Oil Exploration in the Fylla Area

An Initial Assessment of Potential Environmental Impacts

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Data Sheet

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Contents

Preface

New seismic data acquired offshore West Greenland by the Geological Survey of Greenland (GGU) in 1990-92 and by Nunaoil A/S in 1994 have lead to a greatly improved understanding of the regional structure of the sedimentary basins and have revealed new plays for petroleum exploration. This has especially been the case for The Fylla Area where the existence of large structures with direct hydrocarbon indicators in the form of flat-spots have attracted the attention of the oil industry.

The offshore areas in West Greenland south of 70° 30′ N are covered by an open door policy with respect to petroleum licences. Within this open door policy a special application procedure with respect to exploration and exploitation licences for hydrocarbons in The Fylla Area was adopted in May 1995 by the Government of Greenland and the Danish Minister for Environment and Energy.

Under this procedure applications for The Fylla Area are to be submitted to the Mineral Resources Administration for Greenland (MRA) not later than February 29, 1996. Applications received within this deadline will be processed and, if possible, decided upon during the spring of 1996.

On this basis exploration regarding The Fylla Area including further seismic acquisition and exploratory drilling is expected to be carried out during the next years.

This report on environmental considerations regarding The Fylla Area has been prepared for MRA by the National Environmental Research Institute.

Summary

Introduction (1-2)

This is an initial environmental impact assessment of oil exploration in The Fylla Area from late spring to early autumn (May-September). The focus is on potential impacts in West Greenland between 62° N and 68° N to account for possible impacts due to drift of oil out of The Fylla Area should a large oil spill occur. The study includes a description and characterization of the ecosystem (chapter 4), a description of the proposed activity in the area (chapter 5), and an identification and evaluation of the interactions between the proposed activity and the ecosystem (chapter 6). Possible regulation, mitigation and monitoring measures are also considered (chapter 7), and the main problems related to winter operations are briefly mentioned (chapter 8).

Physical conditions (3)

The Fylla licensing area (The Fylla Area) is located in Davis Strait about 50 km from the coast, just west of Fyllas Banke on the southeastern slope of the underwater ridge between Canada and Greenland (Fig. 1). Sea depths in The Fylla Area range from more than 2 000 m in the southwestern corner to less than 100 m on the shelf in the northeastern corner. The shelf area found off West Greenland includes several large shoals and typically ranges between 20 and 100 m in depth. The shelf is narrow to the south and up to 120 km wide to the north. There is deep water to the west of the shelf. The dominant current in Davis Strait off West Greenland is the northgoing West Greenland Current (Fig. 2). The surface layer (0-150m) of this current is dominated by cold water from the East Greenland Polar Current, while the underlying layer (150-800 m) consists of warm water from the Irminger Current (a branch of the Gulf Stream). As a result of this current pattern, the waters at South Greenland are normally free of ice cover all year round, although drift ice is often found in the area during winter (Fig. 3). Thus, the area is called the Open Water Region, in contrast all other West Greenland offshore waters where ice covers the water during winter.

Ecology (4)

The Fylla Area, in addition to the other banks off West Greenland, is considered to be among the most productive regions in Greenland waters, and represents an important site for birds, marine mammals and fisheries. The upwelling of nutrients at the slopes and on the fishing banks throughout the summer sustains high primary productivity over a long period, while in central and western Davis Strait primary productivity is low.

Offshore fish and shrimps

The offshore fish assemblage in the area is dominated by demersal species. The most important fish and invertebrate species are listed in Table 1. Major changes in the fish assemblage have occurred in last few decades, the most noteworthy is the disappearance of the offshore Atlantic cod stock. There are important deep sea shrimp and Greenland halibut fisheries in the area (Fig. 5 & 6) and a stationary stock of sand eels is believed to be the most important prey species for marine mammals and seabirds on the banks.

Coastal zone

The coastal zone in the area (62°-68° N) is dominated by bedrock shorelines with many skeries and archipelagos. Small bays with sand or gravel are found between the rocks in some sheltered areas. Sandy beaches are found in the Marraq-Sermilik area and in the vicinity of the Frederikshåb Isblink glacier, where there are extensive sandy beaches and barrier islands. The area has a tidal amplitude of 3-4 m and a rich intertidal and subtidal flora and fauna on the bedrock shorelines. Lumpsucker and capelin are coastal spawners, and capelin are found inshore during most of the year. During summer, Arctic char also feed in coastal waters.

Seabirds

The Fylla Area, and the assessment area (62°-68° N), has a rich seabird fauna with many species adapted to different ecological niches (Table 2 & 3). There are species that feed predominately on fish, such as thick-billed murres (outer coast and offshore), and cormorants (coastal and fjords), surface plankton feeders, such as the kittiwakes, and bottom feeders, such as eiders (hard bottom) and king eiders (soft bottom). 14 species of colony breeding seabirds occur in the area (Fig. 7 & 8). In August, postbreeders of several duck species gather in the coastal zone for moulting and foraging (Fig. 9), and during autumn large numbers of seabirds arrive at the banks for the winter (Table 3, Fig. 11). The largest seabird populations are believed to be present in the area during winter, and the importance of the open water area during the winter season is unique. The most important seabird areas during summer and autumn in the outer coastal zone (62° - 68° N) are identified.

Marine mammals

A large number of marine mammal species occur in the area (Table 4). However, only few species show a specialized site preference in or close to The Fylla Area. The most important of these is the humpback whale. Relatively high densities of humpback whales have been observed at the eastern edge of Fyllas Banke (off Nuuk), the eastern edge of Fiskenæs and Danas Banke as well as the continental slope off Paamiut (Fig. 12).

Oil exploration operations (5)

Oil exploration in The Fylla Area is expected to start with a number of seismic programs including 2 D and 3D seismic surveys, and followed by exploratory drilling using semisubmersibles or drillships. Localized seismic (2D and 3D), exploratory drilling and accidental oil spills can impact the environment. Simulation studies of oil spill drift in West Greenland indicate that large oil spills could potentially reach any subarea within an area 200-300 km wide and 300-600 km long, but would only cover a small fraction of this area.

Potential impact of seismic activities (6)

Localized seismic (2D and 3D) in the eastern Fylla Area during summer can potentially cause the displacement of humpback whales from a traditional feeding area and the displacement of spawning sand eels from some of their spawning grounds. It is not possible to predict whether these effects will actually occur and what the ultimate consequence for the populations would be. However, we are pretty confident that a few programs of limited duration (few weeks) would only have a limited impact. 3D seismic surveys in the Fylla Area can also affect the Greenland halibut catch taking place in the survey area during seismic surveys, because these may provoke temporary movement of the fish. This is, however, a short-term effect which is unlikely to have any significant ecological consequences.

Potential impact of oil spills (6)

The most serious potential impact of oil exploration activities in the Fylla Area is a major oil spill, especially if the spill reaches the coast. The biological resources in the area (62° -68° N) primarily threatened by a large oil spill from the Fylla Area in summer or autumn are seabirds, fish spawning and feeding in the intertidal zone or shallow waters, and mussels and scallops also in the intertidal zone or shallow waters.

Offshore fish and shrimps

It is unlikely that oil spills from The Fylla area during summer and early autumn would have a significant impact on adult fish and shrimps in offshore stocks. Offshore concentrations of eggs and larvae which could be affected are relatively low and dispersed during this period, and are present only to a minor extent in the upper water layers. In contrast to this, the impact would be greater at the coastline where oil concentrations in the water column can build up.

Lumpsucker and capelin

The lumpsucker and the capelin are especially vulnerable because they spawn in localized areas in the intertidal or subtidal zone during summer. Arctic char, which feed in coastal waters for most of their lives and spawn in rivers, are also vulnerable to coastal oil slicks.

Seabirds

Seabirds are extremely vulnerable to oil spills, primarily because oil soaks into the plumage and destroys insulation and buoyancy, causing hypothermia, starvation and drowning. Because they live in cold water, Arctic seabirds are especially vulnerable to the loss of the insulating capacity of their plumage. Birds which rest and feed on the surface of the sea, such as auks, are particularly vulnerable to even small doses of oil. An oil spill from The Fylla Area during autumn would threaten large numbers of seabirds, because many seabirds are present in the area during autumn. However, an oil spill during the breeding season may cause a longer recovery time because a very high proportion of a single seabird colony can suffer mortality. Based on population dynamics it has been estimated that the recovery time for a severely diminished thick-billed murre colony can be several decades.

Marine mammals

Although the potential for exposure to spilled oil is likely to be high by marine mammals because they come to the surface to breath, it is concluded that oil spills from The Fylla Area during the summer and autumn are unlikely to have a severe impact on marine mammals.

Mitigation (7)

To minimize the environmental risk of large oil spills during oil exploration, emphasis shall be put on planning of activities to avoid operations during the most sensitive periods and in the most sensitive areas, and first of all to operate safely and to prevent accidental spills. There should also be effective oil spill countermeasures and short response times for oil collection at spill sources. Oil spill response plans with operational environmental sensitivity maps to enhance damage control during a spill, should be made. Distribution and catch of lumpsucker, capelin and Arctic char in the area need to be surveyed more thoroughly, i.a. through interviews in local communities, in order to asses this risk in more detail and to compile sensitivity maps.
The impact of noise from drilling on humpback whales feeding just east of the Fylla Area can be mitigated by the type of equipment to be used, and if drilling is going to take place near the humpback area, it is recommended that a survey program be set up to monitor the impact.

Operations during winter (8)

Operations during winter will take place in an oil exploitation phase. During winter, the consequences of a large oil spill will be more serious than during summer and autumn. There are large and important bird and marine mammal populations in the area during winter, although knowledge on numbers and distribution is inadequate. During winter, birds and mammals can be very concentrated in the open water, especially in leads and at the ice edge where spilled oil is also likely to concentrate. The thermal stress experienced by oiled birds and polar bears would be enhanced by low temperatures. Further oil spill countermeasures and damage control in icy waters are presently considered to be inadequate.

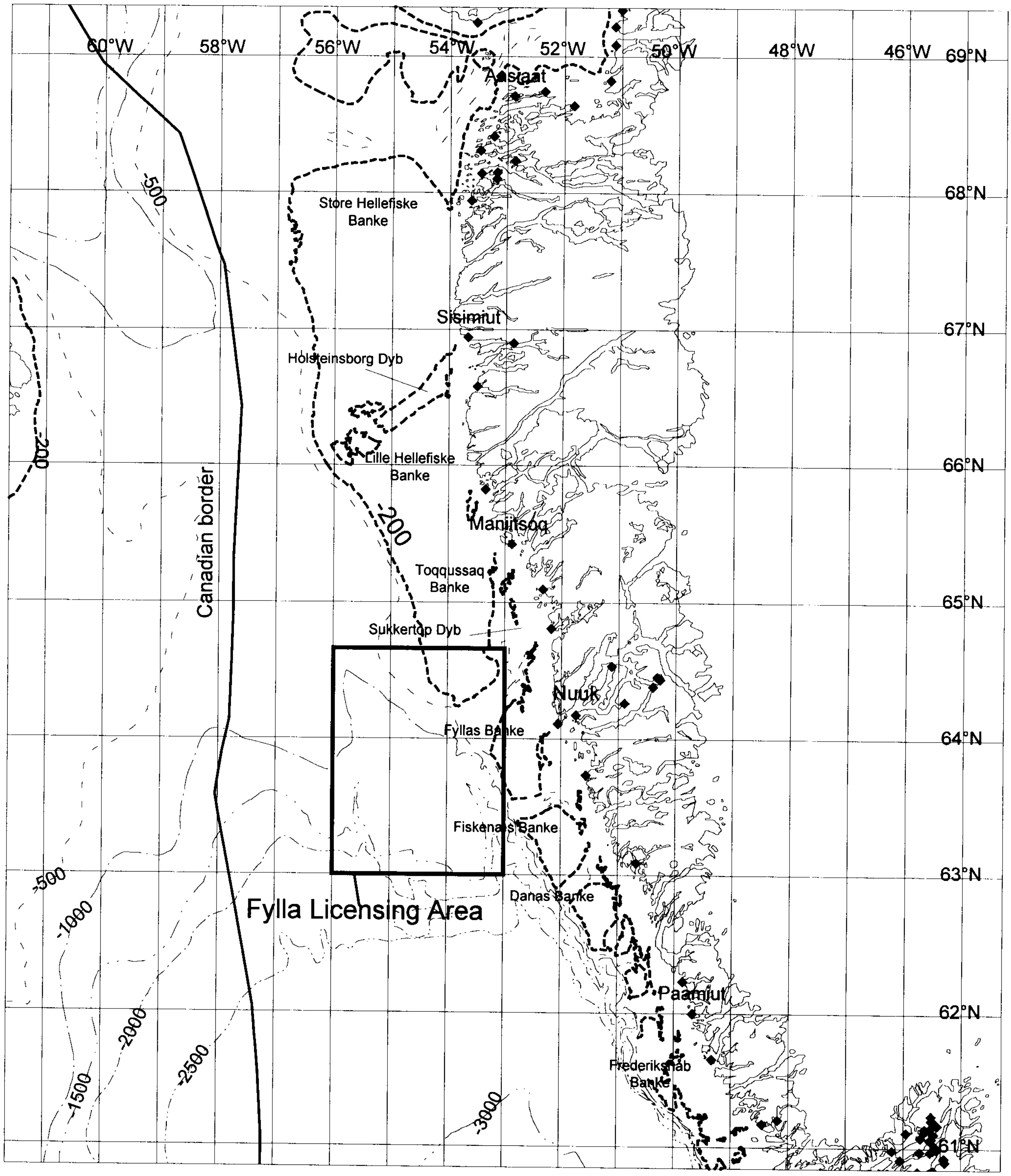

Fig. 1. The Fylla Area and the eastern Davis Strait.

1 Introduction

Assessments of environmental impacts of major activities potentially harmful to the environment are a normal practice in western industrialized countries, although different administrative and political procedures are followed in different countries. The aim is to predict potential environmental damage in a way which allows for an overall cost benefit analysis of the activity in question as a basis for political decisions. Furthermore, this process makes it possible to determine how to conduct the activity in question with minimal impact on the environment. The economic and social impacts of oil exploration and exploitation are outside the scope of this report.

An environmental impact assessment of an offshore drilling program in The Fylla Area has not yet been conducted, but several studies relevant for oil exploration in the western Davis Strait have been carried out. The main ecological issues related to offshore oil exploration in Greenland was recently reviewed by National Environmental Research Institute-Department of Arctic Environment (NERI-AE) (Mosbech et al. 1995). Earlier studies have included numerical oil spill drift simulations (Christensen et al. 1993), an evaluation of the behavior and cleanup of offshore oil-well blowout spills (Ross 1992), and a review of the available data for oil spill sensitivity maps for summer operations (Boertmann et al. 1992). Based on the latter report studies were initiated to improve knowledge about seabird colonies, moulting areas and offshore seabird concentrations. The faunistic data have been integrated in a GIS at NERI-AE and results are under publication (Boertmann & Mosbech in prep., Mosbech & Boertmann in prep., Falk & Durinck in press). During exploratory drilling in West Greenland in 1976-77, baseline studies included a study of hydrocarbons in marine organisms and sediments (Johansen et al 1977) and faunistic surveys of benthic invertebrates on the banks 66°-68° N (Marin ID 1978) and in the intertidal zone (Marin ID 1979).

In order to assess the impact of offshore oil activities in the Arctic region, there should at least be a knowledge of the biological communities present and the major trophic structures within those communities. Basic physical parameters, including the predominant transport pattern, should also be known, and it is important that there is an understanding of the natural variability of both the biological and physical system. Unique habitats and habitats especially susceptible to exploration and development activities need to be identified. Special consideration needs to be given to rare or endangered species and the seasonal occurrence of migratory species. Socioeconomic and cultural important biological resources must also be identified.
This initial assessment outlines the environmental problems and estimates the extent of potential effects. The study includes, a

description and characterization of the ecosystem (chapter 4), a description of the proposed activity (chapter 5) and an identification and evaluation of the interactions between the proposed activity and the ecosystem (chapter 6). Possible regulation, mitigation and monitoring are also considered (chapter 7).

A project specific Environmental Impact Assessment (EIA) will be made if an oil company discovers hydrocarbons in the area and intends to start development of a field. The oil company will then have to provide an EIA of the planned project as stated in the Mineral Resources Act for Greenland.

2 Scope

This report deals mainly with potential environmental impacts of oil exploration in The Fylla Area. However potential operational problems between oil exploration activities and fishing in The Fylla Area are also mentioned. The report focuses on the problems associated with an exploration phase in summer and early autumn (May-September) and will only briefly outline potential problems related to an exploitation phase. During exploitation, year round activities will take place, thus exposing other biological resources in a period where the sea may be ice-covered, resources of which we only have sparse information today (chapter 8).

Land-based support facilities are not expected to be large in the exploration period, but facilities to handle and store different chemical agents in a harbor will probably need to be developed. Such facilities are not addressed in this report.

This assessment deals with most of eastern Davis Strait (62° - 68° N, Fig. 1) as this area may be impacted by an offshore oil spill from The Fylla Area. The delimitation of the risk area is based on numerical oil spill drift simulations (DHI 1992, Christensen et al. 1993) briefly described in chapter 4.

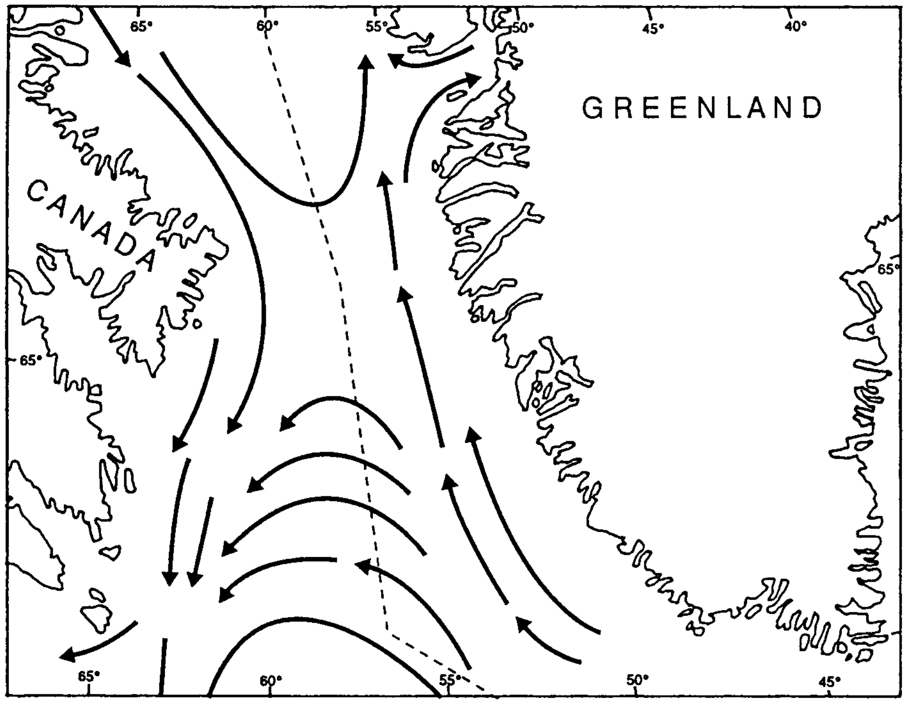

Fig. 2. Major surface current pattern in the Davis Strait (modified from Greenland Technical Organisation 1981).

3 Physical conditions in the eastern Davis Strait

The Fylla licensing area (The Fylla Area) is located in the Davis Strait, just west of Fyllas Banke on the southeastern slope of the underwater ridge between Canada and Greenland (Fig.1). Sea depths in The Fylla Area range from more than 2 000 m in the southwestern corner to less than 100 m in the northeastern corner. The meteorological and oceanographical conditions of Davis Strait are quite well known on a large scale. Recent descriptions are found in Hermann & Olsen (1981), APP (1981) and Buch (1990). The most detailed information from the offshore area was compiled by DHI (1979) based on environmental studies carried out from 1975 to 1978 in connection with oil exploration drilling in Davis Strait. This offshore study was conducted mainly during the months June, July, August and September. The annual changes in ice conditions are presented in an atlas by GTO (1981).

The meteorological and oceanographical conditions include
1) the bathymetry,
2) wind, visibility and air temperature,
3) waves, currents, sea temperatures and salinity, and
4) ice conditions: fast ice, pack ice and icebergs.

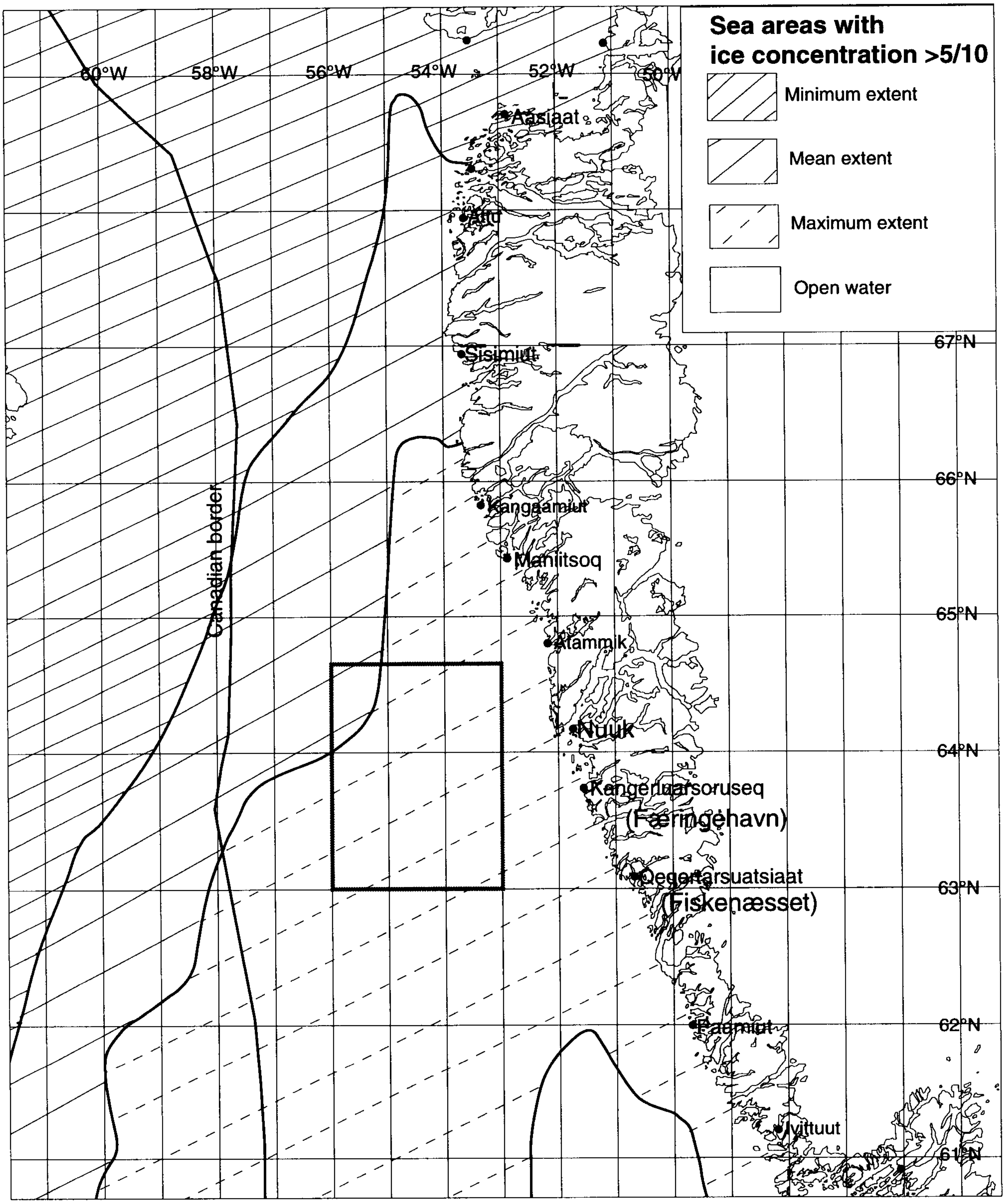

Fig. 3A. Minimum, average and maximum extent of ice concentrations of 50% or more in March, the month with the most extensive ice cover. The information on ice concentrations is based on 574 weekly analyses from 1972 through 1982. (Source: National Climatic Data Center, 1986. Here modified from Greenland Field Investigation Unpublished).

