESE		IH 42

HYPOTHESIS: Pollution and increased hunting pressure due to more traffic can result in a higher mortality rate of glaucous gull and arctic fox, and accordingly in a reduction in predation in the breeding areas of eiders and geese. This will give reduced mortality and increased reproduction of eiders and geese.

EXPLANATION: Increased human activity may lead to a decrease in the populations of predators as a result of increased hunting pressure. This will have a positive effect on the eider and goose populations.

CATEGORY: A

RATIONALE: There is little reason to believe that the glaucous gull and arctic fox populations will be reduced as a result of human activity unless active measures are taken to combat these species. The predator populations will most likely be favoured by human activity. The hypothesis is not regarded to be valid.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SEABIRDS	IH 43

HYPOTHESIS: Oil spills near sea-bird concentrations will cause increased mortality and reduced reproduction of the population.

EXPLANATION: Seabirds fouled by oil will die or be severely affected by a reduction of the insulating properties of the plumage (increased energy expenditure), and/or by direct poisoning. This will increase mortality and reduce the reproduction in affected local populations.

CATEGORY: B

RATIONALE: The validity of the hypothesis has been well documented. Extensive damage to populations as a result of oil spills may have serious effects on the natural environment of Svalbard, as the sea-birds bring a substantial part of the energy and nutrients from sea to land. Therefore the prevention of oil spills and the monitoring of sea bird populations are important measures.

MANAGEMENT RECOMMENDATIONS: Stricter contingency plans should be prepared. Discharge concentrations should be strictly regulated.

SURVEYS: Breeding concentrations, food concentrations and swimming migrations should be surveyed, to provide documentation of damage in the event of an oil spill.

MONITORING: Monitoring of the population development in the event of an oil spill. It should be possible to identify the different populations; accordingly ringing and studies of population genetics should be undertaken.

RESEARCH: Studies of population dynamics and population genetics (identification of different populations).

VEC: SEABIRDS	IH 44

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

EXPLANATION: Disturbance causes stress and possibly abandoning of areas under pressure, reduced grazing efficiency and food access, impaired physical condition as a result of increased activity. Reproduction can be affected by eggs and chicks falling out of the nests, and by a reduction in incubation time for brooding adult birds.

CATEGORY: C

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

MANAGEMENT RECOMMENDATIONS: Seismic activity, use of aircraft etc. close to nesting colonies and other sea-bird concentrations should be avoided.

SURVEYS: Updating of existing maps, surveys of important feeding, moulting and resting areas.

MONITORING: Monitoring of population development in affected areas and in unaffected control areas.

RESEARCH: Study of the effects of disturbances caused by aircraft/helicopter, seismic explosions, hikers etc. on sea-bird concentrations. Studies of population dynamics and population genetics (identification of different populations).

VEC: SEABIRDS	**IH 45**

HYPOTHESIS: An increase in the glaucous gull population resulting from the dumping of edible waste will cause increased predation on sea-birds and their eggs and chicks.

EXPLANATION: An increase in traffic and human activity will cause an increase in the dumping of waste, and accordingly in the food available for glaucous gulls in the area. The size of these populations is regulated by food access. Increased population leads to increased predation and reduced reproduction of the local sea-bird populations.

CATEGORY: C

RATIONALE: A food opportunist, the glaucous gull will benefit from the food waste of human activity. In Svalbard it mainly feeds on sea-birds in the summer. An increase in the dumping of food waste is therefore likely to cause an increase in the glaucous gull population that will have a negative effect on the sea-bird populations. The effect is assumed to be local in character.

MANAGEMENT RECOMMENDATIONS: All waste should be stored in containers and treated in waste treatment units. Predator populations should be monitored and possibly controlled.

SURVEYS: None.

MONITORING: Monitoring of predation pressure in protected sea-bird colonies. Monitoring of population development in affected areas and in unaffected control areas. Monitoring of affected glaucous gull populations.

RESEARCH: None.

VEC: SEABIRDS	IH 46

HYPOTHESIS: Increased traffic will result in reduced local sea-bird populations, due to increased hunting pressure and egg gathering.

EXPLANATION: Increased activity at permanent installations, bases, roads etc. will increase the hunting and egg gathering.

CATEGORY: B

RATIONALE: The hypothesis has in a sense been documented as valid. Hunting is however unlikely to become so extensive as to become a problem. A potential problem may moreover be avoided by means of regulations. Surveying/research/monitoring is not recommended.

