Summary and conclusions

This document is a Strategic Environmental Impact Assessment (SEIA) of activities related to exploration, development and exploitation of hydrocarbons in the Greenland sector of the Labrador Sea and the south-eastern Davis Strait, south of 62° and west of 42° 30' W.

The SEIA was prepared by the Danish Centre for Environment and Energy (DCE) at Aarhus University and the Greenland Institute of Natural Resources (GINR) for the Bureau of Minerals and Petroleum (BMP) to support the decision process for further exclusive licenses for exploration of hydrocarbons in the Greenland offshore areas of the Labrador Sea and Davis Strait. The SEIA uses existing published and unpublished sources, supplemented with dedicated field studies of seals and seabirds, to describe the physical and biological environment, including protected areas and threatened species, background contaminant levels as well as natural resource use. Based on this description of the existing situation, the potential impacts of oil activities are assessed.

If more licences are granted, it is planned that an environmental background study program will be initiated to fill in identified data gaps and information needs to support environmental planning and regulation of the oil activities. The new information will be included in an updated SEIA, which will be a reference document for future management decisions and replace this version.

The assessment area is shown in Fig. 1. This is the region that potentially could be impacted by a large oil spill deriving from activities within the expected licence areas, although spilled oil may drift beyond the borders of this area, most likely northwestwards along the Greenland coast.