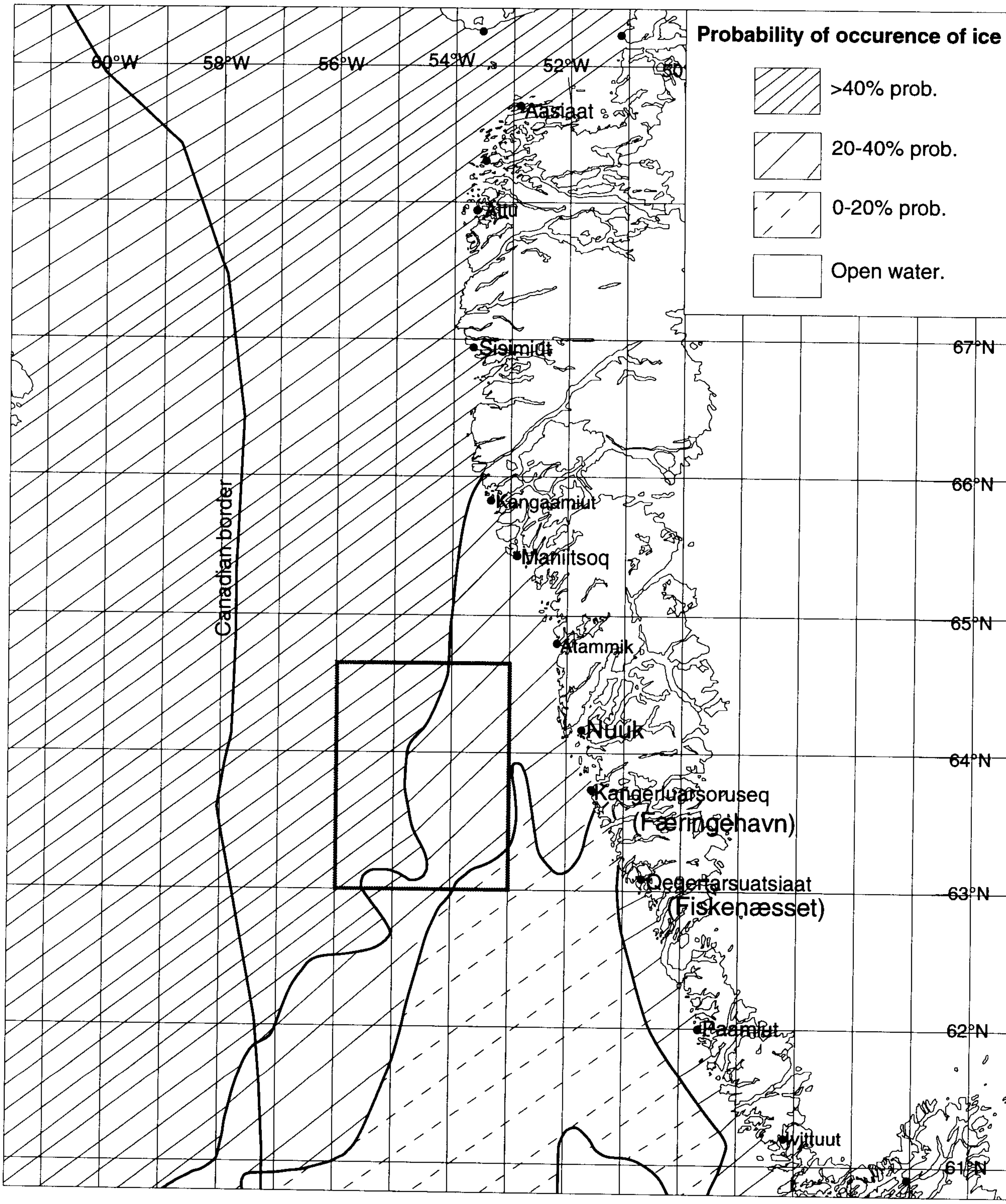

Fig. 3B. Probability of occurrence of any ice in March, the month with the most extensive ice cover. The information on percent probability of occurrence of any ice is based on 574 weekly analyses from 1972 through 1982. (Source: National Climatic Data Center, 1986. Here modified from Greenland Field Investigation Unpublished).

A brief summary of some of these conditions is presented below, particularly those considered to be important to animal life in Davis Strait.

The shelf

The shelf area located off West Greenland includes several large shoals and ranges between 20 and 100 m in depths. The shelf itself stretches from north to south. To the north it is up to 120 km wide, while it becomes narrow to the south. To the west of the shelf there is deep water. Deep water also exists in the channels between the shoals. At its narrowest point, a ridge up to approximately 600 m deep extends between Greenland (at Sisimiut) and Baffin Island (at Cape Dyer). The shoals are illustrated in Fig. 1.

Air and sea surface temperatures were measured offshore in June, July, August, and September in connection with oil exploration drilling from 1975 to 1978, and were found to be positive during that period. No daily mean air or sea temperatures higher than 8° C were recorded. During fall, winter and spring the temperatures are lower, in the southern part of the area positive air temperatures may however occur all year.

The general circulation pattern of the ocean currents is shown in Fig. 2. The dominant current in Davis Strait adjacent to West Greenland is the northgoing West Greenland Current. The surface layer (0-150 m) of this current is dominated by cold water from the East Greenland Current, while the underlying layer (150-800 m) consists of warm water from the Irminger Current (a branch of the Gulf Stream). Mixing and heat diffusion between the two layers are important factors for determining temperature conditions. Years where the East Greenland Current is strong will tend to be cold years.

Open Water Region

As a result of the current pattern there is normally open water at South West Greenland all year round. In this report the area has been termed the Open Water Region. In all other Greenland offshore waters pack ice covers the water entirely or partly at different times of the year or throughout the year.

During winter and spring pack ice from Baffin Bay (the West Ice) partly covers northern Davis Strait. During spring polar pack ice from the East Greenland Current frequently covers the waters in southern Davis Strait at the Greenland coast. The limits of average extent of ice cover in March, the month with largest ice coverage in Greenland waters, is shown in Fig. 3A and 3B. Icebergs are the dominant ice type in the Greenlandic part of the Davis Strait during summer. They are transported by winds and currents moving mainly from the south to the north and west. This is illustrated in Fig. 4.

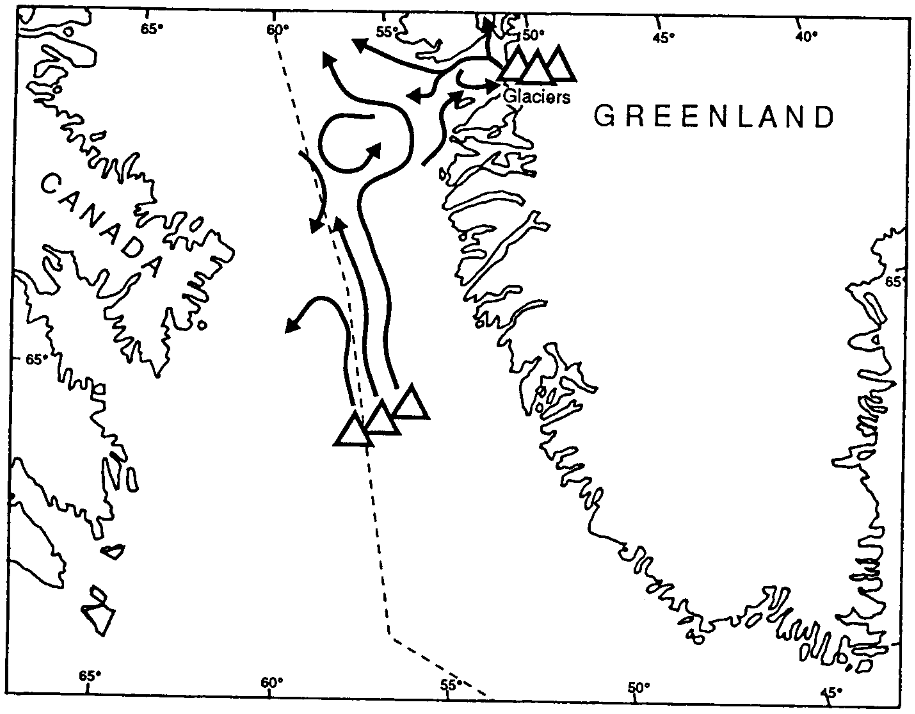

Fig. 4. Examples of ice berg drift in the Davis Strait (modified from Greenland Technical Organisation 1981).

4 Ecology of the eastern Davis Strait

4.1 The offshore ecosystem

The banks off West Greenland, including The Fylla Area, are considered to be among the most productive areas in Greenland waters, and are an important site to birds, marine mammals and fisheries. Upwelling of nutrients that occurs throughout summer at the slopes and the fishing banks sustains high primary productivity for long periods of time. In contrast, primary productivity is low in central and western Davis Strait.

High primary productivity

Smidt (1979) estimated the primary productivity at the mouth of Nuuk Fjord to be in the vicinity of 160 g Carbon/m^2 per year, and considered this to be representative for the productivity off Southwest Greenland. This estimate is higher than estimates of primary productivity in Danish inshore waters (approximately 100 g Carbon/m^2 per year) and the northern North Sea (45-110 g Carbon/m^2 year). However the primary production in the mouth of Nuuk Fjord fluctuates greatly from year to due to variable hydrographic conditions. Such fluctuations are well known from other high latitude marine ecosystems which are largely dependent on an influx of nutrients, like the Barents Sea. Copepods and euphausids (krill) are considered to be the most important components of the pelagic food chain of the offshore - fish and shrimp populations (Hansen et al. 1981). However, the gravel and shell-gravel sediments of the shallow banks are rich in epifauna as well as having a rich and varied infauna, especially at the edge of the banks (Marin ID 1978). At the soft bottom at greater water depths (>200 m) where the sea floor is soft the deep sea shrimp is the dominant species.

Offshore fish assemblage

Offshore fish assemblage in the area is dominated by demersal species (Table 1). German groundfish surveys in the area indicate that since the early 1980's the demersal fish species composition inhabiting the shelf and continental slope off West Greenland down to 400 m depth has changed fundamentally. At the same time there has been a dramatic change in stock abundance, biomass and size structure of ecologically and economically important species. Decreases of biomass estimates vary between 73 % and almost 100 % for cod, American plaice, golden redfish, Atlantic and spotted wolffish and starry skates. There has been no sign of recovery since 1990, and future short-term recovery is considered unlikely (Rätz 1995). An example of the changes occurring in the ecosystem in the last few decades is the decline of the offshore cod stock. In the early 1960's, Atlantic cod was the most important commercial fish species in West Greenland, with

Table 1. Important fish and large invertebrate species in the area (62°-68° N).

Species	Main habitat	Spawning area	Spawning period	Exploitation
Blue mussel	subtidal, rocky coast			s
Scallop	inshore and on the banks with high current velocity, 20 -60 m depth			c & s
Deep sea shrimp	mainly offshore, 100 -600 m depth	larvae released at relatively shallow depth (100-200 m), larvae in middle water-column	(July -September) released March to May	important c
Queen crab	coastal and fjords, 180-400 m depth		released April-May	c
Atlantic cod (offshore stock)	on banks north to 64	(former)western slope of banks, pelagic eggs and larvae in upper water column	March-April,	See text
Greenland cod	inshore/fjords	inshore/fjords, demersal eggs	February-March	c & s
Arctic cod	pelagic	mainly N of 68°		no
Sand eel	on the banks at depths between 10 and 80 m	on the banks, demersal eggs, larvae in the water column	June - July to 66° N later in the north	no, important prey item
Wolffish	inshore and offshore	hard bottom, one area known outside Maniitsoq, demersal eggs	peaks in September	c & s
Atlantic salmon	offshore and coastal	freshwater	-	c & s
Arctic char	coastal, fjords	freshwater	-	c & s
Capelin	coastal	beach, demersal eggs	April-June	c & s, important prey item
Atlantic halibut	offshore and inshore, deep water,	? western slope of banks south of 66° N , pelagic eggs and larvae, deep water	spring	c& s
Greenland halibut	offshore and inshore, deep water,	offshore south of 66° N, deep water, pelagic eggs and larvae	winter	important c & s
Redfish	offshore and in fjords, 150-600 m depth	main spawning southwest of Iceland, larvae drifts to West Greenland banks	-	mainly bycatch & s
Lumpsucker	pelagic	coastal, demersal eggs	May-June	c & s

Exploitation of the species are categorized in c: commercial and s: subsistence fishery.

annual landings peaking at more than 400 000 tons. In the late 1960's the landings showed a drastic decline, and after 1990 the cod has been sparse in West Greenland waters. There are, however, small stationary fjord stocks in the area. The present low productivity of the offshore cod stock is assumed to be due mainly to decreased and unfavorable water temperature conditions for spawning, egg/larvae survival and to changes in the structure of the food web (Pedersen 1994).

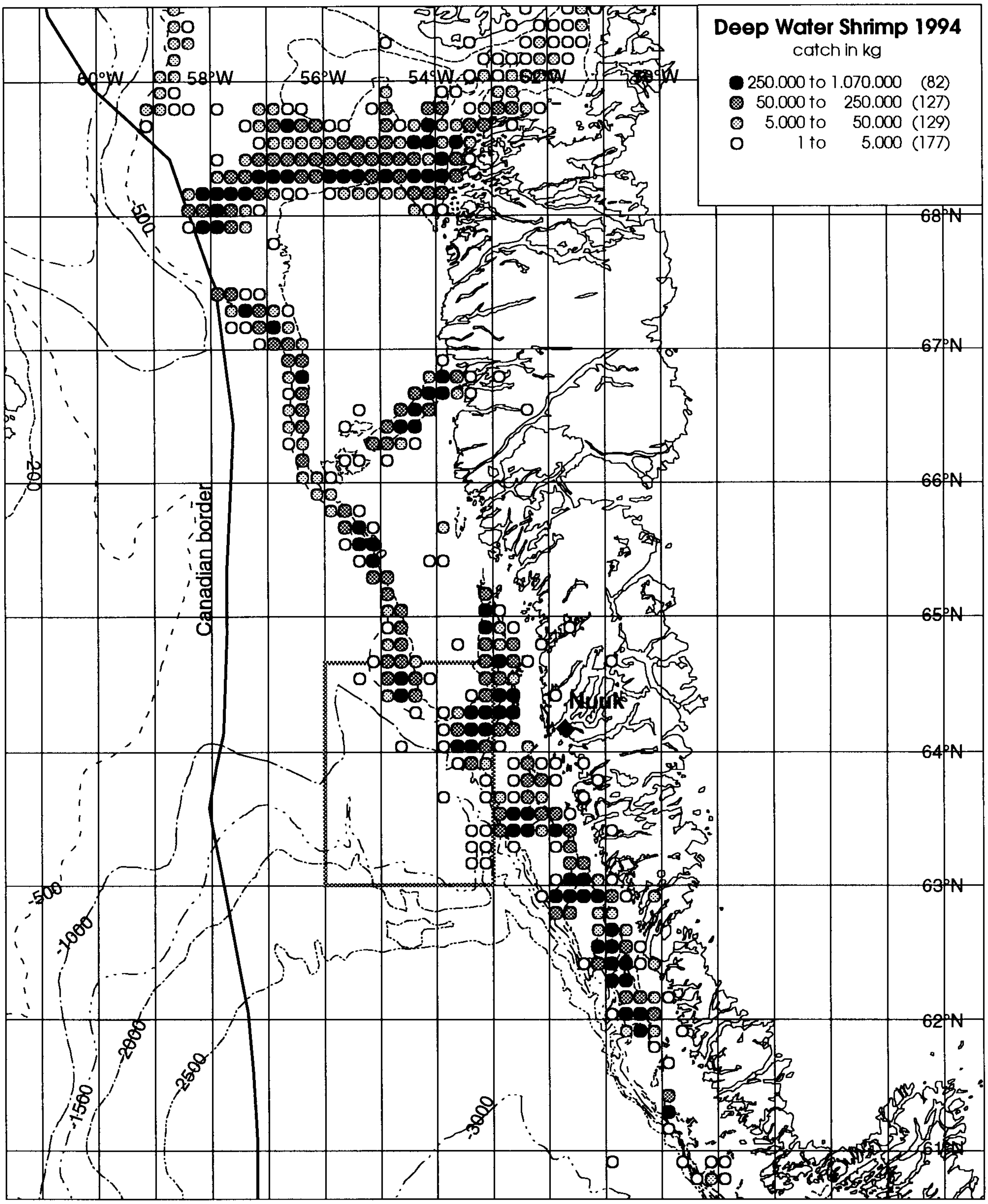

Fig. 5. Distribution of shrimp fishing grounds in the Davis Strait. Based on data from the Greenland Institute of Natural Resources, Nuuk.

Today, the only important offshore fisheries in the area are deep sea shrimp and Greenland halibut. Another important species in the area is the sand eel, which is considered to be a very important prey species in the ecosystem. The three species are be briefly described.

Deep water shrimp

The deep sea shrimp fishery is the most important fishery in Greenland today. The Greenland catch in the Davis Strait area in 1994 was 72 000 tons of which 54 000 tons were caught offshore. The 1995 catch was at a similar level. The majority of the catch (>80 %) is taken between 62° and 69° N. The geographical distribution of the fishery can be seen in Fig. 5. Approximately 6000 tons/year (10 %) is taken within the Fylla Area, with the highest fishing intensity occurring from May to July, and the lowest in September - October. (Based on fishery statistics from the Greenland Institute of Natural Resources, Nuuk).
Shrimps occur in deep water (100-600 m) offshore and in the deep fjords of West Greenland, as far north as Upernavik. They are found in waters with water temperatures ranging from 0° to 4° (Horsted & Smidt 1956, Carlsson & Smidt 1978). Indications of specific nursery areas for juveniles have been found at shallower depths (190 m) on the northwestern part of Store Hellefiskebanke (Carlsson & Kanneworf 1987). Relatively high numbers of shrimp larvae have been found in the Disko Bay area (Pedersen & Smidt 1995).
Shrimps spawn during July to September. Females carry eggs until March - May when they move to somewhat shallower water depths to release the larvae. The larval phase lasts for four months, during which they are pelagic for some of the time (Carlsson & Smidt 1978, Horsted et al. 1978, Klimenkov et al. 1978). During day time both adult and larvae are found near the sea floor, and during night they move upwards in the water column (Horsted & Smidt 1956, Klimenkov et al. 1978).

Greenland halibut

Greenland halibut is a common deep water fish in the fjords and offshore waters from Kap Farvel to Avanersuaq. Spawning takes place during spring and spawning areas are presumed to be in deep water (2-3 000 m) south of the ridge between Greenland and Baffin Island (Smidt 1969). However, spawning may also occur in deep fjords, and some fjord stocks in southwestern Greenland may be recruited from spawning areas off Iceland (Riget & Boje 1989). The eggs and early larval stages remain in the water column at considerable depths (bathypelagic). Later, the larvae rise in the water column and live pelagically (Jensen 1935). They are then dispersed with the currents towards the north and west. The larvae probably settle on the banks, and immature Greenland halibut slowly migrate towards the deep fjords or the deep parts of the Davis Strait (Riget & Boje 1989). The main prey of the adult offshore Greenland halibut is the shrimp, however they also feed on small fish and benthic invertebrates.

A total of about 20 000 tons are taken annually. The main Greenland halibut fishery takes place in fjords north of the Assessment Area (Ilulissat, Uummannaq and Upernavik municipalities). Offshore fisheries carried out by Japanese trawlers a few years ago used to take approximately 1000 tons annually in the area between Nuuk and Sφndre Strφmfjord. The present annual catch in and near the Fylla Area (Fig. 6) is between 4000 and 5000 tons, and is carried out by both trawlers (80 % from September to December) and longliners (20 % from April to December) (Anon. 1995).

Sand eel

Two species of sand eel occur off West Greenland. The most common is the northern sand eel. These are schooling fish, which live offshore on the banks at depths between 10 and 80 m (Andersen 1985). During a survey in 1978, the largest populations were estimated to occur at the western and southern edge of Store Hellefiskebanke, at the southern and southeastern edge of Toqqusaq Banke (in and near The Fylla Area), at Fyllas Banke, and at Fiskenæs Banke (Andersen 1985). The sand eels are an important prey species to cod, salmon, seabirds, seals and baleen whales off West Greenland (Kapel 1979, Larsen & Kapel 1982). More recent studies have found that sand eels are a less important prey species to cod (Grunwald & Koster 1994), which could indicate a dwindling abundance of sand eel at the banks. It is worth noting, however, that the areas presumed to have high sand eel concentrations are still the areas where concentrations of baleen whales are reported.

4.2 Coastal ecosystems

Bedrock shorelines

The coastal zone in the area between 62° - 68° N is dominated by bedrock shorelines with many skeries and several archipelagos. Small bays (pockets) with sand or gravel are found between the rocks in some sheltered areas. Sandy beaches are found in the Marraq-Sermilik area and in the vicinity of the Fredrikshåb Isblink glacier where there are extensive sandy beaches and barrier islands. The flora and fauna of the rocky shoreline has a well developed tidal zonation with numerous barnacles, snails and mussels. The tidal amplitude is 3-4 metres.