MANAGEMENT RECOMMENDATIONS: Hunting should be regulated. Local quotas or curtailment on hunting seasons should be considered in the event of an extensive increase of activity. A tightening up of control measures to curtail illegal hunting and egg gathering may be initiated.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SEABIRDS	IH 47

HYPOTHESIS: Emissions of toxic bioaccumulative substances will cause increased mortality and reduced reproduction of sea-birds.

EXPLANATION: Toxic, resistant substances in spillage from drilling rigs, bases etc. may be accumulated in organs and tissues of sea-birds and cause disease/weakening of physical condition. This may in turn affect the mortality and reproduction of the populations.

CATEGORY: D

RATIONALE: The effect as such has been demonstrated. Provided today's strict regulations for the issue of discharge permits will be enforced, this is not likely to become a serious problem.

MANAGEMENT RECOMMENDATIONS: Strict regulations for the issue of discharge permits, with frequent controls, should be continued.

SURVEYS: None.

MONITORING: If toxic bioaccumulative substances are traced in the marine environment, sea-birds and eggs within the area at risk should be examined.

RESEARCH: None.

VEC: SEABIRDS	IH 48

HYPOTHESIS: Oil contamination will cause increased mortality in the sea-birds' food organisms, or make these less accessible, and thereby cause a reduction in sea-bird populations.

EXPLANATION: If the sea-birds' nutritional base is damaged by contaminants, the quantity of food available will be reduced and the sea-birds' physical condition will be affected. Impaired physical condition can cause a population reduction directly, and through predation and reduced reproduction.

CATEGORY: D

RATIONALE: The effect of oil contaminants on primary and secondary producers is limited. The larval stage of sea-birds' food organisms, and the fauna and flora otherwise associated to the ice, may be damaged. The hypothesis may accordingly be valid in principle. The direct mortality of the sea-bird population as a result of oil spills will however be far greater than the possible effect of a food deficit caused by oil pollution.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SEABIRDS	IH 49

HYPOTHESIS: Pollution, disturbance and increased hunting pressure can reduce the glaucous gull and arctic fox populations. This will reduce the predation on sea-birds and their eggs and chicks and have a positive effect on the sea-bird populations.

EXPLANATION: Self-explanatory.

CATEGORY: A

RATIONALE: A reduction in predatory populations as a result of human activity is unlikely. Both glaucous gull and arctic fox are food opportunists and, compared to sea-birds, they are hardly vulnerable to oil spills. The predator populations are more likely to be favoured by human activity. The hypothesis is not regarded to be valid.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SEABIRDS	IH 50

HYPOTHESIS: Increased ice breaker traffic in ice-filled waters will make the access to food organisms easier for sea-birds and result in a population increase.

EXPLANATION: When water masses are exposed in ice-filled waters sea-birds will more easily find food because food organisms will be attracted by the light and because there will be a blooming of these organisms.

CATEGORY: A

RATIONALE: The drift ice in Svalbard is in continual movement, with frequent opening and closing of leads. An extra lead caused by a ship will be of no consequence. Leads from ships may have a certain effect in icecovered fjords. The hypothesis is however not regarded to be valid.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: PTARMIGAN	**IH 51**

HYPOTHESIS: Edible waste from installations and traffic will increase the area's carrying capacity for arctic fox and glaucous gull and will cause increased predation pressure on the local ptarmigan population.

EXPLANATION: Self-explanatory.

CATEGORY: C

RATIONALE: Arctic fox, and to some extent glaucous gull, prey on ptarmigan. An increased population of these species may lead to a reduction in the ptarmigan population (see also corresponding hypotheses for Seabirds and Eiders/Geese and documentation for Arctic Fox). The ptarmigan population is however abundant, migratory and has a high reproduction potential; the risk of reduction beyond the local population is assumed to be small unless there is a comprehensive increase in activity over large areas.

MANAGEMENT RECOMMENDATIONS: Strict regulations concerning waste treatment to prevent an increase in the food accessible to arctic fox and glaucous gulls.

SURVEYS: None.

MONITORING: None.

RESEARCH: In case of increasing numbers of fox/glaucous gull: Study of the effect on the ptarmigan population.

VEC: PTARMIGAN	IH 52

HYPOTHESIS: Disturbance resulting from increased land transport/traffic (on the ground and in the air) will cause a reduction in local populations of Svalbard ptarmigan.

EXPLANATION: Disturbance causes increased flight, reduced reproduction (because of reduced incubation time) and reduced grazing time. These factors may lead to a reduction in the affected local ptarmigan population.