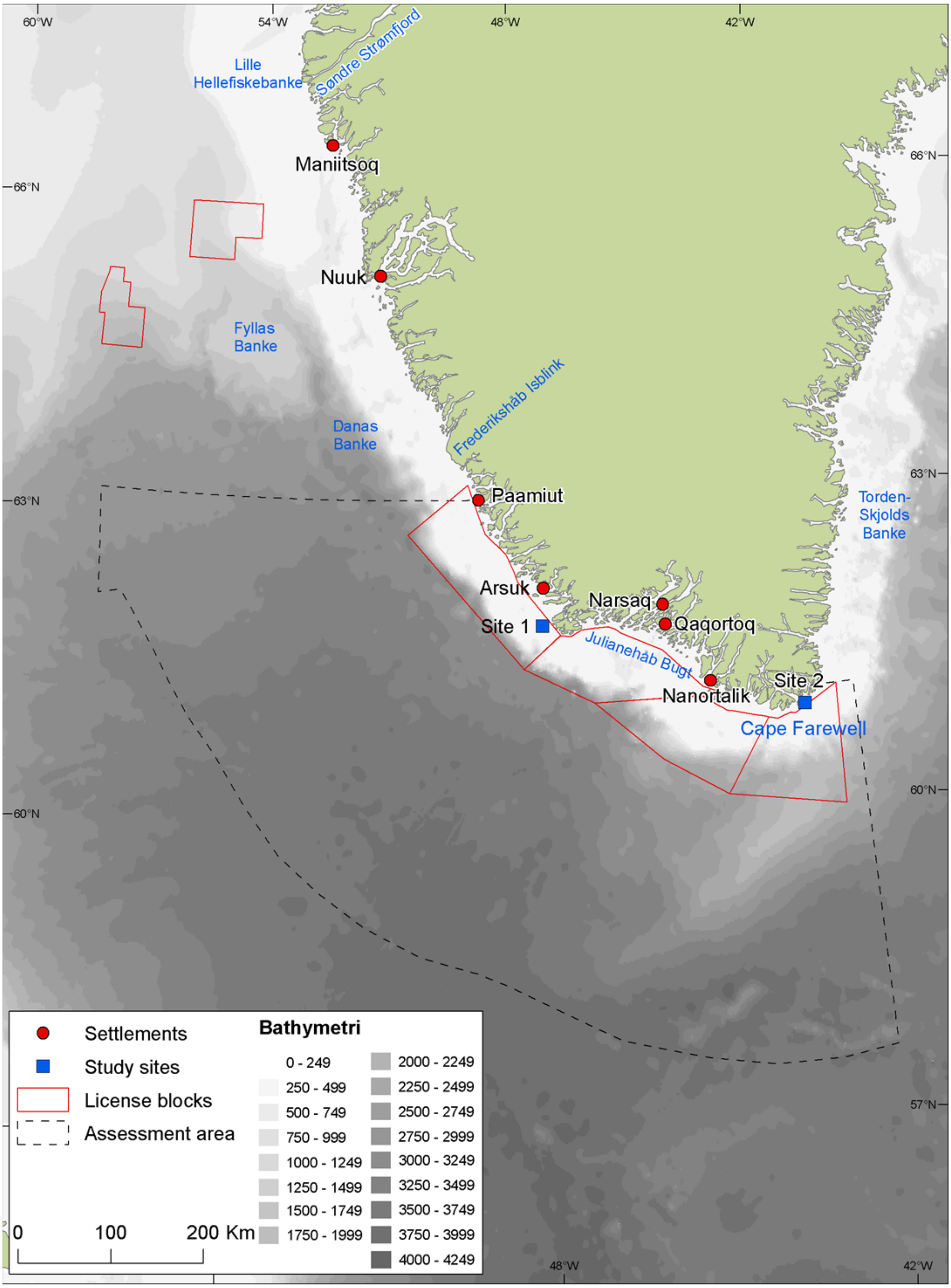

Fig. 1. Map of the South Greenland assessment area, showing existing license areas, towns and other important features. Also shown are the study sites for the two dedicated field studies: Site 1 is Ydre Kitsissut, where a detailed study of the ecology of breeding seabirds was carried out. Site 2 is Qeqertat, where habitat use of several seal species was studied.

The environment

Physical environment

The assessment area is situated in the sub-Arctic sector of the Northwest Atlantic and constitutes the north-eastern part of the Labrador Sea and the south-eastern part of the Davis Strait, and includes the South Greenland coastline from just east of Cape Farewell to Paamiut. The continental shelf (depth < 200 m) is relatively narrow (60-80 km), with a well-defined shelf break. The major part of the assessment area consists of deep water (> 2,000 m), with a maximum depth of ~3,700 m. The coastal topography is complex, with many archipelagos and fjords, and most shorelines are rocky with a relatively large tidal range.

The major current systems in the area are the cold East Greenland Current and the warm Irminger Current, which meet around Cape Farewell and flow north-westwards along the coast of Greenland. The relative strength of these two currents determines annual fluctuations in particularly the near-shore part of the assessment area. Compared to the rest of Greenland, sea ice is relatively sparse in the assessment area. However, the East Greenland Current carries large (but variable) amounts of drift ice and icebergs around Cape Farewell, and this ice often restricts ship access to the coast in late winter, spring and early summer.

The pelagic ecosystem

Very few oceanographic studies have been carried out in the assessment area, and as a consequence little is known about the location of particularly important areas with high productivity. As in other northern seas without ice cover, productivity peaks in spring when the water column stabilises, and declines during summer due to lack of nutrients. The highest productivity is likely to occur where upwelling or hydrographic fronts bring nutrient-rich water to the surface, e.g. along the shelf break and where currents meet. The spring phytoplankton bloom is dominated by diatoms, which to a large extent are grazed by zooplankton, mainly copepods. The most abundant copepod species is *Calanus finmarchicus*, which is a very important food source for small pelagic fish and juvenile stages of larger demersal fish. The deep part of the Labrador Sea is one of the most important overwintering areas for *C. finmarchicus*, and copepods originating from this area are likely to support commercial fisheries in Greenland and Canada.

Benthic flora and fauna

Benthic macrofauna (molluscs, crustaceans, echinoderms and polychaetes) consume a large part of the primary production that is left ungrazed by zooplankton. These animals also provide an important food source for demersal fish, marine mammals and sea ducks. Few studies of benthic fauna exist from the assessment area, and the geographical variation in community composition is largely unknown.

The tidal and subtidal zones often possess dense macroalgal vegetation, which provides food, substrate and shelter for many invertebrates and fish. The tidal vegetation is dominated by fucoid species. At shorelines highly exposed to waves and ice scouring, the characteristic macroalgal vegetation may not be able to establish due to the mechanical stress. Recent studies indicate that subtidal kelp forests may extend down to a depth of 50 m in the assessment area.

Columns of ikaite (a rare form of calcium carbonate) are found in Ikka Fjord. Besides being unique geological structures on a world scale, these columns house a highly diverse flora and fauna, including several species of microorganisms known only from this site. The conservation value of Ikka Fjord is extremely high.

