ANNEX 4

Draft Proforma - The Arctic Ice habitat - multiyear ice, seasonal ice and- marginal ice zone

Presented by WWF and reviewed by Participants at the Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Marine Areas in the North-East Atlantic. Reviewed and revised by an ICES expert group.

Abstract

The permanently ice covered waters of the high Arctic provide a range of globally unique habitats associated with the variety of ice conditions. In the northern hemisphere multi-year sea ice only exists in the Arctic and although the projections of changing ice conditions due to climate change project a considerable loss of sea ice, in particular multiyear ice, the Eurasian Central Arctic high seas are likely to at least keep the ice longer than many other regions in the Arctic basin. Ice is a crucial habitat and source of particular food web dynamics, the loss of which will affect also a number of mammalian and avian predatory species. The particularly pronounced physical changes of Arctic ice conditions as already observed and expected for the coming decades, will require careful ecological monitoring. Eventually measures will be needed to maintain or restore, to the extent possible the resilience of the Arctic populations to changing environmental conditions.

Introduction

Over many past millennia, most of the Eurasian part of the Arctic Basin, and in particular the high seas area in the Arctic Ocean (the waters beyond the 200 nm zones of coastal states, i.e. Norway, Russia, USA, Canada and Greenland/Denmark) have been permanently ice covered. However, in recent years, much of the multiyear permanent pack ice has been replaced by seasonal (1 year) ice. In addition, the former fast pack-ice is now increasingly broken up by leads. This structural change in the Arctic ice quality will result in a substantial increase in light penetrating the thin ice and water column, in conjunction with the overall warming of surface waters and increased temperature and salinity stratification due to the melting of ice.

Some models predict that before the end of the century the permanent ice cover may disappear completely (Anisimov *et al.,* 2007). The reduction and possible loss of permanent ice cover will result in significant changes in the structure and dynamics of the high Arctic ecosystems (CAFF, 2010; Gradinger, 1995; Piepenburg, 2005; Renaud *et al.,* 2008; Wassmann, 2008, 2011).

Understanding and studying the area proposed as EBSA is of particular scientific relevance as already envisaged by the Arctic Council (Gill *et al.,* 2011; Mauritzen *et al.,* 2011). Such studies may in the long-term, become relevant for the commercial exploitation of resources.

Location

The Ecologically or Biologically Significant Marine Area (EBSA) proposed focuses on the presently permanently ice-covered waters in the OSPAR/NEAFC maritime areas, including the high seas section in the Central Arctic Basin north of the 200 nm zones of coastal states, and the area of contiguous seasonal ice directly connected to the multi-year permanent ice (see Fig. 1 attached). Therefore, the boundaries proposed extend from the North Pole (northernmost point of OSPAR/NEAFC maritime areas) to the southern limit of the summer sea ice extent and marginal ice zone, including on the shelf of East Greenland.

The proposal currently only relates to features of the water column and the ice surface itself. Two legal states have to be distinguished: the Central Arctic high seas waters north of the 200 nm zones of adjacent coastal states, generally north of 84° N, and the waters within the Exclusive Economic Zones of Greenland, Russia and the fisheries protection zone of Norway around Svalbard. Figure 1 distinguishes between the high seas beyond national jurisdiction for which the "Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Marine Areas (EBSAs) in the North-East Atlantic" had a mandate3 and national/nationally administered waters within the 200 nm zone (national EEZs), within which the OSPAR Contracting Parties have the competence to report candidate EBSAs to the Convention on Biodiversity EBSA repository (OSPAR Commission, 2011).

[3] Participant Briefing for a Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Marine Areas (EBSAs) in the North-East Atlantic. Invitation Annex 2, 2011

The seafloor of the respective region will likely fall on the extended continental shelves of several coastal states. It belongs to the "Arctic Basin" region of (Gill *et al.,* 2011). Seafloor features were not considered in this assessment.

Figure 1 shows the location of the Arctic Ice „Ecologically or Biologically Significant Area" (EBSA) proposed.

Feature description

The Ecologically or Biologically Significant Marine Area (EBSA) proposed focusses on the presently permanently ice-covered waters in the OSPAR/NEAFC maritime areas, including the high seas section in the Central Arctic Basin north of the 200 nm zones of coastal states, and the marginal ice zone (where the ice breaks up, also called seasonal ice zone) along its southern margins (see Fig. 1 attached). Due to the inflow of Atlantic water along the shelf of Svalbard, and the concurrent outflow of polar water and ice on the Greenland side of Fram Strait, the southern limit of the summer sea ice extent is much further south in the western compared to the eastern Fram Strait, and in former times extended all along the Greenland coast.

Several of the key ecosystem functions and species dependencies are associated with the ice front. Statements made about those functions and dependencies apply to the area where the front is located at any particular time of the year, and not necessarily to either areas fully ice covered (permanently or seasonally) or open waters distant from the ice front in summer.

The high seas section of the OSPAR maritime area in the Central Arctic ocean is generally north of 84° N and much is fully ice-covered also in summer, although the quantity of multiyear ice has already substantially decreased and the 1-year ice leaves increasingly large leads and open water spaces. The ice overlays a very deep water body of up to 5000 m depth distinct from the surrounding continental shelves and slopes of Greenland and the Svalbard archipelago. The Nansen-Gakkel Ridge, a prolongation of the Mid-Atlantic Ridge north of the Fram Strait is structuring the deep Arctic basin in this section, separating the Central Nansen Basin to the south from the Amundsen Basin to the north. Abundant hydrothermal vent sites have been discovered on this ridge at about 85° 38 N (Edmonds *et al.,* 2003).

North of Spitsbergen, the Atlantic water of the West Spitsbergen Current enters the Arctic basin as a surface current. At around 83° N, a deep-reaching frontal zone separates the incoming Atlantic and shelf waters from those of the Central Nansen Basin (Anderson *et al.,* 1989), a transition reflected in ice properties, nutrient concentrations, zooplankton communities, and benthic assemblages (Hirche and Mumm, 1992, and literature quoted). This water subsequently submerges under the less dense (less salinity, lower temperature) polar water and circulates, in opposite direction to the surface waters and ice, counterclockwise along the continental rises until turning south along the Lomonossov Ridge and through Fram Strait as East Greenland Current south to Danmark Strait (Aagaard, 1989; Aagaard *et al.,* 1985). Connecting the more fertile shelves with the deep central basin, these modified Atlantic waters supply the waters north of the Nansen-Gakkel Ridge, in the Amundsen basin, with advected organic material and nutrients which supplement the autochtonous production (Mumm *et al.,* 1998). Due to the import of organic biomass from the Greenland Sea and the Arctic continental shelves, part of which may not be kept in the food web due to the polar conditions, the Arctic Ocean may also represent an enormous carbon sink (Hirche and Mumm, 1992).