CATEGORY: D

RATIONALE: It is questionable whether the current plans for future petroleum activities will involve traffic of such an extent as to affect the ptarmigan population. Ptarmigan pairs breed in a widespread area throughout Svalbard, often in areas which are impassable to traffic (excluding helicopters). In any case, their reproduction potential is high. With regard to the winter situation, favourable grazing ranges may be affected.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: Surveys of the winter distribution of the ptarmigan population.

MONITORING: None.

RESEARCH: Study of the effect of disturbance on breeding ptarmigan hens (physiology and behaviour).

VEC: PTARMIGAN	IH 53

HYPOTHESIS: Increased hunting pressure can cause a reduction in local ptarmigan populations.

EXPLANATION: Self-explanatory.

CATEGORY: D

RATIONALE: Svalbard's ptarmigan population is large, has a wide distribution, and the ptarmigan is a migratory species. The species also has a high reproduction potential, and there is a surplus population which will only reproduce when individuals possessing a territory die or disappear. The hypothesis may in principle be correct, but given the hunting pressure expected in Svalbard, recruitment and migration are expected to keep the hunted populations at a stable level.

MANAGEMENT RECOMMENDATIONS: The ptarmigan hunt can be subjected to stricter regulations if there are indications that the population is being over-hunted.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: PTARMIGAN	IH 54

HYPOTHESIS: Increased traffic over land will result in increased hunting of Svalbard ptarmigan.

EXPLANATION: Self-explanatory.

CATEGORY: D

RATIONALE: Ptarmigan hunting takes place on foot and is therefore limited to areas surrounding populated areas and locations that are accessible by motorized vehicles. Increased use of such vehicles will extend the hunting area and accordingly the total of ptarmigans hunted. The effect is however assumed to be insignificant for the population as a whole.

MANAGEMENT RECOMMENDATIONS: As for IH 56.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: PTARMIGAN	IH 55

HYPOTHESIS: Increased hunting pressure and pollution will result in higher glaucous gull and arctic fox mortality, less predation on ptarmigans and increased ptarmigan survival and reproduction.

EXPLANATION: Self-explanatory.

CATEGORY: A

RATIONALE: There are no indications that the arctic fox and glaucous gull populations will be reduced by increased activity (see corresponding IHs for Seabirds and Eiders/Geese). The hypothesis is considered to be invalid.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None. cf. Arctic Fox (IH 11)

MONITORING: None.

RESEARCH: None.

VEC: PTARMIGAN	**IH 56**
HYPOTHESIS: Oil contamination will result in increased mortality and reduced reproduction of Svalbard ptarmigan.	
EXPLANATION: Self-explanatory.	
CATEGORY: A	
RATIONALE: Ptarmigans are likely to be easily injured if exposed to an oil spill. This is however unlikely to be of such an extent as to affect the local population. The hypothesis is invalid.	
MANAGEMENT RECOMMENDATIONS: None.	
SURVEYS: None.	
MONITORING: None.	
RESEARCH: None.	

VEC: MARINE BIOLOGICAL RESOURCES	IH 57

HYPOTHESIS: Dumping of mechanical waste in the sea will result in loss and damage to fishing equipment and will reduce fishable areas.

EXPLANATION: Self-explanatory.

CATEGORY: B

RATIONALE: Dumping of mechanical waste in the sea has been a problem for the fisheries on the Continental Shelf outside South Norway. A corresponding situation can be imagined in Svalbard, and the hypothesis is therefore valid. The problem may however easily be avoided by management measures.

MANAGEMENT RECOMMENDATIONS: Dumping of mechanical waste on the sea floor in active fishing/trawling/dredging fields should be prohibited.

SURVEYS: Prawn trawling fields, Greenland halibut breeding grounds and Iceland scallop dredging fields should be surveyed.

MONITORING: None.

RESEARCH: None.

VEC: MARINE BIOLOGICAL RESOURCES	IH 58

HYPOTHESIS: The presence of installations will reduce the area available for deep-water prawn trawling and Iceland scallop dredging.

EXPLANATION: Self-explanatory.

CATEGORY: B

RATIONALE: It is a well-known fact that there is actual conflict in the areas in which both fishing and petroleum activities are taking place. Within the Svalbard 4-mile zone there is extensive trawling for deep-water prawns, and in forthcoming years possibly dredging for Iceland scallops. The hypothesis is therefore valid.

MANAGEMENT RECOMMENDATIONS: Petroleum activity should be avoided in main fishing fields.

SURVEYS: Surveys of the resource basis. Surveys of prawn trawling fields and Iceland scallop dredging fields.