Fish and shellfish

Most of the commercially important species in the assessment area are demersal, i.e. they occur near the sea floor. Northern shrimp and snow crab are widely distributed and common. Greenland halibut are less numerous than further north in Greenland, while the largest populations of Atlantic cod in West Greenland occur in the assessment area. Redfish occur in the deep offshore areas. The coastal zone is particularly important for spawning capelin and lumpsucker. The ecologically most important species are bentho-pelagic schooling fish (e.g. capelin and sandeel), which are key prey for many larger predators, including large fish, marine mammals and seabirds.

Seabirds

Populations of breeding seabirds in the assessment area are relatively small, but highly diverse. The most important colony is Ydre Kitsissut, which has the largest population in Greenland of the common murre (red-listed as Endangered in Greenland) and the largest population in the assessment area of thick-billed murre and razorbill. A detailed study of the foraging ecology and migration of these species has been carried out there (see Box 1).

Large populations of non-breeding seabirds occur in the assessment area. The area is particularly important for moulting harlequin ducks and wintering common eiders (both occurring near the coast), and for migrating and wintering thick-billed murres, black-legged kittiwakes, Atlantic puffins and ivory gulls (occurring further offshore). Non-breeding great shearwaters from colonies in the South Atlantic also occur offshore in large numbers during the northern summer. Very few data exist on seabird distribution and abundance in the deep parts of the assessment area.

Marine mammals

Among the seals, the assessment area is particularly important for the harbour seal (red-listed as Critically endangered in Greenland). An important haul-out site was discovered near Cape Farewell during fieldwork related to this SEIA, and the space use and behaviour of this and other seal species was studied in detail (see Box 2). In addition, a recently discovered whelping area of harp seal is located in the drift ice off the South Greenland coast, and very large numbers of hooded seals migrate through the area between their breeding and moulting sites.

The continental shelf and shelf break is a very important summer foraging area for baleen whales, particularly humpback, minke and fin whales. Sperm whales and other toothed whales also occur commonly, although few data exist. In addition, it is possible that individuals of the tiny remnant population of the northern right whale (red-listed as Critically endangered world-wide) pass through the area.

Human use

Commercial fisheries in the assessment area are relatively small, particularly in recent years. The most important species are northern shrimp, snow crab, lumpsucker and Atlantic cod. The most important areas for the fishery are Julianehåb Bugt and the continental shelf break. It is expected that the cod fishery will increase in the near future, if a local spawning stock is re-established.

Subsistence and recreational fisheries and hunting take place around all settlements, but particularly the number of birds taken has decreased since 2000. The most commonly taken birds are thick-billed murre and common eider, while harp seal and ringed seal are most important for seal hunters. Around a quarter of the Greenland catch of minke whales is taken in the assessment area (48 whales in 2010), and harbour porpoises are also important for local hunters.

Contaminants

Contaminant levels are reasonably well studied due to the AMAP programme. Results show that levels of organochlorines (particularly PCBs and DDT) are highest in the marine organisms belonging to the top trophic level (e.g. whales). AMAP activities have also shown a decrease in the levels of some 'legacy' POPs (e.g. PCBs and DDT), as a result of the introduction of bans and restrictions relating to their use in other parts of the world. At the same time, however, new persistent pollutants, such as brominated flame retardants are increasing, also in animals from Greenland. Levels of petroleum compounds, including PAHs, are relatively low in the Greenland environment and are regarded as background concentrations. Past mining activities have resulted in local contamination; most importantly, lead concentrations in mussels around the former cryolite mine at Ivittuut are still too high for human consumption, although they have decreased considerably since the mine closed.

Climate change

Climate change has a large potential to modify marine ecosystems, particular in high latitude regions. Alterations in the distribution and abundance of keystone species at various trophic levels could have significant and rapid consequences for the structure of the ecosystems in which they currently occur. Implications for fisheries and hunting are likely. For some populations, climate change may act as an additional stressor in line with e.g. hunting, leading to higher sensitivity towards oil spill accidents. Other populations may become more abundant and robust as a consequence of climate change. Finally, the species composition may change, with some disappearing or moving north and other species moving in from the south.