In the Fram Strait, the region between Svalbard to the east and Greenland to the west, the East Greenland Current is the main outflow of polar water and ice from the Arctic Basin (Maykut, 1985) (Aagaard and Coachman, 1968). The polar front (0° C isotherm and 34.5 isohaline at 50 m depth) extends approximately along the continental shelf of Greenland, separating the polar surface water from the Arctic (Intermediate) water and the marginal ice zone to the east (e.g. Aagaard and Coachman, 1968; Paquette *et al.,* 1985). The ice cover is densest in polar water, its extent to the east depends on the wind conditions (compare also Angelen *et al.,* 2011; Wadhams, 1981).

The seasonal latitudinal progression of increasing and diminishing light levels, respectively, is the determining factor for the timing of the phytoplankton-related pelagic production. Therefore, the spring bloom and ice break up progress from south to north in spring, reaching the Arctic area by about June/July. Because the currents in Fram Strait move in opposite direction, the polar East Greenland Current to the south, and the Atlantic West Spitsbergen Current to the north, there is a delay of about a month between biological spring and summer between the polar and the Atlantic side (Hirche *et al.,* 1991). Therefore, sea ice and the effect of melting ice are important determinants of the ecosystem processes all along the East Greenland polar front from the Greenland Sea through Fram Strait to the Arctic Basin (Legendre *et al.,* 1992; Wassmann, 2011).

Ice situation

The Arctic Ocean is changing towards a one-year instead of a multi-year sea-ice system with consequences for the entire ecosystem, including ecosystem shifts, biodiversity changes, water mass modifications, and role in the global overturning circulation. At its maximum, sea-ice covers 4.47 million km² in the Arctic Basin (Gill *et al.,* 2011): According to data from ice satellite observations in 1973-76 (NASA, 1987, in (Gill *et al.,* 2011)), permanent ice occupied 70-80% of the Arctic Basin area, and the inter-annual variability of this area did not exceed 2%. Seasonal ice occupied 6-17% (before the melting period of the mid-1970s). By the end of the first decade of the 21st century, the permanent-ice area had decreased greatly, concurrent with a rapid increase in seasonal- ice. Whereas multiyear ice used to cover 50-60% of the Arctic, it covered less than 30% in 2008, after a minimum of 10% in 2007. The average age of the remaining multiyear ice is also decreasing from over 20 % being at least six years in the mid- to late 1980s, to just 6% of ice six years old or older in 2008.

Figure 2: Modelled ice age distribution in 1985-2000 (left) compared to February 2008 (right) (CAFF, 2010).

This trend is likely to amplify in the coming years, as the net ocean-atmosphere heat output due to the current anomalously low sea ice coverage has approximately tripled compared to previous years, suggesting that the present sea ice losses have already initiated a positive feedback loop with increasing surface air temperatures in the Arctic (Kurtz *et al.,* 2011).

About 10% of the sea ice in the Arctic basin is exported each year through Fram Strait into the Greenland Sea (Maykut, 1985) which is therefore major sink for Arctic sea ice (Kwok, 2009). From 2001 to 2005, the summer ice cover was so low on the East Greenland shelf, that it was more of a marginal ice zone (Smith Jr and Barber, 2007). However the subsequent record lows in overall Arctic ice cover brought about an increase in ice cover off Greenland, which minimised the extent of the North East Water Polynia on the East Greenland shelf[4], a previously seasonally ice-free stretch of water (Wadhams, 1981).

Ice related biota

An inventory of ice-associated biota covering the entire Arctic presently counts over 1000 protists, and more than 50 metazoan species (Bluhm *et al.,* 2011). The regionally variable ice fauna (dependent on, *inter alia*, ice age, thickness, origin) consists of sympagic biota living within the caverns and brine channels of the ice, and associated pelagic fauna. The most abundant and diverse sympagic groups of the ice mesofauna in the Arctic seas are amphipods and copepods. Polar cod (*Boreogadus saida)* and to a lesser extent Arctic cod (*Arctogadus glacialis*) are dependent on the sympagic macro- and mesofauna for food. The fish themselves are important food sources for Arctic seals (such as ringed seal Phoca hispida) and birds, for example black guillemots Cephus grylle (Bradstreet and Cross, 1982; Gradinger and Bluhm, 2004 and literature reviewed; Horner *et al.,* 1992; Süfke *et al.,* 1998).

The higher the light level in the ice, the higher is the biomass of benthic algae as well as meiofauna and microorganisms within the ice (Gradinger *et al.,* 1991). Decreasing snow cover induces a feedback loop with enhanced algal biomass increasing the heat absorption of the ice which leads to changes in the ice structure, and ultimately the release of algae from the bottom layer (Apollonio, 1961 in Gradinger *et al.,* 1991). Because of the distance to land and shelves, and the thickness and internal structure of the multiyear pack ice over deeper water, this type of ice has a fauna of its own (Carey, 1985; Gradinger *et al.,* 1991). Arctic multiyear ice floes can have very high algal biomasses in the brine channels and in the bottom centimeters which serves as food for a variety of proto- and metazoans, usually smaller than 1 mm, over deep water (Gradinger *et al.,* 1999). In the central Arctic, ice algal productivity can contribute up to 50 % of the total primary productivity, with lower contributions in the sea ice covered margins (Bluhm *et al.,* 2011).

In the boundary layer between ice floes and the water column, another specific community exists which forms the link between the ice based primary production and the pelagic fauna (Gradinger, 1995). Large visible bands of diatoms hang down from the ice, and are exploited by amphipods such as *Gammarus wilkitzki*, and occasionally by water column copepods such as *Calanus glacialis*, which are important prey of for example polar cod *Boreogadus saida*. The caverns, wedges and irregularities of the ice provide important shelter from predators for larger ice associated species and provide an essential habitat for these species (Gradinger and Bluhm, 2004).

During melt, the entire sympagic ice biota are released into the water column where they may initiate the spring algal plankton bloom (Smith and Sakshaug, 1990) or they may sink to the sea floor and serve as an episodic and first food pulse for benthic organisms before pelagic production begins (Arndt and Pavlova, 2005). In particular the shallow shelves and the shelf slope benthos has been shown to profit of this biomass input, reflected in very rich benthic communities (Klitgaard and Tendal, 2004; Piepenburg, 2005).

The role of the polar front and marginal ice zone for the production system

Primary production in the Arctic Ocean is primarily determined by light availability, which is a function of ice thickness, ice cover, snow cover, light attenuation), the abundance of both ice algae and phytoplankton, nutrient availability and surface water stratification. Generally, the spring bloom occurs later further north and in regions with a

[4] http://www.issibern.ch/teams/Polynya/

thick ice and snow cover. The current production period in the Arctic Ocean may extend to 120 days per year, with a total annual primary production in the central Arctic Ocean of probably up to 10 g C m-2 (Wheeler *et al.,* 1996).

