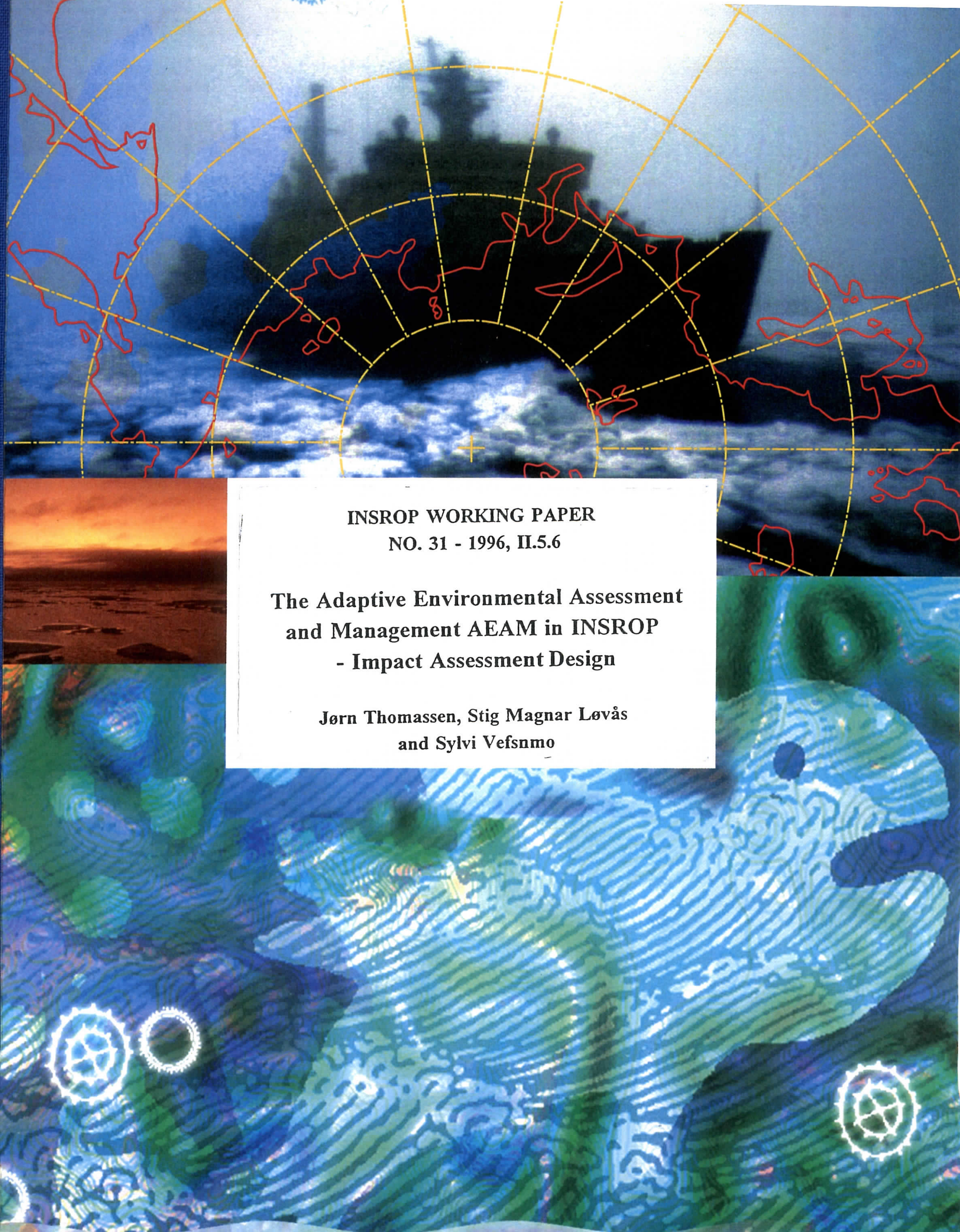

INSROP WORKING PAPER

NO. 31 - 1996, II.5.6

The Adaptive Environmental Assessment and Management AEAM in INSROP - Impact Assessment Design

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and Sylvi Vefsnmo

INSROP International Northern Sea Route Programme

Central Marine Research & Design Institute, Russia

The Fridtjof Nansen Institute, Norway

Ship and Ocean Foundation, Japan

International Northern Sea Route Programme (INSROP)

Central Marine Research & Design Institute, Russia | The Fridtjof Nansen Institute, Norway | Ship & Ocean Foundation, Japan

INSROP WORKING PAPER NO. 31-1996

Sub-programme II: Environmental Factors.

Project II.5.6: The Adaptive Environmental Assessment and Management AEAM in INSROP - Impact Assessment Design.

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FOREWORD - INSROP WORKING PAPER

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

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

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

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

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PREFACE

This INSROP Working Paper summarizes the approach of the Adaptive Environmental Assessment and Management (AEAM) concept to be used in the INSROP Environmental Impact Assessment (EIA) in the International Northern Sea Route Programme (INSROP), Sub-program II.

The paper is linked to the INSROP Discussion Paper of June 1994: Environmental Impact Assessment - Preliminary Assessment Design (Thomassen et al. 1994), and is also closely connected to the INSROP Projects II.4 concerning the baseline studies (see Larsen et al. 1995, Bakken 1994, Wiig 1994), which will give major input to the impact analysis. Information from other Sub-Programme II - projects, i.e. II.2 Russian data sources and II.6 Environmental safety of ships, are also important and necessary for finalizing the EIA.

The Geographical Information System (GIS) as a tool for presentation of data and for the EIA analyses will be important, but also a challenge, for the future work in INSROP. We therefore present the GIS tool linked to the EIA in this working paper.

Valuable comments to this paper have been given from our Russian co-partners in the EIA work. Their considerations are important for the assessment design as well as for the II.4-projects dealing with the focused environmental issues in the EIA. The requirement of further cooperation across borders in the next phases of the INSROP-EIA is obvious, and will be critical for the final success of the project.

Furthermore, the EIA is linked to several other aspects of INSROP, and input from Sub-Programmes I, III and IV, definitely will be of great value in the inter-disciplinary perspective of other aspects than the environment in the Northern Sea Route.

Trondheim 28.12.95

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Supervisor

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1. INTRODUCTION

An important part for the INSROP Sub-Programme II, Environmental Factors, is to work out an Environmental Impact Assessment (EIA) for the Northern Sea Route (NSR). The goal for an EIA is to form a basis for decision makers concerning the NSR. Decisions are human oriented processes, and selections and priorities call for an "intelligent simplification". Normally this process occurs through a scoping phase, which can be described as identifying, from a broad range of potential problems, a number of priority issues to be addressed by the EIA (Beanlands 1988).

The nature of an EIA therefore calls for an inter-disciplinary approach and cooperation between various interests and specialists, which in turn stress the importance of communication on different levels. In INSROP-EIA the importance of communication cannot be overestimated. Communication within projects, between projects, between Sub-Programmes, across borders and finally to decision makers ranging from high political levels down to local community level. One important tool for the inter-disciplinarity in INSROP is the use of the Geographical Information System (GIS), which also will be important in the challenge of communicating the EIA to the recipients.

Furthermore, it is an ambition of INSROP to make the key findings available as hypertext documentation using GIS. To facilitate rapid access to requested information topics, a structured use of keywords is important. To ease the conversion of regular word processor documents to hypertext documents, it is recommended to include keywords also in the written documentation. This working paper shows several examples of this.

The purpose of this INSROP Working Paper is to describe the process in which the Environmental Impact Assessment (EIA) part of INSROP is situated, and to present the methodological approach based upon the Adaptive Environmental Assessment and Management (AEAM) -concept by Holling (1978). One of the strengths of the AEAM concept is that it facilitates an inter-disciplinary evaluation of multi-disciplinary information, which should be necessary in an EIA.

Chapter 2 deals with the basic ideas and the methods selected in the EIA process in INSROP. The plans for using the Northern Sea Route for commercial shipping include identifying, defining and describing the various NSR scenarios in time and space, an aspect treated in Chapter 3. Chapter 4 presents the methodological application in INSROP-EIA of the Adaptive Environmental Assessment and Management procedure, or the assessment design for INSROP. In Chapter 5 we deal with the importance of inter-disciplinarity and communication in the INSROP-EIA, while Chapter 6 gives a focus on the role of GIS in EIA. Appendices 1 and 2 are helpful when working with the EIA-methods, while appendices 3-5 are important for the GIS application of the EIA.

2. INSROP Environmental Impact Assessment - BASIC IDEAS

Keywords: decision makers, scenarios, focusing, AEAM, mitigating measures.

An EIA is a process having the ultimate objective of providing decision makers with an indication of the likely consequences of their actions (Wathern 1988). The consequences projected normally relate to both the environment as well as to the society.

As the ultimate objective of an EIA is to give indications of possible consequences of an environmental encroachment or activity (read NSR-activities), the great challenge is to give an objective view into the future. Environmental impacts must therefore be addressed through the difference between the environment with and without the proposed activity. This also means that one ideally should make scenarios of the development in the particular area or region of concern without the encroachment or activity (see Figure 2.1).

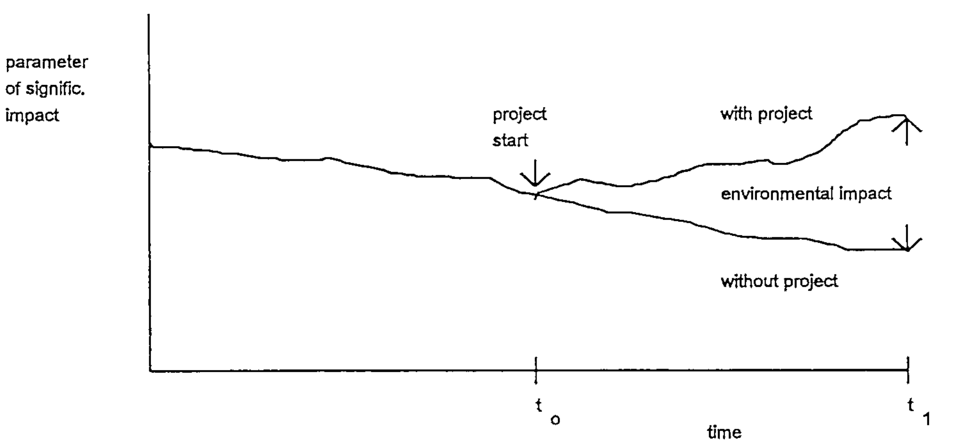


Figure 2.1. A hypothetical impact based on scenarios with and without the project (zero-alternative). After Wathern (1988).

Experience tells us that the greatest contribution of an EIA to environmental management is the adjusting of plans to mitigate negative impacts at an early stage in the process. The importance of focusing in the EIA process on a limited number of priority issues should therefore be obvious.

The scoping phase in EIA is critical for an optimal use of limited resources in the perspective of time and economy, and should be run through in an advance defined process. It is essential to bear in mind that the ultimate goal is to give the decision makers the best possible basis for their decisions.

In INSROP, the EIA is accomplished by using an adjusted form of the Adaptive Environmental Assessment and Management (AEAM) concept (Holling 1978). The AEAM methodology also formed the basis for the assessment system for the environment and industrial activities in Svalbard (Hansson et al. 1990), and has been used for more than ten years in the Canadian hydrocarbon development in the Beaufort Region; i.e. the Beaufort Environmental Monitoring Project (BEMP), the Mackenzie Environmental Monitoring Project (MEMP) and recently, the Beaufort Region Assessment and Monitoring Program (BREAM), see Indian and Northern Affairs Canada (1992a, 1992b, 1993).

2.1 The AEAM process

Keywords: communication, workshops, Valued Ecosystem Components, Schematic Flow Charts, Impact Hypotheses, documentation, quality assurance, evaluations.

As an EIA normally shall cover various themes concerning environment and society, different actors will be involved in different phases of the process. Obviously, communication between decision makers, authorities, management and scientists should be established in a very early stage of an EIA, with the objective to scope on important issues in each specific EIA context.

Using the AEAM methodological approach, communication is essential from the very beginning. Through workshops and working groups, resource people with different interests in the NSR meet to scope the dimensions of the important issues. Figure 2.2 gives a schematic picture of the INSROP Sub-Programme II -AEAM process.

In AEAM the impact predictions are derived from a procedure which includes the selection and prioritization of VECs (Valued Ecosystem Components) that can be affected by the NSR activities. The methodology also identifies major linkages between different components in the system by preparing Schematic Flow Charts including impact factors, which form the basis for the Impact Hypotheses (IHs).