Blue mussel and scallop

Two bivalves are exploited in Greenland: the blue mussel and the scallop. The blue mussel is abundant on the rocky shorelines of West Greenland as far north as Upernavik (74°N). Although it is not exploited on commercial basis, subsistence use is widespread. The scallop, on the other hand, is commercially exploited on local scale, with about 1000-1500 tons taken annually in Nuuk municipality. The scallop is common in western Greenland,

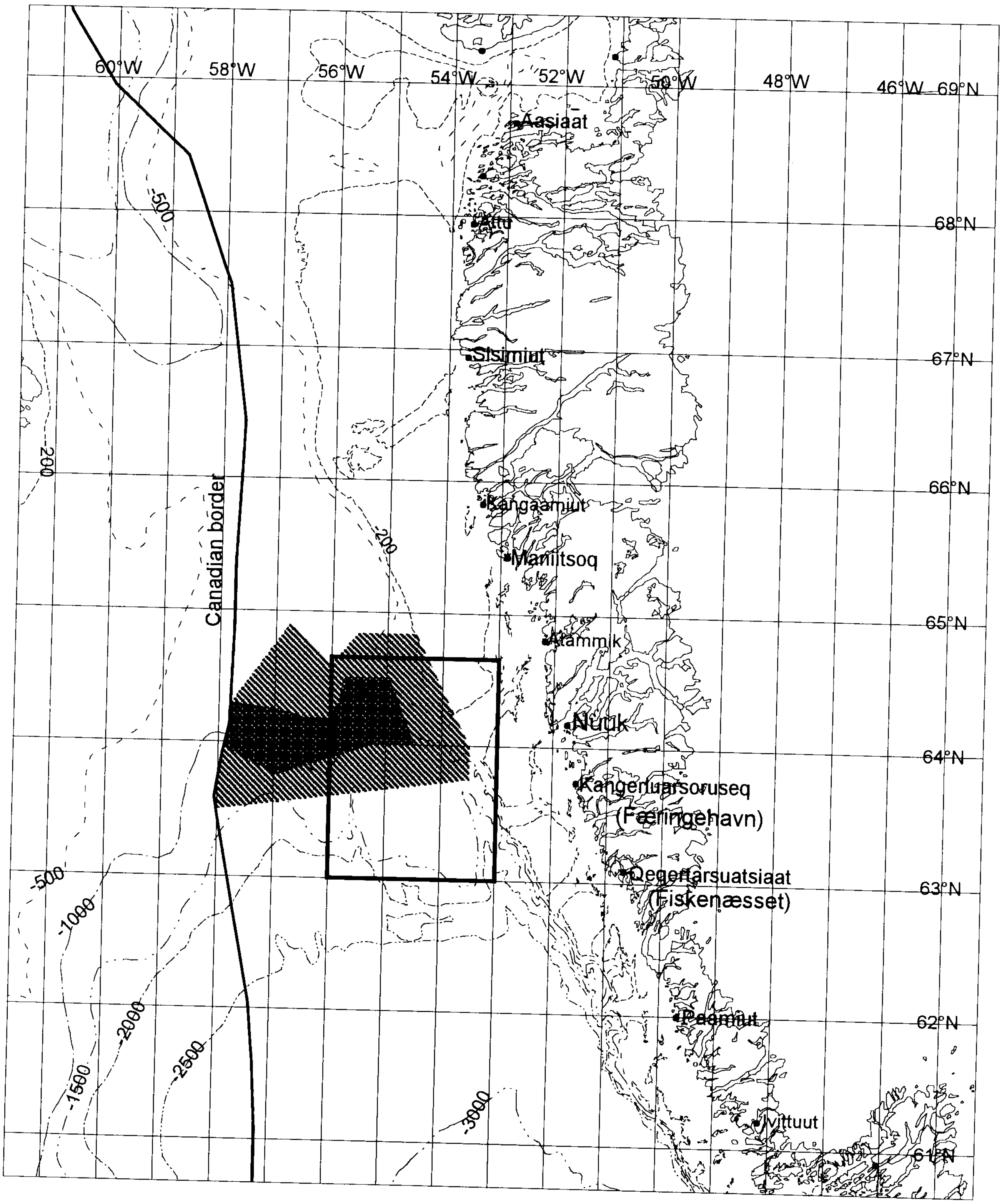

Fig. 6. Distribution of offshore Greenland halibut fishing grounds. The two levels of shading indicate fishing intensity (Based on data from Anon. 1995 and J.Boje pers. comm.).

usually at depths from 20 to 60 m and in areas with large water exchange such as narrow fjords, fjord barriers, and also on the offshore banks (Pedersen 1987, 1988).

Lumpsucker

The lumpsucker is common throughout West Greenland and is found as far north as Uummannaq (71°N). During May-June mature fish seek shallow coastal waters to spawn. Eggs are guarded by the males until they hatch after 14 days. The larvae live in coastal waters near the surface, while the adults probably return to the deep waters of the Davis Strait for the winter (Hansen & Hermann 1953). There is some small scale fishing. During the spawning period, lumpsuckers are often caught at specific areas were they have occurred for generations. "Nipisat" is often the name for such localities. The eggs "caviar" are the main product; 579 tons were landed in 1994 (Anon. 1995).

Capelin

Capelin are common in Davis Strait and occur as far north as Upernavik municipality (74°N) The West Greenland capelin is coastal and rarely occurs offshore on the fishing banks. Greenland capelins are coastal spawners. They spawn during spring and summer; in April in the southern areas and in July in northern areas (Sϕrensen 1985). However, early spawning does also occur in the head of the large fjords, where water temperatures are higher than at the coast. Capelins spawn when they are 3 to 4 years of age. Spawning takes place in shallow waters at the shoreline and on sand or gravel bottom. During spring and early winter, the capelin lives in schools at the outer parts of the fjords, along the coasts or sometimes on the banks. Capelin assemble in the fjords later in the winter, and in spring and summer before the spawning period the schools migrate towards the shoreline. Capelin in West Greenland are believed to belong to several small discrete stocks (Kanneworf 1968, Sϕrensen & Simonsen 1988), making these fish particularly vulnerable to oil spill during spawning. There is a small commercial and a widespread subsistence fishery during spawning periods. The capelin is an extremely important food resource for seabirds, seals and fish such as cod and salmon.

Arctic char

Arctic char are common throughout West Greenland. Two types of Arctic char occur, stationary fish in freshwater and migrating fish, which spawn and winter in rivers and spend the summer in the nearby sea. In the sea they rarely move further away than 50 km from the river (Nielsen 1961). In other words they are coastal, and do not occur offshore. The char is fished in local and small scale fisheries and a large part of the catch is used for private consumption.

4.3 Seabirds

The Fylla Area and the assessment area (62° - 68° N) are rich in seabirds with many species adapted to different ecological niches. Some species feed predominately on fish, such as the thick-billed murres (outer coast and offshore) and cormorants (coastal and fjords), some are surface plankton feeders like the kittiwakes, and some are bottom feeders like eiders (hard bottom) and king eiders (soft bottom). The largest seabird populations are present in the area during winter and the importance of the open water area during the winter season is unique.

Spring

During April and June, when the ice starts to break up further north, large numbers of birds which winter in the open water area leave the area. King eiders head for breeding areas mainly in the western Canadian Arctic, eiders to breeding areas along the Greenland coast and fjords, little auks to the huge colonies in Avanersuaq and thick-billed murres to the large colonies in the northern Baffin Bay as well as Svalbard, Canada and possibly Iceland.

Large numbers of kittiwakes and fulmars, which winter further south, also pass through the area on their way to colonies further north, leaving the area to local breeders and summering non-breeders.

Summer

There are 14 species of colony breeding seabirds in the area (Table 2). The breeding seabird population as well as the average colony sizes (and density) are smaller than further north. The most important colonies in the outer coastal zone are the few thick-billed murre colonies and a number of puffin colonies especially in the area south of Nuuk Fjord (Fig. 7). More than half of the Greenland razorbill population breeds in small colonies (< 100 pairs) in the coastal zone in the area (Table 3) (Fig. 7). The most numerous seabird species in the area, and the species breeding in the largest colonies is the kittiwake (Fig. 8). The colonies are mostly situated in fjords some distance from the outer coast, like most of the glaucous gull and especially Iceland gull colonies. There are many small colonies of black guillemot along the outer coast. There are also small colonies of Arctic tern, razorbill and eider as well as dispersed breeders of eider and great black-baked gull near the outer coast.

In contrast to winter and autumn, the offshore density of seabirds is low during the summer period, when mainly long-range-foraging or nonbreeding fulmars and gulls (kittiwake, glaucous gull and Iceland gull) occur offshore. However, thick-billed murres and puffins from local colonies and nonbreeders also forage outside the fjord mouth and on the banks. From July flocks of several thousand great shearwaters may occur on the banks and along the coast. They breed in the southern hemisphere and spend the southern winter in the North Atlantic.

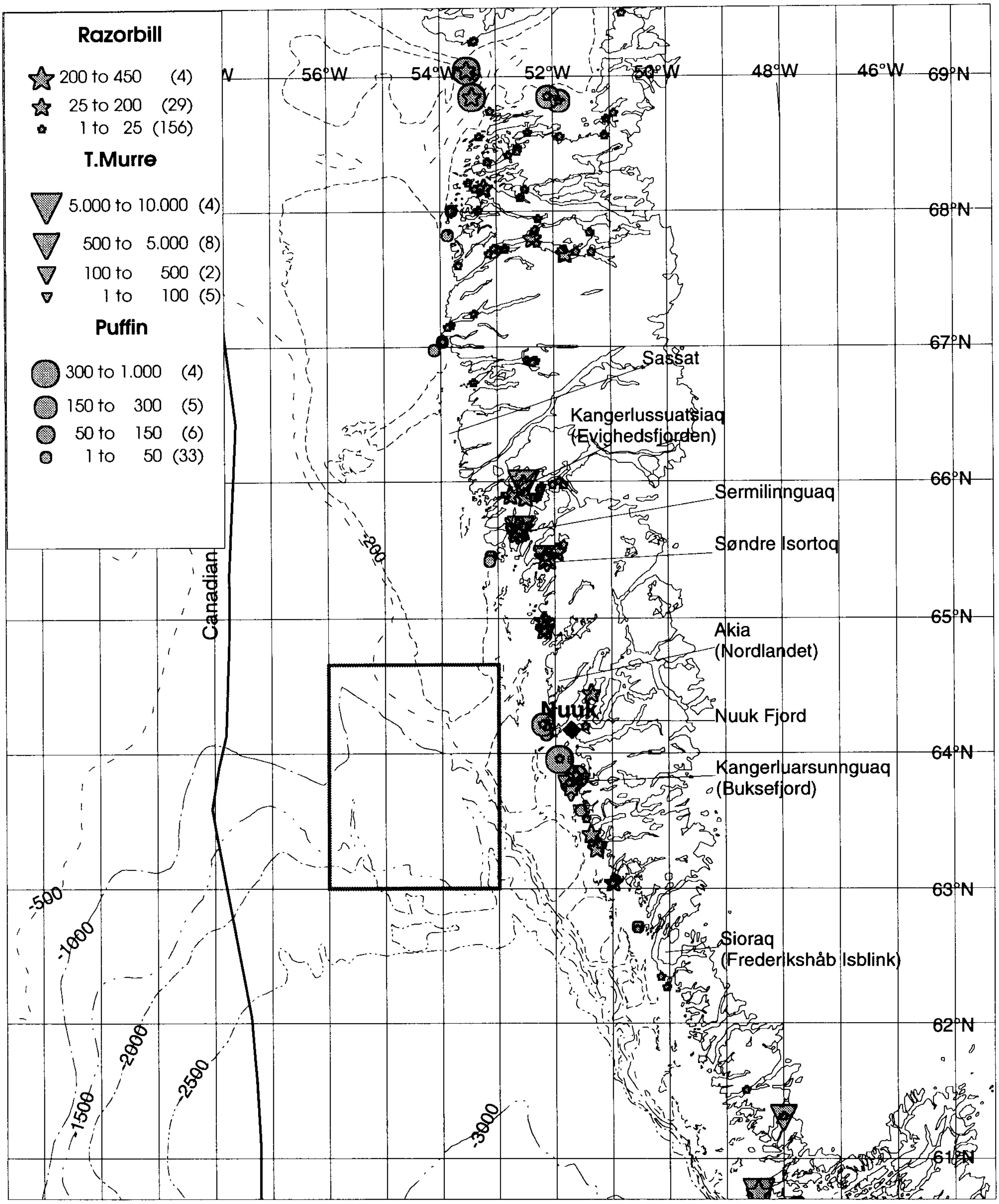

Fig. 7. Colonies of thick-billed murre, puffin and razorbill (May - August). The outer coast and skeries north and south of the Nuuk Fjord has important puffin colonies, and south of Nuuk Fjord is an important and quite isolated thick-billed murre colony.

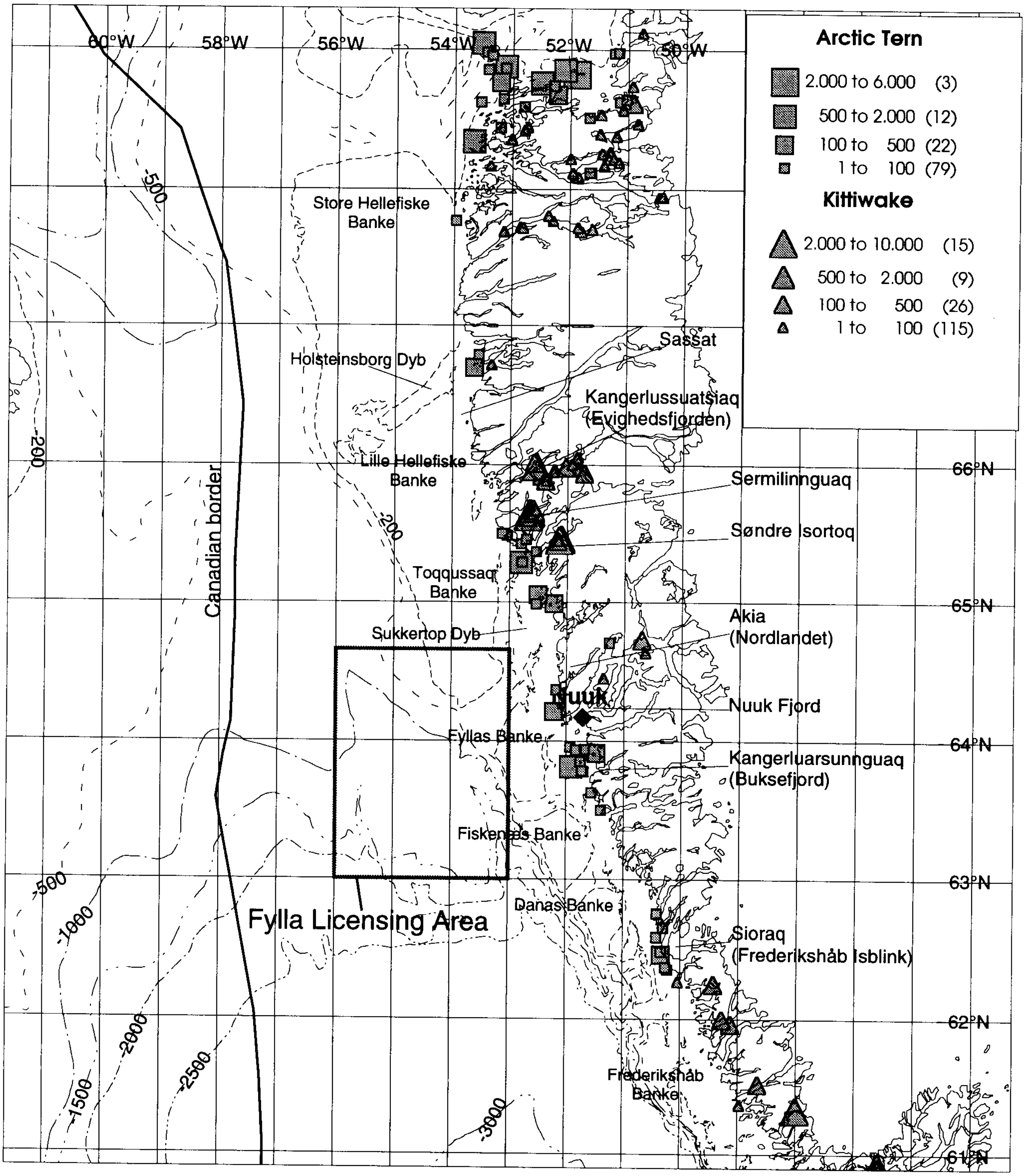

Fig. 8. Colonies of Arctic tern and kittiwake (May - July).

Table 2. Seabird occurrence and activity in the coastal zone and offshore areas between 62° N and 68° N.

Species	Occurrence		Distribution
Fulmar	b/s/w	year-round	c & o
Great shearwater	s	July-October	o
Cormorant	b/s/w	year-round	c, mainly northern part in summer
Eider	b/s/m/w	year-round	c
King eider	(m, few) w	August - September October - May	c c & banks in w
Long-tailed duck	b/m/w	year-round	c & banks in w?
Red-breasted merganser	b/m/w	year-round	c
Harlequin duck	m w	August - September September - April	c (rocky shores) c (rocky shores)
Kittiwake	b/s/(w)	year-round, few in winter	c & o foraging
Glaucous gull	b/s/w	year-round	c & o
Iceland gull	b/s/w	year-round	c & o
Great black-backed gull	b/s/w	year-round	c & o
Arctic tern	b	May - September	c
thick-billed murre	b/s/w	year-round	c & o
Atlantic guillemot	b/w	year-round	c & o
Razorbill	b/w	year-round	c & o
Puffin	b/w	year-round	c & o
Black guillemot	b/w	summer winter	c c & o
Little auk	(b) w	May - August September - May	c & o o
White-tailed eagle	b/w	year-round	c

Occurrence categories: b: breeding. s: summering,. m: moulting, w: wintering.
Categories of distribution: c: coastal, o: offshore.

Moulting seaducks

In August, postbreeders of several duck species gather in the coastal zone for moulting and feeding (Table 3). In August - September seaducks gather in undisturbed coastal areas during moulting of their flight feathers (remiges), where they remain for 3-4 weeks unable to fly. Small eider flocks, both females and immatures and flocks of moulting males, are scattered in the archipelagos along the outer coast. Ikkatooq fjord, in the southern Nuuk municipality supports a large concentration of approx. 1 000 moulting redbreasted mergansers. A surprisingly high number of harlequin ducks use the rocky shores south of the Nuuk fjord in the postbreeding season (Fig. 9).

Autumn

Later in the autumn the concentrations of different auk species start to build up on the banks in the open water area. Thick-billed murres arrive from the colonies further north and little auks from the colonies in Avanersuaq. In October - November thick-billed murres from Svalbard, Canada and possibly Iceland and puffins from Iceland come to the area to winter (Fig. 11).
As the ice covers the sea in Baffin Bay and Disko Bay in December, large numbers of eiders and king eiders from Arctic Canada and high arctic Greenland move south to the open water area for the winter.

Table 3. Seabird populations (individuals) in the coastal zone in the summer and autumn.

Species	Seabird colonies, most recent counts[1]		Postbreeders, moulting/staging in the coastal zone in August[3]	Offshore population September - October[4]
	62°- 68° N	western Greenland	62°- 68° N	62° - 68° N
Fulmar	6	>250 000	-	200 000
Great shearwater	-	-	-	large fluctuations, max. 100 000
Cormorant	1 730	4 200	-	0
Eider	(1500)[2]	(16 500)[2]	20 000	0
King eider	-	-	100	0
Long-tailed duck	-	-	?	? 1- 5 000
Red-breasted merganser	-	-	?	0
Harlequin duck	-	-	1 000	0
Mallard	-	-	?	0
Kittiwake	62 650	206 000	-	> 100 000
Glaucous gull	(1 200)[2]	(12 200)[2]	-	
Iceland gull (+gull sp.)	16 000	65 200	-	all white gulls 100 000
Great black-backed gull	(1 400)[2]	(2 520)[2]	-	5 000
Arctic tern	2 280	29 770	-	0
Thick-billed murre	18 660	492 000	-	500 000
Common murre	>100	>1 000	-	1 000
Razorbill	2 320	3 970	-	2 000
Puffin	990	5 435	-	100 000
Black guillemot	(5 140)[2]	(34 400)[2]	-	10 000
Little auk	3	20 000 000	-	500 000
White-tailed eagle	172	332	-	0

note 1-mainly based on the Greenland Seabird Colony database at NERI/AE, minimum estimates
note 2-breeding in small colonies or dispersed breeder, only a part of the population is included in the colony database
note 3- rough estimates mainly based on an aerial surveys along the outer coast in August 1993
note 4- rough estimates mainly based on shipboard surveys in September - October 1993

Important seabird areas

The most important seabird areas during summer and autumn in the outer coastal zone (62° - 68° N) are

1.-the outer coast between **Nuuk Fjord (Nuup Kangerlua)** and **Buksefjord (Kangerluarsunnguaq)** where the only coastal thick-billed murre colony in the area (62° -68° N) is found (approx. 3000 individuals). There are also several colonies of razorbill, puffin and Arctic tern (Fig. 7 & 8). The area from Nuuk Fjord and further south to **Frederikshåb Isblink** is a moulting area for most of the Greenland harlequin ducks (Fig. 9)

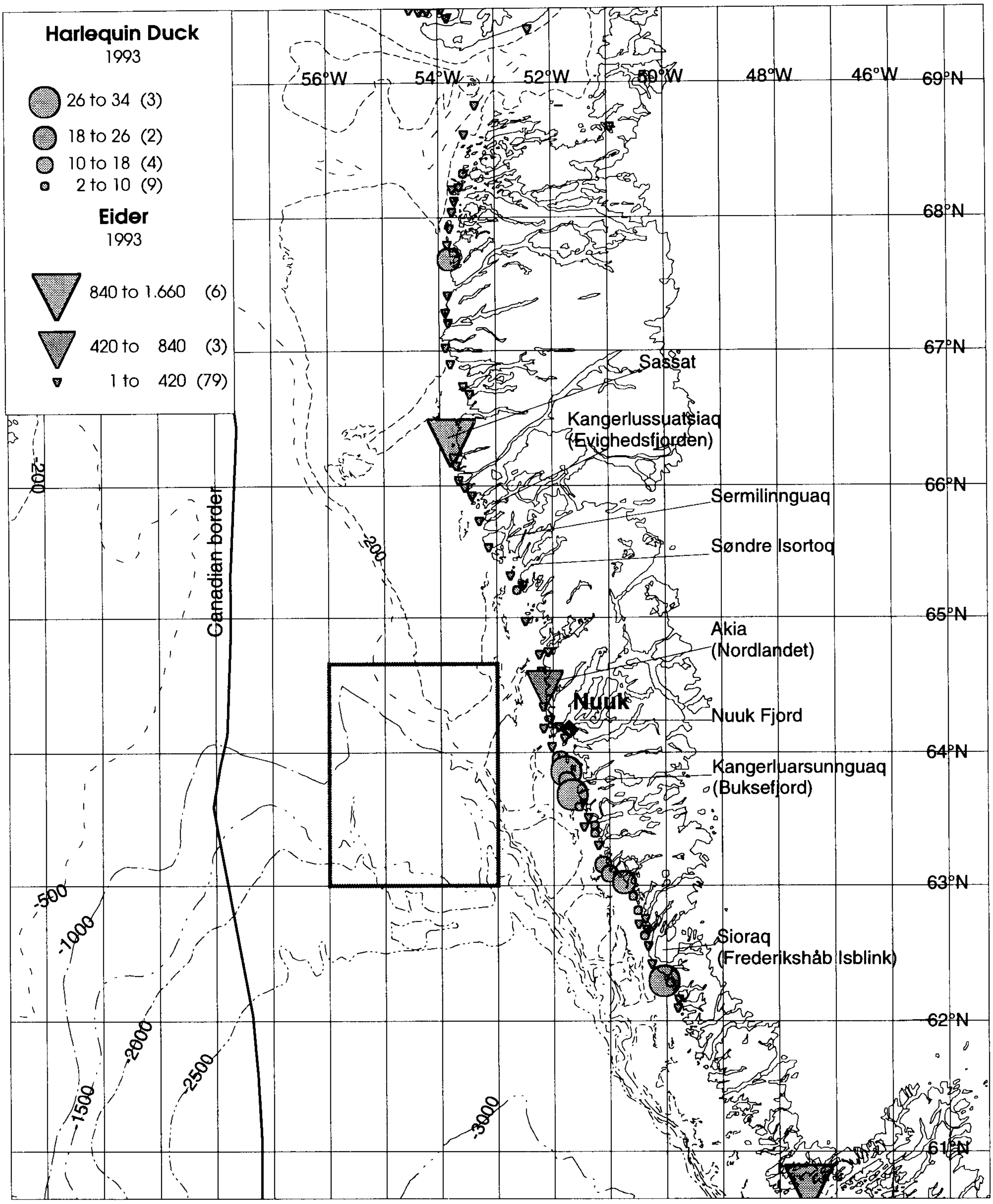

Fig. 9. Moulting areas for harlequin duck and eider. The map shows observations of moulting harlequin ducks and eiders at aerial surveys in the outer coastal zone in August-September 1993. The observed numbers indicates where the important moulting areas are. The numbers are relative and do not represent an estimation of the total population in the area. Sassat (south of Sisimiut) and the western coast of Akia (Nordlandet) are important areas for moulting and postbreeding eiders. The outer coast and skeries South of Nuuk Fjord is an important area for moulting harlequin ducks.