Ice algae start primary production when light levels are relatively low, as melting reduces the thickness of the ice and snow cover. The major phytoplankton bloom develops only after the ice breaks up, when melting releases the ice biota into the water column and meltwater leads to surface stratification. The bloom lasts a few weeks, fuelling the higher trophic food web of the Arctic (Gradinger *et al.,* 1999, and literature quoted).

The marginal ice zones, i.e. where the ice gets broken up in warmer Atlantic or Arctic water, play an important role in the overall production patterns of the Arctic Ocean. Due to the strong water column stratification and increased light levels involved with the melting of the ice, the location and recession of the ice edge in spring and summer determines the timing and magnitude of the spring phytoplankton bloom, which is generally earlier than in the open water (Gradinger and Baumann, 1991; Smith Jr. *et al.,* 1987). Wind- or eddy-induced upwelling in the marginal ice zone, as well as biological regeneration processes replenish the surface nutrient pool and therefore prolong the algal growth period (Gradinger and Baumann, 1991; Smith, 1987). The hydrographic variability explains the patchy patterns of primary and secondary production observed, as well as consequently the patchy occurrence of predators.

The polar front separates to some degree the pelagic faunas of the polar and Arctic waters in the Greenland Sea and Fram Strait, each characterised by a few dominant copepod species with different life history strategies (Hirche *et al.,* 1991; see also review in Melle *et al.,* 2005): In polar waters, *Calanus glacialis* uses under ice plankton production and lipid reserves for initiating its spring reproduction phase, but depends on the phytoplankton bloom for raising its offspring (e.g. Leu *et al.,* 2011). Somewhat later, on the warm side of the polar front in Arctic water, the Atlantic species *Calanus finmarchicus* uses the ice edge-related phytoplankton bloom for secondary production. *Calanus hyperboreus*, the third and largest of the charismatic copepod species has its core area of distribution in the Arctic waters of the Greenland Sea (Hirche, 1997; Hirche *et al.,* 2006).

Zooplankton of the Arctic Basin

Overall zooplankton biomass decreases towards the central Arctic basin, reaching a minimum in the most northerly waters, i.e. the region with permanent ice cover (Mumm *et al.,* 1998). However, investigations in recent years demonstrated increased biomasses compared to studies several decades earlier - possibly a consequence of the decrease in ice thickness and cover which only enabled the investigations to take place from ship board.

There is a south-north decrease in zooplankton biomass, with a sharp decline north of 83°N (Hirche and Mumm, 1992), coinciding with differences in the species composition of the biomass-forming zooplankton species. Whereas the southern Nansen basin plankton is dominated by the Atlantic species *Calanus finmarchicus*, entering the Arctic Basin with the West Spitsbergen Current, the northernmost branch of the North Atlantic current, the Arctic and polar species *Calanus hyperboreus* and *C. glacialis* dominate the biomass in the high-Arctic Amundsen and Makarov Basins (Auel and Hagen, 2002; Mumm *et al.,* 1998). The zooplankton species communities generally can be differentiated according to their occurrence in Polar Surface Water (0-50 m, temperature below –1.7°C, salinity less than 33.0), Atlantic Layer (200–900 m; temperature 0.5–1.5°C); salinity 34.5–34.8) and Arctic Deep Water (deeper than 1000 m, temperature -0,5--1° C, salinity > 34.9) (Auel and Hagen, 2002; Grainger, 1989; Kosobokova, 1982). The polar surface community in the upper 50 m of the water column consists of original polar species as well as species emerging from deeper Atlantic waters, altogether leading to a high abundance and biomass peak in summer. Diversity and biomass are minimal in the impoverished Arctic basin deepwater community (Kosobokova 1982). Apart from a limited exchange with the Atlantic Ocean via the Fram Strait, the central Arctic deep-sea basins are isolated from the rest of the world ocean deepsea fauna. Therefore, the bathypelagic fauna consists of a few endemic Arctic species and some species of Atlantic origin. Due to the separation of the Eurasian and Canadian Basins by the Lomonosov Ridge, significant differences in hydrographic parameters (Anderson *et al.* 1994) and in the zooplankton composition occur between both basins (Auel and Hagen, 2002).

Fish

Polar cod, *Boreogadus saida*, is a keystone species in the ice-related foodwebs of the Arctic. Due to schooling behavior and high energy content polar cod efficiently transfer the energy from lower to higher trophic levels, such as seabirds, seals and some whales (Crawford and Jorgenson, 1993).

Seabirds

Ice cover is a physical feature of major importance to marine birds in high latitude oceans, providing access to resources, and refuge from aquatic predators (Hunt, 1990). As seabirds are dependent on leads between ice floes or otherwise open water to access food, they search for the most productive waters in polynias (places within the ice which are permanently ice free) and marginal ice zones (Hunt, 1990). Here they forage both on the pelagic and sympagic ice-related fauna, especially the early stages of polar cod and the copepods *Calanus hyperboreus* and *C. glacialis*. Likely, they benefit from the structural complexity and good visibility of their prey near the ice (Hunt, 1990).

In the Greenland Sea and Fram Strait, major breeding colonies exist on Svalbard, Greenland and on Jan Mayen, all of these within reach of the seasonally moving marginal ice zone or a polynia (North East Water Polynia on the East Greenland shelf). Breeding seabirds like Little auks (*Alle alle*), from colonies in the northern Svalbard archipelago feed their offspring with prey caught in the vicinity of the nests, however intermittently travel at least 100 km to the marginal ice zone at 80° N to replenish their body reserves (Jakubas *et al.,* Online 03 June 2011). Therefore, the distance of the marginal ice zone to the colony site is a critical factor determining the breeding success (e.g. Joiris and Falck, 2011). Opportunistically, the birds also use other zooplankton aggregations such as a in a cold core eddy in the Greenland Sea, closer to the nesting site (Joiris and Falck, 2011).

A synopsis of seabird data for the period 1974–1993 (Joiris, 2000) showed that the little auk is one of the most abundant species, together with the fulmar *Fulmarus glacialis*, kittiwake *Rissa tridactyla* and Brünnich's guillemot *Uria lomvia* in the European Arctic seas (mainly the Norwegian and Greenland Seas). In the Greenland Sea and the Fram Strait, little auks represented the main species in polar waters, at the ice edge and in closed pack ice, reaching more than 50% of all bird species (Joiris and Falck, 2011). In spring and autumn, millions of seabirds pass through the area when migrating between their breeding sites on Svalbard or the Russian Arctic and their wintering areas in Canada (Gill *et al.,* 2011).