Key statements in every scientific work are the documentation of the process and the choices made. In the EIA process, it is important that the reasons for decisions are visible and transparent, particularly when it involves the rejection of proposed impact scenarios. The requirement of scientific quality in the process of focusing on a limited number of important issues is therefore done by:

- Describing and documenting all choices in the process
- Formulating hypotheses concerning the impacts
- Ranking the hypotheses with respect to the importance of having them tested
- Testing of the hypotheses
- Evaluating the results and the process

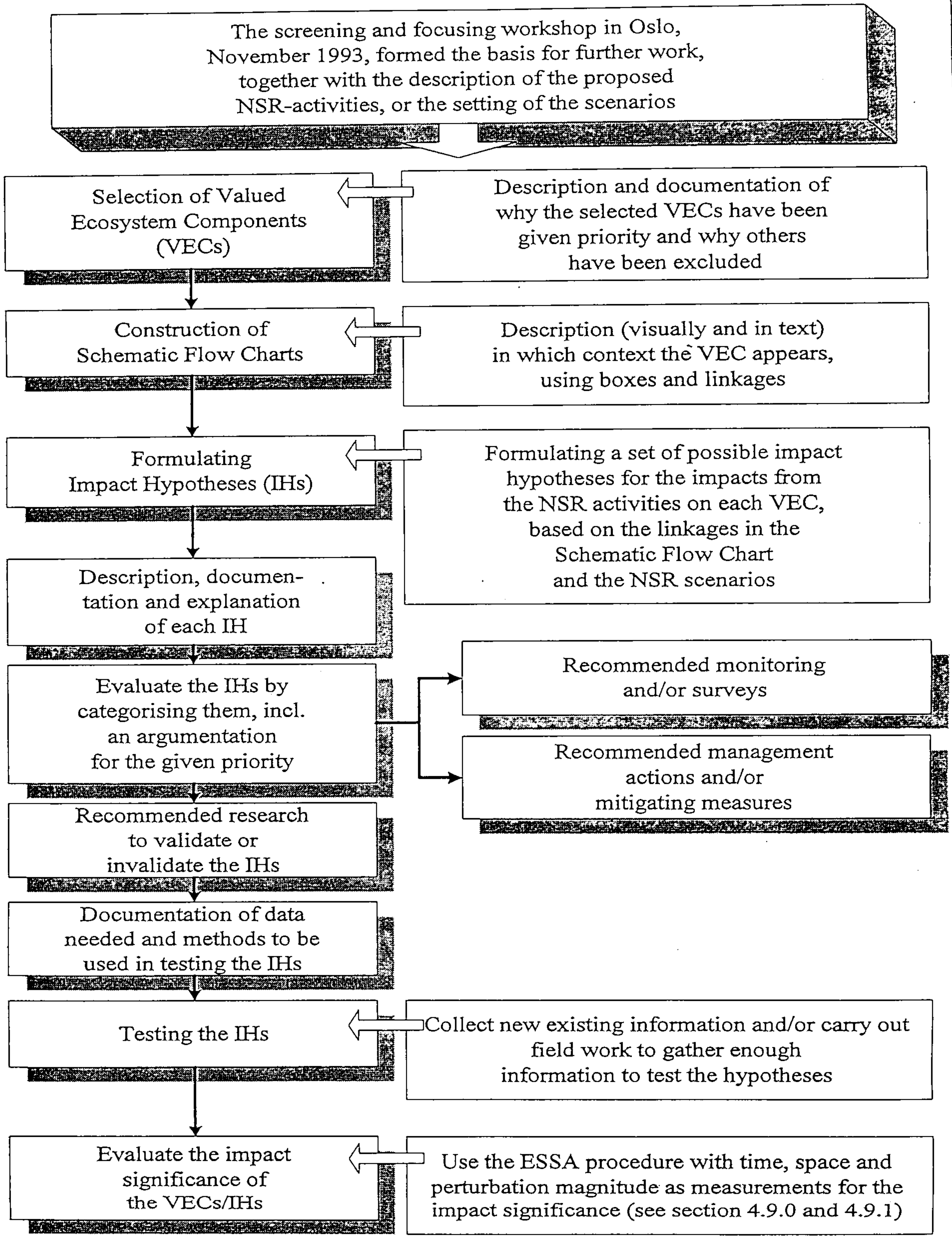


Fig. 2.2. The initial phase of the INSROP- EIA/AEAM process.

2.2 Valued Ecosystem Components (VECs)

Keywords: selection, priority, focusing, decision making, other studies.

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

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

In the EIA work carried out in the Beaufort Sea Region in Canada (see Indian and Northern Affairs Canada 1992b) the social components of the EIA are treated by defining and describing so-called Valued Social Components (VSC) in addition to the VECs. The community is clearly an important part of the EIA, and we will recommend the community based concerns in INSROP to be assessed through a clearly defined process, for example by definitions of VSCs.

2.3 Schematic Flow Charts

Keywords: impact on VECs, type of impact, system components, developments.

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

2.4 Impact Hypotheses (IHs)

Keywords: impact, recommendations, testing the impacts, research, investigations, monitoring, mitigating measures.

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

2.5 The process of documentation

Keywords: evaluation, linkages to II.4-projects, implementation to GIS.

In INSROP there are three principal steps in the documentation process. These are:

1. II.4.-projects are responsible for documenting the use of the AEAM-method within the respective projects (See Appendices 4 and 5).
2. II.5.-projects evaluate and compile the documentation from II.4.-projects.
3. II.5.- projects, in cooperation with Projects II.3.2 and I.3.1) implement the principal AEAM-documentation in the INSROP GIS on-line help system (See Appendix 5).

2.6 Environmental Impact Assessment - a dynamic process

Keywords: dynamic process, evaluation, EIA phases, implementation, recommendations, new information, Environmental Impact Statement, linkages to II.4-projects.

It is important to understand an EIA which has utilized AEAM as a dynamic and iterative process where new information and knowledge concerning the potential consequences of an action can alter the management of the development scenario. Likewise it is important to follow up the findings of the EIA-process with monitoring and/or further investigations and research. This is the only way to evaluate the judgments made. An EIA will therefore consist of different phases (Figure 2.3).

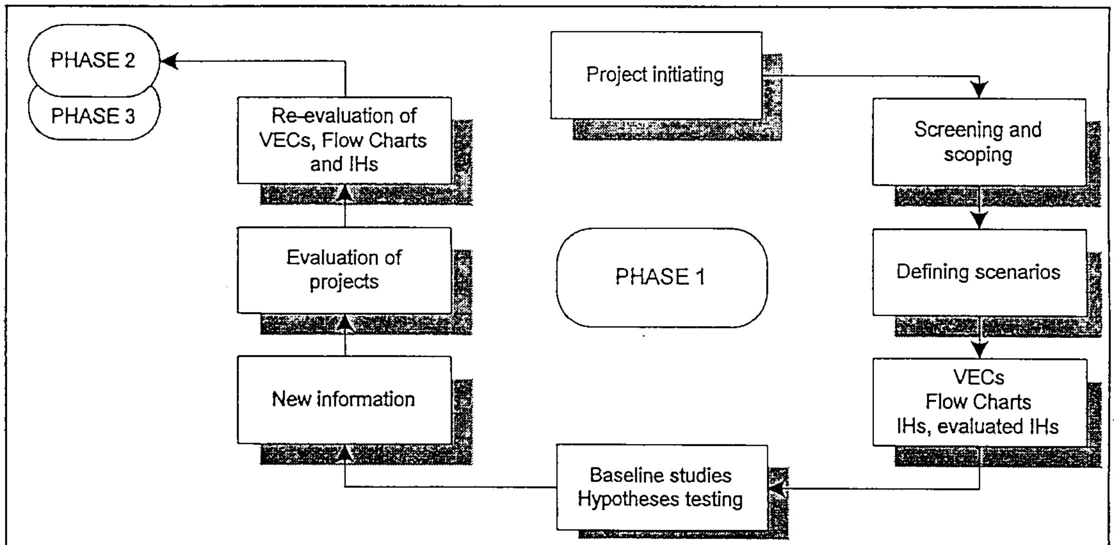


Figure 2.3. The dynamic EIA-AEAM process

In Figure 2.3 a general view of the process is presented. INSROP Sub-Programme II Phase 1 concludes with the preparation of three papers from the projects II.4 (Larsen et al. 1995, Bakken 1994 and Wiig 1994), which summarize and evaluate the information available so far, and address it in an INSROP-EIA context. In phase 2 the data will be analyzed using, among other things, the GIS (Løvås et al. 1994), designed and developed for INSROP. As more information is gathered from Russian sources and from further field work, an evaluation following the Phase 2 approach will be carried out in late 1995/beginning of 1996. Phase 3 will consist mainly of the preparation of an Environmental Impact Statement (EIS) as part of the EIA, including operational recommendations, mitigating measures and further investigations/monitoring Programmes. The EIA/EIS will also form the basis for the proposed Environmental Pilot, which will be an interactive GIS-based tool for secure sailing along the NSR.

3. THE NORTHERN SEA ROUTE SCENARIOS

3.1 Background

Keywords: zero alternative scenario, present situation, inter-disciplinarity, environmental impact.

The initial procedure includes the definition, the description of various NSR-scenarios, and the identification of the geographical and temporal characteristics of each type of NSR activity. Moreover it is important to clarify the main possible impact factors on the environment from the NSR activity, which can be divided into two main categories: impacts from normal operational traffic and from possible accidents. In addition, there are already existing activities in the NSR area which for different reasons must be looked upon as the zero alternative, see Figure 3.1. Hence the environmental impacts will be assessed through three categories: existing impacts/loads and NSR operational- and accidental environmental impacts (see Thomassen et al. 1994).

The «existing, operational and accidental» approach in this process will be essentially the same, even though the impact factors and the ecological components differ in evaluation. The accidental scenarios will, in addition, involve a risk assessment of the operational scenarios to determine high risk areas and seasons. Projects II.6 concerning ship activities, as well as input from the other Sub-Programmes, will be a central part of the evaluation of existing impacts.

As stressed in Chapter 2, the zero-alternative scenario, (concerning the affected NSR area without the proposed NSR activities), should ideally have been the basis for assessing the impacts. Figure 3.1 is an INSROP adapted version of Figure 2.1.

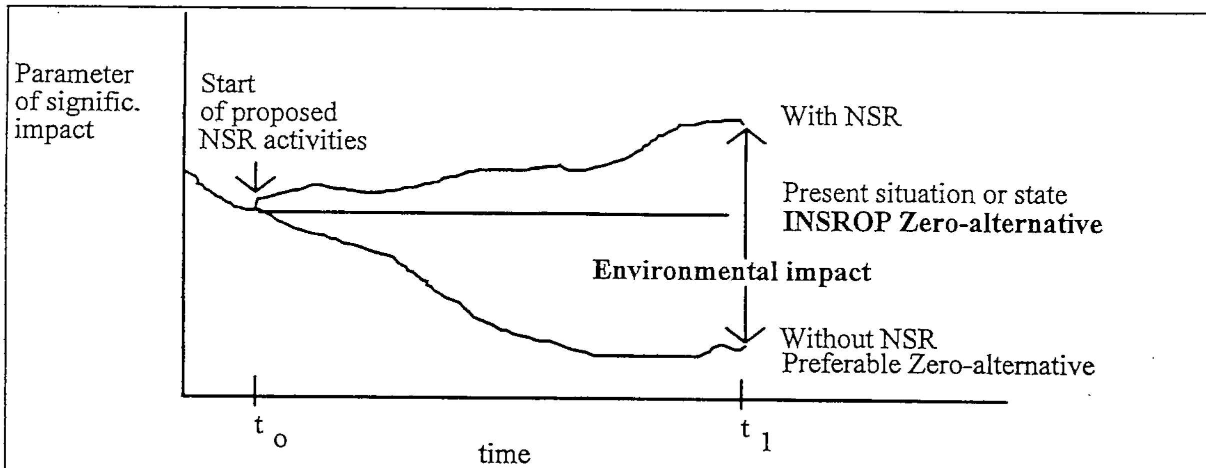


Figure 3.1. Hypothetical impact based on scenarios with and without (zero-alternative) the proposed NSR activities. Redrawn after Wathern 1988. It should be clear that the construction of the zero-alternative requires a multi- or even interdisciplinary cooperation within the Sub-Programmes in INSROP.

The zero-alternative should on the one hand be the basis for assessing the environmental impact as well as all the other impacts (i.e. social, cultural, economic, etc.) in the NSR. On the other hand it is probably extremely difficult, if not impossible, to speculate upon the development in the NSR area mainly due to political and economic uncertainty in Russia and other possible developments in the northern region. For these reasons, we define the present situation or state as the «zero-alternative», and consequently the basis for further analysis in the INSROP-EIA.

3.2 The importance of well defined and detailed scenarios

The difficulties in making good scenarios for the development in the NSR is obvious. It is nevertheless important to stress the importance of well defined and detailed scenarios for an optimal use of the AEAM method in the EIA process. This is also the experience from various Canadian studies using AEAM, summarized by David Stone, chairman of the Environmental Factor Session at the INSROP Symposium Tokyo -95 (IST'95): «AEAM is most effective when the development scenario (in this case the shipping activity) can be described in detail and with a fair degree of certainty. This enables the impact hypotheses to be focused rather than dispersed, and consequently the degree of objectivity applied in the evaluation process can be very high.

