# 6 Introduction

## 6.1 Objectives

This environmental oil spill sensitivity Atlas has been prepared to provide oil spill response planners and responders with tools to identify resources at risk, establish protection priorities and identify appropriate response and clean-up strategies.

The Atlas is designed for planning and implementing year-round oil spill countermeasures in both coastal and offshore areas on the west coast of Greenland between 62° N and 68° N latitude. An important component of the Atlas is a sensitivity ranking system which is used to calculate an index value describing the relative sensitivity of coastal and offshore areas. The sensitivity index value is calculated based on information on resource use (human use), biological occurrences, and physical environment. The sensitivity ranking system is based on a Canadian system used in Lancaster Sound (Dickins et al. 1990) and modified to meet the specific requirements of the Greenland study area (see Chapter 6.3). As a supplement to the Canadian ranking system, a number of smaller areas has been selected for priority in case of an oil spill (see Chapter 6.4). The selection of these areas is based on the principles from a Norwegian system (Anker-Nilssen 1994), which gives priority to oil spill sensitive areas for oil spill contingency planning.

The west coast of Greenland between 62° N and 68° N latitude is the most populated area in Greenland. It is extremely important for fisheries and it is ecologically highly important for a number of seabird and marine mammal species. It is therefore essential that all possible measures are taken to minimise the environmental risk of oil activities in the area. The objective of this Atlas is to contribute to that effort.

## 6.2 Contents and organisation

The study area covers the west coast of Greenland between 62° N and 68° N including offshore areas as far west as the Canadian border. Moreover, it includes most of the information regarding the physical environment further north to 71° N.

All fjords between 62° N and 68° N are included in the Atlas, although the coastal morphology has not been mapped in the easternmost inner part of the long fjords.

This Atlas is produced both as a pdf-document on CD and as a paper version. The pdf-document on CD has, compared to the paper version, a number of extra maps, figures and tables. Furthermore the CD contains a series of air photos covering the area, and the shoreline sensitivity map and physical environment and logistics maps are included in a GIS application, which makes it possible to produce seamless maps at various scales.

The information in the Atlas is organized by map scale moving from summary information (Chapter 8) in a scale of approx. 1: 3.5 million to operational information (Chapter 9) in a scale of 1: 250,000 (G/250 Vector copyright Danish Survey & Cadastre 1998).

Chapter 7 contains a users guide to the maps which supplement the legend.

Chapter 8 contains the summary maps, which include:
- bathymetry,
- sea surface currents,
- overall distribution of important species,
- overview of extreme and high sensitivity areas and special status areas,
- offshore sensitivity (winter, spring, summer and autumn),
- ice conditions.

Chapter 9 contains the operational maps, which include Shoreline Sensitivity Maps with:
- shoreline species,
- resource use (human use),
- archaeological sites,
- sensitivity rankings,
- selected areas.

and Physical Environment and Logistics Maps with:
- shoreline geomorphology,
- anchorage's and safe havens,
- access by boat or aircraft,
- descriptions of potential countermeasures.

Further information on the physical environment is given in Appendix C: Climatic data for logistics.

Detailed accounts of methodology and data documentation and limitations are given in Appendix D.

## 6.3 Sensitivity index system

An environmental sensitivity ranking system is used in the Atlas to determine and illustrate the relative sensitivity of shoreline and offshore areas of West Greenland to the effects of an oil spill. This pre-spill ranking allows spill responders and on-scene planners to do a quick evaluation of which areas and environmental components that are most susceptible to an oil spill, and thus provides the information to consensus regarding protection priorities during a spill event.

Through the use of the sensitivity ranking system, each shoreline and offshore area receive a single numeric value, which represents the relative sensitivity of that area to a marine oil spill. This numeric value is ranked as extremely high, high, moderate or low and is illustrated on the summary, regional and operational maps by the use of a colour code.

This ranking system is based on the scheme developed for the Canadian Atlases (e.g. Lancaster Sound) with some modifications to account for the different biological and physical features of the region. The sensitivity ranking system incorporates the biophysical and social elements of the region that are important from an oil spill perspective. These elements are assigned to and ranked on a relative scale within three major categories: (1) resource (human) use; (2) species occurrence; and (3) oil residence. The latter category considers the oil residence periods associated with various coastal types, and the differences in ice and open water zones for the shoreline and offshore areas of West Greenland, respectively. Each of the categories are assigned a weighting factor, which is based on their relative importance within the region. The elements within each of the categories are ranked based on their relative sensitivity to potential effects of oil spills. These assigned values are then multiplied by the weighting factor to produce a single numeric value the PI (priority index). It is the sum of the priority indices that determines the overall sensitivity of a specific shoreline or offshore area.

PI = AV x WF

and

S = sum of PI

where:

AV = assigned value of the element

WF = weighting factor of the category

PI = priority index

S = relative sensitivity of an area: the **sensitivity value**

Criteria for ranking the relative sensitivity of the human use elements are based on their importance to local residents from a cultural/historic and economic perspective, and the replaceability of the resource.