There are several seabird species in the European Arctic which are only met in ice-covered areas, for example the Ivory gull *Pagophila eburnea* and the Thick-billed guillemot *Uria lomvia* (see e.g. CAFF, 2010): Both species spend the entire year in the Arctic, and breed in close proximity to sea ice although Thick-billed guillemots were observed to fly up to 100 km from their colonies over open water to forage at the ice edge (Bradstreet 1979). The relatively rare Ivory gulls are closely associated with pack-ice, favouring areas with 70 – 90% ice cover near the ice edge, where they feed on small fish, including juvenile Arctic cod, squid, invertebrates, macro-zooplankton, carrion, offal and animal faeces (e.g. OSPAR Commission, 2009b). Ivory gulls have a low reproductive rate and breeding only takes place if there is sufficient food, which makes the population highly vulnerable to the effects of climate warming (e.g. OSPAR Commission, 2009b). Thick-billed guillemots are relatively long lived and slow to reproduce and has a low resilience to threats including oil pollution, by-catch in and competition with commercial fisheries operations, population declines due to hunting – particularly in Greenland (OSPAR Commission, 2009c).

Ivory gull and Thick-billed guillemots are both listed by OSPAR as being under threat and/or decline, (OSPAR Commission, 2008) and in 2011 recommendations for conservation action were agreed (OSPAR Commission, 2011) which will be implemented in conjunction with the circumpolar conservation actions of CAFF (CAFF, 1996; Gilchrist *et al.,* 2008).

Marine mammals

Several marine mammal species permanently associate with sea ice in the European Arctic. These include polar bear, walrus, and several seal species: bearded, *Erignathus barbatus*; ringed, *Pusa hispida*; hooded, *Cystophora cristata*; and harp seal *Pagophilus groenlandicus*. Three whale species also occupy Arctic waters year- round – narwhal, *Monodon monoceros*; beluga whale, *Delphinapterus leucas*; and bowhead whale, *Balaena mysticetus*.

Polar bears *Ursus maritimus* are highly specialized for and dependent on the sea ice habitat and are therefore particularly vulnerable to changes in sea ice extent, duration and thickness. They have a circumpolar distribution limited by the southern extent of sea ice. Three subpopulations of polar bears occur in the European high Arctic: the East Greenland, Barents Sea and Arctic Basin sub-populations, all with an unknown population status (CAFF, 2010). Following the young-of-the-year ringed seal distribution, polar bears are most common close to land and over the shelves, however some also occur in the permanent multi-year pack ice of the central Arctic basin (Durner *et al.,* 2009). Due to low reproductive rates and long lifetime, it has been predicted that the polar bears will not be able to adapt to the current fast warming of the Arctic and become extirpated from most of their range within the next 100 years (Schliebe *et al.,* 2008).

Walruses, *Odobenus rosmarus*, inhabit the Arctic ice year-round. They are conservative benthic feeders, diving to 80-100 m depth for scaping off the rich mollusc fauna of the continental shelves, and need ice floes as resting and nursing platform close to their foraging grounds. Walruses have been subject to severe hunting pressure from the end of the 18th century to the mid-20th century, and are still hunted today in Greenland (NAMMCO). By 1934, the estimated 70000-80000 individuals of the Atlantic population were reduced to 1200-1300, with none left on Svalbard (Weslawski *et al.,* 2000). Today's relatively small sub-populations on the East Greenland and Svalbard-Franz Josef Land coasts have recently shown a slightly increasing trend, in the latter case reflecting the full protection of the species since the 1950´s (CAFF, 2010; NAMMCO). Apart from their sensitivity to direct human disturbance and pollution, it is expected that walruses will suffer from the changing ice conditions (location, thickness for being used as haul-out site) as well as changes in ice-related productivity.

The Atlantic subspecies of the **bearded seal**, *Erignathus barbatus* occurs south of 85° N from the central Canadian Arctic east to the central Eurasian Arctic, but no population estimates exist (Kovacs, 2008b). Because of their primarily benthic feeding habits they live in ice covered waters overlying the continental shelf. They are typically found in regions of broken free-floating pack ice; in these areas bearded seals prefer to use small and medium sized floes, where they haul out no more than a body length from water and they use leads within shore-fast ice only if suitable pack ice is not available (Kovacs, 2008b, and literature quoted).

The **Arctic ringed seal** *Pusa (Phoca) hispida hispida* has a very large population size and broad distribution, however, there are concerns that future changes of Arctic sea ice will have a negative impact on the population, some of which have already been documented in some parts of the subspecies range (Kovacs *et al.,* 2008). As the other seals, the ringed seal uses sea ice exclusively as their breeding, moulting and resting (haulout) habitat, and feed on small schooling fish and invertebrates. In a co-evolution with one of their main predators, the polar bear, they developed the ability to create and maintain breathing holes in relatively thick ice, which makes them well adapted to living in fully ice covered waters the year round.

The West Ice (or Is Odden) to the west of Jan Mayen, at approx. 72-73° N, in early spring a stretch of more of less fast drift ice, is of crucial importance as a whelping and moulting area for harp seals and hooded seals (summarised e.g. by ICES, 2008). Discovered in the early 18th century, up to 350000 seals (1920s) were killed per year, decimating the populations from an estimated one million individuals in the 1950s (Ronald *et al.,* 1982) to today´s 70000 and 243000 of hooded and harp seals, respectively (Kovacs, 2008a, c).

Hooded seal, *Cystophora cristata*, is a pack ice species, which is dependent on ice as a substrate for pupping, moulting, and resting and as such is vulnerable to reduction in extent or timing of pack ice formation and retreat, as well as ice edge related changes in productivity (Kovacs, 2008a, and literature quoted). Hooded Seals feed on a wide variety of fish and invertebrates, including species that occur throughout the water column. After breeding and moulting on the West Ice they follow the retreating pack ice to the north, but also spend significant periods of time pelagically, without hauling out (Folkow and Blix 1999) in (Kovacs, 2008a). The northeast Atlantic breeding stock has declined by 85-90 % over the last 40-60 years. The cause of the decline is unknown, but very recent data suggests that it is on-going (30% within 8 years), despite the protective measures that have been taken in the last few years. The species is therefore considered to be vulnerable (Kovacs, 2008a).

Harp seals *Pagophilus (Phoca) groenlandicus* are the most numerous seal species in the Arctic seas. Their reproduction takes place in huge colonies, for example on the pack ice of the ''West Ice'' north of Jan Mayen, and after the breeding season they follow the retreating pack ice edge northwards up to 85° N, feeding mainly on polar cod under the ice (Kovacs, 2008c) .

Narwhals *Monodon monoceros* primarily inhabit the ice-covered waters of the European Arctic, including the ice sheet off East Greenland (Jefferson *et al.,* 2008b). For two months in summer, they visit the shallow fjords of East Greenland, spending all the rest of the year offshore, in deep ice-covered waters along the continental slope in the Greenland Sea and Arctic Basin (Heide-Jørgensen and Dietz, 1995). Narwhals are deep diving benthic feeders and forage on fish, squid, and shrimp, especially Arctic fish species, such as Greenland halibut, Arctic cod, and polar cod at up to 1500 m depth and mostly in winter. A recent assessment of the sensitivity of all Arctic marine mammals to climate change ranked the narwhal as one of the three most sensitive species, primarily due to its narrow geographic distribution, specialized feeding and habitat choice, and high site fidelity (Laidre *et al.* 2008 in (Jefferson *et al.,* 2008b)).