The lack of development scenarios in general and of specific shipping scenarios in particular must be addressed in the next Phase of INSROP. The EIA cannot be objectively conducted without solid detailed scenarios. The Sub-Programmes I, III and IV should be able to provide the necessary scenarios.

3.3 Operational and accidental scenarios

Figure 3.2 shows a map of the Northern Sea Route identifying major ports and ship routes. The geographical boundaries of the NSR are the Kara Strait and the northern tip of Novaya Zemlya in the west and the Bering Strait in the east.

As stated earlier, the possible impacts from the planned activity can be divided into two main categories: operational impacts and impacts from possible accidents. The environmental impacts in the operational scenarios are generally characterized by low intensity, but depending on shipping regularity the duration of the impact may be more or less continuous. The environmental impacts in the accidental scenarios are characterized by high intensity in a short period and with long uneventful periods in between. The accidental scenarios are closely related to the operational scenarios because the sailing routes and the physical environment conditions are the same. However the accidental scenarios involve a risk assessment of the operational scenario to determine high risk areas and seasons. Since the human error factor related to accidents is generally unpredictable, one must also consider environmental consequences independently of the foreseen risk of the accident happening.

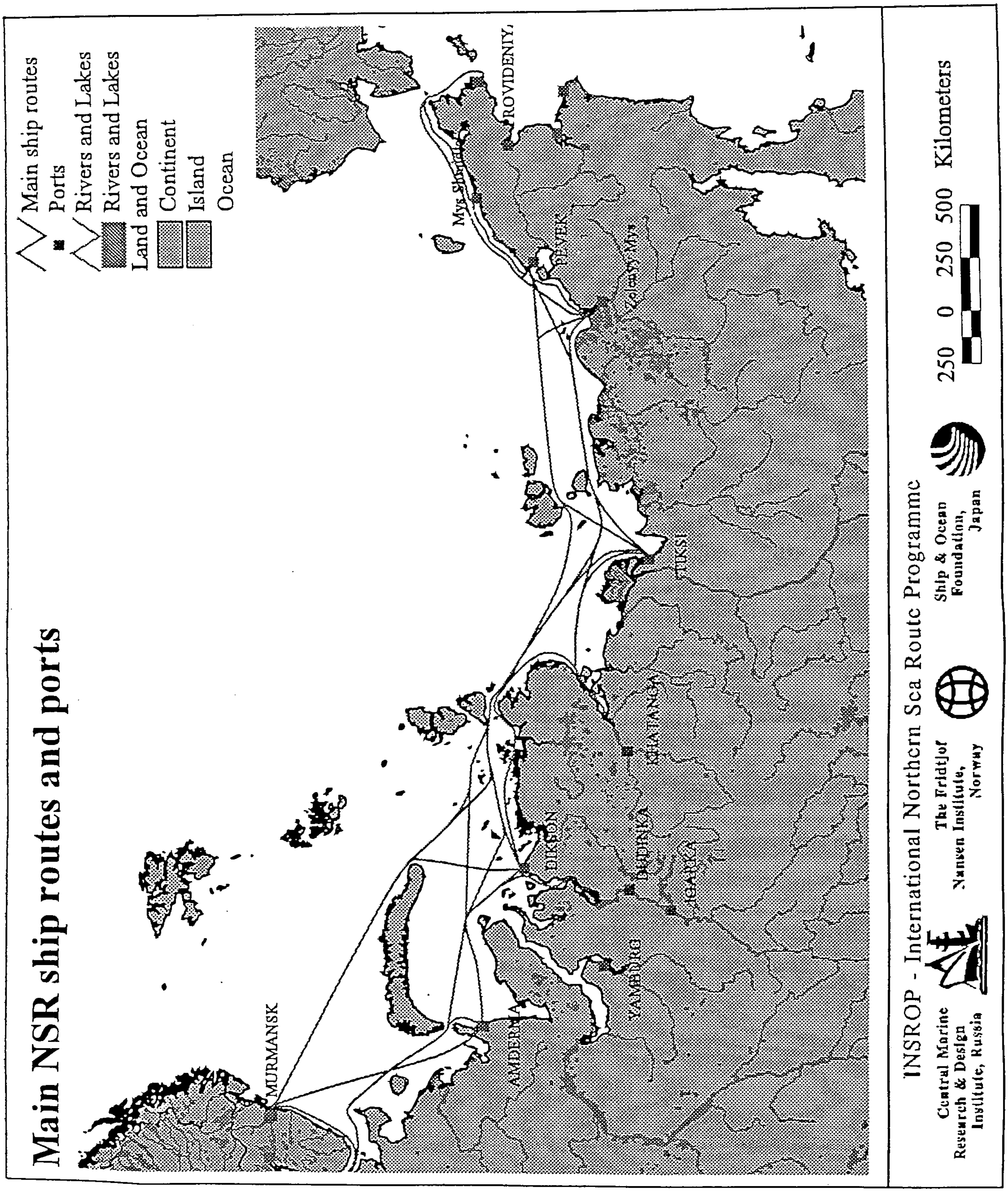


Figure 3.2. The Northern Sea Route with major ports and proposed sailing routes. The map is prepared by INSROP GIS.

As the commercial aspect is a key component for shipping, an important base component in the INSROP EIA is estimates on the type of cargo to be transported and the frequency and volume of the cargo transported in various sections. The destination of the various cargo types will guide the selection of sailing routes, which forms the basis for assessing the limiting factors on sailing due to the physical environment, such as sea ice cover and shallow depths. The type, frequency and volume of cargo form the basis for assessing impacts on the biological environment. The destination of different types of cargo will also affect what administrative (incl. legal and strategic) restrictions any particular sailing must comply with. The cargo scenarios form the basis for describing operational and accidental scenarios.

3.3.1 Operational scenarios

Keywords: cargo, ports, ship type, type of sailing, sailing frequency, sailing routes, sailing seasons, regulations.

The operational scenarios address the environmental impacts causing relatively low, though long-term exposure. The main impact factors from the operational scenarios may be divided into pollution, noise, physical disturbance and waste discharge. Regular ship traffic will cause discharges to ice, sea water, rivers and estuaries.

Navigation along the NSR depends in part on seasonal meteorological conditions and the distribution of sea ice. Ice conditions on the broad continental shelves of the region are a complex mixture of fast ice, first-year ice and multi-year ice from the polar pack. The ice conditions along the NSR are extremely dynamic, leading to large annual, seasonal and regional variations. Large ice fields are observed in the same regions each summer. The Taymyrskiy, Ayonskiy and Vrangelevskiy massifs are the most important obstacles to ship traffic along the NSR since each massif contains significant concentrations of multi-year ice, frequently with heavily hummocked ice being present.

The rivers of Siberia comprise a very extensive network of navigable waterways, offering in many areas long distances without breaks in navigation and with remarkably good coverage of the Russian Arctic and high Arctic areas. However, they are plagued by three major problems: a short ice-free season; water shortage in summer; and a failure to incorporate locks in several hydro-electric dams. For the northern transportation of cargo, river transport offers alternatives to sea transport in many parts of the Arctic. The sea traffic is also closely linked to the river transport. West of the Taymyr peninsula, year-round navigation and favorably located freight origins and destinations have enhanced the role of sea transport. East of the peninsula, the role of marine transportation in the short and medium terms will depend on its ability to reach areas inaccessible to river transport.

As already stated, the cargo scenario will form the basis for the operational scenarios used in the EIA. In order to evaluate the impact factors the scenarios should include information on ship type, frequency of sailing, sailing in convoys versus free sailing, harbors to be visited, pollution potential and characteristics of cargo as well as the geographical and temporal limitations based on the physical conditions. River transport and coastal routes should be evaluated in addition to transit sailing. Helicopter traffic in relation to the regular ship traffic will also contribute to the environmental impact and should be part of the scenarios.

3.3.2 Accidental scenarios

Keywords: ship type, sailing frequency, convoys, ice conditions, shallow waters, icing, probability of occurrence, consequences, workshop.

The accidental scenario is closely related to the operational scenario because the sailing routes and the physical environment conditions are the same. However the accidental scenarios will involve a risk assessment of the operational scenario to determine high risk areas and seasons.

The main causes of ship accidents include elements related to physical conditions, technical or human factors, cargo, procedures and routines. Ice conditions will be one of the physical parameters most affecting risk. Ice damage to the ship hull, its propulsion equipment, steering devices etc., which is large enough may seriously limit the operational capability of the ship or even stop the operation entirely.

Thick ice cover is able to transmit high horizontal forces, and even slight ice compression strongly affects the transiting capability of commercial vessels, while heavy compression will stop an unassisted vessel. If structural failure of the hull occurs in this situation, there may be a total loss of cargo. Minor collisions between ships occur frequently in ice-covered waters. The distance between the assisted cargo vessels and the icebreaker is decreased as ice conditions increase in severity, and the risk of the icebreaker bow bouncing towards the least protected sides of the cargo vessel cannot be ruled out. When a long cargo vessel follows an icebreaker in a crooked lead, there is always the possibility of a sideways impact to the cargo vessel shoulders.

Ice damage results mainly from impact of ships against ice, and from ice compression during strong wind conditions and poor maneuvering. Unfavorable conditions for maneuvering are created after heavy snowfall, when the whole surface becomes homogeneous and it is impossible to detect frozen hummocks and old ice fragments. Due to sharp turns in the heavy ice zone stern bumping may occur, which results in damage to the rudder blade or a twisting of the rudder stock. These causes account for more than 50 % of the total number of damage incidents.

Based on historical information on ship accidents, characteristics of the accidental scenarios should include ship type, physical environment data, probability of occurrence, possible consequences to the ship as well as possible consequences to the environment. With reference to the operational scenarios, ship accidents in rivers should also be evaluated before the accidental scenarios are chosen. The major impacts from the NSR activities, at least on a local or regional scale, will probably be caused by severe accidents, which are also often of major importance for the decision makers. It is therefore recommended to carry out an accidental, or «worst case» workshop later on in the EIA-process.

3.4 Scenarios in time and space

For both the operational and the accidental scenarios, limitations in space and time are necessary. The temporal and spatial characteristics will depend on the type of ship and convoys. By analyzing historical navigation routes, the limitations in space and time are to be determined. If the historical data include information about navigation and physical conditions with relatively good resolution in time and space, they are to be used for analyzing spatial and temporal limitations for the scenarios. If the resolution of the navigation data is poor, historical ice charts (40-50 years) together with an assessment of possible navigation of specific ship types, using an empirical-statistical model of the navigation difficulty, can be used to determine the spatial and temporal limitations of the scenarios. The ultimate goal of the description of the spatial and temporal scenarios is to specify the temporal variation in sailing frequency along various sections of the NSR. If possible the sailing frequency will be specified for a set of cargo types.

3.4.1 Scenarios in space

Keywords: water depth, ice concentration, ice thickness, hummocking, polynyas

The main limiting factors for transit sailing are the ice conditions and the water depth. The sailing length in ice of 7-10/10 concentration serves as criteria for the complicated ice navigation conditions. Outside the limits of the ice massifs, mainly in the summertime there are zones of open (4-6/10 ice concentration) and very open (1-3/10 ice concentration) ice. The presence of such zones significantly influence the optimum choice of transit routes. See also Figure 3.2 for the main ship routes along the Northern Sea Route.

Navigation in dense ice is often accompanied by compaction, which is closely connected to the wind speed and direction and is relatively easily predictable by the weather forecasts. In fall the pressures are accompanied by adhesion to the ship's hull and in some narrow zones with a very rapid drift. In winter the favorable location of polynyas and of discontinuities in the drifting ice will greatly ease transit times.

When choosing the optimum ice navigation route, the following is taken into account (Baskin et al. 1994): the shortest way; minimum ice concentration and total ice extent; maximum amount of young ice; and the minimum amount of hummocking. In the close ice zones transit times are influenced by the following main ice cover characteristics:

- amount and location of different ice age categories
- thickness
- amount of hummocking
- degree of destruction
- presence and location of compacting zones
- geometry and distribution of open water zones

The continental shelf along the NSR is very shallow, and in some straits is only a few meters deep. The minimum depth in most straits exceed 20 meters, but in the Sannikov Strait it is only 13 m and in the Laptev Strait only 8 m. A tanker of 70 000 tons with a draft of 16 m will seriously meet draft limitations in the Kara-, Laptev- and East Siberian Seas. The underkeel clearance must be more than 5 m in open waters. In the rivers and the estuaries the clearance will often be marginal when the ships are loading in a river port like Dudinka and Igarka. The draft limitations will seriously influence ice routing and transit time.

Nine seaports are currently in operation on the NSR. Five belong to the Ministry of the Merchant Marine - Amderma, Dikson, Khatanga, Tiksi, Pevek- and four to other agencies - Dudinka and Igarka on the Yenisey, Zelenyy Mys on the Kolyma and Mys Schmidta. The most important harbors should be part of the scenarios (see also Figure 3.2).