Biological elements (species or species group) selected for the sensitivity index are listed in Table 6.1. They are selected based on their sensitivity to oil spills, their ecological importance and their importance to biodiversity and the local human population.

The following formula is used to calculate the AV (assigned value) for each biological element (species or species group):

AV = (RS x RA x TM x ORI) / C

Where:

RS = relative sensitivity of the species

RA = relative abundance of the species

TM = temporal modifier

ORI = oil residence index

C = constant used to reduce the maximum possible score

The relative sensitivity (RS) for the species rely on available information regarding the vulnerability, recovery potential, potential for lethal and sublethal effects, which are summarised in Table 6.1. The relative sensitivity for the selected species range from 7 to 25. The relative abundance and timing of occurrence of the selected species (biological elements) is extracted from available knowledge and encoded for each shoreline and offshore area.

Table 6.1 The relative sensitivity (RS) and characteristics of the selected species or species groups in relation to oil spills.

| Species Name | Vulnerability | Mortality potential | Sublethal potential | Recovery period | Relative sensitivity |
|---|---|---|---|---|---|
| Alcids | Very High | Very High | Very High | Very High | 25 |
| Arctic char | Moderate | Low/Short | Moderate | Moderate | 14 |
| Baleen whales | Low | Very Low | Very Low | Moderate | 9 |
| Bearded seal | Low | Very Low | Low | Short | 9 |
| Capelin | Very High | High | High | Moderate | 21 |
| Cormorants | High | High | High | Moderate | 19 |
| Deep sea shrimp | Very Low | Very Low | Low | Short | 7 |
| Greenland halibut | Very Low | Very Low | Low | Short | 7 |
| Gulls | Moderate | High | Very High | Short | 17 |
| Harbour seal | Moderate | Moderate | High | No Recovery | 18 |
| Hooded seal | Moderate | Moderate | Moderate | Moderate | 15 |
| Lumpsucker | Moderate | Moderate | High | Short | 15 |
| Scallop | High | Low | High | Long | 18 |
| Seaducks | Very High | High | Very High | Long | 23 |
| Seaducks breeding | Very High | High | Very High | Long | 23 |
| Snow crab | Very Low | Low | Moderate | Short | 9 |
| Tubenoses offshore | Moderate | High | High | Moderate | 17 |
| Tubenoses shoreline | Moderate | High | High | Long | 18 |
| Walrus | High | Moderate | Low | No Recovery | 18 |
| White whale | Low | Low | Low | No Recovery | 13 |

The biological resource constant "C", refers to a value which is used to limit the maximum possible biological resource score, and thus to balance the importance of the biological components with the other components.

The oil residence index (ORI) provides a relative estimate of the potential residence period of oil stranded within the shore zone under normal conditions. The index is only an approximation, because many aspects of a spill are unknown until the time of the spill incident (e.g. the volume of spill, oil type, degree of weathering). The oil residence is ranked from 1 to 5 mainly based on the shorelines exposure class and the shoreline substrate. Table 6.2 shows the basic relation. A few minor modifications to the basic classification of the ORI value are made to account for slope (where steep shorelines are less vulnerable) and to account for a few geomorphological coast types considered to have longer residence times (archipelagos, pocket beach, barrier beach and delta).

Table 6.2 Basic Oil Residence Index (ORI) ranking based on a combination of shoreline substrate and exposure class.

| Substrate / Exposure class | Protected | Semi-protected | Semi-exposed | Exposed |
|---|---|---|---|---|
| Coarse sediment | 4 | 3 | 1 | 1 |
| Fine sediment | 4 | 3 | 1 | 1 |
| Ice | 1 | 1 | 1 | 1 |
| Not classified | 4 | 3 | 2 | 1 |
| Rock | 4 | 3 | 1 | 1 |
| Rock and coarse sediment | 5 | 4 | 2 | 1 |
| Rock and fine sediment | 5 | 4 | 2 | 1 |

## 6.4 Selected areas

In particular, a total of 78 areas along the coast and within fjords have been selected for priority in an oil spill situation. These areas are identified by a black polygon border and a number with the prefix, 's'. The basis for their selection is that they are, relative to the shoreline in general: i) of high value either environmentally or for resource use; ii) sensitive to oil spills; and iii) of a size and form that may allow effective protection in an oil spill situation with a manageable amount of manpower and equipment.

## 6.5 Countermeasure overview

Oil spill countermeasure considerations are described for each of the 34 operational maps in Chapter 9. The following is an overview of their basis and content.

The low level of industrial and marine activity in the waters of West Greenland leads to a very limited number of spill possibilities, both currently and in the foreseeable future. The main possibilities at present are those related to fuel re-supply to the communities, and fuel carried by fishing vessels and other small ships. A small but finite risk will be added with the advent of exploration drilling for crude oil, which is planned for the year 2000 in an area approximately 150 km west of Nuuk. More exploration drilling is anticipated on the offshore area in the coming years.