Assessment of impacts

The assessments presented here are based on our present knowledge concerning the distribution of species and their tolerance and threshold levels toward human activities in relation to oil exploration. However, the Arctic is changing due to climate change, and this process seems to accelerate, so conclusions and assessments may not apply under future conditions. Furthermore, a large part of assessment area is poorly studied, and improved knowledge may also lead to adjusted assessments and conclusions.

Normal operations – exploration

The main environmental impacts of exploration activities derive from noise generated either by seismic surveys or by the drilling platforms, and from the drilling process if cuttings and drilling mud are released to the sea.

The species most sensitive to noise from seismic surveys in the assessment area are the baleen whales (minke, fin, sei and humpback) and toothed whales such as sperm and bottlenose whales. These may be in risk of being displaced from parts of their critical summer habitats. A displacement will also impact the availability (for hunters) of whales if the areas affected include traditionally hunting grounds.

As seismic surveys are temporary, the risk for long-term population impacts of single surveys is low. However, long-term impacts have to be assessed if several surveys are carried out simultaneously or in the same potentially critical habitats during consecutive years (cumulative effect). 3D seismic surveys, which are typically conducted in small areas, may cause more severe temporary impacts.

Commercial fisheries in the assessment area (mainly for northern shrimp and snow crab) will probably not be affected.

Noise from drilling rigs will also be temporary, but locally more long-lasting than seismic surveys. The most vulnerable species in the assessment area are cetaceans (whales and harbour porpoise). If alternative habitats are available to the whales no effects are expected, but if several rigs operate in the same region there is a risk for cumulative effects and displacement even from alternative habitats.

Drilling mud and cuttings that are released on the seabed will cause local impacts on the benthic fauna. Within the assessment area only very local effects on the benthos are expected from discharging water-based muds with non-toxic additives from the drilling of an exploration well. Any drillings should be avoided in the most vulnerable areas. Baseline studies at drill sites must be conducted prior to drillings to document if unique communities or species such as cold-water corals and sponge gardens are at risk of being harmed by increased sedimentation. Post-drilling studies should document that activities did not cause any specific effects.

Exploration drilling is an energy-demanding process emitting large amounts of greenhouse gasses, so even a single drilling will increase the Greenland CO_2 emissions significantly.

Finally, there will be a risk for oil spills during exploration drilling (see below).

Unacceptable environmental impacts from exploration activities are best mitigated by careful planning based on thorough environmental background studies, BEP, BAT and application of the Precautionary Principle and international standards (OSPAR); for example, by avoiding activities in the most sensitive areas and periods.

Normal operations – development and production

Development and production activities are difficult to evaluate when their location and the level of activity are unknown. Overall, impacts will depend on the number of activities, how widely they are scattered in the areas in question, and also on their duration. In this context cumulative impacts will be important to consider. Drilling activities in the assessment area may take place at great depth, and this raises specific issues (see below).

The activities during development, production and transport are long-lasting, and there are several activities which have the potential to cause severe environmental impacts.

Emissions and discharges

Drilling will continue during the development and production phases, and drilling mud and cuttings will be produced in much larger quantities than during exploration. Discharges should be limited as much as possible by recycling and reinjection, and only environmentally safe substances (such as "green" and "yellow" chemicals), tested for toxicity and degradability under Arctic conditions, should be allowed discharged. In Greenland the use of "black" chemicals is not allowed, and the use of "red" chemicals requires specific permission. Even non-toxic discharges will alter the sediment substrate, and if these substances are released to the seabed impacts must be expected on the benthic communities near the release sites.

However, the release giving most reason for environmental concern is residues of oil in produced water. Recent studies have indicated that the small amounts of oil can impact birds, fish and primary production, and there is also concern for the long-term effects if radionuclides and hormone-disruptive chemicals are discharged.

Discharge of ballast water is also of concern, as there is a risk of introducing non-native and invasive species. Ballast water should therefore be treated and discharged according to specific regulations. This is currently not a severe problem in the Arctic, but the risk will increase with climate change and the intensive tanker traffic associated with a producing oil field.

Development of an oil field and production of oil are energy-consuming activities, which will contribute significantly to the Greenland emission of greenhouse gases. A single large Norwegian production field emits more than twice the total current (2010) Greenland CO_2 emission.