The major Siberian river basins differ considerably in physical characteristics, transport functions and even vessel design. The length of the navigation season is mainly determined by the ice conditions and the water depth. The ice-free season at Arctic river mouths west of the Taymyr peninsula averages 120 days. Low water occurs in summer after the spring run-off. This particularly affects the area east of the Yenisey river, where much of the land is underlain by permafrost, and melting snow cannot seep into the ground to even out stream flow. But sparse precipitation means that the problem occurs farther west too, notably along the Irtysh river and it affects small rivers everywhere. Many rivers, even in the south where the ice-free season is well over 160 days, have a normal navigation season of only 30 days. In a dry year the navigation season may be less than 10 days. Unpredictability, and a short season even in average years, are the chief problems faced by river transport.

The main navigable rivers are the Yenisey, Irtysh, Ob and Lena. The Yenisey river is mainly a lowland river, though there are difficult rapids above the mouth of the Angara. Most of the right-bank tributaries are mountain rivers originating in regions underlain by permafrost. Spring run-off is fast and heavy, and it causes extreme fluctuations in depth on the main river. The Yenisey river may rise 15-20 m at Igarka and at Dudinka, the port is normally evacuated for two weeks or more to avoid ice and flood damage. Most of the Lena basin and the Northeast are underlain by permafrost and experience low precipitation. Problems of rapid spring run-off and summer low water are therefore especially acute.

3.4.2 Scenarios in time

Keywords: cargo, operational period of ports, navigational period of river, sea traffic

The main transportation route in the Russian Arctic is from Murmansk to Dudinka and the traffic is mainly handled by SA-15 type cargo vessels transporting mixed cargo from Murmansk and mainly iron ore from Dudinka. The traffic is maintained year-round by the assistance of Russian nuclear icebreakers. The whole route to Dudinka is only ice-free for some months every year. Heavy ice during February-March obliged some convoys to go around the northern end of Novaya Zemlya. Traffic to other ports east from Dudinka is done mostly during summer. While the Yenisey traffic volumes continue to be the largest, the oil and gas industries on the lower Ob have greatly increased traffic to that river system. Traffic starts each year with voyages to the west coast of Yamal in mid-April using the fast ice as a quay. Then it moves into the Ob estuary, serving both Novyy Port on the west shore and

Yamburg in the east. The Laptev Sea is mainly operational on average from July to October. In the period 1986-87 the whole route was accessible from mid July until mid- or late October, with icebreakers stationed at the difficult points.

The year can be divided into three navigational periods: summer navigation, prolonged summer navigation and winter navigation. The assessment of the actual voyages of ships along the NSR will probably enable satisfactory determination of the summer navigation period as well as of the prolonged summer navigation period, or the period in favorable years with good ice conditions. The length of the river navigation season is mainly determined by the ice conditions and the water depth and should be part of the temporal limitations.

3.5 Types of cargo

Keywords: hydrocarbon transportation, dry cargo transportation, pipeline, river tankers, river barges, linkages to Sub-Programme III.

The INSROP Sub-Programme III is responsible for defining the cargo scenarios which can be divided into two categories: hydrocarbon transportation and others. The 1995 project descriptions from Sub-Programme III probably reflect the most relevant types of cargo in the NSR.

Marine transportation of oil from Timan Pechora and from inland Russian oil fields are assumed to be important in the future. The export of crude oil from the North-West Russian fields, with a focus on Timan Pechora will affect the NSR on the easterly sailing route. The hinterland perspectives of crude oil transport from the Novoportovskoye field and the fields on the Ob and Yenisey rivers will directly affect the NSR as well as transport of condensates and oil products from the two latter rivers. The scenario will evaluate three modes, pipeline transport, river tankers and river barges as input to a hydrocarbon terminal for the region. In addition, the seaborne export option for the production of gas on the Yamal peninsula and in the Kara Sea is included in the hydrocarbon transportation scenario.

Commercial transport with dry cargoes originating in Europe with destinations in the Northern Far East is a realistic scenario for the NSR. Another is the seaborne logistic option for oil field material supplies to the West Siberian oil fields. The potential for dry cargo which may exist along the rivers Yenisey and Ob is currently evaluated in Sub-Programme III, together with the return cargo for both barges and deep-sea bulk carriers.

3.6 High risk areas

Keywords: accident statistics, sailing frequency, probability of occurrence, ice conditions, shallow waters, icing.

In the summer season, when the ice conditions are most favorable, there are several ships with low ice classification navigating along the NSR without icebreaker assistance. This operational practice may increase the occurrence of ship damage. At the end of the summer season (August-September) deteriorated hummocks and old ice may be present under the water surface. Sailing alone in such conditions may be dangerous, especially during poor visibility. The frequency of ship accidents is very much dependent on ship type, navigation with and without icebreaker and the ice conditions. In regions with severe ice conditions, for instance the Vilkitskiy Strait and the Sannikov Strait, the probability for ice damage increases. The high intensity of navigation in the Kara Sea represents a potential for increased frequency of ship accidents.

In order to point out high risk areas, historical data on ship accidents should be analyzed based on spatial and temporal resolution of the data. With high spatial resolution the navigation routes can be divided into segments, and the areas and periods with high risks may be identified.

3.7 Areas of special importance

Keywords: nature reserves, national parks, sanctuaries, evaluation, CAFF, linkages to II.4-projects.

Through the establishment of protected areas such as nature reserves, national parks, sanctuaries etc., an evaluation of areas of special importance in the NSR area has already been done. In INSROP special attention will be given to these areas as well as other areas of special value, including for example feeding areas of special importance for seabirds, migration routes for domestic reindeer and important fishing areas for indigenous people.

3.8 Risk assessment

Keywords: accidents, pollution, pollution transport, environment, consequences.

The risk assessment can be viewed from two angles. In the first the purpose is to specify when and where the environment is most vulnerable to the various impacts from NSR shipping, especially pollution. This assessment specifies the "worst case" scenarios. The other is to consider the probability of various accidents occurring, which and how areas may be affected by an accident, and the associated effect upon the environment. This assessment specifies the "most probable" accidental scenarios.

The Environmental Impact Statement (EIS), will form a basis for evaluating the need for adding or modifying regulations, and will be based on a combination of the two viewpoints described above.

4. THE USE OF THE AEAM-CONCEPT IN INSROP

In INSROP, a modified version of the AEAM concept is used, where the iterative component involving the testing of quantitative models is simplified (see Hansson et al. 1990). To illustrate major linkages between the different components in the system and the significance of impact factors, schematic flow charts have been developed to define impact hypotheses (IHs) (Chapter 2). Figure 4.1 gives a schematic picture of the initial process in Sub-Programme II, and identifies the Chapters in this paper in which further information can be found.

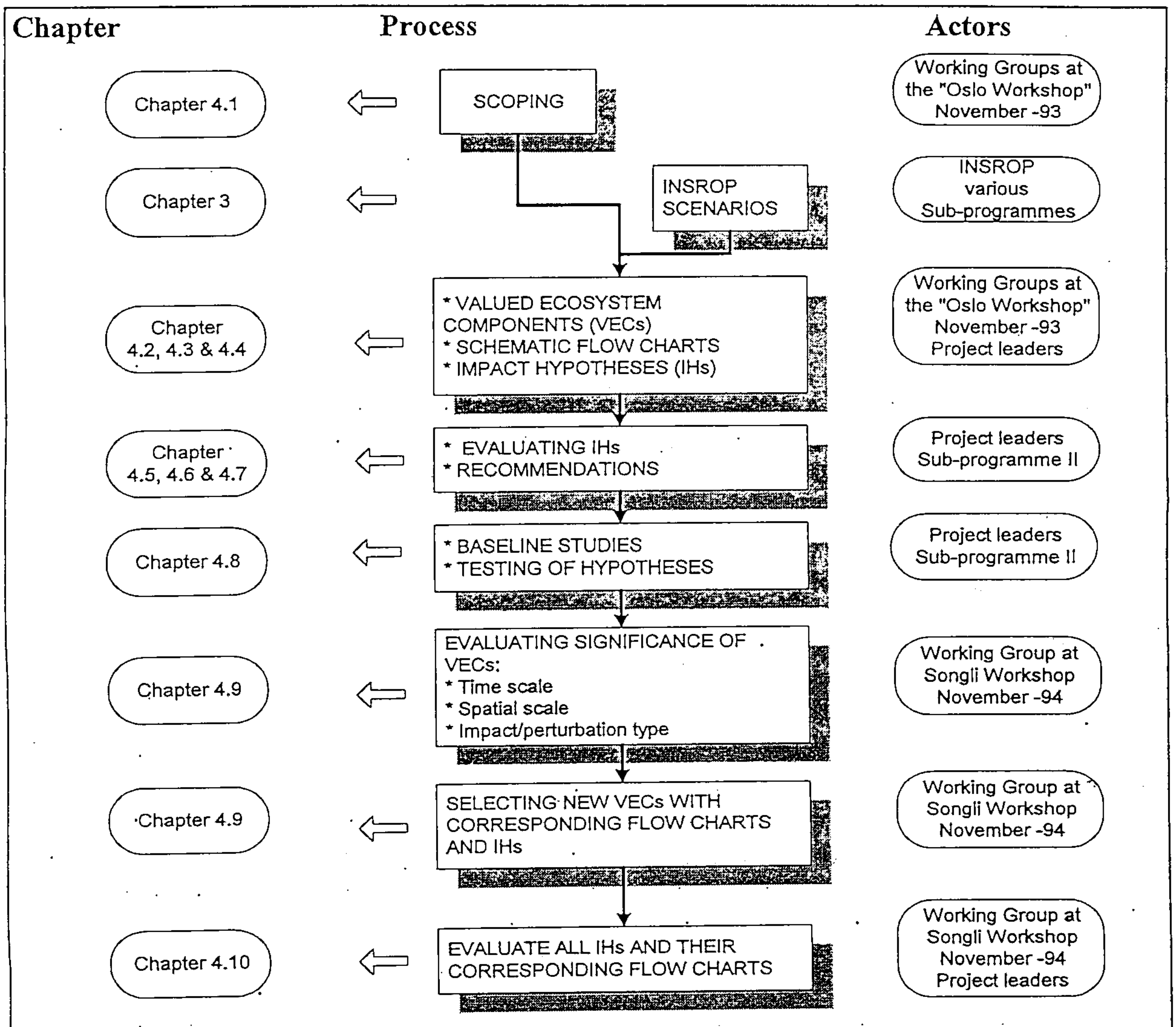


Figure 4.1. Schematic chart of the INSROP Sub-Programme II - AEAM process, initial phase.

The «Assessment System for the Environment and Industrial Activities in Svalbard» (Hansson et al. 1990) has been used as a basis for the INSROP-EIA work. Likewise, the important experience from the work carried out in the Beaufort Region in Canada in recent years using the AEAM concept (see Indian and Northern Affairs Canada 1992a, 1992b, 1993) has been of great value in the INSROP-EIA process, especially in the evaluation procedures concerning the VECs, the schematic flow charts, the IHs and the significance of impacts.

4.1 Scoping

Keywords: focusing, priority, workshops, linkage to II.4-projects.

The scoping process in Sub-Programme II was carried out at the «Screening and Focusing Workshop» held in Oslo and Trondheim in November 1993, with experts from Norway and Russia associated with Sub-Programme II and I (Hansson et al. 1994). The workshop concentrated on Sub-Programme II, with discussions both in plenary sessions and in working groups. An important feature of the workshop was to define VECs as the basis for the Environmental Atlas project (Projects II.4) and for the EIA (Projects II.5). The results from the workshop can be found in Hansson et al. (1994).

4.2 Selection of Valued Ecosystem Components (VECs)

Keywords: selection, priority, documentation, evaluation.

During the Oslo workshop VECs were selected and given priority (Table 4.1). As stated earlier in this paper, an important part of the AEAM-process is to document all the choices made. Consequently the selection of VECs must also be documented by a description of why

Table 4.1. VECs selected at the Oslo-workshop in November 1994, and VECs after evaluation at the Songli-workshop one year later.

VECs from the Oslo- workshop	VECs - evaluated from the Songli-workshop
VEC Infauna	VEC Bentic invertebrates
VEC Fish	VEC Marine estuaries and anadromous fish
VEC Epifauna	
VEC Polynyas	VEC Plant and animal life in polynyas
VEC Seabirds	VEC Seabirds
VEC Sea ducks and geese	VEC Sea ducks and geese
VEC Resting and feeding areas for waders	VEC Waders in feeding and resting areas
VEC Beluga	VEC Beluga
	VEC Bowhead whale
	VEC Grey whale
VEC Ringed seal	VEC Ringed seal
	VEC Bearded seal
VEC Walrus	VEC Walrus
VEC Polar bear	VEC Polar bear
VEC Water/land border zone	VEC Water/land border zone
VEC Human settlement	VEC Human settlement

the VECs have been given priority and why others have been excluded. This documentation is described in Larsen et al (1995), Bakken (1994) and Wiig (1994). The set of VECs concerning the NSR selected at the Oslo-workshop, and later evaluated at the Songli-workshop approximately one year later is shown in Table 4.1.