If a significant spill occurs, there would be severe limits to the response, particularly during the critical initial stages of the incident. The remoteness of the region, the distance of existing response bases, and, most importantly, the low marine activity practically eliminate the possibility of an effective initial marine-based response unless dedicated response plans and equipment are available as is the case for offshore exploration drilling. The main countermeasure activities that could be carried out are described in general terms below, with specific local notes where applicable on each of the operational maps. These countermeasures could include surveillance and tracking, in situ burning of spills in ice conditions, dispersant-use in offshore areas, and the protection and clean-up of important coastal entities, such as the "selected areas" (see Chapter 6.4).

Surveillance and tracking activities will be critical in determining the location and extent of spilled oil. This will be particularly important in establishing clean-up priorities and adjusting strategies when a long-term and geographically widespread response is required. Aircraft-based remote sensing and surveillance overflights could be mounted from airports at Kangerlussuaq, Maniitsoq, Nuuk, or Sisimiut. A program to track oiled ice would be required for spills that occur among pack ice or for open water spills that reach the pack ice edge or persist through freeze-up in protected inshore waters.

Conventional containment and recovery techniques will be severely limited by the lack of vessels with which to deploy and operate equipment unless vessels and equipment are available on standby in the area as part of a response plan for specific activities such as offshore drilling. Spills that are not contained within the first few days of a response will likely be too thin and widespread to allow effective recovery.

In situ burning may be applicable as an initial response measure for spills in ice conditions. Pack ice concentration of 6 tenths or greater will limit the spread of an oil spill and may allow the opportunity for burning until some time after an incident. For inshore areas and fjords that freeze over winter, oil that persists through the freezing season may be available for burning the following melt season when released into leads and melt pools. This would require a tracking and monitoring program through the winter to delineate oiled areas and to prepare for the likely release period.

Dispersant-use should be considered for use in offshore areas to prevent or reduce surface oil from contaminating more sensitive inshore areas. This technique will be particularly applicable for slicks that threaten to approach nearshore bird and marine mammal habitats, and for which containment and recovery countermeasures may not be fully effective due to the size of the spill, the limited logistical support for a large-scale clean-up, the prevailing weather and sea conditions, or a combination of the three.

Shoreline protection countermeasures will also be limited by a lack of logistical support. There is, however, limited need for shoreline protection through much of the areas that are exposed to marine transportation risks, as described further below. The main exceptions to this generalisation are the “selected areas” within each map area that have been identified as priorities for protection. These areas are particularly vulnerable to oiling, can generally be protected with a relatively modest effort, and in some cases, could be difficult to clean if heavily oiled. In many cases, deflection rather than containment booming will be preferred because the tidal currents exceed 1 knot. While deflection booming may not offer complete protection of the “selected area” it will be valuable in limiting the extent and degree of contamination and lead to faster and more complete post-spill recovery. Deflection booming strategies will require monitoring and perhaps repositioning periodically to account for changes in current strength and direction.

A more significant limitation for shoreline protection countermeasures will be that dictated by the water currents and topography. Little water current information is available for the area; the few data available indicates that tidal currents are strong in most areas - as high as 7 knots in one instance. This coupled with steep, rocky shorelines and bottom contours may preclude effective booming. As noted above, for areas that can be boomed, the most effective strategy may be to use deflection booming to limit the extent of shoreline oiling and thereby hasten recovery.

It should be noted that there are many areas, including some of the “selected areas” for protection, for which effective containment operations are not likely to be possible. In many areas, offshore countermeasures present the only realistic option for effective protection. For spills that may affect these areas, strong consideration should be given to dispersant-use (and in situ burning for spills in ice conditions).

Much of the coastline in this Atlas consists of high-relief rocky shoreline that is moderately or highly exposed to prevailing weather and sea conditions as well as some ice action. In many areas, fjords, bays, and other inshore areas may also be somewhat protected from extensive contamination by the flushing action of tidal currents and by the natural outflow of streams and rivers. As a result, much of the shoreline may not require a widespread active cleaning effort unless it is heavily contaminated. Where active shoreline clean-up is required, priorities for restoration can be established based on both the environmental sensitivity and oil persistence factors. Preference should be given to in situ cleaning techniques such as in-place washing of rocky shores, use of shoreline cleaning agents, in situ burning, and bioremediation. Use of these techniques will minimise the amount of oily material collected and subsequent hauling requirements. Disposal site selection was beyond the scope of this study, and would require extensive study involving technical, logistical, environmental, and political factors. An alternative to land disposal within the region would be the trans-shipment of collected oily materials from temporary stockpiles to disposal sites and/or incineration elsewhere.

Marine access for shoreline clean-up may be limited in some areas by shoaling and offlying rocks and islets. In some areas, locally forming ice and the encroachment of seasonal pack ice may also limit access. The steep shorelines in many areas will rule out the use of remote staging areas and may necessitate ship- or barge-based clean-up operations.