Noise

Noise from drilling and the positioning of machinery, which will continue during the development and production phases, may potentially lead to permanent loss or displacement of important summer habitats for cetaceans, especially if several production fields are active at the same time. Noise from ships and helicopters, now more frequent than during the exploratory phase, can affect both marine mammals and seabirds. The most sensitive species within the assessment area are colonial seabirds, minke whales, fin whales and harbour porpoise – species that may associate noise with negative experiences (hunting).

Traditional hunting grounds may also be affected. Introducing fixed flying lanes and altitudes will reduce impacts from helicopter noise.

Placement of structures

Placement of offshore structures and infrastructure may locally impact seabed communities and there is a risk of spoiling important feeding grounds. Inland structures may locally impact breeding birds, obstruct rivers with implications for anadromous Arctic char, damage coastal flora and fauna, as well as having an aesthetic impact on the pristine landscape, which again may impact the local tourism industry.

A specific impact on fisheries is the exclusion/safety zones (typically 500 m), which will be established around both temporary and permanent offshore installations. These may affect some of the important fishing areas for northern shrimp.

Illuminated structures and flares may attract seabirds at night, and there is a risk of mass mortality for especially eiders and perhaps little auks.

Cumulative impacts

Cumulative impacts of several oil fields (including other human impacts and climate change) are difficult to evaluate when the level of activity is unknown, and the impacts will depend on the scale of activities, the density of operation sites and the duration of the activities. A complete assessment must await such information.

The best way of mitigating impacts from development and production activities is to combine a detailed background study of the environment (in order to locate sensitive ecosystem components) with careful planning of structure placement and transport corridors. Then BEP, BAT and the application of international standards such as OSPAR and HOCNF can do much to reduce emissions to air and sea.

Oil spills

The environmentally most severe potential accident from hydrocarbon activities is a large oil spill. Accidental oil spills may occur either during drilling (blowouts), or from accidents when storing or transporting oil. Large oil spills are relatively rare events today due to ever-improving technical solutions and HSE policies. However, the risk of an accident cannot be eliminated. The potential consequences of oil spills at depth are described below.

Drift modelling shows that oil from a surface spill in the assessment area is most likely to spread north-westwards along the Greenland coast. Much of the oil is likely to end up on the shoreline, both in the assessment area and further north. Due to persistent ocean currents, areas east of Cape Farewell will not be affected.

Large oil spills have the potential to affect all levels in the marine ecosystem, from primary producers to top predators. A large oil spill represents a threat at population and maybe even species level, and the impacts may last for decades as documented after the *Exxon Valdez* spill in Prince William Sound in Alaska in

1989. For some populations, oil spill mortality can to some extent be compensatory (be partly compensated by reduced natural mortality due to less competition), while for others it will be largely additive to natural mortality. Some populations may recover quickly, while others will recover very slowly to pre-spill conditions, depending on their life history and population status. For species which are vulnerable to oil spills and are also harvested, oil spill impacts could be mitigated by managing the harvest wisely and sustainably. The lack of efficient response methods in partly ice-covered waters and the remoteness will add to the severity of an oil spill, and therefore exploration drilling is not allowed when ice is present.

For this impact assessment, the offshore part of the assessment area has been divided into six subareas, which have been classified according to their sensitivity to oil spills, taking into account the relative abundance of species/species groups, species- or population-specific oil sensitivity values, oil residency and human use. During all seasons, the subareas on the continental shelf are the most sensitive. These areas are especially important for migrating/wintering seabirds, human use of northern shrimp and snow crab and as foraging areas for baleen whales. Areas further from the shore are ranked as less sensitive, mainly because seabirds and marine mammals occur at lower densities.

A comparison of seasons, based on absolute sensitivity values and averaged across all offshore areas, shows that autumn and summer are most sensitive to oil spills, while winter and spring are least sensitive. The main reason for this difference is the large number of moulting and migrating seabirds during summer and autumn, which are very sensitive to oil.