According to our Russian co-partners, some of the VECs have been formulated so widely that it will be difficult to evaluate them within the proposed frames. This will be an important issue in the further work in INSROP, especially against the II.4 projects.

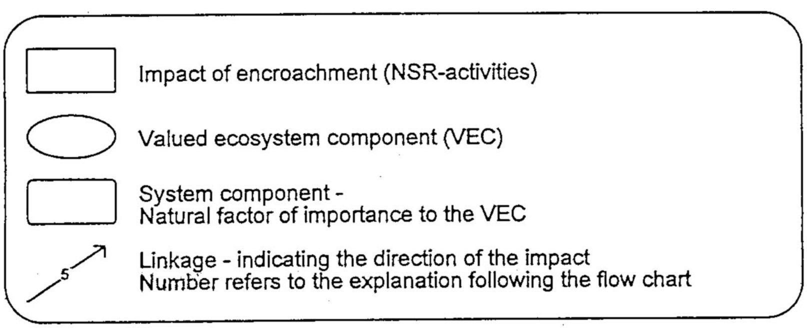
4.3 Schematic Flow Charts

Keywords: system components, developments, linkages, impacts on VECs, explanation, social and political factors, linkages to Sub-Programme I, III and IV.

The next step in the process is the construction of a schematic flow chart for each of the selected VECs. The relationships between the components are called linkages. It is not intended to extensively quantify these linkages by means of for example energy flow, biomass, importance etc., but it is important that each linkage in the flow chart is followed by a brief explanation.

If all the connections between each VEC and the different components on the primary, secondary, tertiary, ... level should be included in the flow chart, a more or less chaotic picture would occur. Each flow chart, therefore, only comprises the components that are in direct contact with the VEC.

When building up the flow chart we use the following symbols:



An example of a flow chart (from Hansson et al. 1990) with explanations can be found in Appendix 1. The INSROP flow charts are documented in Larsen et al (1995), Bakken (1994) and Wiig (1994).

In the INSROP scoping process in Sub-Programme II, the social and political factors were not given priority, which is a weakness in the process so far. However, in the total INSROP Programme, efforts will be made to include these factors, anchored in Sub-Programmes I, III and IV, see Chapter 5.

4.4 The Impact Hypotheses (IHs)

Keywords: NSR activity affecting the VECs, scientific documentation.

The flow charts and the linkages indicate which activities in the NSR will influence the VEC directly or indirectly via the system components. By means of the linkages a series of impact hypotheses can be prepared for each VEC. All IHs shall be scientifically documented if possible. In this stage of the process it is important to cover all the impacts that can affect the VEC. The hypotheses for the selected VECs are described in Larsen et al (1995), Bakken (1994) and Wiig (1994).

4.5 The evaluated Impact Hypotheses

Keywords: categorizing Impact Hypotheses, validation, recommendations, documentation, linkages to II.4-projects.

After the preparation of the IHs, a screening procedure is made for each IH, placing them into 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. Mitigating measures can be recommended if the hypothesis is proved to be valid.
D. The hypothesis may be valid, but is not worth testing for professional, logistic, economic or ethical reasons, or because it is assumed to be of minor environmental influence only or of insignificant value for decision making.

We use a standard diagram (Appendix 2) when listing the evaluated IHs, one diagram for each IH. In the active assessment system, only IHs placed in category B or C have been given priority. Normally, the category C -hypotheses will be tested through research, monitoring or surveys, which also will reflect the different ongoing activities in Sub-Programme II. Moreover, it is important that all decisions are explained and that significant references for the decisions are given. In the EIA process it is of significant value to document the different steps and choices against the defined objectives. The evaluated IHs, based on the VECs, can be found in Larsen et al (1995), Bakken (1994) and Wiig (1994).

4.6 The need for research, monitoring and/or surveying

Keywords: decision makers, recommendation, «good enough» principle, methods.

To validate or invalidate the IHs, research, monitoring and/or surveying may be necessary. It is also important to describe the methods to be used in testing the hypotheses and when necessary to identify the need for more information. The recommendations for research, monitoring and/or surveying are described in Larsen et al (1995), Bakken (1994) and Wiig (1994). The same standard diagram as given in Appendix 2 is used when describing the needs for research, monitoring and/or surveying.

4.7 The need for management actions and mitigating measures

A natural output from an EIA will be recommendations concerning management actions and mitigating measures with respect to the NSR activities. This should be considered in the earlier phases of the EIA-work, but is a particularly important element of the EIA/EIS in phase 3 of the process.

4.8 Baseline studies

Keywords: background information, scoping, new data, existing data, environmental atlas, testing of IHs, linkages to II.1 and II.4-projects.

Beanlands (1988) states that baseline studies refer to the collection of background information on the environment and socioeconomic setting for a proposed development project, and that a programme on baseline studies can be designed around the results of a scoping exercise.

The baseline studies in INSROP have their origin from the scoping workshop in Oslo and consist of a survey of existing Russian data sources (Project II.1), and of the acquisition of new data through field studies (Projects II.4). In INSROP the baseline studies have two functions. One is to form the basis for the environmental atlas, the other is directed towards the testing of the IHs.

The finite limitation of resources concerning time and economy in INSROP clearly set boundaries for collecting new environmental data, and a major part of the VEC information is therefore based on existing written Russian sources combined with information gathered through cooperation between Russian and Norwegian scientists.

4.9 The re-evaluation of VECs - impact significance

Keywords: documentation, assessment, reviewing VECs, methods, significance, IHs, Canada, linkages to II.4-projects.

The documentation process for the VECs and their corresponding flow charts and IHs are described in Larsen et al (1995), Bakken (1994) and Wiig (1994). After approximately one year of work, the project leaders of projects II.4 met in November 1994 at Songli, Trondheim, with the objective to critically re-evaluate the existing VECs and the impact significance of the same. The assessment procedures described for BREAM (Indian and Northern Affairs Canada 1992b) were used in the re-evaluation of the VECs. Two methods are described in BREAM, one called the «ESSA Procedure», the other called the «Duval and Vonk

Procedure». The purpose of both methods is to re-evaluate the significant effect/impact from the activities on the selected VECs and thereby provide the basis for reviewing the IHs linked to the VECs. In principle both methods should give the same result, i.e. the determination of effects/impacts as «insignificant» or «significant». In the BREAM studies (Indian and Northern Affairs Canada 1992b) both methods have been used to clarify the significance of potential impacts on each VEC, and thereby evaluate the VECs.

As stated in BREAM, it is important to avoid the use of more than one assessment method to assess the significant effects/impacts of the activity (read NSR-activity). At the Songli-workshop the two methods were discussed and selected VECs were re-evaluated. From a scientific point of view the working group agreed that the ESSA Procedure is more convenient in the evaluation and reviewing procedure in INSROP-EIA, even though it is the most time-consuming method. This simple semi-quantitative estimating system avoids the use of complicated calculations concerning valuation and vulnerability of the different resources, but should nevertheless capture the most important conclusions concerning the environmental significance of each VEC. The ESSA Procedure has an advantage in that the criteria used in the assessment procedure (i.e. spatial and temporal scale and perturbation magnitude) are more clearly defined and probably also more understandable for decision makers than the Duval and Vonk Procedure.

The ESSA procedure was consequently chosen for the re-evaluation of VECs in INSROP. Since there was limited time for this re-evaluation at the Songli workshop, the project leaders of the II.4 projects are responsible to carry out the re-evaluation. The two methods briefly described above both have the objective to simplify a rather complex set of environmental impacts as a consequence of the proposed NSR activities. Given the answer «Significant» in the evaluation of the VECs, the corresponding IHs must be evaluated.

4.9.1 The ESSA Procedure

Keywords: evaluation, significance of impacts, VECs.

The significance of potential impacts on the VECs from the NSR activities were evaluated using three scalar parameters; the spatial scale of potential impact; the temporal scale of potential impact; and the magnitude of the perturbation or the change that likely will occur (Indian and Northern Affairs Canada 1992b). Each of these categories are then combined to express the potential impact/effect from the NSR activities, using the procedure shown in Table 4.2. As in the BREAM, we define low and medium impacts as insignificant and high impacts as significant.

Using the ESSA method each VEC will be categorized as either «Significant» or «Insignificant» with respect to the proposed NSR activity and impacts. In the iterative EIA-process the significant impacts must be assessed assuming a range of feasible mitigating measures, and/or through more investigations or research if the issue is considered important enough, but the available data is insufficient to support evaluation of the IH.

Spatial scale. Four categories were used:

Site impact: The effect/impact is on a portion of a single, relatively independent and unconnected resource or value.

Local impact: The effect/impact is on a large proportion of a single relatively independent and unconnected resource or value. Other, similar resources or values may or may not exist in the region, but these are unaffected if they do exist.

Regional impact: The effect/impact is on a group of similar resources or value. Other, similar resources or values may exist in the region, but these are unaffected. Alternatively, the effect is on a single resource which has a regional distribution.

National impact: Anything larger than a regional impact.

Temporal scale. Three categories were used:

Short term: The effect/impact can/will occur over a time period less than one generation of the resource or value being considered. For resources that are defined with the word «quality» such as for example «water quality», it is appropriate to use the generation time of the medium, in this case the water turnover.

Medium term: The effect/impact can/will occur over a time period approximately equivalent to one generation of the resource or value being affected. The «quality» issue described above also applies here.

Alternatively, recovery of the resource or value after removing the influence of the project activity(ies) will take approximately one generation of the resource or value. The «quality» issue described above also applies here.

Long term: The effect/impact can/will occur over a time period greater than one generation of the resource or value being affected. The «quality» issue described above also applies here.

Alternatively, recovery of the resource or value after removing the influence of the project activity(ies) will take more than one generation of the resource or value. The «quality» issue described above also applies here.

Perturbation magnitude. Three categories were used:

Small perturbation: The effect/impact cannot be statistically detected (under normal assessment budgets; given enough resources, any perturbation can be detected).

Moderate perturbation: The effect/impact can be statistically detected and ascribed to the influence of the project.

Large perturbation: Statistics are not required to observe the effect/impact.

It is, however, important to bear in mind the comments of our Russian co-partners concerning the ESSA procedure and the definitions of scales used. In their opinion it would probably be advisable to make more concrete limits of local and regional impacts by using scales of kilometers or square kilometers. Furthermore, the same comments are given in relation to impact scale. In particular, a «moderate» perturbation is determined as «an effect that can be statistically detected», but the reliability of statistics depends in part upon the scope of observations.

Table 4.2. Significance of impacts based on the combination of temporal, spatial and perturbation categories (after Indian and Northern Affairs Canada 1992b).

Re-evaluation of VECs

VEC:

TIME SCALE	
Short term	
Medium-term	
Long-term	

SPATIAL SCALE	
Site	
Local	
Regional	
National/International	

PERTURBATION TYPE	
Small	
Moderate	
High	

Time scale		Spatial scale		Perturbation type		Significance	Conclusion
Short term		Site		Small		Low	Insignificant
Short term		Site		Moderate		Medium	Insignificant
Short term		**Site**		**Large**		**High**	**Significant**
Short term		Local		Small		Low	Insignificant
Short term		Local		Moderate		Medium	Insignificant
Short term		**Local**		**Large**		**High**	**Significant**
Short term		Regional		Small		Medium	Insignificant
Short term		**Regional**		**Moderate**		**High**	**Significant**
Short term		**Regional**		**Large**		**High**	**Significant**
Short term		**National/International**		**Small**		**High**	**Significant**
Short term		**National/International**		**Moderate**		**High**	**Significant**
Short term		**National/International**		**Large**		**High**	**Significant**
Medium term		Site		Small		Low	Insignificant
Medium term		Site		Moderate		Medium	Insignificant
Medium term		**Site**		**Large**		**High**	**Significant**
Medium term		Local		Small		Low	Insignificant
Medium term		Local		Moderate		Medium	Insignificant
Medium term		**Local**		**Large**		**High**	**Significant**
Medium term		Regional		Small		Medium	Insignificant
Medium term		**Regional**		**Moderate**		**High**	**Significant**
Medium term		**Regional**		**Large**		**High**	**Significant**
Medium term		**National/International**		**Small**		**High**	**Significant**
Medium term		**National/International**		**Moderate**		**High**	**Significant**
Medium term		**National/International**		**Large**		**High**	**Significant**
Long term		Site		Small		Medium	Insignificant
Long term		**Site**		**Moderate**		**High**	**Significant**
Long term		**Site**		**Large**		**High**	**Significant**
Long term		Local		Small		Medium	Insignificant
Long term		**Local**		**Moderate**		**High**	**Significant**
Long term		**Local**		**Large**		**High**	**Significant**
Long term		Regional		Small		Medium	Insignificant
Long term		**Regional**		**Moderate**		**High**	**Significant**
Long term		**Regional**		**Large**		**High**	**Significant**
Long term		**National/International**		**Small**		**High**	**Significant**
Long term		**National/International**		**Moderate**		**High**	**Significant**
Long term		**National/International**		**Large**		**High**	**Significant**

Conclusions: **Significant** ☐ **Insignificant** ☐

4.10 The evaluation of existing Impact Hypotheses

Keywords: new information, re-interpretation of data, accessibility of data.