MONITORING: Monitoring of prawn and Iceland scallop fields in the event of drilling/production and during an actual oil spill.

RESEARCH: None. Basic research on the marine biological resources surrounding Svalbard is incomplete; intensified research concerning the life histories and environmental requirements of the individual species is essential. This is however in an area where the responsibilities of MUPS and the fishery authorities overlap.

VEC: MARINE BIOLOGICAL RESOURCES	1H 59

HYPOTHESIS: Oils spills, and possibly oil spill dispersants, can cause reduced quality/increased mortality of the benthic resources.

EXPLANATION: An oil spill on the sea surface will gradually disappear. Part of the oil will adhere to particles in the water which will settle on the sea floor and be accumulated in the sea floor sediments. In this way benthic organisms can be damaged.

CATEGORY: B

RATIONALE: Data from the monitoring programmes around North Sea installations display local effects within a radius of 1 km. The oil may both affect the taste of the food resources, making them unfit for human consumption, and cause increased mortality. Results from toxicity tests have proved to be of little ecological relevance, and research in this field has therefore been given low priority. The problem may be real where the water circulation is poor, e.g. in Van Mijenfjorden.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: Surveys of prawn trawling fields and Iceland scallop dredging fields.

MONITORING: Monitoring of marine biological resources in the event of drilling/production and in an actual oil spill situation.

RESEARCH: None.

VEC: MARINE BIOLOGICAL RESOURCES	**IH 60**

HYPOTHESIS: Oil spills, chemicals and drill cuttings will reduce the populations of deep-water prawns, Iceland scallops and Greenland halibut.

EXPLANATION: Eggs and larvae of prawns and Iceland scallops, and Greenland halibut larvae are found in the free water masses. When exposed to oil or other toxic chemicals they are likely to be damaged or die. This may cause local damage to the populations.

CATEGORY: C

RATIONALE: Oil is considered to be most harmful to fish and benthos at the egg and larval stages. An oil spill occurring in the spawning season or immediately afterwards may therefore affect prawn, Iceland scallop or Greenland halibut fisheries. The hypothesis is however difficult to test under natural conditions. While laboratory tests can provide some information on the validity of the hypothesis, the hypothesis is not regarded as particularly important at present.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: Surveys of prawn trawling fields, Greenland halibut breeding grounds and Iceland scallop dredging fields.

MONITORING: Monitoring of prawn and Iceland scallop grounds and Greenland halibut breeding grounds when drilling/producing and in the event of an oil spill.

RESEARCH: Testing of the toxic effect of the oil on the egg and larval stages of the three species.

VEC: MARINE BIOLOGICAL RESOURCES	IH 61

HYPOTHESIS: Accumulation of drilling products (sediments, cuttings, chemicals) will result in increased mortality and reduced recruitment of the resources.

EXPLANATION: Emissions from drilling rigs in normal operation are accumulated on the sea floor around the rigs. This can have a negative effect on the benthic organisms and may cause damage on prawns, Iceland scallops and Greenland halibut.

CATEGORY: D

RATIONALE: Emissions from drilling rigs in normal operation are known to affect the benthic organisms. The pollution controlling authorities employ recordings of the benthic organisms as an indicator of the extent of emissions from drilling rigs. The monitoring methods used in the North Sea can be transferred to Svalbard. The management authorities may use this knowledge to reduce the effect that drilling products have on marine resources. The hypothesis is therefore considered to be of little consequence in a MUPS context.

MANAGEMENT RECOMMENDATIONS: The arrangement concerning drilling rig discharge permits and discharge control used in Norway should be adopted. Drilling products must not be discharged into areas with Iceland scallops, prawns or Greenland halibut.

SURVEYS: None.

MONITORING: Monitoring of benthic organisms around rigs to prevent damage being caused by discharge.

RESEARCH: None.

VEC: MARINE BIOLOGICAL RESOURCES	**IH 62**

HYPOTHESIS: Seismic activities will cause growth disturbances and increased mortality at the earlier developmental stages of Greenland halibut and prawns.

EXPLANATION: Certain types of marine seismic activities are known to affect the marine organisms. This applies to e.g. plankton and the larval stages of fish that are frightened away.

CATEGORY: D

RATIONALE: The effects on populations of pelagic animals can be studied by means of echo sounders, but this is given low priority, as our knowledge of the life histories of marine resources is inadequate. The problem is moreover regarded to be of minor importance.