The coastal zone of the assessment area is even more sensitive to oil spills (Fig. 2), due to a higher biodiversity and related to the fact that oil may be trapped in bays and fjords where high and toxic concentrations can build up in the water. There will be a risk of negative impacts on spawning concentrations of fish such as capelin and lumpsucker in spring, Arctic char assembling outside their spawning rivers and on many seabird populations both in summer, during migration periods and in winter. Long-term impacts may occur in the coastal zone if oil is buried in sediments, among boulders, in mussel beds or is imbedded in crevices in rocks, where it may persist for decades. In Prince William Sound in Alaska, such preserved oil has caused negative long-term effects e.g. on birds utilising the polluted coasts, and some populations have still not recovered after more than 20 years. The coastal zone is also of crucial importance for local hunters and fishermen, and in case of an oil spill, these activities may be adversely affected by closure zones and/or by changed distribution patterns of targeted species. The tourist industry in the assessment area will probably also be impacted negatively by oil exposure in the coastal area.

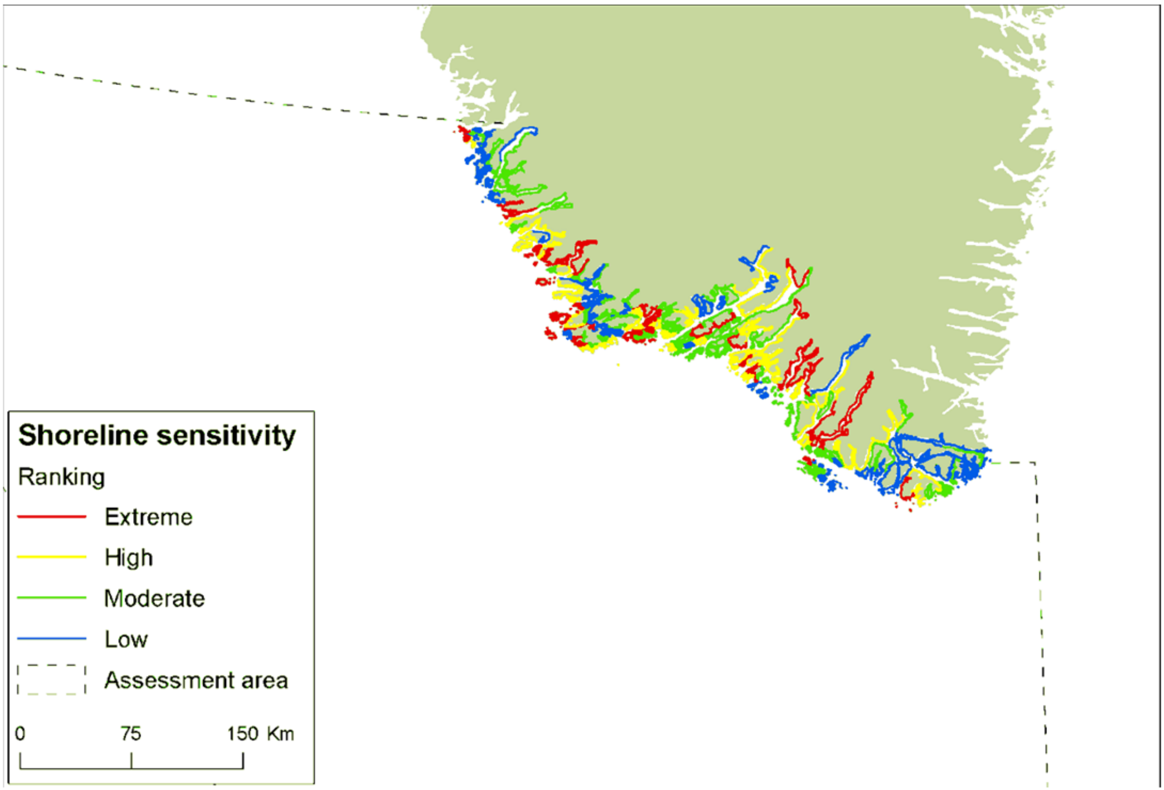

Fig. 2. Oil spill sensitivity of coastlines in the assessment area according to the NERI oil spill sensitivity atlas from 2004. The most sensitive coastlines are indicated in red, and the least sensitive in blue

In general, accidents are best mitigated by careful planning, strict Health, Safety and Environment (HSE) procedures and application of the Precautionary Principle in combination with BEP, BAT and international standards (OSPAR).