Bowhead whales *Balaena mysticetus* are found only in Arctic and subarctic regions and a Svalbard-Barents population occurs from the coast of Greenland across the Greenland Sea to the Russian Arctic. They spend all of their lives in and near openings in the pack ice feeding on small to medium-sized zooplankton. They migrate to the high Arctic in summer, and retreat southward in winter with the advancing ice edge (Moore and Reeves 1993 in (Reilly *et al.,* 2008)). Whaling has decimated the original bowhead whale populations to be rare nowadays, listed by OSPAR as being under threat and/or decline (OSPAR Commission, 2008). The species is considered to be very sensitive to changes in the ice-related ecosystem as well as sound disturbance, possible consequences of a progressive reduction of ice cover (OSPAR Commission, 2009a).

Belugas *Delphinapterus leucas* prefer coastal and continental shelf waters with a broken-up ice cover. They have never been surveyed around Svalbard. Pods numbering into the thousands are sighted irregularly around the archipelago, and pods ranging from a few to a few hundred individuals are seen regularly (Gjertz and Wiig 1994; Kovacs and Lydersen 2006 in (Jefferson *et al.,* 2008a)).

Little is known about the populations of the larger fauna in the Central Arctic Basin over the deepsea basins and ridges. But it is not likely that it is currently an area of great abundance - too far from the coastal nesting sites of marine birds, and over too deep water to allow feeding on benthos, as most of the larger mammals would need, and currently of too low plankton production to feed the large whales. All of these groups have their distribution center along the continental shelves presently - however, following the receding ice edge out to the central Arctic basin may be one of the options for the future.

Feature condition, and future outlook

This high Arctic region is particularly vulnerable to the the loss of ice cover and other effects of the anticipated global warming, including elevated UV radiation levels (Agustí, 2008). (Wassmann *et al.,* 2010) summarise what changes may be expected within the subarctic/Arctic region:

- northward displacement (range shifts) of subarctic and temperate species, and cross-Arctic transport of organisms;
- increased abundance and reproductive output of subarctic species, decline and reduced reproductive success of some Arctic species associated with the ice and species now preyed upon by predators whose preferred prey have declined;
- increased growth of some subarctic species and primary producers, and reduced growth and condition of animals that are bound to, associated with, or born on the ice;
- anomalous behaviour of ice-bound, ice-associated, or ice-born animals with earlier spring events and delayed fall events;
- changes in community structure due to range shifts of predators resulting in changes in the predator–prey linkages in the trophic network.

(Wassmann, 2008) expects radical changes in the productivity, functional relationships and biodiversity of the Arctic Ocean. He suggests that a warmer climate with less ice cover will result in greater primary production, a reduction of the stratified water masses to the south, changes in the relationship between biological processes in the water column and the sediments, a reduction in niches for higher trophic levels and a displacement of Arctic by boreal species. On the shelves, increased sediment discharges are expected to lower the primary production due to higher turbidity, and enhance the organic input to the deep ocean. A more extensive review of expected or suspected consequences of climate change for the marine system of the Arctic is given in (Loeng *et al.,* 2005).

Figure 3, extracted from (Gill *et al.,* 2011), presents the conceptual ideas about possible Arctic ecosystem changes mediated by human impact:

The normal situation shown in the upper left panel consists of ice-dependent species and species that tolerate a broader range of temperatures and are found in waters with little or no sea ice. Primary production occurs in phytoplankton (small dots in the figure) in ice-free waters and in ice-attached algae and phytoplankton in ice-covered waters. Phytoplankton (small t-shaped symbols in the figure) and ice algae are the main food sources for zooplankton and benthic animals. The fish community consists of both pelagic and demersal species. Several mammals are ice-associated, including polar bears and several species of seals. A number of sea bird species are also primarily associated with ice-covered waters.

At moderate temperature increases (upper right) populations of ice-dependent species are expected to decline as sea ice declines, and sub-Arctic species are expected to move northwards. Arctic benthic species are expected to decline, especially if their distributions are pushed close to or beyond the continental slope.

The expected effects from fisheries relate to the continental shelves. Two major effects are changes in populations of benthic organisms due to disturbance from bottom trawling and removal of large individuals in targeted fish stocks. In addition, the size of targeted stocks, both demersal and pelagic, may be reduced.

In addition, the effects of ocean acidification are considered (lower right). Ocean acidification will result in depletion of carbonate phases such as aragonite and calcite. This will alter the structure and function of calcareous organisms, particularly at lower trophic levels. Changes in pH can also alter metabolic processes in a range of organisms. It is not known how these changes will propagate to higher trophic levels, but the effects could be substantial.

Figure 3: Conceptual models showing potential impacts on Arctic marine ecosystems under different scenarios (Gill *et al.,* 2011).

Gill *et al.* (2011) conclude that the central part of the Arctic Basin is not a region for fisheries or oil and gas exploration. However, this region has played and will continue to play a very important role in the redistribution of pollutants, due to ice drift and/or currents between coastal and shelf areas and the Arctic Basin peripheries, far from sources of pollution.

Assessment against CBD EBSA Criteria

Table 1 Relation of each of the CBD criteria to the proposed area relating to the best available science. Note that a candidate EBSA may qualify on the basis of one or more of the criteria, the boundaries of the EBSA need not be defined with exact precision.

<table>
<tr><th rowspan="2">CBD EBSA Criterion</th><th rowspan="2">Description</th><th colspan="4">Ranking of criterion relevance
(please mark one column with an X)</th></tr>
<tr><th>Don't Know</th><th>Low</th><th>Some</th><th>High</th></tr>
<tr><td>Uniqueness or rarity</td><td>The area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td colspan="6">Explanation for ranking

Arctic sea ice, in particular the multiyear ice of the Central Arctic is globally unique and hosts endemic species such as the Gammarid amphipod Gammarus wilkitzki and sea ice meiofauna which will disappear with the melting of the ice. Polar bears, walrusses, bowhead whales, narwhales, belugas, several seal species and many bird species are endemic to the high Arctic ice.

While sea ice species such as G. wilkitzki are not endemic to the proposed EBSA they are endemic to the Arctic and unique within the OSPAR area</td></tr>
<tr><td>Special importance for life-history stages of species</td><td>Areas that are required for a population to survive and thrive</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td colspan="6">Explanation for ranking

Sea ice is essential for its sympagic fauna, and to some extent also for the pelagic associated fauna which also depends on the right timing of biomass production (match/mismatch with bloom periods). The marginal ice zone and other openings in the ice are essential feeding grounds for a large number of ice-associated species which exploit the seasonally high production there.