MANAGEMENT RECOMMENDATIONS: Use of explosives should not be permitted.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: SVALBARD CHAR	IH 63

HYPOTHESIS: Increased population and traffic resulting from industrial activities in Svalbard will lead to a reduction in the local char populations.

EXPLANATION: The growth and turnover in a population of Svalbard char takes place at a very slow rate. The fish becomes sexually mature at the age of 9-10 years. This implies that reproduction will take longer if the population is being over-harvested.

CATEGORY: B

RATIONALE: The validity of the hypothesis has been confirmed locally in Svalbard. Management measures should be introduced to prevent over-harvesting. More research on char biology may be needed to be able to supply the management authorities with more information on which to base regulations to prevent over-harvesting. This also applies to transplantation as a compensation for over-harvesting.

MANAGEMENT RECOMMENDATIONS: To stipulate a limit to the number of nets thrown per day in the individual lakes. A ban against casting nets in lagoons and against the barring of the courses of rivers. Alternating protection of individual lakes.

SURVEYS: Surveys of the char population in the watercourses of Svalbard. Surveys of the localization and size of populations potentially exposed to development activities.

MONITORING: Monitoring of the populations in watercourses potentially exposed to development.

RESEARCH: More research on the char's biology is needed in order to decide on sensible management measures.

VEC: SVALBARD CHAR	IH 64

HYPOTHESIS: Impacts on watercourses by gravel quarrying, damming or pollution will lead to a reduction in individual growth and of the population of Svalbard char.

EXPLANATION: Anadromous char has its greatest growth period when in the sea. If the migrations are obstructed its growth will be reduced. This may prevent sexual maturation and lead to a greater number of small stationary char.

CATEGORY: B

RATIONALE: Any of the above-mentioned hypothesized encroachments can obstruct the char's migration and thus affect the size and composition of the population. Anglers find sea char more attractive than stationary char. The problem can however be avoided by management measures.

MANAGEMENT RECOMMENDATIONS: Encroachments in rivers flowing from lakes with char populations should be avoided.

SURVEYS: Surveys of the char population in Svalbard's watercourses. Surveys of localization and size in populations potentially exposed to development activities.

MONITORING: Monitoring of populations in watercourses potentially exposed to development activities.

RESEARCH: Research on the char's biology is needed in order to decide on practical management measures.

VEC: SVALBARD CHAR	IH 65

HYPOTHESIS: Emissions of oil and other chemicals in fresh water or along the coast may cause increased mortality and reduced production in char populations.

EXPLANATION: The recruitment may fail due to poisoning of egg and larval stages in fresh water. Adult mortality may increase and growth may be reduced. Pollution in salt water may deter migration, reduce food availability and cause illness. The migratory pattern may possibly also be changed.

CATEGORY: D

RATIONALE: The hypothesis is probably valid. It is however unlikely to affect more than very restricted areas. Oil spills in fresh water/rivers or near estuaries can reduce the local population. Oil spills in the sea will probably only have a minor impact in Svalbard char. The hypothesis is regarded to be of minor importance/relevance.

MANAGEMENT RECOMMENDATIONS: Strict regulations concerning routine discharges in rivers and lakes.

SURVEYS: Surveys of main fishing lakes.

MONITORING: None.

RESEARCH: None.

VEC: VEGETATION AND SOIL	IH 66

HYPOTHESIS: Traffic and installations will cause damage of vegetation and soil. The degree and type of wear can to a great extent be predicted merely on the basis of climate, soil geology and vegetation characteristics.

EXPLANATION: Traffic and installations can leave tracks in vegetation and soil. The schematic flow chart and Fig. B indicate the processes involved. Whether damage is likely to develop can partly be predicted on the basis of weather and terrain characteristics.

CATEGORY: B

RATIONALE: There is already considerable terrain damage in Svalbard. The current activities are leaving new tracks. The general knowledge of the processes involved is sufficient for the hypothesis to be considered valid. When surveying and studying existing damage the possibilities of further damage can be predicted with greater certainty and the regulations concerning the activity can be improved. Such surveying should be carried out with the sub-target of identifying methods for possible experimental studies.

MANAGEMENT RECOMMENDATIONS: Traffic should, to the greatest extent possible, pass through in the winter, primarily on snow-covered and frozen ground. Traffic in the summer season (after about 10 May) should not be allowed on wet and relatively wet tundra, in sloping terrain exposed to erosion by mass transport or on fine-grained soils with a large ice or water content.