A set of evaluated IHs has been compiled based on the VECs given priority in the scoping session at the Oslo Workshop. Due to new information, re-interpretation of existing information, accessibility of data sources or high cost levels to gain previously recommended information, the hypotheses were evaluated during autumn 1994. The results of this evaluation are found in three INSROP Papers (Larsen et al. 1995, Bakken 1994 and Wiig 1994).

4.11 Risk assessment

Keywords: accidents, vulnerability of VECs, time, space, NSR-activities.

As stated in Chapter 3.8, the main purpose of the risk assessment will be to consider appropriate mitigable measures and to evaluate possible consequences of accidents on the environment. On the one hand, the risk assessment will be focused on the environment, and addressed through the selection of VECs and their corresponding IHs. The vulnerability of each VEC in time and space is of major importance when considering the possible negative impacts of the NSR activities. These environmental factors combined with the probability in time and space of various accidents will give necessary input to the EIA.

4.12 Quality Assurance

Keywords: documentation, data, methods, coverage, representativeness, competence, honesty.

One purpose of the quality assurance is to reduce the possibility of improper use of data and information, by evaluating and documenting the coverage and uncertainties inherent in the data and information. Another purpose is to ensure that the representativeness of the outcome of the EIA study is as high as possible, which is a function of the quality and representativeness of the participants in the EIA process.

The projects providing information to the EIA study, as well as the EIA project itself, rely on several data sets provided by other INSROP projects. Therefore the quality of the data must be communicated through documentation which should include specifications of the physical storage of the data (file names, data formats, etc.), the topical, spatial and temporal data coverage, and the data lineage. With *data coverage* we mean both extent and resolution, and topical data coverage includes what data parameters (e.g. species, population, age distribution) are included and the units of measurement.

Spatial coverage includes which area(s) the data represent and the spatial resolution of the data. Temporal coverage includes what time period the data represent and the temporal resolution of the data (e.g. spot observations, daily, weekly, or monthly observations). Topical and spatial data generally have lower and upper limits. If, for instance, only populated places with more than 500 inhabitants are termed populated places, 500 represents the lower limit of this topical data parameter. *Data lineage* is the history of the data set, given as a description of what has been done with the data from data collection, through various processing steps (e.g. re-sampling, statistical analyses), up to the current status of the data.

Quality assurance of information is generally a more complex task than quality assurance of data sets. One reason for this is that the quality of the information relies both on the competence of the provider of the information, as well as his/hers ability to communicate this information in a way that does not foster misinterpretations. The competence of the information provider is reflected through a proper documentation of the analyses and reasoning behind the results and conclusions, while the communicative aspect is best handled by a structured documentation layout and competent use of the reporting language, and by clearly stating the important findings and any associated uncertainties or limitations in the validity of the results and conclusions. Maps, charts and tables are often important and communicative additions to textual descriptions. The cross-disciplinary aspect of INSROP can only be handled through information sharing, which is best achieved through efficient communication of information to the INSROP participants requiring your information for their own study. It is the momentum of the flow of information that carries INSROP forwards.

The quality assurance of the EIA study itself is an ongoing process which will be further assessed in a later phase of the EIA.

4.13 Handling of uncertainty

Keywords: Uncertainty, data, models, methods, predictability, safety, competence, honesty.

Environmental Impact Assessment involves assessing the impacts caused by an activity on ecosystems or parts of ecosystems. The AEAM process, which is employed in INSROP, uses VECs (ref. Chapter 4.2) , schematic flow charts (ref. Chapter 4.3) and impact hypotheses (ref. Chapter 4.4 and 4.5) to model the ecosystems and impacts. Uncertainty arises from how well the impacting activities, the ecosystems, and potential effects are known, and this knowledge involves both the current state and how the systems change. Knowledge about the current state (or any other point in time) is represented as *data*, while knowledge about how changes occur is represented as *models*.

For activities which may cause a severe negative impact on the environment, high uncertainty is similar to high risks and low safety, and will hence require higher «precaution costs», such as strict regulations, control by authorities, high fees and insurance rates. A conscientious handling of uncertainty will often reduce the short term economic potential, but the intention is to reduce costs (for example to accidents) in the long run. However, to increase the economic benefits (without increasing risks), it may be beneficial to invest in reducing uncertainties. INSROP is an example of such an investment, and the knowledge base forming the outcome of INSROP is intended to reduce uncertainties about NSR shipping and associated consequences at an international level. To achieve this, objective assessments of uncertainties in data and models are required from all INSROP participants.

It is not the uncertainty in itself which is most important, but its influence on the predictability of the effects. The handling of uncertainty involves three main issues:

1. What uncertainty is inherent in the data, models, methods being used?
2. Can the uncertainty be reduced, and how?
3. How should remaining uncertainty be handled?

Uncertainty in predictions is a function of uncertainties in both data and models. Costanza and Maxwell (1993) have evaluated the effect of resolution on predictability. They used the concepts of spatial auto-predictability (P_a) and spatial cross-predictability (P_c). P_a is the reduction in uncertainty about the state of a spatial area given knowledge about adjacent areas, while P_c is the reduction in uncertainty about the state of a spatial area given knowledge about the same area in another point in time. They found that in general P_a increases (meaning that the uncertainty decreases) with increasing resolution (smaller area), while P_c decreases (meaning that the uncertainty increases) with increasing resolution, and that for a particular modeling problem, there exists an optimum resolution where P_a and P_c balance to give the lowest uncertainty given the current level of knowledge. If the uncertainty is still unacceptably high, more research is needed to increase data knowledge and modeling capability.

How can the concept of P_a and P_c be utilized in INSROP? In this context consider the case of bathymetry in relation to hazards to shipping. A ship will always try to sail the fastest route, and the isolated effect of bathymetry on sailing time is through sailing distance and maximum speed due to uncertainties in bathymetry. Uncertain bathymetric conditions require reduced speed. Improved mapping may render some areas as safe, and others as hazardous and sailing speed must be reduced severely, or the ship must avoid the hazardous area. We will deal with two cases: shallow water outside river deltas, and areas with underwater cliffs.

Shallow waters outside river deltas are examples of areas with changing water depths due to sediment transport. By increasing the resolution of the bathymetric mapping, the knowledge of the river channel system improves and hence P_a increases. But, if one is not able to model how sediment transport changes the bathymetry over time at a similar resolution, the uncertainty increases. On the other hand, if the boundaries of the sea area influenced by sediment transport is known, P_c is high, but the maximum allowed speed may be low due to the uncertainty about the detailed bathymetry within the influenced area (P_a is low). Hence, the maximum safe sailing speed can be achieved by mapping bathymetry at a resolution where the benefits of increased knowledge about the current state balances the decrease in knowledge about changing conditions due to imperfect modeling capabilities. Repeated mapping (monitoring) is the same as increasing the (temporal) resolution. If the river ice movement is the major factor causing sediment transport at a level affecting sailing, re-mapping bathymetry after the ice run season might maximize the benefits of increased sailing speed and safety when mapping costs are included.

Underwater cliffs are another matter. They do not move or change within the time frames of the NSR. Once the location and shape of a cliff are known, the cross-predictability of this cliff (P_c) is at its maximum. However, if the bathymetry is not mapped at a resolution where the surrounding bathymetry informs about cliff occurrences, the auto-predictability (P_a) is low. A first level of uncertainty for underwater cliff areas is how well the outer boundaries of the cliff areas are known. Another level is how well any channels within the areas are mapped. A third level is how well individual cliffs are known. How much effort should be put into mapping within underwater cliff areas must here primarily be justified by added costs due to increased sailing distance when avoiding the cliff areas.

For the environmental mapping (II.4-projects) the concept of auto-predictability is a measure for the possibility of spatial extrapolation. For instance, if a VEC is mapped thoroughly in one area, how likely is it that the VEC is also present in other (similar) areas. This is basically a question of how well the physical and climatic conditions required by the VEC are known and mapped. Another autopredictability issue is for example feeding areas. In the case of a seabird colony, how well are the feeding areas (range) of the seabirds in this colony known? Cross-predictability is applicable for migrating VECs. How well are the migration routes and times known, or the life cycle of the VEC?. How well are the various stages in the life cycle known and specified? How well are factors influencing the life cycle known?

Summarizing this section we may state that uncertainty assessments are based on objectivity and competence, and that uncertainty should be handled in a conservative manner. Hence, uncertainty is a major factor when deciding precautionary measures. Efforts to reduce uncertainty can therefore be justified by both cost reductions and increased safety. When dealing with predictions, describing what is still unknown is often as important as describing what is known. However, since an EIA is to result in an EIS (Environmental Impact Statement), a strategy to handle uncertainties (unknown issues) must be devised.

4.14 Russian considerations

Our Russian co-partners have given the following comments or considerations to the EIA: In practice when applying the EIA-process in Russia, a significant part is given to the concept of "a permissible load" or "a permissible impact". This is considered a load or an impact not exceeding the capability of affected organisms (animal or plant) or any ecosystem (water, soil) to adapt. There is a wide system of norms PDK (limits of permissible concentrations) for various media and for different time periods of chemical substances impacts, as well as standards for physical impacts (noise, radiation). There are similar standards in force in other countries. An impact intensity is assessed by a percentage of the values above, or below PDK, and then consequences are forecast.

According to our Russian co-partners, there is another important point to be taken into consideration in the course of an EIA process. Russia will have to master its own northern territories where the main deposits of oil, gas and ores including gold are located, and the NSR activity will also rely on the development and exploitation of these resources. Under the current circumstances in Russia, developments can be difficult to assess as changes probably will fluctuate.

5. THE NEED FOR AN INTER-DISCIPLINARY APPROACH

As stated earlier, an Environmental Impact Assessment shall cover a broad range of different disciplines with the objective to provide decision makers with an indication of the likely consequences of their actions. In INSROP it should be obvious that the environmental factors (Sub-Programme II) are important for the decision makers. It is even more obvious that other factors anchored in Sub-Programmes I, II an IV will play an important part when deciding how the Northern Sea Route can or shall be used for commercial shipping, and which type of sailing shall be accomplished.

This calls for an inter-disciplinary approach in INSROP, where not only the environmental factors are included in the EIA, but also other important factors including economics, safety, legislation, and concerns and information from local communities and indigenous people. One of the strengths of the AEAM concept is that it facilitates an inter-disciplinary evaluation of multi-disciplinary information. The inter-disciplinarity in INSROP is therefore totally dependent on communication on different levels both within projects, between projects and between Sub-Programmes (Figure 5.1).

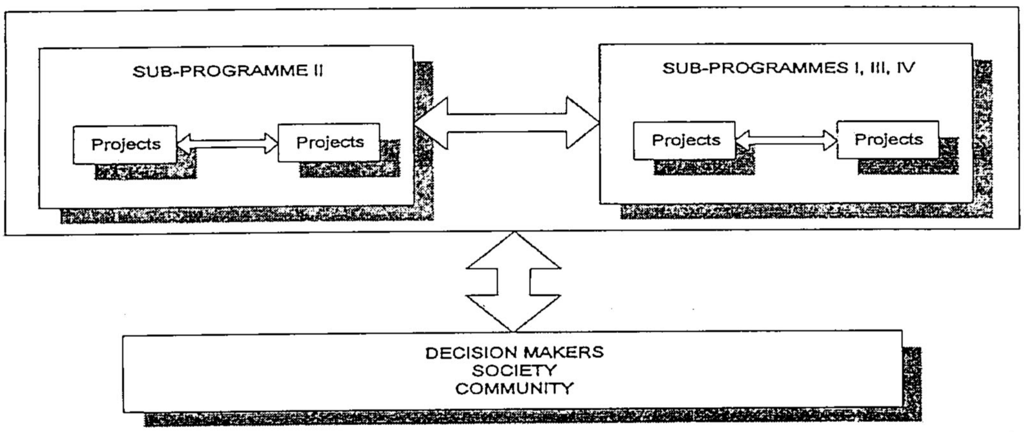


Figure 5.1. A schematic view of the different levels of communication in INSROP.

The INSROP geographic area is enormous, and questions concerning NSR activities are numerous. A preliminary social scoping has already been done in the other Sub-Programmes by selecting important issues and defining them as projects. In the Beaufort Region Environmental Assessment and Monitoring Programme (BREAM) the VEC concept was expanded to include the so-called Valued Social Components (VSCs) with the objective of integrating community-based concerns into the EIA.