At present the area covered by the proposed EBSA includes both the area of permanent ice and, the area covered by seasonal ice and the ice edge. The community associated with the ice edge requires it special structural features for a number of ecological processes, including increased primary and secondary productivity, and feeding and resting of seabirds and marine mammals.</td></tr>
<tr><td>Importance for threatened, endangered or declining species and/or habitats</td><td>Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species</td><td></td><td></td><td>x</td><td></td></tr>
<tr><td colspan="6">Explanation for ranking

The high arctic ice hosts endemic species such as the Gammarid amphipod Gammarus wilkitzki and sea ice meiofauna which will disappear with the melting of the ice. Many of the obligatory ice-related species are listed as vulnerable by IUCN, and/or listed as under threat and/or decline by OSPAR, examples include the Ivory gull, thick-billed guillemot, bowhead whale, hooded seal and polar bear. With the overall trend of retreating sea ice extent, the proposed EBSA may become increasingly important for all ice-dependent species in the future.</td></tr>
<tr><td>Vulnerability, fragility, sensitivity, or slow recovery</td><td>Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery</td><td></td><td></td><td></td><td>x</td></tr>
</table>

Explanation for ranking The ice-related foodweb and ecosystem is highly sensitive to the ecological consequences of a warming climate. Beyond this the Arctic is at the forefront of the impacts of ocean acidification (Wicks & Roberts 2012). The largest changes in ocean pH will occur in the Arctic Ocean, with complete undersaturation of the Arctic Ocean water column predicted before the end of this century (Steinacher *et al.* 2009). Many of the seabird and mammal populations are particularly sensitive to changes due to their already low population numbers, and low fertility. If the retreat of the ice to the north will lead to increased shipping and oil and gas exploitation in Arctic waters, the increased risk of spills would also pose a potential hazard for example for guillemots, which are extremely susceptible to mortality from oil pollution (CAFF, 2010). In addition, some species like Ivory gull are sensitive to an increased heavy metal load in their prey.					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity				
Explanation for ranking This criterion was not evaluated in the *OSPAR/NEAFC/CBD Workshop*. ICES did not have enough information to evaluate this criterion.					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity				
Explanation for ranking This criterion was not evaluated in the *OSPAR/NEAFC/CBD Workshop*. ICES did not have enough information to evaluate this criterion.					

References

Aagaard, K., 1989. A synthesis of Arctic Ocean circulation. Rapport Proces et Verbeaux Réunion du Conseil international pour l'Exploration de la Mer 188, 11-22.

Aagaard, K., Coachman, L.K., 1968. The East Greenland Current north of Denmark Strait: Part II. Arctic 21, 267-290.

Aagaard, K., Swift, J.H., Carmack, E.C., 1985. Thermohaline circulation in the Arctic mediterranean seas. Journal of Geophysical Research 90, 4833-4846.

Agustí, S., 2008. Impacts of increasing ultraviolet radiation on the polar oceans. In: Impacts of global warming on polar ecosystems. Duarte, C.M. (Ed.) Fundación BBVA pp. 25-46.

Anderson, L.G., Jones, E.P., Koltermann, K.P., Schlosser, P., Swift, J.H., Wallace, D.W.R., 1989. The first oceanographic section across the Nansen Basin in the Arctic Ocean. Deep Sea Research 36, 475-482.

Angelen, J.H.v., Broeke, M.R.v.d., Kwok, R., 2011. The Greenland Sea Jet: A mechanism for wind-driven sea ice export through Fram Strait. Geophysical Research Letters 38 (L12805).

Anisimov, O.A., Vaughan, D.G., Callaghan, T.V., Furgal, C., Marchant, H., Prowse, T.D., Vilhjálmsson, H., Walsh, J.E., 2007. Polar regions (Arctic and Antarctic). In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., Canziani, O.F., Palutikof, J.P., Linden, P.J.v.d., Hanson, C.E. (Eds.)Cambridge University Press, Cambridge pp. 653-685.

Arndt, C., E. , Pavlova, O., 2005. Origin and fate of ice fauna in the Fram Strait and Svalbard area. Marine Ecology Progress Series 301, 55-66.

Auel, H., Hagen, W., 2002. Mesozooplankton community structure, abundance and biomass in the central Arctic Ocean. Marine Biology 140, 1013-1021.

Bluhm, B.A., Gebruk, A.V., Gradinger, R., Hopcroft, R.R., Huettmann, F., Kosobokova, K.N., Sirenko, B.I., Weslawski, J.M., 2011. Arctic marine biodiversity: An update of species richness and examples of biodiversity change. Oceanography 24 (3), 232-248.

Bradstreet, M.S.M., Cross, W.E., 1982. Trophic relationships at high Arctic ice edges. Arctic 35 (1), 1-12.

CAFF, 1996. International Murre conservation strategy and action plan. CAFF International Secretariat, CAFF Circumpolar Seabird Working Group, Akureyri, Iceland, pp. 1-16.

CAFF, 2010. Arctic Biodiversity Trends 2010. Selected indicators of change. CAFF International Secretariat, , Akureyri, Iceland.

Carey, A.G.I., 1985. Marine Ice Fauna. In: Arctic Sea Ice Biota. A., H.R. (Ed.)CRC Press, Boca Raton. Florida pp. 17-190

Crawford, R.E., Jorgenson, J.K., 1993. Schooling behaviour of arctic cod, *Boreogadus saida* in relation to drifting pack ice. Environmental Biology of Fishes 36 (4), 345-357.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C., McDonald, T.L., Stirling, I., Mauritzen, M., Born, E.W., Wiig, Ø., Deweaver, E., Serreze, M.C., Belikov, S.E., Holland, M.M., Maslanik, J., Aars, J., Bailey, D.A., Derocher, A.E., 2009. Predicting 21st-century polar bear habitat distribution from global climate models. Ecological Monographs 79 (1), 25-58.

Edmonds, H.N., Michael, P.J., Baker, E.T., Connelly, D.P., Snow, J.E., Langmuir, C.H., Dick, H.J.B., Mühe, R., German, C.R., Graham, D.W., 2003. Discovery of abundant hydrothermal venting on the ultraslow-spreading Gakkel ridge in the Arctic Ocean. Nature 421, 252-256.

Gilchrist, G., Strøm, H., Gavrilo, M.V., Mosbech, A., 2008. International Ivory Gull conservation strategy and action plan. CAFF International Secretariat, Circumpolar Seabird Group (CBird). CAFF Technical Report No. 18.

Gill, M.J., Crane, K., Hindrum, R., Arneberg, P., Bysveen, I., Denisenko, N.V., Gofman, V., Grant-Friedman, A., Gudmundsson, G., Hopcroft, R.R., Iken, K., Labansen, A., Liubina, O.S., Melnikov, I.A., Moore, S.E., Reist, J.D., Sirenko, B.I., Stow, J., Ugarte, F., Vongraven, D., Watkins, J., 2011. Arctic Marine Biodiversity Monitoring Plan (CBMP-MARINE PLAN), CAFF Monitoring Series Report No.3, April 2011. CAFF International Secretariat,, Akureyri, Iceland.