2.-the archipelago on the west coast of **Nordlandet** (NW of Nuuk) has several small seabird colonies and many breeding and postbreeding (>2 000) eiders.

3.-the fjords **Søndre Isortoq, Sermilinnguaq and Evighedsfjorden (Kangerlussuatsiaq)** holds large thick-billed murre colonies quite far from the outer coast, while the mouths of the fjords hold significant concentrations of foraging thick-billed murres in the breeding season.

4.- the extensive archipelago **Sassat** south of Sisimiut (66° 20′ N) has more than 100 pairs of eiders and also holds many (>2 000) postbreeding eiders.

Some aspects of the biology of two auk species (thick-billed murre and puffin) and a diving duck (harlequin duck) will be mentioned to illustrate their vulnerability to oil pollution.

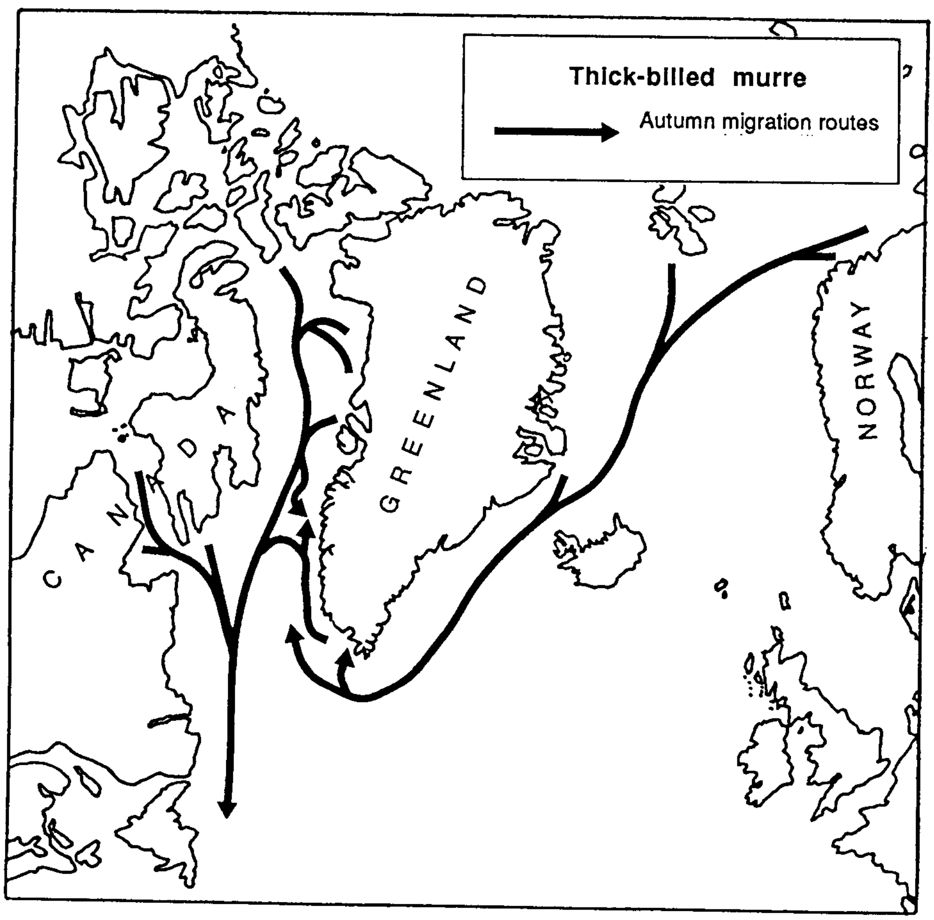

Fig 10. Autumn migration of thick-billed murres occurring in West Greenland waters. Modified from Kampp (1988).

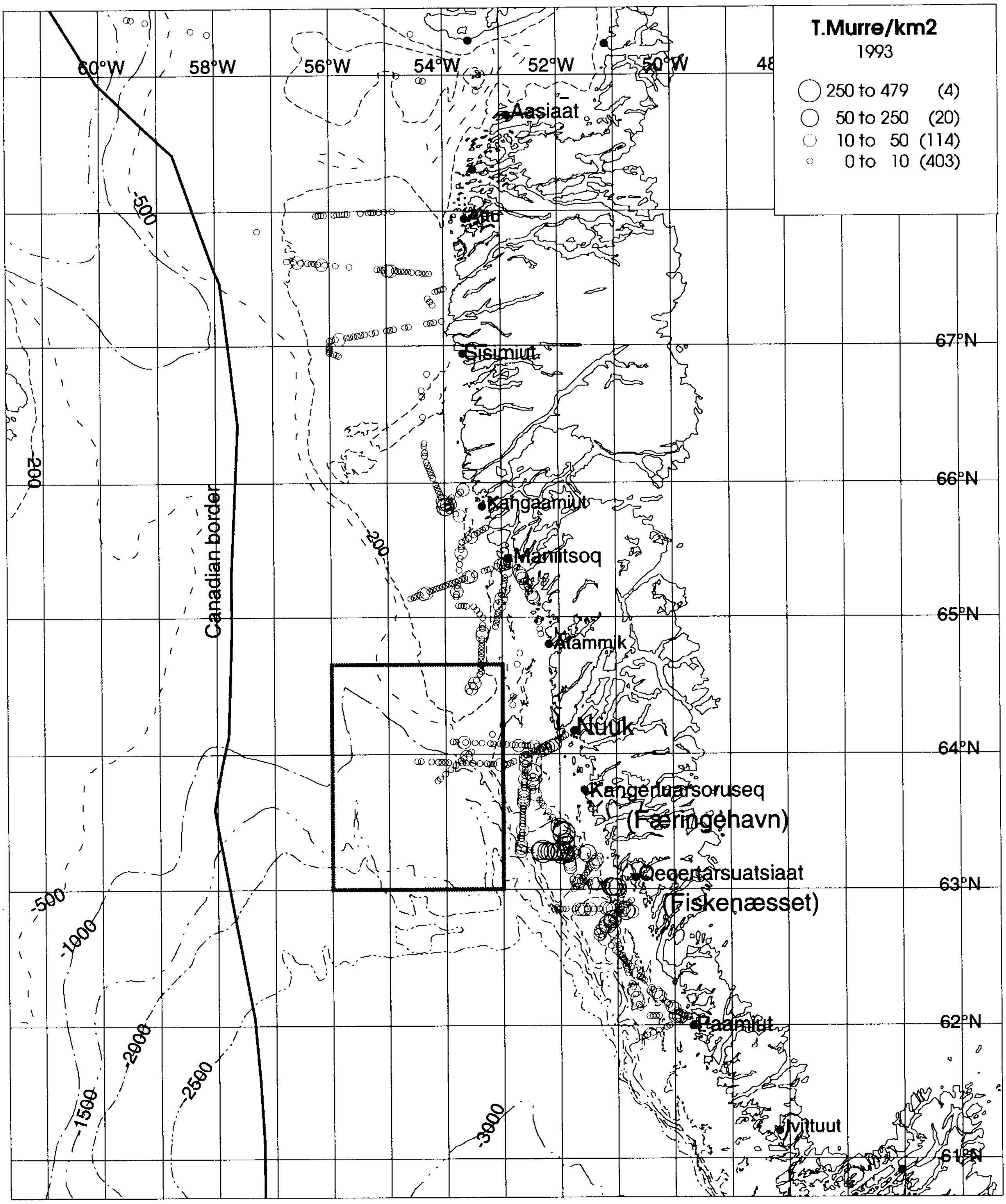

Fig. 11. Concentrations (individuals/km^2) of thick-billed murres on offshore transects in September - October 1993.

Thick-billed murre

Thick-billed murre breed in five colonies between 62° and 68° N (Fig. 7). The size of the colonies range from 1900 to 9600 individuals, and in total the colonies hold approx. 25000 individuals. The thick-billed murres arrive at the colonies during May. The still downy and flightless chicks leap from the breeding ledges from late July to late August. The thick-billed murre families then swim or drift away towards north, usually far from the coast. The adults moult their flight feathers and become flightless for more than one month. There is a very large colony (130 000 pairs) situated at Reid Bay on Baffin Island west of Sisimiut. Flightless adults and juveniles from this colony probably occur on the Greenland side of the Davis Strait in late august (Orr & Ward 1982).

The majority of the West Greenland population moves to winter quarters off Newfoundland, while the remaining birds stay in the northern part of the Open Water Region (Kampp 1988). During the autumn large numbers of thick-billed murres from Svalbard, Arctic Canada, and probably also Avanersuaq municipality, migrate to the Open Water Region, where at least one million spend the winter (Fig. 10) (Kampp 1988).

Breeding thick-billed murres may feed far offshore and feeding flights of up to at least 60 km have been reported (Gaston & Nettleship 1981). However, little is known about feeding areas for the breeding populations of thick-billed murres in Greenland. The population of breeding thick-billed murres in Greenland has seriously decreased over the past few decades, most seriously between Disko Bugt and Upernavik. This decline is ascribed to summer hunting close to the colonies (Kampp et al. 1994). The colony closest to The Fylla area, just outside the Nuuk fjord, appears to be stable or at least not to have decreased between 1977 and 1992 when it was last surveyed. In 1992 the colony had approx. 3 000 individuals (Boertmann & Mosbech in prep.). The thick-billed murre is an important resource in West Greenland. In the Open Water Region, the harvest during winter 1988/89 was estimated to be between 300 000 and 400 000 birds (Falk & Durink 1990). Hunting is not permitted from 15.3 to 15.10.

Puffin

Puffin breed in small colonies on islands close to the open sea, south of Disko Bay. They are most numerous in the Nuuk municipality (Boertmann & Mosbech in prep.) while only very few small colonies are found elsewhere. However, Puffins are more common in Disko Bugt and further north. The puffin's breeding period extends from June to August or September. The chick stays in the nest until it is able to fly. The winter quarters of the Greenland puffins are unknown. However, puffins ringed in colonies in Iceland, Norway and Faeroe Islands have been recovered in the Open Water Region, indicating that puffins from other areas winter there (Salomonsen 1967). In September - October 1993 there were approximately 75 000 puffins on the banks in the open water region south of 66° N, which is much more than the total Greenland breeding population (approx. 5 400 individuals). The puffin is protected from hunting.

Harlequin duck

The Harlequin duck is a rather rare breeder in West Greenland nesting at turbulent rivers. When the females brood, the males move to exposed rocky coasts to moult. There males and non-breeders spend the summer. When juveniles are able to fly, they migrate to these localities along with the females, where the entire population spends the winter. The Greenland population is probably isolated from the populations in Iceland and North America. The majority of the male population disperse along the Greenland coasts of Davis Strait during summer, but seems to be concentrated between Nuuk and Paamiut. The harlequin duck is protected from hunting.

4.4 Marine mammals

The Fylla Area and the assessment area (62°-68°N) has always been inhabited by a large number of marine mammal species. Each species has adapted to the arctic environment to become specialized to different ecological niches. One of the important specialization's is food preferences. Some of the marine mammals, such as walruses and bearded seals feed on the benthic fauna in "shallow" (<50 m) water. Ringed seals, harp seals and harbour seals feed on a broad range of pelagic prey items, whereas hooded seals mainly feed close to the bottom at great depths. Whales show a similar feeding segregation. Baleen whales feed pelagic on krill and smaller fish species often present in the productive upwelling areas of the banks at depths less than 200 m. Toothed whales cover a broader depth range. Harbour porpoises feed on fish in the upper water layers whereas e.g. sperm whales and narwhals are deep divers capable of going down to depths more than 1000 m to feed. Marine mammals are also separated in time and space. In March and April bowheads, narwhals, belugas and walruses still inhabit the pack ice. During this period the hooded seals give birth to their young on the ice on whelping grounds in the central Davis Strait between 62° and 64° N. As the ice starts to break these ice associated animals moves further north through "The mouth of the sea". In May-June new species like minke, humpback, and fin whales arrive from the south and some species like the sei and blue whales do not arrive before July. Ringed seals can be seen in all areas year round, but is most often seen in association with ice. Harp and hooded seals start their migration along the Greenland coasts in May-June and stays until October. Details on these patterns are summarized in Table 4. Several of the marine mammals mentioned in Table 4 are present in West Greenland between 62 and 68°N during summer. However, only few species show a specialized site preference in or close to The Fylla area.

Table 4. Overview of marine mammals present in the Fylla area or areas that could be affected by operations in the Fylla area (62° - 68° N).

Species	Period	Main habitat	Fylla importance	Stock size	Protection/ exploitation	Stock status
Bowhead whale	March-May	Pack ice/ice edge	SA	250	Protected (1930)	Vulnerable
Minke whale	April-November	Coastal waters	NEI	8 371	Hunting regulated	Unknown
Sei whale	July-October	?	NEI	?	Protected (1993)	Vulnerable
Humpback whale	June-November	Edge of banks	EI	430	Protected (1986)	Vulnerable
Fin whale	June-October	Edge of banks	NEI	<2 000	Hunting regulated	Vulnerable
Blue whale	July-October	Edge of banks	NEI	?	Protected (1966)	Endangered
Harbour porpoise	April-November	Whole area	NEI	?	Hunting unregulated	Unknown
Bottlenose whale	(June-August)	Deep water	NEI	?	Hunting unregulated	Unknown
Pilot whale	June-October	?	NEI	?	Hunting unregulated	Unknown
Killer whale	June-August	Whole area	NEI	?	Hunting unregulated	Unknown
Sperm whale	May-November	Deep water	NEI	?	Protected (1985)	Unknown
Harp seal	June-October	Whole area	NEI	2-3 mill.	Hunting unregulated	Not threatened
Hooded seal	May-October	Whole area	SA	100 000	Hunting unregulated	Not threatened
Ringed seal	Whole year	Whole area	NEI	?	Hunting unregulated	Not threatened
Harbour seal	Whole year	Coastal waters	PA	?	Hunting regulated	Vulnerable

Abbreviations used: SA: Area visited in early spring. NEI: Not ecological important, i.e. few animals present during summer. EI: Ecological important for a significant number of animals during summer. PA: Possible impact in coastal areas from an oil spill in the Fylla area.

Humpback whale

The available observations on marine mammals show that the humpback whale frequents the banks close to The Fylla area every summer. They occur in the Davis Strait from June to November and most frequently in July and August (Kapel 1979). Their distribution, based on annual surveys made during the last decade, seems to be relatively close to the coast compared to the fin whale for example (Boertmann et al. 1992). They are sighted most frequently in the region between Paamiut and the mouth of Søndre Strømfjord. A number of areas with higher densities have been observed at the eastern edge of Fyllas Banke (off Nuuk), the eastern edge of Fiskenæs and Danas Banke as well as the continental slope off Paamiut (Fig. 12). The areas off Nuuk and Paamiut were traditional catching sites in Greenland, however, whales have been protected since 1986. Only few sightings have been recorded within The Fylla Area. No report has been made in relation to the feeding habits of humpback whales from the Greenland area, however small krill like euphausiids and sand lance are believed to be of importance (Winn & Reichley 1985 and F. Larsen pers. comm.). The summer population of humpbacks off West Greenland is probably discrete (Katona & Beard 1990) and was estimated at approx. 400 individuals in 1988 and 1989 (Larsen

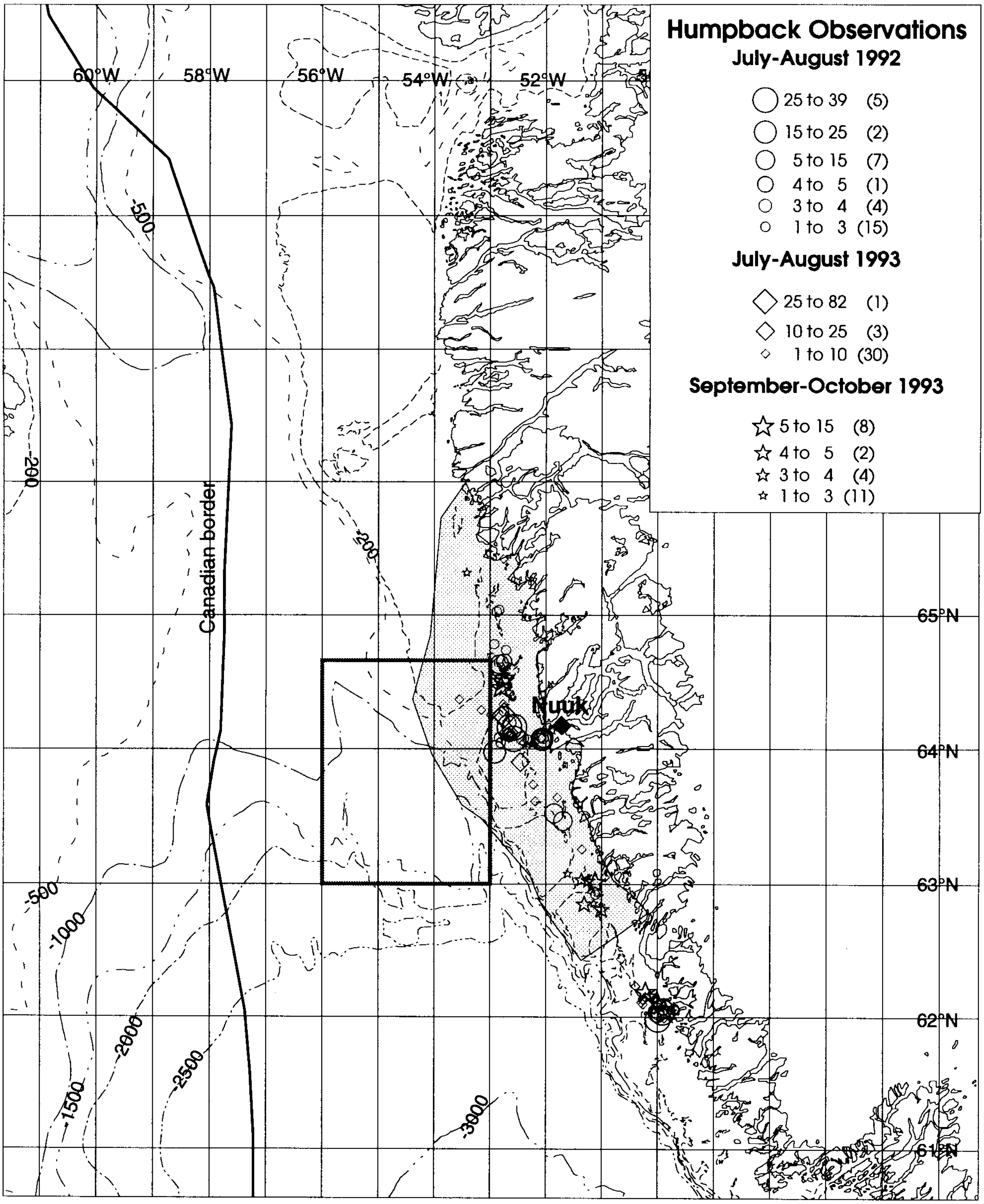

Fig. 12. Observations of humpback whales. The hatched area indicates possible zone of influence from seismic sound sources.

& Hammond 1990). Calculations from 1989 and 1990 gave a similar figure (430 ind.) according to F. Larsen (pers. comm.). Estimates of the total northern Atlantic stock are within the range of 5 000-6 500 animals (Klinowska & Cooke 1991). The species is still regarded as vulnerable despite signs of recovery under protection (Klinowska & Cooke 1991). According to the IUCN Red Data Book, the identification and protection of critical feeding and breeding habitats are needed to allow recovery to proceed unhindered. Humpback whales undertake substantial annual migrations. Photoidentification of fluke patterns have revealed a connection between the West Greenland and Newfoundland summering stocks as well as the wintering grounds in the Caribbean (Larsen 1991). In order to protect this population the winter breeding grounds off the Dominican Republic have recently been designated a sanctuary (F. Larsen pers. comm.).

Other whales

Although the other baleen whales may regularly appear in or close to The Fylla Area, they do not show the same kind of site fidelity to the area as the humpback whale.