Primary production and zooplankton

The impact of a surface oil spill in the assessment area on primary producers and zooplankton in open waters is likely to be low, because these organisms occur over very large areas. There is, however, a risk of impacts (reduced production) on localised primary production areas, and the spring bloom will be the most sensitive period. Copepods overwintering at great depth may be exposed in the case of a subsea blowout, and their sensitivity to such exposure is essentially unknown.

Fish and crustacean larvae

In general, eggs and larvae of fish and crustaceans are more sensitive to oil than adults, and may theoretically be impacted by reduced annual recruitment strength with some effect on subsequent populations and fisheries for a number of years. Atlantic cod is especially sensitive because their eggs and larvae are concentrated in the upper 10 m of the water column, whereas larvae of shrimp and Greenland halibut, for instance, are found deeper and would therefore be less exposed to harmful oil concentrations from an oil spill at the surface. However, a large subsea blowout may expose eggs and larvae over much larger areas and depth ranges, and may potentially also impact the recruitment and stock size of other species, such as northern shrimp, snow crab and sandeel.

Benthos

Bottom-living organisms such as bivalves and crustaceans are vulnerable to oil spills; however, no effects are expected in the open water unless oil sinks to the seabed. In shallow waters (< 10-15 m), highly toxic concentrations of hydrocarbons can reach the seafloor with potentially severe consequences for local benthos and thus also for species utilising the benthos – especially common eider, harlequin duck, long-tailed duck and bearded seal. A large subsea spill may have the potential to impact seabed communities in deep waters too.

Tidal and subtidal macroalgae and the associated invertebrate fauna are sensitive to smothering and toxic effects of oil hitting the shore. The unique ikaite columns and their associated flora and fauna in Ikka Fjord are likely to be very sensitive to toxic effects of oil, but it is probably unlikely that they will be exposed even in the case of a major spill.

Adult fish

Impacts from a surface spill on adult fish stocks in the open sea are not expected. The situation is different in coastal areas, where high and toxic oil concentrations can build up in sheltered bays and fjords resulting in high fish mortality. Spawning capelin and lumpsucker are particularly vulnerable in the coastal zone.

Fisheries
An oil spill in the open sea will affect fisheries mainly by means of temporary closures in order to avoid tainting of catches. The duration of a closure will depend on the duration of the oil spill, weather, etc. The assessment area is an important fishing ground for northern shrimp and snow crab, and closure zones may have significant economic consequences for this section of the fishing industry.

Oiled coastal areas would also be closed for fisheries for a period – the duration of the closure would depend on the behaviour of the oil. There are examples of closures lasting many months due to oil spills, particularly if oil is caught in sediments or on beaches. The commercial inshore fishery targets primarily lumpsucker and local populations of Atlantic cod, while capelin are taken in the subsistence and recreational fishery.

Seabirds
Seabirds are extremely vulnerable to oil spills in the marine environment because they usually spend much time at the surface where most oil spills occur. Their plumage is highly sensitive to oil, as only small amounts will destroy its insulation and buoyancy properties. Exposed birds usually die from hypothermia, starvation, drowning or intoxication. In the assessment area, the coastal zone is particularly sensitive because high concentrations of seabirds are found year-round. A substantial part of these birds, including breeding birds, moulting birds and wintering birds, are associated with habitats along the highly exposed outer coastline. In such areas, oil spill response is hampered by remoteness, the complex coastal morphology and often harsh weather conditions. The seabird species most vulnerable to mortality from oil spills are those with low reproductive capacity (low population turnover), a trait especially found among auks, fulmars and many sea ducks.

During autumn and winter, a number of species are also at risk further offshore in the assessment area, including the shelf areas, although birds tend to be more dispersed in the open water compared to coastal habitats. Some of the important species include northern fulmar, black-legged kittiwake, Atlantic puffin, little auk and thick-billed murre.

Marine mammals
Whales and seals are vulnerable to surface oil spills. Baleen whales may get their baleens smothered with oil and ingest oil. This may affect filtration capability, or lead to toxic effects and injuries in the gastrointestinal tract if oil is ingested. There is also a risk of inhalation of oil vapours and direct contact with eye tissues. The extent to which marine mammals actively will avoid an oil slick and also how harmful the oil will be to fouled individuals is uncertain. However, observations indicate that at least some species do not perceive oil as a danger and have repeatedly been reported to swim directly into oil slicks.