SURVEYS: Terrain forms, soil type (quarternary geological classification) and vegetation in the entire area affected by industrial activity should be surveyed in order to evaluate vulnerability to wear. Humus types and soil profiles should be registered.

MONITORING: Possible damage in the surveyed areas should be recorded after the implementation of development activities. Long-term effects will be of greatest interest, and monitoring should therefore preferably be carried out on a long-term basis in specially selected areas.

RESEARCH: Testing the effects of:
a) Pedestrian damage on different types of ground and vegetation
b) Driving with off-road vehicles over different types of ground and vegetation.
Experiments with active re-vegetation of formerly damaged areas and experimentally damaged test sites.

VEC: VEGETATION AND SOIL	IH 67

HYPOTHESIS: Pollution can cause erosion and damage to the vegetation.

EXPLANATION: The schematic flow chart and Fig. B indicate what mechanisms are activated when vegetation is being polluted. Various impacts are caused by pollution: individual plants may obtain better conditions for growth, allowing them to dominate (fertilizing effect) but parts of plants may also die and the soil may be laid bare to erosion.

CATEGORY: B

RATIONALE: Extensive oil spills (blowouts, acute chemical pollution) can cause much local damage and erosion. Moderate contamination can result in marked local changes of flora. Oil spills and other kinds of pollution will have varying effects on different types of vegetation. Wetlands below the emission sites for liquids or water soluble pollution are exposed. Few experimental trials have hitherto been carried out on pollution of the Svalbard flora, but the hypothesis is assumed to be valid.

MANAGEMENT RECOMMENDATIONS: Drilling activity and installations involving a risk of pollution should not be located on or above vulnerable or valuable areas of vegetation.

SURVEYS: Surveys of the area surrounding the installation, including, in the case of oil drilling, areas below the installation, and of other areas that may be exposed to oil spills.

MONITORING: Monitoring of damage and re-vegetation after oil spills and other accidents.

RESEARCH: Experiments with the application of oil and/or other contaminants to various plant communities in which re-vegetation is being monitored. The experiments should be combined with measures aimed at accelerating re-vegetation programmes.

VEC: VEGETATION AND SOIL:	IH 68

HYPOTHESIS: Soil organisms can be effective in breaking down oil spills.

EXPLANATION: Even in cold regions, bacteria can be effective agents for the breaking down of oil. Favourable environmental conditions such as sufficient oxygen and ample nutritional supply are essential to growth. The activity of soil fauna can have a stimulating effect on breakdown.

CATEGORY: C

RATIONALE: "Cleaning up" oil spills by application of fertilizers or specialized organisms should be possible. The hypothesis is assumed to be valid but more research within this field is required before feasible methods can be established for Svalbard. SINTEF is about to terminate a project within this field. Planners of new projects will find it necessary to take their starting-point from SINTEF's results.

MANAGEMENT RECOMMENDATIONS: Possible use of fertilization to increase the breaking down of oil instead of cleaning-up actions.

SURVEYS: None.

MONITORING: Monitoring of the fate and speed of the breaking down in the event of an oil spill.

RESEARCH: Field and laboratory experiments of the composition of oil spills, both with and without fertilization.

VEC: VEGETATION AND SOIL	IH 69

HYPOTHESIS: The soil fauna can be more vulnerable than the vegetation cover to certain pollutants. Impacts on this fauna may have secondary effects on the vegetation.

EXPLANATION: The schematic flow chart and Fig. B indicate the processes involved. The soil fauna is very vulnerable to certain types of pollution, while being more tolerant to others. Toxic effects can both be reflected in mortality and in altered activity.

CATEGORY: C

RATIONALE: Our knowledge of specific types of pollution is limited but the knowledge available makes it reasonable to assume that the hypothesis is valid. Interesting studies are under way at several research institutes abroad (Sweden, the Netherlands). A certain insight into the problem ought to be obtainable within the MUPS framework.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: Monitoring of the effect on soil of possible emissions of oil or other chemicals.

RESEARCH: Experimental field and laboratory studies of the effect on vegetation and soil obtained from the application of different types of pollutants.

VEC: VEGETATION AND SOIL	IH 70

HYPOTHESIS: The damage caused by management measures in relation to developments can be reduced if information on the geographical distribution of biologically and geologically "valuable objects" is provided in advance.

EXPLANATION: Self-explanatory. As an impact hypothesis this hypothesis is not set up on the basis of the same criteria as the other hypotheses but is included because of its importance to the VEC.