Minke whales are distributed throughout the area with some preference for the west side of the fishing banks Store Hellefiskebanke and Lille Hellefiskebanke. However, since 1983 concentrations of minke whales have not been seen in these areas. Instead, they seem to be distributed further to the south and closer to the coast and in the fjords (Larsen 1984, 1985, pers. comm.). Fin whales occur on the western edges of the fishing banks and in some of the deep channels whereas sei whales and blue whales are rare in Davis Strait and only occur in small numbers. The smallest of the toothed whales, the harbour porpoise, is common in West Greenland waters, both offshore and inshore. They occur all year round in the Open Water Region. The bottlenose whale and sperm whale both tend to occur at great depths and are likely to be encountered in The Fylla Area. However, rather limited information is available on these two species. Sperm whale males (females are not seen in Greenland) are mainly seen outside the fishing banks, in the channels between the banks, and occasionally in the deep fjords. During annual summer surveys carried out since 1979, from 2 to 29 sperm whales have been seen at a time. In general, observations are widely dispersed, however sperm whales have been frequently seen in Sukkertoppen Dyb, around Fyllas Banke and Danas Banke (Larsen 1981, 1983, 1984, 1985, Kapel & Larsen 1982, Larsen & Nielsen 1988, Larsen et al. 1989, Boertmann et al. 1992). Small scale hunting took place until 1972, however the sperm whale has been protected since 1985. Most other toothed whales occur as more or less rare summer visitors, although they may sometimes also be present during winter (see Table 4).

Ringed seal

The ringed seal is the most common seal in Greenland. As ringed seals are most common in areas with ice, their distribution in West Greenland is mainly north of 69° N. They are usually associated with coastal areas, where they breed in fjords with stable ice cover. However, large offshore populations also occur in the drift ice of Baffin Bay (Kapel 1982, Finley et al. 1983). The harp seal and hooded seal are both migrating seals which arrive in large numbers along the Greenland coasts during summer. The harp seal is the second-most important seal in the Greenland subsistence hunting.

Harbour seal

Harbour seals occur in the archipelagoes of Greenland where they whelp during early summer and in the fjords where they moult on banks often in estuaries (Vibe 1990, Teilmann & Dietz 1994). This species is rare today, and limited information is known on their present numbers and distribution. Harbour seals occur regularly in the head of Søndre Strømfjord during the summer. This population has decreased from several hundred individuals in the early 1960s to less than 10 today. The harbour seal is the only seal that hauls out on land in Greenland. From late May to August it breeds and moults on land in certain fjords and on some remote skerries. This behaviour makes the species particularly vulnerable to hunting, disturbance, oil spills etc. Of the eight known previous offshore locations between Nuuk and Aasiaat listed by Teilmann & Dietz (1994), harbour seals are only known to still be present at three, and only one of these locations (Ikatua) is still known to be a breeding site.

5 Expected oil exploration activities which can impact the environment

Oil exploration in The Fylla Area is expected to start with a number of seismic programmes including 3D seismic surveys, and in a few years exploratory drilling is expected to start in the area. This section describes the main activities which can have an impact on the environment. These activities are seismic operations, exploratory drilling and accidental oil spills.

5.1 Seismic operations

The most common energy source used in marine geophysical surveys is airgun arrays. Airguns function by suddenly venting high-pressure air into the water (Richardson et al. 1995). Large arrays of 12-70 airguns or even more are towed at a depth of 4-8 m. Behind the airguns is a long cable with a number of hydrophones to receive the reflected signals from beneath the seafloor (Richardson et al. 1995). Peak levels of sound pulses from airgun arrays are much higher than the continuous sound from any ship or industrial source. Broadband source levels of 248-255 dB re 1 μPa-m are typical for a full-scale array (Richardson et al. 1995). The signals from airguns are short sharp pulses typically emitted every 10-15 seconds, although shorter or longer intervals may be used. Most emitted energy lies within 10 to 120 Hz, but the pulses contain considerably more energy, up to 500 to 1000 Hz. In waters 25-50 m deep, airguns are often audible to ranges of 50-75 km, and in deeper water or during quiet times with efficient propagation, detection ranges can exceed 100 km.

5.2 Exploratory drilling

Exploratory drilling is expected to take place from drill ships or semisubmersibles operating for a period of approx. 3 months for each well drilled. For operational and safety reasons there will be an exclusion zone extending 1 - 3 km^2 around the drilling rig/vessel during the drilling. Fishing and unauthorized sailing is normally not allowed in this zone. It is assumed that exploratory drilling will only take place during summer when the operational conditions are most favourable. In a development and exploitation phase, the company operations are going to take place on a year round basis, however, a number of environmental problems will first need to be addressed.

The most probable scenario of a drilling operation in West Greenland would be drilling by semisubmersibles or drillships.

Such vessels can either be anchored firmly or dynamically positioned, depending on the water depths. Drilling vessels are supported by supply vessels and, in some cases, by icebreakers.

Noise

Drillships are noisier than semisubmersibles, as the latter lack a large hull area. Semisubmersibles have the machinery raised above the water so sound and vibrations are carried to the water through either the air or the risers in contrast to direct path through the hull of a drillship (Richardson et al. 1995). The source levels estimated from the semisubmersible SEDCO 708 operating in the Bering sea was 154 dB re 1 μPa-m (80-4000Hz) whereas as the drillship Kulluk emitted between 179 to 191 dB re 1 μPa-m (10-10 000 Hz) during tripping and drilling (Richardson et al. 1995). If vessels are dynamically positioned, noise will be generated from the propellers and thrusters as well. The primary sources of sound from vessels are produced by cavitation, propeller singing and propulsion, and other machinery. The noise from the propellers and thrusters of a semisubmersible or a drillship is not greater than the noise from other vessels of a similar size. However, the noise from stationary vessels will constantly add to the background noise, with the potential of masking marine mammal communication in the area.

Discharges

During drilling there will be a regular discharge of cuttings and drilling fluids, sewage from kitchen and lavatory and water runoff from the rig surface. A discharge of 500 m^3 cuttings and 600-3000 m^3 drilling fluid will usually be produced for each well. Discharge of oil-based drilling fluids in the North Sea has created pollution in oil exploration areas and may course tainting in bottom fish. Water based drilling fluids are generally of less environmental concern. However several hundred chemicals are used in the different water based drilling fluids, and for some of them the chemical composition and toxicity are not well documented. This situation is slowly improving due to tighter regulation and international cooperation.

Barite, a weighting agent used in the drilling fluid, is by far the main component of most water based drilling fluids, with a typical consumption of 1500 tons/well . It consists of $BaSO_4$ but also contains impurities of oxides and heavy metals. Some of the used drilling fluid together with cuttings, will be discharged from the rig, and it is likely to cause local changes in sediment composition. No acute toxic effects are expected for water-based drilling fluids, however elevated concentrations of metals (barite) can be expected several km's away from the drill site. Studies of benthic communities in the Norwegian offshore oil- and gas fields show that barite and other compounds associated with discharges may have an environmental impact, however there is a clear reduction in the biological effects when compared to the use of oil based drilling fluids (Olsgård & Gray 1995).

5.3 Accidental oil spills

There is a risk of accidental spills of oil during offshore exploratory drilling. Most spills are small (less than 1 m^3) however large spills due to blowouts can also occur and can be the cause of the most significant environmental impacts associated with offshore oil exploration. Based on historical data, the probability of a blowout is 1 blowout for each 1800 exploratory or delineation wells drilled (0,055%) (Thomassen et al. 1993).

Drift simulations

A scenario approach for 3 different oil types and 3 different drilling positions for a major blowout offshore West Greenland (flow rate of 2000 m^3/d for 30 days) were selected to assess oil spill drift, fate simulations and countermeasures (Ross 1992, Christensen et al. 1993). The three drilling positions involved in the imaginary oil spills are located in the northeastern part of The Fylla Area (64° 30′N 54° 15′ W) west of The Fylla Area (63° N 51° W) and northeast of The Fylla Area (65° N 56° W).With average weather and wave conditions, evaporation and natural dispersion would remove 30 - 77 % of light oil, and 12 - 32 % of heavy oil within a 1 kilometer radius from the spill site. Evaluation of offshore cleanup possibilities showed that with the best practicable cleanup capabilities, recovery efficiencies would range from 7 % to 25 %, and if dispersants were applied, dispersion efficiencies would be approximately 25 %. Accordingly, with all scenarios, it would be unavoidable that large amounts of oil (20 - 70 % of original volume) would escape the countermeasures, primarily because of the inability to operate during the night and under high sea state conditions (Ross 1992). The fate of the oil-slicks in the scenarios differed depending on the oil type and distance to the coast from the release point. It was concluded that light oil released far offshore (100 km) would be quickly removed from the water surface, primarily by natural dispersion and evaporation, and with little risk of reaching the coast. At the other extreme, a heavy oil released close to the shore could foul up to three hundred kilometers of coastline (Christensen et al. 1993). Spills at most locations could potentially reach any subarea within an area 200-300 km wide and 300-600 km long, but would only cover a small fraction of this area. An example of the oil spill simulations is shown in figure 13. The study concluded that oil spreading from blowouts in the 1993 licensing area could potentially threaten the Greenland coast from Fiskenæsset to Disko Bugt (DHI 1992). The Fylla Area does not extend as far north as the 1993 area, and for the purpose of this assessment we have chosen an oil spill risk area in the Greenland part of Davis Strait between Paamiut (62° N) and Attu (68° N).

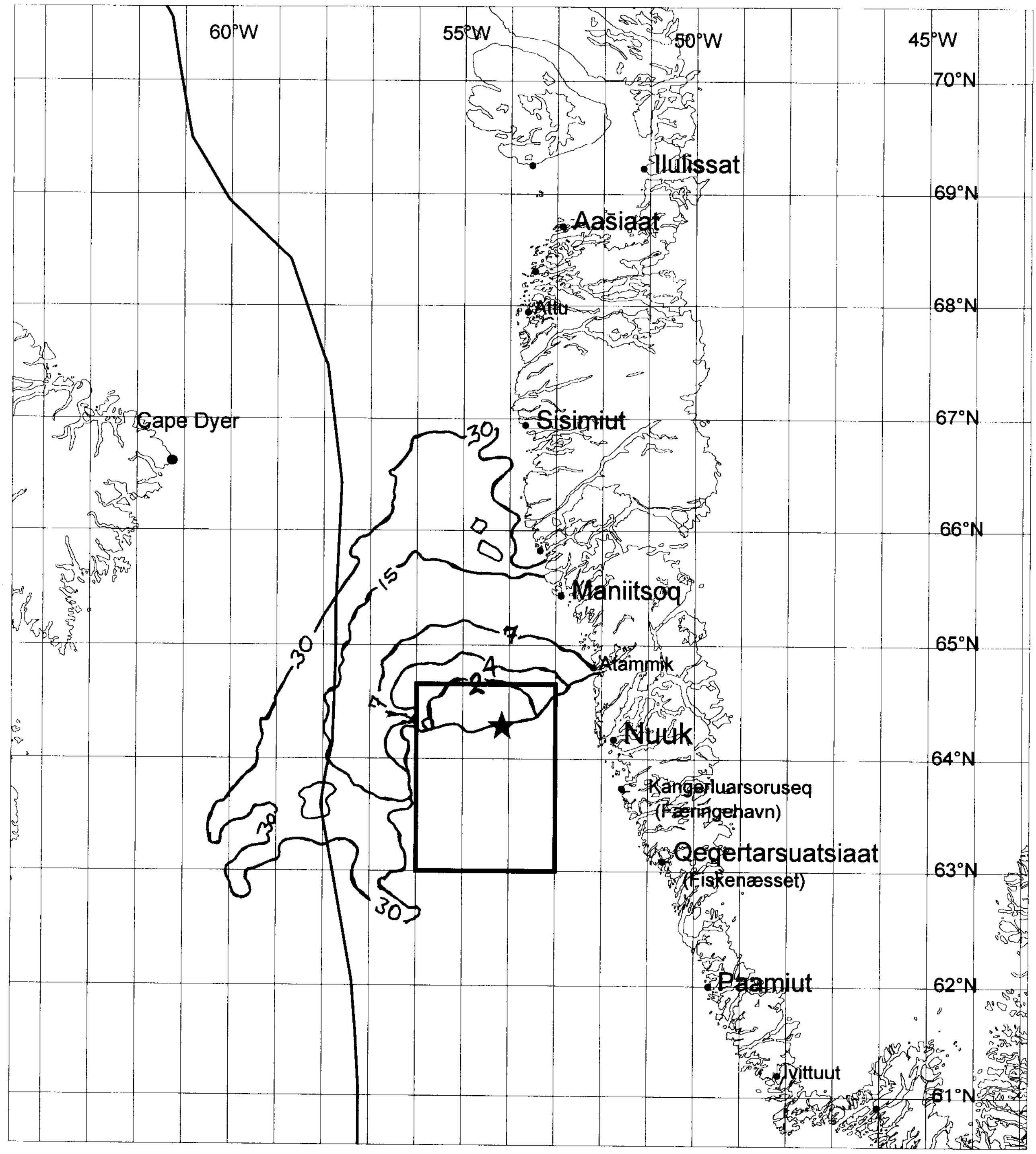

Fig. 13 Time of first contamination according to the simulations given that a spill has occurred at spill point 64° 30′ N, 54° 15′ W. Unit is number of days. The figure shows how far the oil potentially can move in 2, 4, 7, 15 and 30 days. It is important to realize that the contour lines do not represent the potential slick size, but rather the maximum distance a slick could move from the spill point within a specified time. Furthermore the contour lines do not illustrate the weathering processes whereby the oil will evaporate and disperse from the sea surface. The rate of removal of oil from the sea surface depends on the oil type and weather conditions. It is estimated that between 5% and 50% of a heavy oil will remain when the slick reaches the coast, and less or nothing for a light oil (figure modified from Christensen et al 1993).

6 Potential impact of oil exploration in the Fylla Area

6.1 Potential impact of noise (in air)

Noise from oil activities in the Arctic can disturb wildlife which are unfamiliar with industrial noise and which do not readily habituate to it. Aircraft's, and especially helicopters, are used extensively in Arctic oil exploration and can cause significant disturbance in e.g. thick-billed murre colonies (Fjeld et al. 1988, Olsson & Gabrielsen 1990) The research suggest the helicopter traffic should maintain a minimum distance of 3 to 6 km from thick-billed murre colonies, depending on traffic intensity. Marine mammals can be also be disturbed by aircrafts e.g. walruses can be disturbed at their haul-out sites, where helicopter traffic can cause mortality as a result of stampedes (Fish and Wildlife Service 1993).

During exploration in The Fylla Area, regular helicopter traffic between coastal towns and ships / platforms could potentially disturb coastal seabird colonies, especially the thick-billed murre colony south of Nuuk Fjord. However, this can easily be avoided by maintaining a distance of 5 km from the thick-billed murre colonies and more than 200 m to other important seabird colonies in the breeding season.

6.2 Potential impact of underwater noise

Underwater noise is generated from seismic activities, drilling and icebreaking vessels. Underwater noise can disturb fish and marine mammals, and can potentially mask marine mammal underwater communication and perception of natural sounds of importance. Birds are not likely to be impacted (Dietz & Mosbech 1989, Davis et al. 1991, Richardson et al. 1995).

Ambient noise

The sea is far from being a silent environment, even without the contributions of man-made noise. The velocity of sound in water is four times greater than in air, and the transmission loss in water is much lower due to lower attenuation. Therefore sound pressure waves can travel long distances under water. However, there are great variations between locations because transmission loss is strongly dependent on local conditions such as water depth, sound velocity profile and amount and type of ice cover. Ice cover reduces sound propagation because reflections are scattered from the rough underside of the ice. The ambient noise level under fast ice is low, as ice reduces sound waves in general, while ice-break-up and calving icebergs create considerable noise. This natural noise is characterized by a relatively constant base level with overlying periodic powerful pulses.

6.1.1 Fish, shrimps and seismic activity

Fish

Concern has been raised, especially in Norway, that fish populations may be negatively affected by the seismic airgun arrays usually used in offshore seismic surveys (Bjørke et al 1991). The pressure waves from the airgun can cause instant egg and larval mortality within app. 1.5 metres and mortal lesions within a distance of 3-6.5 metres from the airgun. However, because of the relatively limited water volume affected, the ecological effect of this mortality will be marginal, unless the seismic lines are very close in an area where fish and larvae are very concentrated. In Norway, seismic activities are strictly regulated (Bjørke et al. 1991) until the possible impacts are further investigated.

Fish generally display avoidance patterns in response to the seismic pressure waves. When cod and redfish are 30-50 mm long, they have the swimming ability to avoid the mortal zone near the airguns. Adult fish generally swim to the bottom and escape. It has been estimated, from seismic source pressure, fish hearing ability and general fish behavior, that fish will react to a seismic array at a distance of more than 30 km, and intense avoidance behavior can be expected within 1-5 km (Fig.14)(Nakken 1992). Norwegian studies (Engås et al. 1993, Soldal & Løkkeborg 1993) measured fish densities around a small area (4x4 km) experiencing intense seismic activity (3D). Fish density was measured using trawls, longliners and acoustic methods and was reduced by 50% within 10-25 km from the site of seismic activity. Five days after seismic activity stopped the fish density had not yet been reestablished. The results are surprising considering decades of coexistence of fishery and oil exploration in e.g. The North Sea. However, temporal displacement of fish is not necessarily harmful to either fish or fishery, however further research is needed. Spawning should be given special consideration because displacement during spawning may affect recruitment to fish stocks.

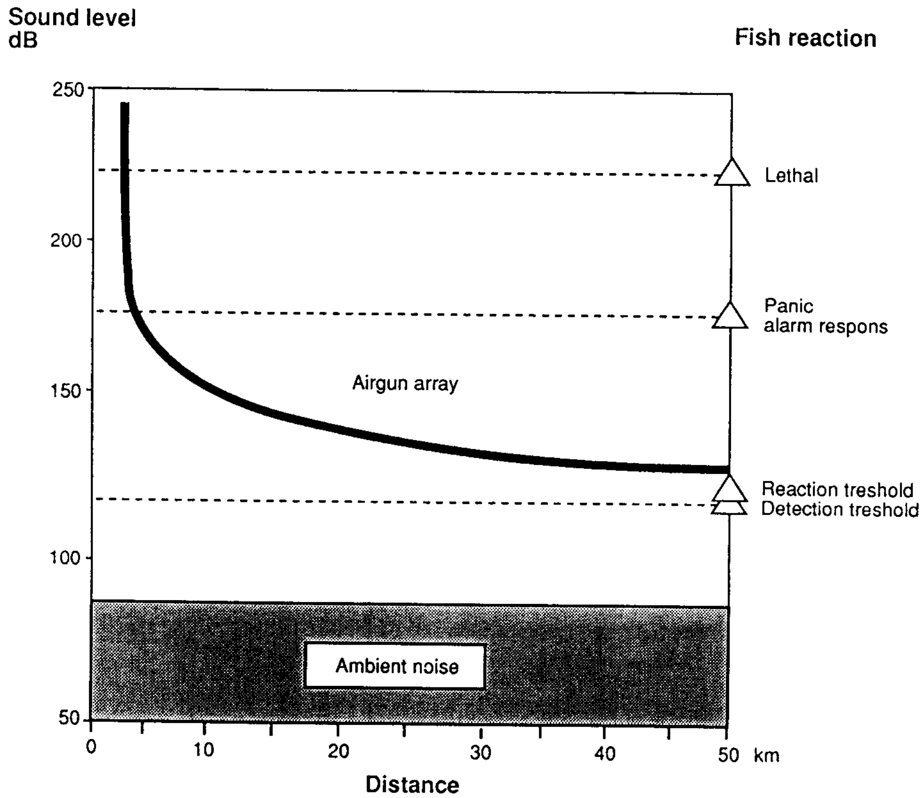

Fig. 14. Generalized responsiveness of cod to sound pressure levels. The sound pressure levels versus distance of an array of airguns are given as well as the ambient noise level. The sound pressure level from the airgun is reduced to less than 200 dB within the first kilometer (modified from Nakken 1992).

Shrimps

In general, pressure waves have relatively little effect on marine invertebrates, presumably due to lack of aircontaining chambers, such as the swim bladder of fish. In experiments with dynamite explosives, which are more damaging than airguns, there where no effects on shrimps beyond 15 m (Gowanloch & McDogall 1946 as cited by Falk & Lawrence 1973). In studies of Dungeness crab, no significant effects were detected on crab larvae exposed to high pressure levels from airguns (peak level 230 dB re 1 μPa) at 1 m distance. This result suggests that crab larvae may be more resistant to effects from energy released from airguns than are fish eggs and larvae (Pearson, Skalski, Sulkin & Malme 1994).

The Fylla Area

In The Fylla Area 3D seismic activity may cause temporary displacement of fish. It is known that Atlantic cod, Atlantic halibut and Greenland halibut spawn at the western slope of the banks in The Fylla Area and sand eel spawn at the banks in The Fylla Area (Table 1). Sand eels are, however, the only species spawning during the summer season when seismic activity is expected to take place. The reaction of sand eels to seismic activity is unknown. Small fish in general seem to react less than larger fish, so it is likely that the reaction would not be great. Some displacement of spawning sand eels during 3D seismic activity at western Fylla banke and southern Toqqussaq banke is possible,

however, these areas are just a small part of the spawning areas which apparently cover a large portion of the banks in West Greenland (Pedersen & Smidt 1995)
3D seismic activity in The Fylla Area could affect the catch of Greenland halibut which takes place during seismic operations because they may cause a temporary movements of fish. This is, however, only a short-term effect.
Information on the effect of seismic pressure waves on shrimps are limited, but i.a. the study on crab larvae clearly indicates that there is no reason to expect significant effects on shrimp populations.

6.1.2 Marine mammals, seismic and ship noise

Seismic noise

Because of the intermittent nature of the seismic noise, there is no risk of masking marine mammal communication. Gray and bowhead whales are often observed behaving normally in the presence of strong noise pulses from seismic vessels several kilometres away or more. However, most gray and bowhead whales interrupt their prior activities and swim away when a full-scale seismic vessel emitting pulses approaches within a few kilometres (Richardson et al. 1995). In an experiment, the reactions of humpback whales to pulses of a 1.62-L airgun were observed on a summering ground in southeast Alaska. The whales were scared at ranges up to 3.2 km when the airguns were first turned on, but these responses did not persist (Malme et al. 1985, cited in Richardson et al. 1995). Opportunistic observations of different whales during seismic activity are not equivocal, with observations of bowheads swimming rapidly away from a seismic vessel at a distance of 24 km (Koski and Johnson 1987 in Davis et al. 1991), and minke whales, apparently approached a seismic vessel to a distance of 100 m during shooting (J. Durinck pers. comm.). Sonars and similar pulsed sources may elicit quieting or avoidance behaviour by sperm and humpback whales, as documented by Richardsen et al. (1995). Even though toothed whales have poor hearing sensitivity at low frequencies, seismic pulses are strong enough to be heard several kilometres away. Recent work has shown that sperm whales may become silent in response to noise pulses from a seismic vessel at a distance of over 50 km (Mate et al. 1994). Some local displacement of ringed seals has been observed during operations of vibroseis on the ice, while other seal species have shown tolerance to strong impulsive noises to which they have been accustomed (Richardson et al. 1995).