Seal pups are highly vulnerable to direct oiling, and even short exposures can be lethal, as the oil will affect the isolation properties of the fur. Whelping of harp seal occurs in the assessment area.

Marine mammals species affected by an oil spill during winter in the assessment area could include bearded seal, hooded seal, ringed seal, harbour seal, harbour porpoise, bottlenose whale and sperm whale. Harbour seals are especially vulnerable because they are rare and endangered in Greenland, and the most important concentration occurs in the assessment area. Marine mammals that use the area as feeding grounds during summer include harp seal, hooded seal, ringed seal, harbour seal, fin whale, humpback whale, minke whale, sei whale, harbour porpoise, white-beaked dolphin, bottlenose whale, sperm whale, and pilot whale. Blue whales occur only rarely in the assessment area, but are vulnerable due to a very small population. The globally highly endangered northern right whale may also occur in the area.

Mitigation
The risk of accidents and their environmental impacts can be minimized with extremely high safety levels, planning to avoid the most sensitive areas and periods and efficient contingency plans with access to adequate equipment. Oil spill sensitivity maps (e.g. Fig. 2), where the most sensitive areas have been identified, can assist in the planning phase.

Risk, fate and consequences of a large deep-water oil spill
Because much of the assessment consists of very deep water, where the experience of drilling (and response to spills) is very limited, it is important to consider carefully the attendant risks. The risk of blowouts is in general very low (estimated as 1 in 13,000 wells), but is likely to be somewhat elevated when drilling takes place in deep water, as may be the case in the assessment area. Drilling in oil reservoirs at high temperature and pressure is considered more risky, and such conditions are more likely to be encountered at great depth. The best way of reducing the risk is to apply high safety standards and careful planning.

Should a subsea blowout occur in the deep part of the assessment area, the general pattern of horizontal dispersal will be similar to a surface spill, implying that oil is expected to drift northwestwards and a large fraction will reach the coast. However, expected drift rates are lower due to lower current speeds at depth. At present, it is very difficult to predict whether a fraction of the oil is likely to remain dispersed at depth following such a spill, instead of rising to the surface. This is because the oil type in the assessment area is unknown, and the processes determining the behaviour of spilled oil under high pressure and low temperature are poorly understood.

The experience from the *Deepwater Horizon* blowout in the Gulf of Mexico in 2010 – the largest peacetime oil spill in history – shows that under some conditions large amounts of oil may remain dispersed at depth and form extensive subsea plumes. It is unclear to what extent this was due to the unprecedented large-scale application of dispersants directly at the wellhead, and what the role of gas hydrate formation and dissolution was.

At the time of writing, the picture of the ecological consequences of the *Deepwater Horizon* spill is still incomplete. However, it appears that much of the oil dispersed at depth was metabolized by microorganisms within a few weeks of the spill. While this is likely to have limited the toxic effects on other biota, oxygen depletion may have occurred as a consequence. As far as is known, impacts on fish and other vertebrates have also been limited, although some mortality of seabirds, marine mammals and sea turtles was observed following the spill. Potential long-term effects have still to be assessed.

Knowledge gaps and new studies

There is a general lack of knowledge on many of the ecological components and processes in the South Greenland area, as well as on the likely fate of spilled oil. A preliminary identification of information needs and knowledge gaps for environmental management and regulation of future oil activities in South Greenland can be found in chapter 11. To manage future oil activities, more information is needed to a) assess, plan and regulate activities so the risk of impacts are minimized; b) identify the most sensitive areas and update the oil spill sensitivity mapping of coastline and offshore areas, and c) establish a baseline to use in 'before and after' studies in case of impacts from large oil spills.

Suggested studies in the assessment area include:

- Identification of offshore hotspots and understanding of their ecological linkages
- Are diapausing copepod populations at depth in the assessment area likely to be affected by a subsea oil spill?
- More detailed understanding of the fate and behaviour of hydrocarbons especially in deep water in the assessment area
- Biodiversity studies of deep-water macrobenthos, e.g. corals and sponges
- Detailed modelling studies of the likelihood of oil slicks entering complex, narrow fjord systems
- Impact of seismic exploration on the cetaceans of Southwest Greenland