Gradinger, R., 1995. Climate change and biological oceanography of the Arctic Ocean. Phil. Trans. R. Soc. A 352, 277-286.

Gradinger, R., Bluhm, B.A., 2004. In situ observations on the distribution and behavior of amphipods and Arctic cod (*Boreogadus saida*) under the sea ice of the high Arctic Canadian Basin. Polar Biology 27, 595-603.

Gradinger, R., Friedrich, C., Spindler, M., 1999. Abundance, biomass and composition of the sea ice biota of the Greenland Sea pack ice. Deep Sea Research 46, 1457-1472.

Gradinger, R., Spindler, M., Henschel, D., 1991. Development o Arctic sea-ice organisms under graded snow cover. In: Proceedings of the Pro Mare Symposium on Polar Marine Ecology. Sakshaug, E., E., H.C.C., Øritsland, N.A. (Eds.), Polar Research 10 (1), Trondheim pp. 295-307.

Gradinger, R.R., Baumann, M.E.M., 1991. Distribution of phytoplankton communities in relation to the large-scale hydrographical regime in the Fram Strait. Mar. Biol. 111, 311-321.

Grainger, E.H., 1989. Vertical distribution of zooplankton in the central Arctic Ocean. In: Proc 6th Conf Comite´Arctique Int 1985. Rey, L., Alexander, V. (Eds.) Brill Leiden pp. 48–60.

Heide-Jørgensen, M.P., Dietz, R., 1995. Some characteristics of narwhal, *Monodon monoceros*, diving behaviour in Baffin Bay. Canadian Journal of Zoology 73, 2106-2119.

Hirche, H.J., 1997. Life cycle of the copepod *Calanus hyperboreus* in the Greenland Sea. Marine Biology 128 (4), 607-618.

Hirche, H.J., Baumann, M.E.M., Kattner, G., Gradinger, R., 1991. Plankton distribution and the impact of copepod grazing on primary production in Fram Strait, Greenland Sea. Journal of Marine Systems 2 (3-4), 477-494.

Hirche, H.J., Mumm, N., 1992. Distribution of dominant copepods in the Nansen Basin, Arctic Ocean, in summer. Deep Sea Research Part A. Oceanographic Research Papers 39 (2, Part 1), S485-S505.

Hirche, H.J., Muyakshin, S., Klages, M., Auel, H., 2006. Aggregation of the Arctic copepod *Calanus hyperboreus* over the ocean floor of the Greenland Sea. Deep Sea Research Part I: Oceanographic Research Papers 53 (2), 310-320.

Horner, R., Ackley, S.F., Dieckmann, G.S., Gulliksen, B., Hoshiai, T., Legendre, L., Melnikov, I.A., Reeburgh, W.S., Spindler, M., Sullivan, C.W., 1992. Ecology of sea ice biota. Habitat, terminology, and methodology. Polar Biology 12 (3), 417-427.

Hunt, G.L.J., 1990. The pelagic distribution of marine birds in a heterogeneous environment. Polar Research 8, 43-54.

ICES, 2008. Report of the ICES Advisory Committee In: ICES Advice, Book 3, The Barents and the Norwegian SEa.

Jakubas, D., Iliszko, L., Wojczulanis-Jakubas, K., Stempniewicz, L., Online 03 June 2011. Foraging by little auks in the distant marginal sea ice zone during the chick-rearing period. Polar Biology, 1-9.

Jefferson, T.A., Karczmarski, L., Laidre, K., O'Corry-Crowe, G., Reeves, R.R., Rojas-Bracho, L., Secchi, E.R., Slooten, E., Smith, B.D., Wang, J.Y., Zhou, K., 2008a. *Delphinapterus leucas* In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org Downloaded on 31 August 2011.

Jefferson, T.A., Karczmarski, L., Laidre, K., O'Corry-Crowe, G., Reeves, R.R., Rojas-Bracho, L., Secchi, E.R., Slooten, E., Smith, B.D., Wang, J.Y., Zhou, K., 2008b. *Monodon monoceros*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. . www.iucnredlist.org Downloaded on 31 August 2011.

Joiris, C., Falck, E., 2011. Summer at-sea distribution of little auks *Alle alle* and harp seals *Pagophilus (Phoca) groenlandica* in the Fram Strait and the Greenland Sea: impact of small-scale hydrological events. Polar Biology 34 (4), 541-548.

Joiris, C.R., 2000. Summer at-sea distribution of seabirds and marine mammals in polar ecosystems: a comparison between the European Arctic seas and the Weddell Sea, Antarctica. Journal of Marine Systems 27, 267-276.

Klitgaard, A.B., Tendal, O.S., 2004. Distribution and species composition of mass occurrences of large-sized sponges in the northeast Atlantic. Progress in Oceanography 61, 57-98.

Kosobokova, K.N., 1982. Composition and distribution of the biomass of zooplankton in the central Arctic Basin. Oceanology 22, 744-750.

Kovacs, K., 2008a. *Cystophora cristata*. IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org Downloaded on 31 August 2011.

Kovacs, K., 2008b. *Erignathus barbatus*. IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org Downloaded on 31 August 2011.

Kovacs, K., 2008c. *Pagophilus groenlandicus*. IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org Downloaded on 31 August 2011.

Kovacs, K., Lowry, L., Härkönen, T., 2008. *Pusa hispida*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. . www.iucnredlist.org Downloaded on 31 August 2011.

Kwok, R., 2009. Outflow of Arctic Ocean sea ice into the Greenland and Barents seas: 1979-2007. Journal of Climate 22, 2438-2456.

Legendre, L., Ackley, S.F., Dieckmann, G.S., Gulliksen, B., Horner, R., Hoshiai, T., Melnikov, I.A., Reeburgh, W.S., Spindler, M., Sullivan, C.W., 1992. Ecology of sea ice biota. Polar Biology 12 (3), 429-444.

Leu, E., Søreide, J.E., Hessen, D.O., Falk-Petersen, S., Berge, J., 2011. Consequences of changing sea ice cover for primary and secondary producers in the European Arctic shelf seas: timing, quantity, and quality. Progress in Oceanography 90, 18-32.

Loeng, H., Brander, K., Carmack, E.C., Denisenko, S., Drinkwater, K., Hansen, B., Kovacs, K., Livingston, P., McLaughlin, F., Sakshaug, E., 2005. Marine systems. In: Arctic Climate Impact Assessment, ACIA. Symon, C., Arrisand, L., Heal, B. (Eds.),Cambridge University Press, Cambridge pp. 453-538.