Noise from ships

The noise from ships, especially the intense noise from large icebreakers and drillships, are constant and have the potential to mask natural sounds and communication. The local displacement of certain marine mammals has been observed, however this is not always the case. Reactions to offshore drilling and production has been reported by a number of authors. Baleen whales, toothed whales and seals are often seen near drillships (e.g. Kapel 1979; Richardson et al. 1995). Studies involving both playback experiments as well as actual drilling sites have been carried out.

More reactions were recorded for playback experiments, which may be explained by reactions to the onset of the brief playback, whereas marine mammals may habituate to the continuous sound from an actual drillship. However, animals seen near drillsites may be the less responsive individuals, while more responsive animals might have left the exposed area.

The Fylla Area

Although the majority of humpbacks and other baleen whales are expected to prefer habitats outside **the Fylla Area**, whales will be exposed to underwater noise outside the area. Whales will be able to hear the seismic ships more than 100 km away (Richardson et al. 1995). Vocal reactions may occur up to at least 50 km, but avoidance reactions are only expected to be seen at distances of 0.1-2 km. Animals may only swim a few kilometres away from the site of disturbance, and their normal activity may be disrupted for an hour or more. Weaker reactions such as change in surfacing and respiration patterns may also occur.

As previously mentioned, bottlenose whales and sperm whales are likely to be encountered in deep water in The Fylla Area. Sperm whales have frequently been seen around Sukkertoppen Dyb and Fyllas Banke. It is likely that they will be able to hear a seismic operations in The Fylla Area, but their reaction is unpredictable. However these whales may be able to utilize alternative sites such as Danas Banke. The reactions expected for toothed whales are similar to those mentioned for baleen whales. Greenland seal species occurring offshore are widely dispersed, and the Fylla area is not of special importance to seals.

6.3 Potential ecological impact of pollution - oil spills

Offshore oil exploration, production and transportation presents a risk of accidental oil spills with potentially serious environmental effects. Pollution during normal offshore activities, disposal of drilling mud and production water etc., from production and exploration platforms also pose environmental problems. It seems however, that the continuos development of modern more environment-safe products and production technologies, such as the use of water-based drilling fluids, can reduce this problem to acceptable levels. The pollution during normal activities will not be dealt with further in this report.

Offshore oil exploration in the Arctic may cause serious environmental effects if a major oil spill occurs, particularly if the oil spill coincides with concentrations of ecologically important and vulnerable species in the ice or at the coast. However, a high degree of uncertainty in assessing the potential impact of an oil spill is inevitable, because the impacts depend on numerous more or less unpredictable events which interact in a complex fashion.

The total volume of oil released to the marine environment in the Arctic from accidental spills is small compared to inputs received from river transport, atmospheric transport and sewage (Futsæter et al.1991). However, accidental spills constitute a large environmental threat because of high oil concentrations, although spills mainly have local or regional impacts. Chronic pollution from many minor marine oil spills in heavily populated regions south of the Arctic can also represent a serious environmental threat (Mosbech 1990).

In the Arctic the natural degradation of oil will generally be slow due to low temperatures, and the possibilities of recovery and cleanup can be hampered by the harsh climatic conditions and lack of infrastructure. Furthermore, if oil is spilled on broken ice, it will tend to pool in the open leads, and wind may keep it in the ice edge area (Futsæter et al. 1991). In spring, leads and ice edges are utilized by high concentrations of birds and mammals during their northward migrations.

Oil is toxic to nearly all organisms; however, the toxic effect depends on the composition and concentration of the oil and the sensitivity of the species affected. A species may have a high individual sensitivity and a low population sensitivity if individuals are evenly distributed and have a high reproductive capacity. This is the case for many species in lower trophical levels. Oil vulnerability and sensitivity of fish, seabirds and marine mammals, and a few important invertebrates are reviewed here. We have chosen to focus on the highest trophic groups in the ecosystem because they have the greatest potential for long-lasting effects and the ultimate impacts on higher levels cause the greatest conservation and economic concerns.

6.3.1 Fish, invertebrates and oil

Fish

Extensive fish kills during oil spills in the open sea have not been documented (National Research Council 1985). This is primarily due to the fact that toxic concentrations are seldom reached over large areas and great depths in the open sea. Furthermore, adult fish are mobile and are capable of avoiding oil. In laboratory studies, several fish species have been exposed to the water soluble fraction (WSF) of different crude oils. The WSF of crude oils consists mainly of aromatics, and are dominated by benzene, toluene and xylenes (Serigstad 1992). Toxicity to fish appears to be functionally related to the total aromatic hydrocarbon concentration in the WSF (Rice 1985). As a broad generalization, lethal effects (LC_{50}) among adult fish are found in the range of 1 - 10 mg/l water soluble aromatics and sublethal effects in the range of 0.1 - 1 mg/l (Rice 1985). Fish eggs and larvae are generally more sensitive than adult fish. Lethal effects (LC_{50}) of water soluble aromatic hydrocarbons on larvae have been estimated to be in the range of 0.1 - 1 mg/l (Rice 1985).

In coastal areas where oil can be trapped in shallow bays and inlets, toxic concentrations can build up to levels where adult fish kills can occur. However, fish usually avoid oil by swimming away. During the Braer spill in Shetland 1993, a storm dispersed the oil and caused very high oil concentrations in the water column near the coast. After the grounding, the concentration of oil in the water was 'some hundreds' of mg/l in the area close to the tanker (The Scottish Office 1993). Ten days after the spill, 4.3 mg/l was measured in a bay within a few kilometers from the wreck. Subsequent monitoring programs found no evidence of major effects on fish populations (Richie & O'Sullivan 1994). Work not yet completed indicates that there may have been some subtle effect on larval growth, and on the proportion of sexually mature sandeels in given length classes (Richie & O'Sullivan 1994).

Intertidal and subtidal shorezone

Oil that enters intertidal and subtidal shorezones can have an effect on the bottom fauna. After an experimental oil spill on a sheltered beach on Baffin Island, it was concluded that effects were mainly temporary and apparently without serious consequences. After a two year post-spill monitoring period it was further concluded that there was no evidence of large-scale mortality of subtidal benthic biota attributable to the oil spill (Sergy & Blackall 1987). The natural removal of the oil from the shoreline slowed down over time, and after a period of eight years, approximately 5 % of the original spill volume remained on the beach in a highly weathered state (Humphrey et al. 1991). After the Exxon Valdez oil spill most surface deposits of oil on the shorelines of Prince William's Sound decreased by a factor 10 in one year, however oil in low-energy sediment areas and in areas of subsurface burial was expected to be retained much longer (Wells 1995). Wolfe et al. (1994) estimated that 3 years after the spill approximately 2 % of the spilled oil remained on the intertidal shorelines, much of it highly weathered, biologically inert residues.

Oil that is trapped in an unweathered state and is slowly released into the environment can cause chronic pollution. Research in Prince William's Sound after the Exxon Valdez oil spill has shown that oil can be trapped in sediment beneath mussel beds on protected shorelines without being cleansed by wave action. Because the underlying sediment often is anaerobic, oil can remain there in an relatively unweathered state. In Prince William's Sound, the leaking of unweathered oil from contaminated mussel beds is suspected to have caused chronic intoxication of harlequin ducks, which feed on the mussels (Rice et al. 1993, Patten 1993a, 1993b). However other scientists estimate that the oil dosage is well below the 'no-effect' level for wildlife feeding on the mussels and for the mussels themselves (Wells et al. 1995).

If oil persists in the environment for long periods of time, local fish populations can suffer from a number of sublethal toxic effects (Khan 1990). Following the Exxon Valdez oil spill, studies involving the tagging of two trout species (Dolly Varden and cutthroat trout) have demonstrated increased mortality and reduced growth in oil contaminated areas. This condition still persisted two years after the spill (Anon. 1992, 1993). There are conflicting results on the effects on herring and salmon populations in Prince William's Sound, primarily due to large natural fluctuations. Wells et al. (1995) conclude that only continued studies of the fish populations will clarify the true causes of changes in these fish populations.

Few effects of the Exxon Valdez oil spill were detected on bottom fish and crustaceans, even considering the noted sensitivity of larval crustaceans to hydrocarbons (Armstrong et al 1995). These fisheries remained unimpaired after the spill, as far as was known in 1993. A study focused on species with meroplanktonic larvae and demersal or benthic juveniles and adults, including several pandalid shrimps. For deep sea shrimp (the shrimp important in Greenland) there was no significant difference in catch per unit effort (CPUE) between oiled and non-oiled areas (Armstrong et al 1995).

Effect on fish larvae

Oil spills which coincide with spawning events or high fish larvae concentrations can result in significant egg and larval mortalities. Fish larvae have been found to be very sensitive to oil during the period between when they absorb the final eggyolk and start to swim and feed (Føyn & Serigstad 1988, 1989a, 1989b, Serigstad 1992). Furthermore, during early stages of development, larvae are unable to avoid the oil. Most species of fish produce large numbers of eggs, of which only relatively few reach adulthood due to natural mortality. The relative importance of oil spill induced mortality compared with the high natural mortality of fish eggs and larvae is disputable.

The impact of a 10 000 m^3 crude oil spill was simulated on George Bank, off New England in USA. In a worst case scenario, the impact on the Atlantic cod was estimated to be a loss of 0.5 % of a year's catch when the simulated oil spill coincided with spawning (Reed & French 1989). A simulation of an oil well blowout in the Barents Sea (over a duration of 10 days, total spill 24 000 m^3) has also been carried out. In relation to cod spawning, a worst case scenario of a spill in April may result in a 10 - 15 % reduction of the yearclass. A spill simulated in July gave a reduction of less than 0.5 % of the yearclass (Børresen et al. 1988).

Fish readily absorb oil components into their tissues after exposure in water, food or sediment. However, these components are unlikely to build up to high concentrations in fish tissue as fish are able to metabolize these contaminants. Nevertheless, this detoxification can be stressful to fish, and the tissue may become tainted.

Tainting

Tainting is a term used to describe the development of an atypical flavor caused by natural spoilage or by the assimilation of contaminants into edible tissue. Consequently, oil spills may affect a fishery by making the catch unmarketable, due to tainting. In a review by Ross (1993), the risk of tainting due to offshore blowouts in deep water was considered to be minimal. Even below a chemically dispersed offshore slick, fish are unlikely to encounter oil concentrations sufficiently high to cause tainting. The risk of tainting will, however, be larger in shallow coastal waters, where oil concentrations in the water may build up. Where the oil disappears fish depurate the hydrocarbons taken up. In the Braer spill tainting and contamination of fish and shellfish around southern Shetland did occur and a fisheries exclusion zone was established. Contamination in fish samples from the exclusion zone fell rapidly, and three months after the spill, the ban on fishing was lifted. However, one year later there were still areas with elevated levels of oil in the sediment. Shellfish, which are more exposed to oil in the sediment than fish because of their close association with sediments, still had low levels of contamination present in some species, and fishing remained prohibited.

The Fylla Area

Based on the literature reviewed above, it can be concluded that **oil spills in the Fylla Area** during summer and early autumn are unlikely to have a significant impact on adult fish in offshore stocks. Eggs and larvae, which could be affected, occur relatively dispersed. However distribution and concentrations of eggs and larvae are dynamic and fluctuating in terms of long (decades), medium (year to year) and small (days) timescales due to changes in fish populations and variations in ocean currents. Only sand eels spawn offshore during summer (Table 1), when exploratory drilling is likely to take place. Larval Greenland halibut and Atlantic cod drift through the area, with most of the cod larvae occurring in the upper part of the water column (Smidt 1979) where it may be exposed to oil during an oil slick. However, the data available on offshore fish and shrimp eggs and larvae (Pedersen & Smidt 1995) indicates that these, at least during summer, occur at lower more dispersed concentrations in the area (62°-68° N) than is the case with the Barents Sea cod for instance (max. concentrations 500 - 5 000 eggs/m^2 , Børresen et al 1988). A worst case scenario model for Barents Sea cod gave a 10-15 % reduction in the yearclass.

Shrimps

It is unlikely that a spill would have a severe effect on shrimp populations as these animals live close to the bottom at depths of 100 to 600 meters, and their pelagic larvae is most often found in the middle of the water column (Smidt 1979) where toxic concentrations are very unlikely to occur, ever during a large dispersed spill. However, dispersed oil, which subsequently sinks to the bottom (attached to silt) may potentially have some effect on the bottom, but this is not very likely.

In contrast to this, the impact at the coastline may be much worse, where oil concentrations can build up in the water column. In the coastal area (62° -68° N) the lumpsucker and the capelin are especially vulnerable to oil during the spawning period. These fish spawn in localized areas in the intertidal or subtidal zone. The Arctic char, which feed for most of its life in coastal waters and spawn in rivers, is also vulnerable to coastal oil slicks where oil concentrations in the water column can build up and affect the fish directly or indirectly through the food chain.

6.3.2 Seabirds and oil

Seabirds are extremely vulnerable to oil spills, primarily because oil soaks into the plumage and destroys insulation and buoyancy, causing hypothermia, starvation and drowning. Because they live in cold water, Arctic seabirds are especially vulnerable to the loss of the insulating capacity of their plumage. Birds which rest and feed on the surface of the sea, such as auks, are particularly vulnerable to even small doses of oil (Leighton et al. 1985). It was estimated that 300 000-645 000 seabirds died as a direct result of the Exxon Valdez oil spill in Prince William Sound, Alaska in 1989. Several murre colonies in the area suffered a 50-70 % decline in numbers, and the survivors had reduced a reproductive success in the following years (1990-92) (Nysewander et al. 1993, Piatt 1993).

When birds attempt to clean oiled plumage or feed on oil-contaminated food, they ingest oil and subsequently become intoxicated. Although external oiling is likely to be responsible for the majority of seabird losses after an oil spill, the long-term effects after intoxication may hamper reproductive capacity by increasing the proportion of non-breeders in a population (Fry et al. 1985). Harlequin ducks, which feed in shallow water along the coast were found to have petroleum hydrocarbon contaminants in 40 % of specimens sampled after the Exxon Valdez oil spill. This species has since suffered from low reproductive success in areas affected by the oil spill. Some scientist believe that these reproductive problems have resulted from low level intoxication via feeding on mussels from contaminated mussel beds (Patten 1993a, 1993b, Rice et al. 1993). Others dispute this conclusion (Wells et al. 1995).

Sea surface contact

In the case of an oil spill the more time birds spend on the sea-surface, the more likely they are to be fouled with oil. There are birds that feed at sea throughout the year (cormorants, auks, diving ducks, many terns and gulls) and for part of the year (some ducks, grebes, divers (loons), phalaropes). Gregarious bird species, which spend most of their time on the water, and dive rather than fly when disturbed, suffer the most serious causalities during oil spills.

Auks and ducks moult their flight feathers after the breeding season, and are unable to fly for a period of two to seven weeks. Auks and most diving ducks spend this flightless period at sea, where they are safe from terrestrial predators. Most ducks gather in flocks during the moulting period, while auks undertake a more dispersed swimming migration.

Seabird concentrations

Birds which aggregate in small areas on the sea are more vulnerable than birds which are dispersed, because a single spill has the potential to affect a significant proportion of the population. High seabird concentrations are found at colonies, moulting and feeding areas, and in leads in the ice during winter and spring. Little is known about whether seabirds deliberately avoid oil slicks; however, evidence strongly suggested that fulmars avoided settling on sea surface polluted with heavy oil during a Norwegian experiment (Lorentsen & Anker-Nilssen 1993).

Low reproductive capacity

Bird populations which are most seriously affected by acute oil spills are those which have a low reproductive capacity and a corresponding high average lifespan. This is the life strategy adopted by auks and many other seabirds (Furness & Monaghan 1987). Seaducks, however, have a different strategy. They have a higher reproductive potential, which can result in a more rapid replacement of adult losses.

In conclusion, major oil spills do have the potential to significantly deplete bird populations, and cause desertion of seabird colonies. However, it is unlikely that an oil spill could wipe out an entire seabird population unless other factors, such as hunting and by-catch in gillnets hamper the recovery of the population, or a population is small and has a very restricted distribution.

The Fylla Area

Oil spills spreading from the Fylla Area during summer and autumn could potentially cause the death of a very large number of birds in the assessment area. The oil spill vulnerability and conservation value (importance) of the seabirds present in the area (62° - 68° N) during summer and autumn are summarized in Table 5. The oil slick can hit breeding colonies, moulting areas and important offshore areas. The largest numbers of birds are present in the offshore area during autumn. More than a million thick-billed murre, little auks, gulls and fulmars are found in the area (62° - 68° N) during this period (Table 3). This number includes representatives of birds from many breeding colonies from several countries. They are spread out over a large area on the banks, although shipbased surveys indicate that there are often concentrations on the banks and slopes between 63° and 65° N (Fig. 11). Even a large oil spill can only affect a small fraction of these birds because they are distributed over a large area. The impact on the population will to a high degree depend on the distribution of the birds at the time of the spill. At one extreme, the birds might be mixed so the oil mortality is spread out on birds from many colonies. At the other extreme, the birds might be distributed in flocks together with colony mates, so that a single colony could suffer a high extra mortality, and consequently experience a long recovery period.

If a large oil spill occurs during the breeding season the total bird mortality will most probably be less than during autumn, as there are fewer birds in the area at this time. However, if the oil reaches the coast, single colonies could experience very high mortalities and be virtually extinguished. The impact will be most serious if the colony involved is large and isolated, because isolation inhibits recolonization. The thick-billed murre colony outside the mouth of Nuuk Fjord (Fig. 7) is quite large and isolated, and is considered to be the most vulnerable colony in the area. The recovery from a large oil slick hitting this colony could take decades, or longer if other factors such as disturbance or hunting hamper recovery. Single colonies of puffins, razorbills and Arctic terns in the coastal zone can also be seriously diminished, however these colonies are smaller, more numerous, and widely dispersed in the area, so the proportion of the population in the area which may be effected by the oil will be smaller.

Populations of moulting and postbreeding ducks in the coastal zone are relatively well dispersed in the area (compared to king eiders and eiders in the Disko Bay for instance) thereby diminishing the risk of a large oil spill induced mortality. However, as mentioned in chapter (B4.3), areas with high concentrations of postbreeding harlequin ducks and eiders have been identified, and there are areas where a high proportion of the Greenland harlequin duck population could be severely affected.

Table 5. Summary of oil spill vulnerability and conservation value of seabird populations in the assessment area (62°- 68° N, summer and autumn). Oil spill vulnerability is primarily a function of risk of contact with the oil and the capacity to compensate for an extra mortality due to oil (Restitutional capacity). The risk of contact is composed of an individual risk due to the species inherent behavior and a population risk due to the distributional pattern of the population in the area during summer and autumn. The individual risk expresses how much contact the species has with the water surface (during foraging, resting ect.). The population risk expresses whether the population in the area occurs in concentrations (primarily during moulting and breeding) so a large proportion of the population can be affected by a single oil slick. The population's capacity to recover depends on the fecundity of the species (intrinsic rate of increase; age when first breeding, clutch size, reproductive lifespan) and on a complex interaction between environmental factors regulating population growth in an area (food availability, predators, climate, hunting, disturbance ect.). The population trends in the area (if known) are given as an indication of the combined impact of these other factors.

Species	Oil spill vulnerability aspects (summer and autumn)				Importance of the Assessment Area	
	Risk of contact with oil		Capacity to recover			
	Individual risk	Population risk (62° - 68° N)	Fecundity	Population trend	summer population	autumn population
Fulmar	medium	medium	low	unknown	-	I
Great shearwater	medium	medium	low	unknown	(I)	(I)
Cormorant	high	low	medium	increasing	I	I
Eider	high	medium	medium	decreasing	N	I
King eider	high	high	medium	decreasing	-	-
Long-tailed duck	high	medium	high	unknown	-	?
Red-breasted merganser	high	high	high	unknown	I	I
Harlequin duck	high	high	high	unknown	I	I
Mallard	medium	low	high	unknown	I	I
Kittiwake	low	medium	medium	stable?	I	I
Glaucous gull	low	low	medium	stable?	N	I
Iceland gull (+gull sp.)	low	low	medium	stable?	(I)	I
Great black-backed gull	medium	low	medium	increasing?	I	I
Arctic tern	medium	medium	low	decreasing	N	-
Thick-billed murre	high	high	low	stable?	-	I
Common murre	high	high	low	unknown	N	N
Razorbill	high	medium	low	stable?	N	N
Puffin	high	high	low	increase?	N	N
Black guillemot	high	low	low	unknown	N	N
Little auk	high	medium	low	unknown	-	I
White-tailed eagle	medium	low	low	stable?	I	I

Individual risk (general sea surface contact) is rated low, medium or high

Population risk (occurrence in concentrations) is rated low (dispersed), medium or high (aggregated,) in a combined rate for summer and autumn.

Fecundity is rated low, medium or high.

For **population trends** an indication is given of whether populations are stable, increasing or decreasing. Or if the trend is unknown (?).

Importance of the Assessment Area (Conservation Value)indicates the significance of the population in the area in a national and international context as defined by Anker Nilssen (1987); If the population in the area constitutes more than 2.5 % (for species with low fecundity), 5 % (for species with medium fecundity) or 10 % (for species with high fecundity) of the international population it is considered of international importance (I). If the population in the area is more than 5 % (for species with low fecundity) 10 % (for species with medium fecundity) 20 % (for species with high fecundity) of the national population is it considered of national importance (N). The population in the area is evaluated separately for summer and autumn. The Greenland population data are given in Table 3. For auks, kittiwake, glaucous gull, Arctic tern, and fulmar, population figures from the North's Atlantic are used in assessing the international importance (data from Tucker & Heath 1994 and Brown 1986). For eiders only eastern Canadian and Greenland birds are considered the relevant international population. The Greenland populations of cormorant, redbreasted merganser, harlequin duck, mallard, Iceland gull, great black-backed gull and white-tailed eagle are considered isolated and of importance for the species overall distribution. Because the Greenland populations are isolated, populations in the Assessment Area of national importance are also of international importance.

The harlequin duck has a higher fecundity compared to the auks (Table 5), thus recovery would most probably occur within a few years unless other factors hamper population growth. This is also the case for eiders, which are of socioeconomic and cultural importance as game species, and which occur rather dispersed in the area during summer and autumn.