6. USE OF GIS IN THE EIA

Keywords: GIS, information, communication, Environmental Impact Assessment

In the world of today decision-makers are often literally «drowned» in information. It may therefore be difficult to always make decisions based on a sound evaluation of all significant aspects of a case, and it is important to focus on relevant issues. To improve the quality of decision-making involving a variety of information sources, the information must be organized and communicated effectively. An Environmental Impact Assessment (EIA), and its associated studies, involve analyses and evaluations based upon geographic data. A Geographic Information System (GIS) may serve a useful role in the EIA as a database of geographic data and related documentation, facilitating production of updated customized maps and sharing of data, and as an analysis tool. Current GIS technology enables decision-makers access to all organized information about an issue in the form of hypermedia. This means that textual documentation, tables, charts and maps are integrated and can be retrieved and studied depending on the problem at hand. In addition, if the GIS is designed and used in a way that increases the quality of communication, interdisciplinary analysis can be enhanced, and the quality of the EIA should increase.

6.1 The role of GIS in an EIA

Keywords: Data base, hypertext documentation, maps, tables

One important role of a GIS is to serve as a data base comprising data of importance for the EIA study. A GIS data base consists of map data, tabular data, graphic data (e.g. photos) and textual descriptions. The data in the GIS can be retrieved and studied, either as a complete data set, or through selection of subsets based on some selection criteria. Another role of a GIS is to carry out analyses, e.g. to classify observations according to specific criteria.

As documentation of component selections, the hypertext option is a useful tool to communicate the findings in the individual discipline studies efficiently to other experts involved in the EIA process. A structured use of keywords rapidly gives the user an overview of related items (e.g. the outcome of classifications). For instance, if VEC is a keyword, then a search for VEC will list all VEC topics implemented in a GIS for the EIA. Similarly, if the IH categories are used as keywords, a search for B (see Chapter 4.5 and Appendix 3) will list all valid and already verified impact hypotheses. All background information about an item (e.g. a VEC), is made available as related topics when needed. Therefore the key findings about an item are efficiently made available to the user of the GIS.

In the sensitivity assessment, a GIS which includes results of field programs and other relevant existing data sets is useful to reveal the resources being affected by an activity in different important temporal periods. The GIS may also indicate high risk areas and show which areas may be affected by an accident (e.g. an oil spill). The GIS analyses can be numerical calculations (e.g. statistics) or a selection of features or cases satisfying certain criteria. By varying the selection criteria, the most significant features/cases can be identified.

The GIS may also provide input data to numerical models and import the results for further analysis. By updating and extending the GIS as the EIA proceeds, the GIS can also be used for integrated analyses and document the final outcome of the EIA. The GIS becomes especially beneficial when consequences of modifications in the planned activity (e.g. due to the outcome of the EIA) are to be evaluated.

6.2 Use of GIS in the scoping phase

Keywords: region of activity, geography, component documentation

A basis for the scoping phase is a description of the planned activity on the "context scale". At this level the type of activity (NSR shipping), the geographic region where the activity takes place (the North-East Passage) and any other boundary restrictions should be known. The main use of GIS in the scoping phase is to create maps showing the general geography of the region, and the main areas of activity (main sailing routes and ports). The outcome of the scoping phase is a set of identified key components describing the activity, affecting the activity or potentially being affected by the activity. The selected key components (e.g. VECs) and the reasons for selecting them will be included in the GIS as hypertext.

6.3 Use of GIS in baseline studies

Keywords: knowledge, documentation, hypertext, maps, tables

The purpose of the baseline studies is to obtain more knowledge about the components selected in the scoping phase. The impacting activity is described in a set of scenarios, while the impacted environment is described through a set of VECs. The knowledge to be obtained and documented through the baseline studies comprises both qualitative (process) and quantitative (e.g. distribution) knowledge. The qualitative knowledge will be documented in the GIS as hypertext, while the quantitative knowledge will be included as maps and tables.

6.4 Use of hypertext to document qualitative knowledge

Keywords: qualitative documentation, hypertext, hierarchic structure

The hypertext documentation, which can include text and graphics, makes it possible to:

- structure information topics hierarchically
- search for information using pre-defined keywords
- jump to related information through cross-links
- access glossary information (See Appendix 3) as pop-up references

The documentation of an EIA component should:

- describe why the component was selected

- show how the component is linked to the NSR. A schematic flowchart (See example in Appendix 1), accompanied by a description of flow chart components and linkages is recommended
- provide background information about the component
- describe how the component affects or may be affected by the activity (NSR shipping)
- provide evaluated information showing the significance of any effect of the component on, or from the activity
- refer to data sets providing quantitative information

See Appendix 5 for more information.

The hypertext documentation should provide rapid access to the most important findings of the baseline studies, but also enable access to more detailed information when needed, and point to quantitative data sets (e.g. maps).

6.5 Use of GIS to document quantitative knowledge

Keywords: quantitative documentation, GIS, maps, tables

The quantitative documentation is displayed in maps and tables. Maps are especially useful to show the location and spatial extent of geographic features or activities. Tables comprise various parameters providing quantitative information. If the tabular information is linked to objects in a map through a common ID parameter, the map content may vary depending on the contents of the table, and hence show how the table values are distributed spatially.

The information expressed on a map can be thought of as a set of themes, in which each theme consists of a set of geographic objects. The map may show the following quantitative measures of an object: location, size, shape and value. But the map also shows how the object is located in relation to other objects, e.g. how far away, and on which side. Distance and direction to other geographic objects are also quantitative figures, which may be determined by, or used in GIS analyses. See Section 6.6 for information on GIS analyses.

The quantitative information consists of two main parts:

- The NSR scenarios
- The NSR environmental atlas

The NSR scenarios consist of a quantitative description of the foreseen NSR shipping activity, and include quantitative information on the influence of the physical environment, socio-economic and administrative issues on the level and type of activity.

The NSR environmental atlas will provide information on the seasonal distribution of selected environmental components (e.g. VECs) and the distribution and composition of physical environment components affecting the biological environment.

6.6 Use of GIS in EIA analyses

Keywords: EIA analyses, consequences, maps

In the baseline studies forming a knowledge base for the EIA, several GIS analyses are carried out. These analyses are described in the documentation from the respective projects. The additional EIA analyses are of the following types:

- preparation of sensitivity maps based on information from all EIA components
- evaluation of consequences of various levels of activity
- production of maps to be used in the EIS.

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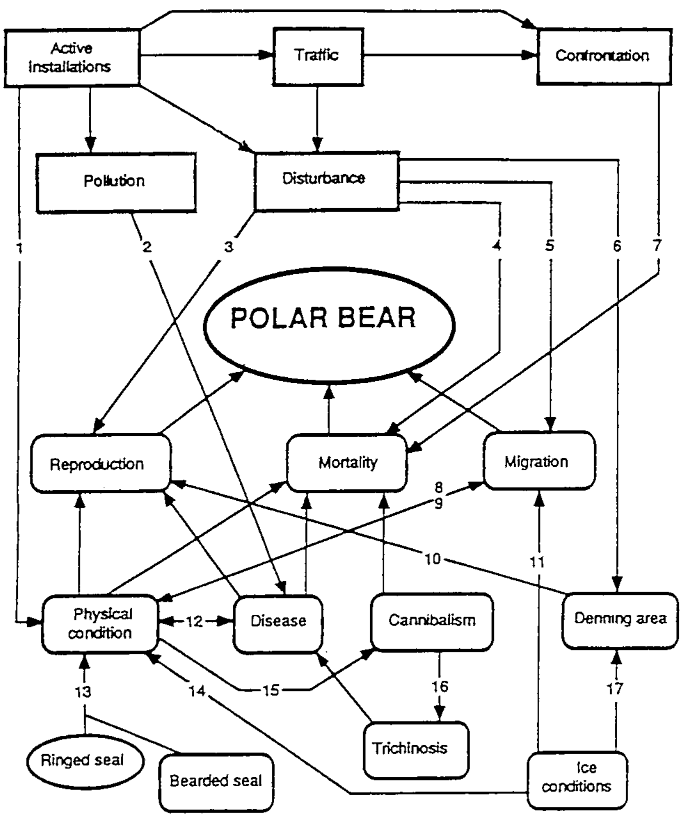
Appendix 1 - Example of a Schematic Flow Chart

Example of schematic flow chart, with corresponding explanations, descriptions of impact hypotheses, categorizing and recommendations concerning measures and surveys. Evaluated impact hypothesis. Example taken from the *VEC Polar bear* in Hansson et al. (1990).

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.

Appendix 2 - Standard diagram for preparing IHs

VEC:	IH: no.
Impact hypothesis:	
Explanation:	
Category:	
Rationale:	
Recommended research:	
Recommended monitoring and/or surveys:	
Recommended management actions:	
Recommended mitigating measures:	
Literature cited:	

Appendix 3 - Glossary

EIA/AEAM-process

AEAM:

Adaptive Environmental Assessment and Management (Holling, C.S., 1978: Adaptive environmental assessment and management. John Wiley and Sons; Chichester - New York - Brisbane - Toronto, 1986)

VEC:

A resource or environmental feature that is important (not only economically) to a local human population, or has a national or international profile, or if altered from its existing status will be important for the evaluation of environmental impacts from industrial developments, and the focusing of administrative efforts.

(Impact) system component:

A physical, biological and possibly also social and political factor influencing a VEC.

(Impact) developments:

Identified impacts of encroachment. In INSROP the following impacts are identified: physical disturbance, waste, noise, pollution, or social and cultural factors from an *impact scenario*.

(Impact) system linkages:

The relationship between impact developments, system components and a VEC.

Impact hypothesis:

A description of how an *impact development* may influence a *VEC*. The impact hypothesis includes all *system components* and *linkages* in a 'chain of influence'.

Impact scenarios

Existing environmental impacts/loads:

Existing impacts independent of increased NSR activity

NSR operational environmental impacts:

Impacts from increased regular ship traffic along the NSR. Leads from icebreaking ships, regularly occurring waste dumping and oil spillage from ships and ports, and helicopter noise from ship routing are examples of operational impacts.

NSR accidental environmental impacts:

Impacts due to accidents from (increased) regular ship traffic along the NSR. Accidental oil spills, noise and physical disturbance from clean-up operations, and social/cultural changes (e.g. major income changes for local clean-up personnel) are examples of accidental impacts.

Selection of VECs - Evaluation items:

Ecology:

Factors demonstrating the ecological role and importance of this possible VEC in the ecology in the NSR area.

Economy:

Factors of direct economic importance (e.g. hunting, fishing, as an indication of food resource availability to local human settlements).

Other human affairs:

Factors such as conservation, cultural value, special needs for indigenous people, other social or society effects.

Foreseen effects of NSR activity:

Factors indicating how regular ship traffic, or accidents from such ship traffic, may affect this possible VEC.

Data availability:

Factors indicating how much data are available, and what costs are associated with getting new data.

Impact Hypothesis categories

A. The hypothesis is assumed not to be valid

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

C. The hypothesis is assumed to be valid. Research, monitoring or surveys is recommended to validate or invalidate the hypothesis. Mitigating measures can be recommended if the hypothesis is proved to be valid.

D. The hypothesis may be valid, but is not worth testing for professional, logistic, economic or ethical reasons, or because it is assumed to be of minor environmental influence only or of insignificant value for decision making.

Appendix 4 - Contents of VEC documentation

When preparing working papers on VECs, the following Table of Contents is recommended (See Appendix 5 for more information):

INSROP Foreword
Preface
Executive summary
<Table of contents>
1. Introduction
2. The VEC selection process
    2.1 List of VEC candidates
    2.2 Evaluation of VEC candidates
    2.2.1 <name of VEC candidate 1>
    2.2.2 <name of VEC candidate 2>
    ....
    2.2.n <name of VEC candidate n>
3. Documentation of selected VECs
    3.1 VEC <name of VEC no.1>
    3.1.1 Schematic flowchart
    3.1.2 Background
    3.1.3 Impact hypotheses
    3.1.4 Data sets
    3.2 VEC < name of VEC no.2>
    3.2.1 Schematic flowchart
    3.2.2 Background
    3.2.3 Impact hypotheses
    3.2.4 Data sets
    <repeat for all VECs>
4. Evaluated impact hypotheses
    4.1.1 VEC <name of VEC no.1> - <reference ID of IH no. 1>
    4.1.2 VEC <name of VEC no.1> - <reference ID of IH no. 2>
    ...
    4.2.1 VEC <name of VEC no.2> - <reference ID of IH no. 1>
    4.2.2 VEC <name of VEC no.2> - <reference ID of IH no. 2>
    <repeat for all IHs for each VEC>
5. Uncertainty assessment
    5.1 VEC <name of VEC no.1>
    5.2 VEC <name of VEC no.2>
    ...
    5.n VEC <name of VEC no.n>

Appendix 5 - Documenting the use of AEAM in INSROP GIS

The implementation of the INSROP AEAM-documentation is based on the contents of the documentation from the II.4.-projects. To simplify this implementation, it is imperative that the documentation follows a common layout specification. *This documentation layout provides a more detailed specification of elements listed in **Appendix** 4.*

The documentation of a VEC comprises the following components:

A. The VEC selection process
B. Documentation of selected VECs
C. Evaluated impact hypotheses
D. Re-evaluation of VECs/IHs

This documentation is already a part of the Discussion/Working Papers from the II.4 projects. Figure A1 shows how the various information topics are linked in the hypertext system. A basic idea is to have the most important findings available at a high level in the information hierarchy, and have background information and, where appropriate, older versions of an information topic at lower levels. To be implemented into INSROP GIS as hypertext the selected parts of the written documentation should be provided in Microsoft Word (preferably) or WordPerfect format on MS-DOS diskettes. Figures should be provided in a Windows Bitmap (BMP) format or a device-independent bitmap (DIB) format.