CATEGORY: B

RATIONALE: Information on geographical location of "valuable objects" will be very important in order to evaluate the location of relevant developments. In particular this applies to immovable botanical and geographical objects. It may e.g. be an alternative to avoid affecting areas housing such objects at the expense of less important areas with a greater tolerance to wear and erosion.

MANAGEMENT RECOMMENDATIONS: Developments should be located outside of areas housing known "valuable objects".

SURVEYS: The localities of species/populations, populations, habitats, type localities and geological formations should be surveyed in areas affected by developments. Potentially affected types of objects should be surveyed over a larger area in order to evaluate the importance of the development.

MONITORING: "Valuable objects" affected by developments, and which may be submitted to continued modification, should be monitored. A data base system should be established in which information on "valuable objects" can be continuously updated.

RESEARCH: None.

VEC: VEGETATION AND SOIL	IH 71

HYPOTHESIS: Soil organisms affect the possibility of re-vegetation through mineralization of organic material, by influence on soil structure and by the dispersal of diaspores. Soil fauna disturbance due to traffic may accordingly damage vegetation.

EXPLANATION: The soil organisms play an important part in the decomposition and dynamics of the soil - vegetation system.

CATEGORY: C

RATIONALE: Deciding upon the validity of the hypothesis is currently impossible, due to the soil fauna and its effects being so complex and our knowledge being insufficient. At the low temperatures prevailing in the Arctic the soil decomposition is so slow that possible research projects would take several years longer than in temperate regions.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: THE "LITTORAL ZONE"	IH 72

HYPOTHESIS: Oil contamination can cause considerable damage in the "littoral zone". The areas least exposed to waves are the most vulnerable.

EXPLANATION: A contaminated coast is a disadvantage to general traffic and can cause poisoning of coastal fauna, the sea floor and shore meadows. The self-cleaning ability of the shores is variable.

CATEGORY: B

RATIONALE: Exposed rocky shores and wave-exposed sediment beaches are only minimally vulnerable and have a great self-cleaning ability regarding oil pollution. Wave-exposed sediment beaches are however vulnerable to pollution in the supralittoral zone (kelp banks, lagoons etc.) Beaches unexposed to waves are also vulnerable to pollution. The microbic decomposition of oil is dependent upon beach type and nutritional supply. Information on the above processes in Svalbard is lacking. Sunlight as well as annual ice covering would indicate that the decomposition fates may be "anomalous" when compared to the mainland.

MANAGEMENT RECOMMENDATIONS: When carrying out pollution-risk activities, laying of booms to protect vulnerable areas should be considered. For fine-grained sediment beaches the harmful effects of cleaning-up measures should be given special consideration. Measures to accelerate the normal decomposition of oil may be a relevant alternative.

SURVEYS: Surveys of coastal areas of special importance to other VECs (Eiders, Geese, Seabirds and Walrus).

MONITORING: Monitoring of coastal areas that are affected by pollution.

RESEARCH: Experimental oil spills on different types of shores in order to register the damage and the rehabilitation ability of the system. Studies of oil decomposition on different types of shores, including experiments to accelerate the decomposition process.

VEC: THE "LITTORAL ZONE"	IH 73

HYPOTHESIS:

A: Remedial measures to handle oil spills in the "littoral zone" can be effective in arctic temperatures.

B: The effects of the remedial measures can cause more damage than the oil as such.

EXPLANATION: The validity of the sub-hypotheses will decide the choice of strategy for the treatment of oil spills in Svalbard. The validity must be expected to vary with the type of spill, shore type, season and other conditions.

CATEGORY: C/C

RATIONALE:

A: The temperature conditions of the Arctic generally imply that chemical/ biological processes such as decomposition are slow (at a standstill in the winter). Light conditions (summer) and biological adaptation (bacteria) may however accelerate decomposition.

B: Toxic traces from chemical oil removal, vegetation/soil damage from mechanical oil clean-up actions may cause more harm than the oil spill as such. Both sub-hypotheses are assumed to be valid under certain conditions.

MANAGEMENT RECOMMENDATIONS: An oil spill contingency plan should be prepared on the basis of the available information (immediately) and based on further research (in future).

SURVEYS: As for IH 72.

MONITORING: Monitoring of the impacts of various types of oil spills, abatement on different types of beaches.

RESEARCH: Experimental study of effectiveness of different oil spill treatment methods. Studies of biological damage caused by specific oil spill treatment methods.

VEC: THE "LITTORAL ZONE"	IH 74

HYPOTHESIS: Traffic and installations can cause wear of the "littoral zone".