6.3.3 Marine mammals and oil

Marine mammals have a high potential of being exposed to spilled oil, given that they need to come to the surface to breathe.

Seals

The severity and duration of the physical effects of oil on seals depend on the amount and type of oil present. Hair seals seem to be relatively unaffected by light oiling. Heavy oiling - especially of pups - probably kills some seals. Hair seals, such as ringed, harp, hooded, bearded and harbour seals, seem to be relatively unaffected by oil spills during most of their life cycle. However, pups are more susceptible during early development, when they are dependent on fur (lanugo) for insulation until their blubber layer develops (e.g. Richardson et al. 1989, Geraci & St. Aubin 1990). Oil apparently reduces buoyancy and impedes mobility. The time it takes to get rid of oil in the fur is dependent of the type of oil and the stage of moulting (Le Boeuf 1971, Geraci & Smith 1976). Temporary skin and eye irritations have been reported, but these effects appear to be transient (Geraci & Smith 1976). Field immersion studies have revealed that the internal effects of hydrocarbon inhalation by the seals are minor (Geraci & Smith 1976, Engelhardt et al. 1977, Engelhardt 1978). Geraci & St. Aubin (1982) concluded that 'Animals exposed to oils weathered in the open ocean for as little as 2-4 hours would not be expected to suffer any consequences from inhalation ...'. Recent information from the Exxon Valdez oil spill, however, has shown that inhalation of aromatic hydrocarbons can affect seals (Anon. 1993). Harbour seals in the area were reported to be sick, lethargic or unusually tame in the weeks immediately following the oil spill, and later examination of 19 dead seals from the same area showed that debilitating lesions had developed in the brains of many of these (Frost & Lowry). Ringed seals fed isotopically labeled oil showed rapid petroleum hydrocarbon absorption and deposition in a variety of tissues, but these were cleared rapidly and only trace amounts remained after one month (Engelhardt 1978, 1982). Harp seals fed single high doses of oil showed no consistent changes in circulating liver enzymes or consistent pathological lesions (Smith & Geraci 1975, Geraci & Smith 1976).

Walruses and bearded seals are believed to be at a higher risk from ingestion of petroleum hydrocarbons than whales and other seals, as they feed mainly on benthic animals (Richardson et al. 1989, Geraci & St. Aubin 1982). Benthic invertebrates are known to accumulate petroleum hydrocarbons. Walruses are believed to be more vulnerable to an oil spill because of a number of features (see

Born et al. 1995): The gregarious behaviour of walruses would allow for larger numbers to be effected if exposed. Pronounced thigmotaxic behaviour on ice and on land makes it likely that these animals will rub oil into their skin or eyes. Walruses inhabit areas such as loose pack-ice and coastal areas where spilt oil tends to accumulate. Finally, the narrow feeding niche of the walruses make them particularly vulnerable as they depend on access to mollusk banks in shallow waters.

Whales

Oil has not been proven to cause mortality on whales. The fact that whales depend on a blubber layer to minimize heat loss in cold water means that oiling is unlikely to have serious thermal consequences, even if oil does adhere to the skin. In baleen whales (fin, gray, humpback and sei whales), coating of the baleen by oil reduces filtration efficiency. However, there is evidence that these effects are reversible within a few days (Geraci & St. Aubin 1981, 1982, 1985). Brief exposure to gasoline had significant sublethal effects on these animals, but no more severe than those on the skin of other mammals. All effects were found to be largely reversible. Based on the literature concerning ingestion of oil and petroleum products by other mammals, Geraci & St. Aubin (1982) concluded that "it is unlikely that any whale would ingest enough spilled oil to cause death". There are no data concerning inhalation of petroleum vapors by whales. Based on evidence from other mammals, Geraci & St. Aubin (1982) concluded that petroleum vapors are harmful and can be fatal if inhaled at sufficiently high concentrations and for a sufficiently long period. The oil spill caused by the Exxon Valdez was mentioned as a possible explanation to the disappearance of 14 killer whales from a resident pod in Prince William Sound (Dahlia & Matkin 1993).

There is sufficient evidence to conclude that oil can foul the fur of polar bears, and that this fouling increases heat loss. Increased heat loss and elevated metabolic rates are particularly dangerous for species that inhabit cold waters. Polar bears are particularly susceptible to spilled oil because of their demonstrated habit of swallowing oil that has been groomed from the fur. Such ingestion has the potential of causing polar bear death (Øritsland et al. 1981, Hurst & Øritsland 1982, Hurst et al. 1982). The preference of polar bears to eat such things as seal blubber suggests that they are attracted by fatty products. Polar bears have occasionally been observed consuming motor oil and grease (Engelhardt 1983).

In conclusion, the polar bear seems to be the marine mammal which is most vulnerable to oil spills. However, whales and seals may also experience harmful effects if they are trapped in areas where oil has accumulated, for example in leads or along the ice edge. In general, however, whales do not seem to be particularly vulnerable to oiling, although it is still somewhat uncertain whether mortalities can occur due to inhalation of petroleum vapors.

The Fylla Area

A number of whale species are known to occur in **the Fylla Area** or in areas that could be affected by an oil spill from this area during summer. Among these are minke, sei, humpback, fin, blue, pilot and sperm whales. During the open water season, whales can move freely along the coast of Greenland. However, ecological niches of the different species have proven to be restricted, and important summering areas have been detected close to The Fylla Area. Most of the larger whales are protected from hunting as populations are small. As such, the large whales are more vulnerable to oil spills as even a low number of affected animals could constitute a significant proportion of the population. However, it seems unlikely that even a small number of whales should be seriously affected by an oil spill, given the fact that no such event has previously been recorded.

None of the seal populations, with the possible exception of harbour seals could be threatened by an oil spill, as they are numerous and widely distributed. Harbour seals haul out on land mainly between June and August. This behaviour makes the species particularly vulnerable to hunting, disturbance, oil spills etc. A very dramatic decline in the stock in Greenland has been observed over the last few decades, and an oil spill during summer could have significant effects on the population. On the other hand, a number of the haul out sites are located far into the fjord systems, where exposure to oil is unlikely to occur.

In summary, an oil spill during the open water season is unlikely to cause severe impact on marine mammals.

6.3.4 Potential impact of oilspills from the Fylla Area

It can be concluded that the biological resources in the area (62° - 68° N) primarily threatened by an oil spill from The Fylla Area in summer and autumn are seabirds, fish spawning and feeding in the intertidal zone or shallow waters, and mussels and scallops in the intertidal zone or shallow waters.

An oil spill in autumn could potentially impact the largest number of seabirds, because there are more seabirds present than in the breeding season. In terms of recovery time, however, coastal colonies of auk species are probably more vulnerable to an oil spill in the breeding season, because a very high proportion of individuals in a single colony can suffer mortality. It is estimated based on population dynamics that the recovery time for a severely diminished thick-billed murre colony could be up to several decades, or even longer if other human impacts or ecosystem changes are unfavourable.

There is also a risk of local impacts on coastal fish species. However the distribution and catch of lumpsucker, capelin and Arctic char in the area need to be surveyed more thoroughly through interviews in local communities, in order to asses this risk in more detail.

To illustrate the complexity and inherent uncertainty in assessing the impact of an oil spill, imagine an oil slick which reaches the coast at a thick-billed murre colony during the breeding season. Among the parameters which have to be estimated to predict the future of the colony are: how many birds will be fouled by oil, how many of these will die and how many of the survivors will give up reproduction for the year or have reduced reproductive success for the rest of their lives due to subletal effects. When there are few birds in the colony, the social life suffers and recruitment can be expected to diminish due to a higher predation rate. On the other hand, when there are fewer birds there will be less competition for breeding sites and food, and room for immigration from other colonies, if there is a surplus of mature birds at hand in the other colonies.

7 Mitigation

7.1 Seismic activities

Temporal and spatial restrictions of seismic activities are the main mitigative measures which could be applied to minimize potential impacts on the environment. In Norway, seismic activity is regulated so as to protect spawning areas during spawning periods, and in Canada and Alaska some important whale areas are closed for seismic activities during certain periods. Furthermore, there are restrictions demanding that seismic activity cease if a marine mammal is within a range of 500 m (Canada) or there is a bowhead whale within 4 km (3 miles in the US).

It does not seem likely that regional seismic activity in The Fylla Area would have an impact which would justify the implementation of mitigative measures. However programmes of 2D and 3 D seismic in the Fylla Area in summer can potentially cause displacement of humpback whales from an important feeding area, and displacement of spawning sand eels from a fraction of the spawning area. We are not able to predict whether or not, these effects will actually occur and what the ultimate consequences for the populations would be. However, we are pretty confident that a few seismic programmes of limited duration (few weeks) would only have a limited impact. Based on actual applications for seismic programmes, we recommend that it be considered whether a monitoring program is appropriate and can be set up to assess the impacts.

7.2 Exploratory drilling

The most serious potential impact of oil exploration activities in The Fylla Area is the impact of a major oil spill, especially if the spill reaches the coast. To minimize the environmental risk of large oil spills during oil exploration, emphasis should be put on wise planning of activities to avoid operations in the most sensitive periods and areas, and safe operation practices to prevent accidental spills. This means that exploratory drilling should be conducted in the summer period. Effective oil spill countermeasures and short response times for oil collection at the spill source should also be implemented. Oil spill response plans with operational environmental sensitivity maps to enhance damage control during a spill need to be constructed. Distribution and catch of lumpsucker, capelin and Arctic char in the area need to be surveyed more thoroughly, i.a. through interviews in local communities, in order to asses the potential risks in more detail, and to assist with collecting information from sensitivity maps.

In some cases another way to mitigate the environmental risks may be to improve the status of the populations which can be impacted of an oil spill. This may, for some seabird species, be achieved by reducing disturbance during breeding and reducing mortality due to hunting so the species would be in a better position to tolerate higher mortality rates due to an oil spill.

The impact from discharge of drilling fluid adhering to cuttings can be minimized by regulation of the use of additives in accordance with the international standards.

The impact of noise from a drilling rig on humpback whales feeding just east of The Fylla Area could be mitigated by using the least noisy equipment (semisubmersibles seem to be less noisy than drilling vessels). Furthermore, if drilling is going to take place near the humpback whale feeding area, it is recommended that a monitoring program be set up to assess the impact.

During exploration in The Fylla area regular helicopter traffic between coastal towns and ships / platforms could potentially disturb coastal seabird colonies, especially the thick-billed murre colony south of Nuuk fjord. This impact can be avoided by maintaining a distance of 5 km from thick-billed murre colonies and more than 200 m from other important seabird colonies in the breeding season.

8 Main environmental problems related to operations in winter

A large number of seabirds and marine mammals winter in offshore coastal zones in southwest Greenland. Although the area is called the Open Water Area, drift ice is often encountered, especially in the northwestern part during winter. However, the ice seldom packs and closes the water surface in the entire area. Offshore and coastal areas have large numbers of wintering thick-billed murres, little auks, black guillemots, king eiders and eiders. It has been estimated that 170 000 thick-billed murres were present within a 6 000 km^2 area and 280 000 king eiders within a 5 000 km^2 area west of Nuuk in February 1989 (Durinck & Falk in press). The entire area has never been surveyed and knowledge of numbers and distribution of the birds is presently inadequate for sensitivity mapping and impact assessment. It is evident that an oilspill during winter could have a severe impact on seabird populations.

A number of marine mammal species occur in the Fylla area or in the areas that could be affected by an oil spill from this area only during winter and early spring. Among these are bowhead whales, narwhals, white whales, walruses and polar bears. At least some of the bowheads migrate from Canada towards Greenland in the loose pack-ice during March-April. The population is still low in number (app. 250), although it has not been hunted for more than 60 years. Narwhals and white whales inhabit the pack-ice and ice edge zones in the same period from 66°30′N and northward. One of the breeding areas of hooded seals may, depending on the extent of pack ice, occur within The Fylla area in March. An oil spill is generally regarded as devastating to newborn seal pubs, although a short lactation period of only 3-5 days makes this species vulnerable to oiling only for a very short period. Walruses (and bearded seals) are believed to be at a higher risk of ingestion of petroleum hydrocarbons than whales and other seals, as they feed mainly on benthic animals. However, the major feeding banks of the walruses are more than 200 km north of The Fylla area, which means that there is only a very small risk that their food would be contaminated by oil. The walrus population in Southwest Greenland has decreased due to hunting within the last few decades.

The polar bear is the marine mammal most vulnerable to oil spills. An oil spill could cause the death of a significant number of bears, as oil causes thermal stress as well as having a toxic effect upon grooming of the animals and subsequent ingestion. An oil spill would mainly affect the polar bear population in winter and spring, as their presence in the area is determined by the extent of the pack ice coverage. The polar bear population in Southwest Greenland is distributed over an extensive area, and even a large oil spill could only affect a minor proportion of the population.

In summary the main problem of winter operations is the risk of a large oil spill because:
- there are large and important bird and marine mammal populations in the area
- birds and mammals can be very concentrated in the open water in the leads and at the ice edge where spilled oil will tend to concentrate
- the thermal stress experienced by oiled birds and polar bears will be enhanced by low temperatures
- present oil spill countermeasures and damage control in icy waters are inadequate.

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Sammenfatning

Indledning (1-2)

Rapporten indeholder en beskrivelse og foreløbig vurdering af de mulige miljømæssige konsekvenser af olieefterforskning i Fyllaområdet fra det sene forår til det tidlige efterår (maj-september). Der fokuseres på mulige miljøeffekter i det vestgrønlandske havområde mellem 62°N og 68°N for at tage hensyn til, at olie kan drive ud af Fyllaområdet, hvis der sker et stort oliespild. Rapporten indeholder en beskrivelse af økosystemet (kapitel 3-4), en beskrivelse af den forventede olieefterforskningsaktivitet (kapitel 5) og en identifikation og vurdering af mulige effekter på ¯kosystemet (kapitel 6). Regulering, overvågning og minimering af de mulige miljømæssige konsekvenser er beskrevet (kapitel 7), ligesom de væsentligste problemer ved operationer om vinteren er nævnt kort (kapitel 8).

Fysisk miljø (3)

Fyllalicensområdet (Fyllaområdet) ligger i Davisstrædet ca. 50 km fra kysten umiddelbart vest for Fyllas Banke på den sydøstlige skråning af undervandshøjderyggen mellem Canada og Grønland (figur 1). Havdybderne i Fyllaområdet varierer fra mere end 2000 m i det sydvestlige hjørne til mindre end 100 m på sokkelområdet i det nordøstlige hjørne. Sokkelområdet ved Vestgrønland består af flere store banker med typiske havdybder mellem 20 og 100 m. Sokkelområdet er smalt mod syd og op til 120 km bredt mod nord og med store vanddybder mod vest. Den dominerende havstrøm i Davisstrædet er den nordgående Vestgrønlandske Strøm (figur 2). Denne strøms overfladelag (0-150 m) domineres af koldt vand fra den Østgrønlandske Polarstrøm, mens det underliggende lag (150-800 m) består af varmt vand fra Irmingerstrømmen (en gren af Golfstrømmen). Som et resultat af dette strømsystem er havet ved Sydvestgrønland normalt isfrit hele året, selvom der ofte forekommer drivis i området om vinteren (figur 3). Dette område kaldes Åbenvandsområdet i kontrast til andre udenskærs vestgrønlandske havområder, som er isdækkede om vinteren.

Økologiske forhold (4)

Fyllaområdet anses sammen med de andre banker ved Vestgrønland for at være blandt de mest produktive i det vestgrønlandske havområde og er et vigtigt område for fugle og havpattedyr og for fiskeri. "Upwelling" af næringssalte på bankernes skråninger og på selve bankerne i løbet af sommeren er grundlaget for en høj primærproduktion i en lang periode, mens produktionen er lav i det centrale og vestlige Davisstræde.

Fisk og rejer udenskærs

Den udenskærs fiskefauna er domineret af arter, der lever nær bunden. Tabel 1 giver en oversigt over de vigtigste arter af fisk og invertebrater. I løbet af de seneste årtier er der sket store ændringer i forekomsten af flere af de væsentlige fiskearter. Den mest bemærkelsesværdige ændring er, at den udenskærs torskebestand næsten helt er forsvundet. Der foregår et vigtigt fiskeri efter dybvandsrejer og hellefisk i området (figur 5 & 6), og tobis er en vigtig fiskeart i økologisk sammenhæng. Tobisen forekommer på bankerne og er en vigtig føderessource for større fisk, havfugle og havpattedyr.

Kystzonen

Kystlinien i området (62°-68° N) domineres af grundfjeld med klippekyster og der er talrige skærgårde og småøer. Her og der ses små sand- eller grusstrande i beskyttede bugter. Egentlige sandstrande findes i to områder, ved Marraq-Sermilik og ud for Frederikshåb Isblink. Ved sidstnævnte ses udstrakte strande med laguner og barriereøer. Tidevandsforskellen i området er 3-4 meter, og på klippekysterne ses en rig fauna og flora i fjæren og umiddelbart under denne. Stenbider og lodde trækker om foråret ind til kysten og gyder lige under lavvandslinien. Om sommeren strejfer fjeldørred rundt lang kysterne nær deres gydeelv.

Havfugle

Der er et rigt fugleliv både i selve Fyllaområdet og hele vurderingsomrÅdet (62°-68° N). Tabel 2 og 3 giver en oversigt over de vigtigste fugle. Af disse yngler 14 arter i kolonier indenfor området (figur 7 & 8). I august samles dykænder efter yngletiden i flokke langs kysterne for at fælde (figur 9), og i løbet af efteråret ankommer store mængder af især alkefugle og ederfugle for at overvintre på bankerne og i de kystnære farvande (tabel 3 og figur 10 & 11). De største mængder fugle er tilstede i området om vinteren, og betydningen af Åbenvandsområdet som overvintringsområde for havfugle fra hele det nordatlantiske område er i særklasse. De vigtigste områder for havfugle om sommeren og efteråret i den ydre kystzone (62°-68° N) er lokaliseret.

Havpattedyr

Mange arter af havpattedyr forekommer i området (tabel 4). Imidlertid er det kun få som ser ud til at foretrække at opholde sig i og nær Fyllaområdet. Hertil hører pukkelhval. De vigtigste opholdsteder for denne art er den østlige kant af Fyllas Banke, de østlige kanter af Fiskenæs og Danas Banker og kontinentalskrænten ud for Paamiut (figur 12).

Olieefterforskningsaktiviteter (5)

Olieefterforskning i Fyllaområdet vil starte med en række seismiske undersøgelser. Disse undersøgelser følges af efterforskningsboringer fra boreskibe eller flydende boreplatforme (semisubmersibles). Lokaliserede seismiske undersøgelser (2D og 3D), efterforskningsboringer og oliespild kan give anledning til effekter på miljøet. Simulering af oliespild ud for Vestgrønland tyder på, at store oliespild vil kunne spredes indenfor et område der er 200-300 km bredt og 300-600 km langt, men selve oliespildet vil kun kunne dække en meget lille del af dette område.

Mulige effekter af seismiske undersøgelser (6)

Lokaliserede seismiske undersøgelser i den østlige del af Fyllaområdet kan om sommeren muligvis medføre, at pukkelhvaler forlader et vigtigt fødesøgningsområde og tobis forlader en del af deres gydeområde. Det er umuligt at afgøre, om dette virkelig vil ske, og hvad de eventuelle følger for bestandene vil blive. Nogle få seismiske undersøgelser af kort varighed (få uger) vil sandsynligvis kun have begrænsede følger. 3D seismiske undersøgelser i Fyllaområdet kan måske også påvirke fangsterne af hellefisk tæt ved det seismiske undersøgelsesområde, fordi hellefiskene midlertidigt kan søge væk fra området. Dette er dog en korttids-effekt, som efter al sandsynlighed ikke har nogen væsentlige økologiske følger.

Mulige effekter af oliespild (6)

Den væsentligste påvirkning af olieefterforskning i Fyllaområdet vil kunne komme fra et større oliespild, især hvis dette når kysten. De vigtigste biologiske ressourcer der vil kunne blive påvirket om sommeren og efteråret er havfugle samt i kystområder især fisk og muslinger i kystområdet.

Fisk og rejer udenskærs

Det er ikke sandsynligt at selv et stort oliespild fra Fyllaområdet om sommeren eller i det tidlige efterår vil kunne påvirke udenskærs fiske- og rejebestande væsentligt. Fiskeæg og -larver forekommer på denne tid relativt spredt i området, og rejelarver forekommer kun i mindre grad nær vandoverfladen.

Fisk indenskærs

Derimod kan et stort oliespild medføre væsentlige påvirkninger af fiskebestande langs kyster, hvor koncentrationen af oliekomponenter i vandet kan bygges op i hele vandsøjlen. Stenbider og lodde er særligt sårbare, fordi de gyder på bestemte steder lige under lavvandslinien i sommerperioden. Fjeldørred, der tilbringer sommeren langs kysterne nær den elv de gyder og overvintrer i, er også sårbar over for oliespild der når kysten.

Havfugle

Havfugle er meget sårbare overfor oliespild, bl. a. fordi fjerdragtens isolerende og opdriftsgivende evne ødelægges. Dette medfører afkøling, sult og i sidste ende død. På grund af de lave omgivende temperaturer i arktis er fuglene her særligt afhængige af fjerdragtens isolerende evne. Fugle som ligger på og søger føde fra overfladen er særligt udsatte og følsomme overfor selv små oliepletter på fjerdragten. Desuden forekommer de ofte i store koncentrationer, hvorfor væsentlige dele af bestande kan blive udsat for oliespild. Et oliespild fra Fyllaområdet om efteråret kan true store mængder af havfugle som samles her for at overvintre. Om sommeren er der færre fugle tilstede, men disse yngler i området. Et oliespild på denne tid kan forårsage nedgange i de lokale bestande, som det vil tage længere tid at genoprette, fordi en stor andel af fuglene i de enkelte kolonier risikerer at blive ramt af olie. Regenerationstiden for en stærkt reduceret polarlomviekoloni kan være mange årtier, og endnu længere hvis bestanden påvirkes af andre menneskelige aktiviteter, som f eks. jagt.

Havpattedyr

Havpattedyr skal til overfladen for at ånde og har derfor en stor risiko for at komme i kontakt med oliespild på havoverfladen. Men det konkluderes at der ikke er stor sandsynlighed for at oliespild fra Fyllaområdet i sommer- og efterårsperioden vil kunne få væsentlige effekter på bestande af havpattedyr.