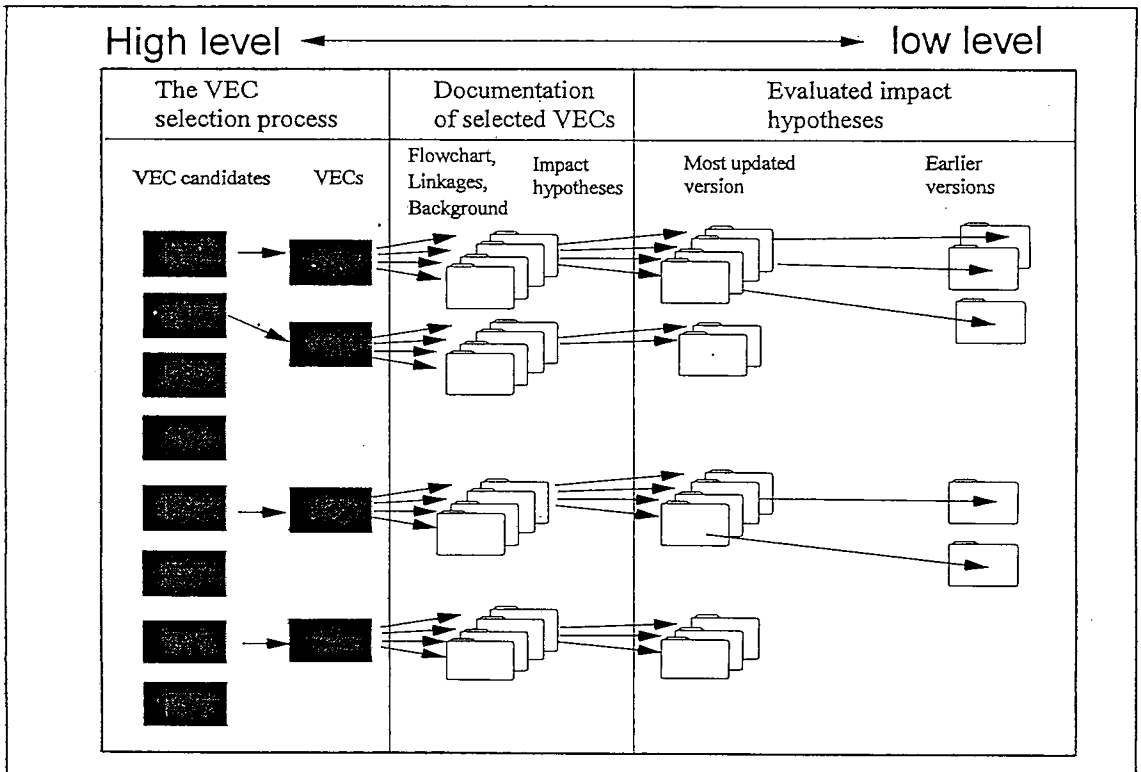


Figure A1. Hierarchic structure of the hypertext VEC documentation

A. The VEC selection process (Chapter 2 in written documentation)

A1. **VEC group.** e.g. Marine mammals

A2. **List of VEC candidates.** A numbered list of possible VECs (ref. Section 2.1 in the written documentation). The VEC-ID consists of a letter and a running number (e.g. A-1). The running numbers are chosen by the respective supervisors, while the letters to be used are:

A: Project II.4.1 VECs (Marine and anadromous fish and invertebrates)
B: Project II.4.2 VECs (Marine birds)
C: Project II.4.3 VECs (Marine mammals)
D: Project II.4.4 and II.4.5 VECs (The coastal zone, Large river estuaries and deltas)

A3. **Description and evaluation of each possible VEC** (ref. Section 2.2 in the written documentation). This information should be short and concise.

- Sub-section title: 2.2.x Name
  (e.g. 2.2.1 Polar bear)

The following descriptive items are recommended:

- Distribution (as presently known)
- Habitat
- Food
- Life cycle (including age and reproduction time/capacity)
- (- possible other items of importance for this particular type of VEC)

The following evaluation (of importance) items are **required**:

- Ecology:
  The importance of this possible VEC for the total ecology in the NSR area.
- Economy:
  Factors of direct economic importance (i.e. hunting, fishing, as food resource to local human settlements).
- Other human affairs:
  Factors such as conservation, cultural value, special needs for indigenous people, other social or society effects.
- Foreseen effects of NSR activity:
  How may regular ship traffic, or accidents from such ship traffic, affect this possible VEC.
- Data availability:
  How much data are available, and what costs are associated with getting new data.
- Status: **VEC** or **Not a VEC**

The present conclusion based upon the description and evaluation described above. A comparison with other possible VECs is also involved before a final decision on status is made.

B. Documentation of selected VECs (Chapter 3 in written documentation)

B1. **Section 3.x**: Name and VEC-ID of the VEC (ref. A2).
E.g.: 3.1 VEC Polar bear (C-1)

B2. **INSROP Project**: Project number of the INSROP project(s) being responsible of documenting the VEC; e.g. II.4.1.

B3. **Section 3.x.1 Schematic flow chart**. Provide each 'VEC impact flowchart', described in Section 3.2, as a separate BMP or GIF file. Contact Project I.3.1 if you cannot supply GIF-files. Include impacts *on* the VEC only, not further consequences from an impact on the VEC.

B4. **Linkages**. List the numbered linkages included in the schematic flowchart described above.

B5. **Section 3.x.2 Background**. This item provides a link to the contents of A3. (See Sub-section 2.2.x)

B6. **Section 3.x.3 Impact hypotheses**, incl. ID-number: The IH-ID consists of the VEC-ID and an impact hypothesis number (e.g. A-1-IH1). The running IH--numbers are chosen by the respective supervisors.
E.g.: C-1-IH1 Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population.

B7. **Section 3.x.4 VEC data sets**: None, or a list and brief description of currently available data sets.

B8. **VEC project files**: None, or a list and brief description of currently available INSROP GIS project files.

C. Evaluated impact hypotheses (Chapter 4 in written documentation)

C1. **Section 4.x**: VEC Name and IH-ID
E.g.: Polar bear - C-1-IH1

Keywords: One purpose of the keywords is to be able to list all IHs dealing with an impact, by searching for the impact keyword. Another purpose is to find all significant IHs. The third purpose is to find all IHs within a certain category (A, B, C, or D).

The keywords are of three types: Impact, Scenario, Significance. The impacts identified in INSROP are: *Pollution*, *Noise*, *Waste*, *Physical disturbance*, and *Social and cultural* *factors*. The scenarios causing suggested impacts are: Existing environmental impacts/loads, NSR operational environmental impacts and NSR accidental environmental impacts. The significance keywords are Significant, Insignificant, and Unknown. Unknown implies that more research is needed.

Keyword examples are:
Keywords: Waste, operational, D, insignificant
Keywords: Pollution, accidental, B, significant
Keywords: Noise, accidental, C, unknown
Keywords: Physical disturbance, existing, A, insignificant

C2. **Impact Hypothesis**: Name of the IH. E.g.: C-1-IH1 Oil pollution in polar bear habitats will cause suffering and death for the affected polar bears and may result in a decrease of the population.

C3. **Category**: A, B, C, or D (ref. Section 3.3).

C4. **Rationale**:

C5. **Recommended research**: Ref. Section 3.4.

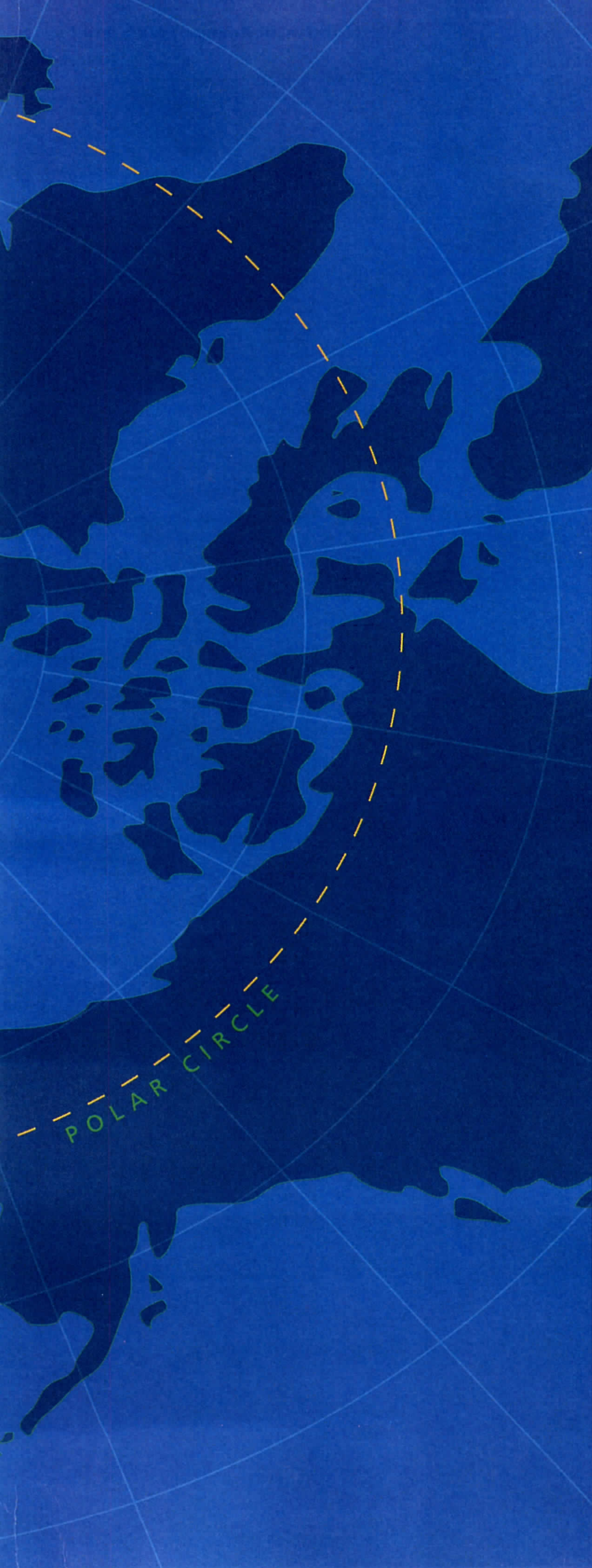
C6. **Recommended monitoring and/or surveys**: Ref. Section 3.4.

C7. **Recommended management actions**: Ref. Section 3.5.

C8. **Recommended mitigating measures**: Ref. Section 3.5.

C9. **Literature cited**: List references affecting this particular IH.

D. Re-evaluation of VECs/IHs



The three main cooperating institutions of INSROP

Ship & Ocean Foundation (SOF), Tokyo, Japan.

SOF was established in 1975 as a non-profit organization to advance modernization and rationalization of Japan's shipbuilding and related industries, and to give assistance to non-profit organizations associated with these industries. SOF is provided with operation funds by the Sasakawa Foundation, the world's largest foundation operated with revenue from motorboat racing. An integral part of SOF, the Tsukuba Institute, carries out experimental research into ocean environment protection and ocean development.

Central Marine Research & Design Institute (CNIIMF), St. Petersburg, Russia.

CNIIMF was founded in 1929. The institute's research focus is applied and technological with four main goals: the improvment of merchant fleet efficiency; shipping safety; technical development of the merchant fleet; and design support for future fleet development. CNIIMF was a Russian state institution up to 1993, when it was converted into a stockholding company.

The Fridtjof Nansen Institute (FNI), Lysaker, Norway.

FNI was founded in 1958 and is based at Polhøgda, the home of Fridtjof Nansen, famous Norwegian polar explorer, scientist, humanist and statesman. The institute spesializes in applied social science research, with special focus on international resource and environmental management. In addition to INSROP, the research is organized in six integrated programmes. Typical of FNI research is a multidisciplinary approach, entailing extensive cooperation with other research institutions both at home and abroad. The INSROP Secretariat is located at FNI.