EXPLANATION: Fine-grained sediment beaches, protected against the wash of waves, are vulnerable to wear. Rocky shores and wave-exposed sediment beaches do not suffer damage by erosion.

CATEGORY: B

RATIONALE: The hypothesis has been documented as valid in several locations. A general map and a data base of the cost-line of Svalbard (video and still photographs) are under preparation but the biological and geological dynamics of the coast-line have been only marginally studied.

MANAGEMENT RECOMMENDATIONS: Existing maps/data base must be consulted before the start-up of activity in the "littoral zone". Detailed maps must be prepared. In general heavy traffic and installations should be avoided on fine-grained beaches with minimal wave exposure. Activity should be avoided in lagoon areas. In winter, when the ground is frozen and snow-covered, such areas can be used by traffic.

SURVEYS: General maps/data base should be completed. The surveying of "littoral zones" is of special importance to other VECs.

MONITORING: Monitoring of development after damage is inflicted.

RESEARCH: None.

VEC: THE "LITTORAL ZONE"	IH 75

HYPOTHESIS: Accumulation of contaminants in kelp banks can serve as a reservoir for a continuous leak of contaminants.

EXPLANATION: Kelp banks can serve as a "sponge" and cause the effects of oil spills to become particularly long-lasting.

CATEGORY: D

RATIONALE: The hypothesis is regarded as possible but the quantity of kelp banks and the potential for accumulation/leakage of contaminants is not considered to be of special significance.

MANAGEMENT RECOMMENDATIONS: None.

SURVEYS: None.

MONITORING: None.

RESEARCH: None.

VEC: OUTDOOR RECREATION	IH 76

HYPOTHESIS: Industrial activity will affect the practice and experience of outdoor recreation in Svalbard in the form of plants and installations, marine traffic, commercial transport on land and in the air.

EXPLANATION: Traffic and installations will lessen the wilderness character of the areas and make them more accessible. A decrease in the wilderness character combined with increased user density will diminish the quality of the experience to the individual recreationist.

CATEGORY: C

RATIONALE: Even if such effects have not been documented in Svalbard, experience from a number of areas confirm the fact that industrial activity affects outdoor recreation by occupying areas, and by altering fauna, landscape configuration and infrastructure. The hypothesis is assumed to be valid.

MANAGEMENT RECOMMENDATIONS: The short-term management measures should be based on local user research/area surveys. In the long term a Recreation Opportunity Spectrum (ROS) type of management plan should be prepared.

SURVEYS: Surveys of the use of potential development areas ahead of development activities. Assessment of the area's suitability for outdoor recreation. User qualifications should be examined.

MONITORING: Monitoring of change in the use of a development area and in an untouched control area.

RESEARCH: None.

9. DEFINITIONS

A brief definition of some words and expressions used:

AEAM: Adaptive Environmental Assessment and Management, a method for developing projects/programmes concerning environmental management.

BEMP: Beaufort Environmental Monitoring Project, a monitoring programme for oil activity in the Beaufort Sea.

Development: industrial/human influences on VECs.

Expert group: Group consisting of representatives of the various relevant fields as well as environmental management and industry. Size of group, approximately 10 persons.

IH - (impact hypothesis): Postulation of impacts on the VEC caused by industrial or other activity in Svalbard.

IH - category: IH groupings according to assumed validity and to what measures and studies will be relevant to carry out.

Linkage: The connection between development, system components and VECs in the schematic flow chart.

Management recommendation: The measures, procedures etc. connected with the development that will prevent or reduce environmental damage.

Monitoring: Studies measuring the extent of impact, or assessing the cause-effect relationship connected with a development affecting a VEC, or associated system components, in which the VEC impact as such is not under discussion.

Population: Number of individuals within a given area.

Research: Testing the potential impact of a development on a VEC or its associated components. May form the basis for management recommendations.

Schematic flow chart: A diagram of boxes and arrows indicating the position of the VEC in the ecosystem and how developments and system components will affect the VEC.

Surveys: Occurrence of relevant resources/attributes (VECs) at relevant times/locations are recorded.

System component: A natural factor of importance to the VEC, such as disease, predation and reproduction. As opposed to development (see above).

VEC: Valued Ecosystem Component, a resource or environmental feature which is important to a local human population, has a national/international profile, and which, if altered from its existing status, will be important for the evaluation of environmental impacts of industrial developments and the focussing of administrative efforts. The VECs were selected by the expert group.

Working group: A group consisting of representatives of; the various relevant professional fields, the Svalbard management, industry, the local residents of Svalbard, and persons with a general ecological and administrative background.