Regulering, overvågning og minimering af miljømæssige konsekvenser (7)

Den miljømæssige risiko ved efterforskningsboringer, kan minimeres ved bl.a. planlægning af aktiviteterne og således undgå de mest risikofyldte aktiviteter i de mest følsomme perioder og i de mest følsomme områder, men først og fremmest ved at forhindre oliespild ved at lægge vægt på sikkerhed.
Effektivt oliespildsbekæmpelsesudstyr skal være tilgængeligt og mobilisering af olieopsamling ved kilden skal være hurtig. Som en del af oliespildsbekæmpelsesplanen skal der udarbejdes kort over oliespildsfølsomme områder for at forstærke indsatsen i disse områder i tilfælde af et spild. Et led i denne følsomhedskortlægning omfatter udbredelsen og fangst af stenbider, lodde og fjeldørred. Påvirkning af pukkelhvalerne lige øst for Fyllaområdet med støj fra boringer kan nedsættes ved at bruge den mindst støjende teknik, og hvis der skal bores nær pukkehvalområdet anbefales det, at pukkelhvalerne overvåges for at registrere eventuelle effekter.

Vinteraktiviteter (8)

I olieudvindingsfasen vil der også være aktiviteter om vinteren. Effekterne af et stort oliespild på denne årstid vil kunne være meget alvorligere end om sommeren og efteråret. Der er store forekomster af havfugle og havpattedyr i området, og disse kan være meget koncentrerede f. eks. i revner og våger i isen, hvor også olie fra et spild vil samles. Men den nuværende viden om disse fugle og dyrs antal og fordeling er utilstrækkelig. Desuden er der endnu ikke udviklet effektive metoder til at opsamle og bekæmpe oliespild i isfyldt farvand.

Imaqarnersiorlugu naalisagaq (summary in Greenlandic)

Aallaqqaasiutitut nassuiaaneq (1-2)

Una Fylla-p qanigisaani uuliasiorluni aasalerneraniit ukialerneranut (maji - septemberi) misissuinissap avatangiisinut sunniisinnaaneranik aallarnersaasumik naliliineruvoq. Pingaarnerutillugu sammineqarpoq Kitaani allorniusat sanimukartut 62-aniit 68-ianut sunniutaasinnaasut Fylla-p qanigisaaniit uuliakoornerujussuusinnaasup tissukalernermini sunniutigisinnaasai sillimaffigisinnaaniarlugit. Naliliiniarnerup ilagai uumassusillit assigiinngitsut imminnut sunniuteqaqatigiinnerata (økosystem-ip) nassuiarneqarnera suussusilersorneqarneralu (kapitel 4), tamaani suliassarineqartussatut ilimagineqartut nassuiarneqarnerat (kapitel 5), suliassatut ilimagineqartut økosystem-illu imminnut sunniuteqaqatigiinnerisa suussusiliersorneqarnerat nalilerneqarnerallu (kapitel 6). Killilersuisinnaaneq, isumannaallisaaneq kiisalu nakkutilliinerit atorneqarsinnaasut aamma eqqarsaasersuutigineqarput (kapitel 7), taamatullu ajornartorsiutit annerusut ukiuunerani ingerlatsinermut attuumassuteqartut eqqaallatsiarneqarput (kapitel 8).

Pinngortitap issusaa (3)

Fylla-mi misissuiffissatut akuerineqarsimasoq (Fylla eqqaanilu) Davis Stræde-mi inissisimavoq sineriammiit 50 km-inik avasissuseqarluni, Fyllas Banke-p kitinnguani Kalaallit Nunaata Canada-llu akornanni ikkannersap kujammut kangimut killingani (ass. 1). Fylla-p eqqaanilu immaq kujammut kimmut teqeqquani 2000 m-iniit avannamut kangimut teqeqquani ikkannersami 200 m-inut itissuseqarpoq. Kalaallit Nunaata kitaani ikkannersaqarfik arlalinnik annertuunik ikkannerusortaqarpoq 20 m-it 100 m-illu akornanni itissuseqakkajunnerusunik. Ikkannersaqarfiup kujataatungaani sanimut isorartussusaa annikippoq avannaatungaanili 120 km-it tikillugit sanimut isorartussuseqarluni. Ikkannersaqarfiup kitaani imaq itisuujuvoq. Kitaani Davis Stræde-mi Kitaata sarfaa avannamukartoq sarfani annersaavoq (ass. 2). Sarfap qaavatungaa (0-150 m) immamik nillertumik Tunup sarfaaneersumik akoqarneruvoq, itinerusortaanili (150-800m) immamik kissartumik Irminger-ip sarfaanersumik (Gulf-ip sarfaanik aallaavilik) akoqarnerulluni. Sarfaq tamanna pissutigalugu Kitaata kujataa ukioq kaajallallugu naliginnaasumik sikuneq ajorpoq, naak ukiukkut sikorsuit takussaakkajuttaraluartut (ass. 3). Taamaattumik tamanna sikujuitsumik taaneqartarpoq, tamatumunnga illuatungiliuttuuvoq Kitaata imartaata sinnera ukiukkut sikusartuusoq.

Uumassusillit pissusaat (4)

Fylla eqqaalu Kitaani ikannersaqarfittulli allatut uumassusilinnik Kalaallit Nunaata imartaanni pilersuinerpaat ilaattut isigineqartarpoq, taamaasilluni timmissanut, immami miluumasunut aalisarnermullu pingaaruteartuulluni. Inuussutissartallit ikkannersami killinganilu qummukaajuarnerisigut aasaanerani sivisuumik uumasuaqqanik annertuumik pilersuijuartarpoq, tamatumunngalu naleqqiullugu Davis Stræde-p qeqqani kitaanilu pilersuineq annikkippoq.

Avataani aalisakkat kinguppaallu

Avataani aalisakkat akuleriiaartut assigiinngitsut arlaqanngitsuinnaapput. Aalisakkat pingaarnerit uumasullu saaneqanngitsut Tabel 1-mi takutinneqarsimapput. Ukiuni kingullerni aalisakkat akuleriiaarnerat allanngungaatsiarsimavoq, ersarinnersaavoq Atlantikup saarullianik avataani saarulleqarfeerussimammat. Tamaani pingaarutilimmik itisuup kinguppaanik qaleralinnillu aalisartoqarpoq (ass. 5 & 6) nimeriaqarfillu tamaaniitsuartoq ilimagineqarpoq immami miluumasunut timmissanullu imarmiunut inuusutitut pingaarnerpaajusoq.

Sineriammut qanitsoq

Tamaani sineriammut qanitsoq (62°-68° N) innaanganertaqarneruvoq qaarsuusunik ikkarluppassuaqarluni qeqertaararpassuaqarlunilu. Kangerliumaneeqqat siorallit imaluunniit tuapallit qaarsut akornanni unguneqarsimasut takussaasarput.Sissat sioraasut Marraq-Sermilimmi Frederikshåb isblink-illu eqqaani takussaapput, tamaanilu annertuumik siorarsuarnik sissaqarpoq qeqertaamanertaqarlunilu. Tamaani tinittarnera 3-4 m-inik annertussuseqarpoq assullu innaanganerni qaarsuusuni tinittarfimmiusunik naasoqarluni uumasoqarlunilu. Nipisat ammassaallu sissamut qanittumi suffisartuupput, ammassaallu sissamut qanittumi ukiup annertunersaani takussaasarluni. Aasaanerani eqaluit aamma sineriammi inuussuteqartarput.

Timmissat imarmiut

Fylla eqqaalu kiisalu sumiiffiit nalilerniarneqartut (62°-68° N) assut imarmiunik timmiaqarput, timmissallu assigiinngitsorpassuullutik tamarmik assigiinngitsunik inuussuteqarlutik (Tabel 2 & 3). Timmiaqarpoq aalisagartornerusunik soorlu appa (sineriak avalliunerusoq avataanilu), kiisalu oqaatsut (sineriak kangerluillu), immap qaavatungaaniitsunik plankton-inik inuussutillit soorlu taateraat, kiisalu naqqinnittartut soorlu miteq siorartooq (manngernerusuni) aamma miteq siorakitsoq (aqinnerusni). Timmissat imarmiut timmiaqarfinni piaqqisartut assigiinngitsut 14-nit tamaani takussaapput (Ass. 7 & 8). August-imi qeerlutuut assigiinngitsut kingullilisartut sinerissamut qanittumi katersuuttarput isaniarlutik nerisassarsiorniarlutillu (Ass. 10), ukiallu ingerlanerani timmiarpassuit imarmiut takkussuuttarput ukiiartorlutik (Tabel 3, ass. 11). Ilimagineqarpoq tamaani timmissat ukiukkut amerlanerpaajusartut, immallu sikuneq ajornerata pingaaruteqarluinnarnera immikkoorluinnarpoq. Sinerissap avasinnerusortaani (62°-68° N) aasakkut ukiakkullu imarmiunik timmiaqartartut pingaarnerusut sumiiffissineqarput.

Immami miluumasut

Immami miluumasut assigiinngitsorpassuit tamaaniittarput (Tabel 4). Taamaakkaluartorli assigiinngitsut arlaqanngitsuinnaat Fylla eqqaaluunnit pingaarnerutillugu najorumanerusarpaat. Tamakkunani pingaarnerpaajuvoq qipoqqaq. Qipoqqaat annertunerusumik takuneqartarsimapput Fyllas Banke-p kangimut killingani (Nuup avataani), Fiskenæs Danas Banke-llu kangimut killingani kiisalu Paamiut avataanni ikkannersaqarfiup killingani (Ass.12).

Uuliasiorluni misissuinerit (5)

Uuliasiorluni misissuinerit Fylla-mi eqqaanilu ilimagineqarpoq aallarnerneqassasut nunamik sajuppillatsitsisarnikkut tamatumanilu ilaallutik nunap ammut qanoq issusaa ilanngullugu assiliiorneq (3D), ukiualunnguillu qaangiuppata umiarsunik imaluunniit ataannarnerusunik qillerutinik qillerinerit aallarnersarneqarnissaat ilimagineqarpoq. Nunamik sajuppillatsitsisarnerit (3D), misissuilluni qillerinerit kiisalu ajutoorluni uuliakoornerit avatangiisinik sunniisinnaapput. Kalaallit Nunaata kitaani uuliakoornerit ingerlaarsinnaanerinik naatsorsuillu misissuinerit ersersippat uuliakoornerujussuup 200-300 km-inik isorartussusilik 300-600 km-inillu takissusilik angusinnaajumaaraa, kisiannili tamatuma annikitsortaannaa mattusimassallugu.

Nunamik sajuppillatsitsisarnerit sunniutigisinnaasai (6)

Fylla-mi eqqaanilu aasaanerani nunamik sajuppillatsitsisarnerit (3D) sunniutigisinnaavaat qipoqqaat neriniartarfitoqqaminniit qimagunnerat kiisalu nimerissat suffiniartut suffisarfiinit qimagutitaanerat. Naatsorsoruminaappoq sunniinerit takkukkumaarnersut kiisalu uumasunut qanorpiaq kinguneqavikkumaarnersut. Kisiannili qularinngilluinnarparput misissuinerit arlaqannngitsuinnaat killilimmillu sivisussusillit (sapaatip akunneri arlaqanngitsuinnaat) annikitsuinnarmik sunniuteqarumaartut. Fylla-mi eqqaanilu nunamik sajuppillatsitsilluni misissuinerit aamma qaleralinniarneq sunnersinnaavaat sajuppillatsitsisarnerup nalaani, tassami tamtuma qalerallit nuukkallarnerannik kinguneqarsinnaammat. Taamaakkuluartorli sunniinerat sivikitsuinnaavoq uumasuqatigiillu sunniuteqatigiittarnerannut allanik kinguneqassanani.

Uuliakoornerit sunniisinnaanerat (6)

Fylla-mi eqqaanilu uuliasiorluni missuinerit sunniisinnaanerisa annertunersaraat angisuumik uuliakoorneq, pingaartumik uuliakoornerup sineriak angussappagu. Tamaani (62°-68° N) uumassusillit Fylla-mit eqqaanilluunniit aasakkut ukiakkullu uuliakoornersuarmik akornuserneqarsinaasut tassaapput timmissat imarmiut, aalisakkat tinittarfiusumi ikkannerusumiluunniit suffisartut imaluunniit nerisaqartut, kiisalu uillut uiluiillu aammattaaq tinittartumiittut imaluunniit ikkannerusumiittut.

Avataani aalisakkat kinguppaallu

Ilimananngilaq Fylla-mit eqqaaniillu aasaanerani ukiakkulluunniit uuliakoornerit avataani aalisakkanut inersimasunut kinguppannulluunniit annertuumik sunniuteqarnissaat. Avataani suaat tukerlaallu sunnertissinnaasut annikitsuinnaapput piffisanilu taakkunani siammasillutik kiisalu annikitsuinnarmik immap qavatungaaniillutik. Tamatumunnga naleqqiullugu sineriammi sunniineq anertunerussaaq sineriammi uuliap immap itissusaanut katersuussinnaasup annertunerusinnaanera pissutigalugu.

Nipisat ammassaallu

Nipisat ammassaallu sunnertianerujussuupput aasaanerani aalajangersimasuni tinittarfiusuni suffisaramik. Eqaluit inuunermi annersaani sinerissami nerisassarsiortartut kuunnilu suffisartut sinerissami uuliakunik aamma sunnertiapput.

Timmissat imarmiut

Timmissat imarmiut assorujussuaq uulakoornernut sunnertiapput, uulia meqquinuk millutsittarmat oqorsarnerat puttasinnaanerallu aserortarlugu, tamannalu kinguneqartarluni qiunerannik, perlernerannik kiisalu ipinerannik. Immami nillertumi inuunertik pissutigalugu issittuni timmissat imarmiut pingaartumik meqqumik oqorsaasinnaassutaannik katatsineranik sunnertiasuujupput. Timmissat immami mitsimasartut nerisaqartullu, soorlu appat, uuliakoornernik anniktsuinnarnilluuniik assut sunnertiapput. Fylla-miit eqqaaniillu ukiaanerani uuliakoornerit timmissat imarmiorpassuit ulorianartorsiortittussaavai, tassami timmissat imarmiorpassuit ukiakkut tamaaniittarmata. Taamaattoq timmissat piaqqiornerisa nalaanni uuliakoorneq timmissat sivisunerusumik utersaarniarnerannik kinguneqarsinnaavoq, tassami timmissat timmiaqarfimmit ataatsimeersut annertuumik ilanngarneqarsinnaammata. Timmissat kinguaariikkuutaartarnerat tunngavigalugu naatsorsorneqarsimavoq appat annertuumik ikilineqarsimasut utersaarniarnerat ukiunik qulikkuutaartunik arlalinnik sivisussuseqarsinnaasoq.

Miluumasut imarmiut

Naak immami miluumasut uuliakoornernik eqqorneqarsinnaanerat anersaarniarlutik puisarnerat pissutigalugu annertungaluartoq, imatut nalilerneqarpoq Fylla-mi eqqaanilu aasaanerani ukiaaneranilu uuliakoortoqassagaluarpat ilimananngitsoq immami miluumasunut sunniuteqangaarnissaa.

Isumannaallisaaneq (7)

Uliaqarsinnaaneranik misissuinermi uuliakoornerujussuusinnaasut pissutigalugit avatangiisinik innarliisinnaaneq annikillisarniarlugu pingaartinneqartariaqarpoq suliassanik isumatusaarluni pilersaarusiorneq, piffissanilu sanngiinnerusuni sumiiffinnilu sunnertianerusuni suliaqarnissaq pinngitsoorniassallugu minnerunngitsumillu isumannaatsumik periaaseqarnissaq ajutoornerillu uuliakoorneertalli pinngitsoorniassallugit. Taamatuttaaq sukumiisumik uuliakoornernut akiuussutissaqartariaqarpoq sukkasuumillu uuliakoorfiusuni

katersipallassinnaasoqartariaqarluni. Uuliakoornernut akiuussinnaanermut pilersaarutit suliarineqartariaqarput avatangiisinik sunnertiasunik nunap assiliornertallit akornusiimerit killerlersorniassallugit.Nipisat, ammassaat eqaluillu siammarsimaffii pisarineqartarfiilu sukumiinerusmik misissorneqartariaqarput, soorlu inunnik tamaanimiuusunik apersuinikkut isumannartut misissorluarnerussallugit kiisalu sunnertianerusut nunap assigisigut sumiiffilersussallugit.
Qillerinerit nipiliornerisa qipoqqarnut Fylla-p kangiatungaani neriffeqartunut sunniuttarnerat annikillisarneqarsinnaavoq atortut nipikinnerpaat atorlugit, kiisalu qipoqqaqarfiup eqqaani qillerisoqassappat siunnersuutigineqarpoq misissuinerit aallartinneqassasut sunniutaasut nakkutiginiassallugit.

Ukiuunerani ingerlatsisarnerit (8)

Ukiuunerani ingerlatsinerit pisussaapput uuliamik maqqitsisoqarnerani. Ukiuunerani uuliakoornerup kingunerisai aasaneranit ukiaaneranillu annertunerusussaapput. Tamaani annertuumik pingaarutilinnillu ukiuunerani timmiaqartarpoq immamilu miluumasoqartarluni, naak amerlassusaannut siammarsimassusaannullu ilisimasat annikikkaluartut. Ukiuunerani timmisat miluumasullu sikusimanngitsumi assut katersuussimasinnaasarput, pingaartumik quppani sikullu killingani uuliakoornerit aamma katersuuffigisinnaasaannit. Timmissat nannullu uuliaarluersimasut kissassutaasa sunnerneqarnerat nillertillugu annertunerusarpoq. Maannakkuugallartoq immami sikulinni uuliakoornernut akiuussutissat akornusiinernullu killilersuutiginiakkat naammiginartutut isigineqanngillat.

List of animal species mentioned in the text, in English, Latin, Danish and Greenlandic.

Liste over anvendte engelske dyrenavne samt dansk og grønlandsk oversættelse

Uumasut tuluttut kiisalu qallunaatut kalaallisullu taagutaat

engelsk og videnskabeligt navn tuluttut ilisimatuussutsikkullu taaguutaat	dansk navn qallunaatut taaguutaat	grønlandsk navn kalaallisut taaguutaat
Fisk m.m. **Aalisakkat il. il.**		
American plaice *Hippoglossoides platessoides*	håising	oquutaq
Arctic char *Salvelinus alpinus*	fjeldørred	eqaluk
Arctic cod *Boreogadus saida*	polartorsk	eqalugaq
Atlantic cod *Gadus morhua*	torsk	saarullik
Atlantic halibut *Hippoglossus hippoglossus*	helleflynder	nataarnaq
Atlantic salmon *Salmo salar*	laks	kapisilik
Atlantic wolffish *Anarichas lupus*	havkat	qeeraaraq
blue mussel *Mytilus edulis*	blåmusling	uiloq
capelin *Mallotus villosus*	lodde	ammassak
cutthroat trout *Salmo clarki*	cutthroat ørred	-
deep sea shrimp *Pandalus borealis*	dybvandsreje	kinguppak
Dolly Varden *Salvelinus malma*	ørred art	-
Golden redfish *Sebastes marinus*	stor rødfisk	suluppaagaq
Greenland cod *Gadus ogac*	uvak	uugaq
Greenland halibut *Reinhardtius hippoglossoides*	hellefisk	qaleralik
lumpsucker *Cyclopterus lumpus*	stenbider	nipisa
redfish *Sebastes spp.*	rødfisk	suluppaagaq
scallop *Chlamys islandica*	kammusling	uiluiq
spottet wolffish *Anarhicas minor*	plettet havkat	qeeraq milattooq

starry skate *Raja radiata*	tærbe	allernaq

Fugle
Timmisat

Arctic tern *Sterna paradisaea*	havterne	imeqqutaalaq
Atlantic guillemot *Uria aalge*	almindelig lomvie	appa sigguttooq
Atlantic puffin *Fratercula arctica*	lunde	qilanngaq
black guillemot *Cepphus grylle*	tejst	serfaq
Thick-billed murre (Brünnich's guillemot) *Uria lomvia*	polarlomvie	appa
common eider *Somateria mollissima*	ederfugl	miteq siorartooq
glaucous gull *Larus hyperboreus*	gråmåge	naajarujussuaq
great black-backed gull *Larus marinus*	svartbag	naajarluk
great cormorant *Phalacrocorax carbo*	skarv	oqaatsoq
great shearwater *Puffinus gravis*	storskråpe	qaqullunnaq
harlequin duck *Histrionicus histrionicus*	strømand	tornarviarsuk
Iceland gull *Larus glaucoides*	hvidvinget måge	naajarnaq
king eider *Somateria spectabilis*	kongeederfugl	miteq siorakitsoq
kittiwake *Rissa tridactyla*	ride	taateraaq
little auk *Alle alle*	søkonge	appaliarsuk
long-tailed duck *Clangula hyemalis*	havlit	alleq
mallard *Anas platyrhynchos*	gråand	qeerlutooq
northern fulmar *Fulmarus glacialis*	mallemuk	qaqulluk
razorbill *Alca torda*	alk	apparluk
red-breasted merganser *Mergus merganser*	toppet skallesluger	paaq
white-tailed eagle *Haliaeetus albicilla*	havørn	nattoralik

Pattedyr
Uumasut miluumasut

bearded seal *Erignathus barbatus*	remmesæl	ussuk
blue whale *Balaenoptera musculus*	blåhval	tunnulik

bottlenose whale *Hyperoodon ampullatus*	døgling	anarnak
bowhead whale *Balaena mysticetus*	grønlandshval	arfivik
fin whale *Balaenoptera physalis*	finhval	tikaagulliusaaq
grey whale *Eschrichtius robustus*	gråhval	-
harbour seal *Phoca vitulina*	spættet (spraglet) sæl	qasigiaq
harbour porpoise *Phocoena phocoena*	marsvin	niisa
harp seal *Phoca groenlandica*	grønlandssæl	aataaq
hooded seal *Cystophora cristata*	klapmyds	natsersuaq
humpback whale *Megaptera novaeangliae*	pukkelhval	qipoqqaq
killer whale *Orcinus orca*	spækhugger	aarluk
minke whale *Balaenoptera acutorostrata*	vågehval (sildepisker)	tikaagullik
narwhal *Monodon monoceros*	narhval	qilalugaq qernertaq
pilot whale *Globicephala maelaena*	grindehval	niisarnaq
polar bear *Ursus maritimus*	isbjørn	nanoq
ringed seal *Phoca hispida*	ringsæl (netside)	natseq
sei whale *Balaenoptera borealis*	sejhval	tunnullit ilaat
sperm whale *Physeter macrocephalus*	kaskelot	kigutilissuaq
walrus *Odobenus rosmarus*	hvalros	aaveq
white whale (beluga) *Delphinapterus leucas*	hvidhval (hvidfisk)	qilalugaq qaqortaq

National Environmental Research Institute

The National Environmental Research Institute - NERI - is a research institute of the Ministry of the Environment and Energy. NERI's tasks are primarily to do research, collect data and give advice on problems related to the environment and Nature.

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