Mauritzen, C., Hansen, E., Andersson, M., Berx, B., Beszczynska-Möller, A., Burud, I., Christensen, K.H., Debernard, J., de Steur, L., Dodd, P., Gerland, S., Godøy, Ø., Hansen, B., Hudson, S., Høydalsvik, F., Ingvaldsen, R., Isachsen, P.E., Kasajima, Y., Koszalka, I., Kovacs, K.M., Køltzow, M., LaCasce, J., Lee, C.M., Lavergne, T., Lydersen, C., Nicolaus, M., Nilsen, F., Nøst, O.A., Orvik, K.A., Reigstad, M., Schyberg, H., Seuthe, L., Skagseth, Ø., Skar∂hamar, J., Skogseth, R., Sperrevik, A., Svensen, C., Søiland, H., Teigen, S.H., Tverberg, V., Wexels Riser, C., 2011. Closing the loop - Approaches to monitoring the state of the Arctic Mediterranean during the International Polar Year 2007-2008. Progress in Oceanography 90 (1-4), 62-89.

Maykut, G.A., 1985. The ice environment. In: Sea-ice biota. Horner, R. (Ed.)CRC Press, Boca Raton pp. 21-82.

Melle, W., Ellertsen, B., Skjoldal, H.R., 2005. Zooplankton: The link to higher trophic levels. In: The Nordic Seas: An integrated perspective oceanography, climatology, biogeochemistry, and modelling. . Drange, H., Dokken, T., Furevik, T., Gerdes, R., Berger, W. (Eds.)Geophysical Monograph Series 158 pp. 137-202.

Mumm, N., Auel, H., Hanssen, H., Hagen, W., Richter, C., Hirche, H.J., 1998. Breaking the ice: large-scale distribution of mesozooplankton after a decade of Arctic and transpolar cruises. Polar Biology 20 (3), 189-197.

NAMMCO, The Atlantic Walrus. North Atlantic Marine Mammal Commission. Status of Marine Mammals in the North Atlantic, Tromsø, pp. 1-7.

OSPAR Commission, 2008. OSPAR List of Threatened and/or Declining Species andHabitats. Reference number 2008-6. http://www.ospar.org/documents/dbase/decrecs/agreements/08-06e_ospar%20list%20species%20and%20habitats.doc.

OSPAR Commission, 2009a. Background Document for Bowhead whale *Balaena mysticetus*. OSPAR Commission, Biodiversity Series 494/2010, pp. 1-20.

OSPAR Commission, 2009b. Background Document for Ivory gull *Pagophila eburnea*. OSPAR Commission, Biodiversity Series 410/2009, pp. 1-16.

OSPAR Commission, 2009c. Background Document for Thick-billed murre *Uria lomvia*. OSPAR Commission, Biodiversity Series 416/2009, pp. 1-20.

OSPAR Commission, 2011. Meeting of the OSPAR Commission (OSPAR) London: 20-24 June 2011. Summary Record OSPAR 11/20/1-E. OSPAR Commission, London.

Paquette, R., Bourke, R., Newton, J., Perdue, W., 1985. The East Greenland Polar Front in autumn. Journal of Geophysical Research 90 (C3), 4866-4882.

Piepenburg, D., 2005. Recent research on Arctic benthos: common notions need to be revised. Polar Biology 28 (10), 733-755.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., , Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J., Zerbini, A.N., 2008. *Balaena mysticetus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. . www.iucnredlist.org Downloaded on 31 August 2011.

Renaud, P.E., Caroll, M.L., Ambrose, W.G.J., 2008. Effects of global warming on Arctic seafloor communities and its consequences for higher trophic levels. In: Impacts of global warming on polar ecosystems. Duarte, C.M. (Ed.)Fundación BBVA pp. 141-177.

Rey, F., 2004. Phytoplankton: the grass of the sea. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 97-136.

Ronald, K., Healey, P.J., Fisher, H.D., 1982. The harp seal, *Pagophilus groenlandicus*. In: Small cetaceans, seals, sirenians and otters. FAO Fisheries Series No. 5, Vol. IV, Food and Agriculture Organisation of the United Nations. Workding Party on Mammals.

Schliebe, S., Wiig, Ø., Derocher, A.E., Lunn, N., 2008. *Ursus maritimus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. www.iucnredlist.org Downloaded on 31 August 2011.

Smith Jr, W.O., Barber, D., 2007. Polynyas and climate change: a view to the future. In: Polynays, windows to the world. Halpern, D. (Ed.), Elsevier Oceanography Serie 74, Elsevier, Amsterdam pp. 411-420.

Smith Jr, W.O., Baumann, M.E.M., Wilson, D.L., Aletsee, L., 1987. Phytoplankton biomass and productivity in the Marginal Ice Zone of the Fram Strait during summer 1984. Journal of Geophysical Research 92 (C7), 6777-6786.

Smith, W.O.J., 1987. Phytoplankton dynamics in the marginal ice zones. Oceanography and Marine Biology Annual Review 25, 11-38.

Smith, W.O.J., Sakshaug, E., 1990. Polar phytoplankton. In: Polar oceanography. Part B. Chemistry, biology and geology. Smith Jr, W.O. (Ed.) Academic Press, San Diego pp. 477-525.

Steinacher, M., Joos, F., Frölicher, T., Plattner, G. & Doney, S.c. 2009. Imminent ocean acidification in the Arctic projected with the NcAR global coupled carbon cycle-climate model. *Biogeosciences* **6**, 515–533.

Süfke, L., Piepenburg, D., Dorrien, C.C.v., 1998. Body size, sex ratio and diet composition of *Arctogadus glacialis* (Peters, 1874) (Pisces: Gadidae) in the Northeast Water Polynya (Greenland). Polar Biology 20, 357-363.

Wadhams, P., 1981. The ice cover in the Greenland and Norwegian Seas. Rev. Geophys. Space Physics 19, 345-393.

Wassmann, P., 2008. Impacts of global warming on Arctic pelagic ecosystems and processes. In: Impacts of global warming on polar ecosystems. Duarte, C.M. (Ed.)Fundación BBVA pp. 113-148.

Wassmann, P., 2011. Arctic marine ecosystems in an era of rapid climate change. Progress in Oceanography 90, 1-17.

Wassmann, P., Duarte, C.M., Agustí, S., Seijr, M., 2010. Footprints of climate change in the Arctic Marine Ecosystem. Biological Global Change.

Weslawski, J.M., Hacquebord, L., Stempniewicz, L., Malinga, M., 2000. Greenland whales and walruses in the Svalbard food web before and after exploitation. Oceanologia 42 (1), 37-56.

Wheeler, P.A., Gosselin, M., Sherr, E., Thibault, D., Kirchman, D.L., Benner, R., Whitledge, T.E., 1996. Active cycling of organic carbon in the central Arctic Ocean. Nature 380, 697-699.

Wicks, L., Roberts, J.M. (2012) Benthic invertebrates in a high CO_2 world. Oceanography & Marine Biology: An Annual Review 50: 127 -188

Maps and Figures

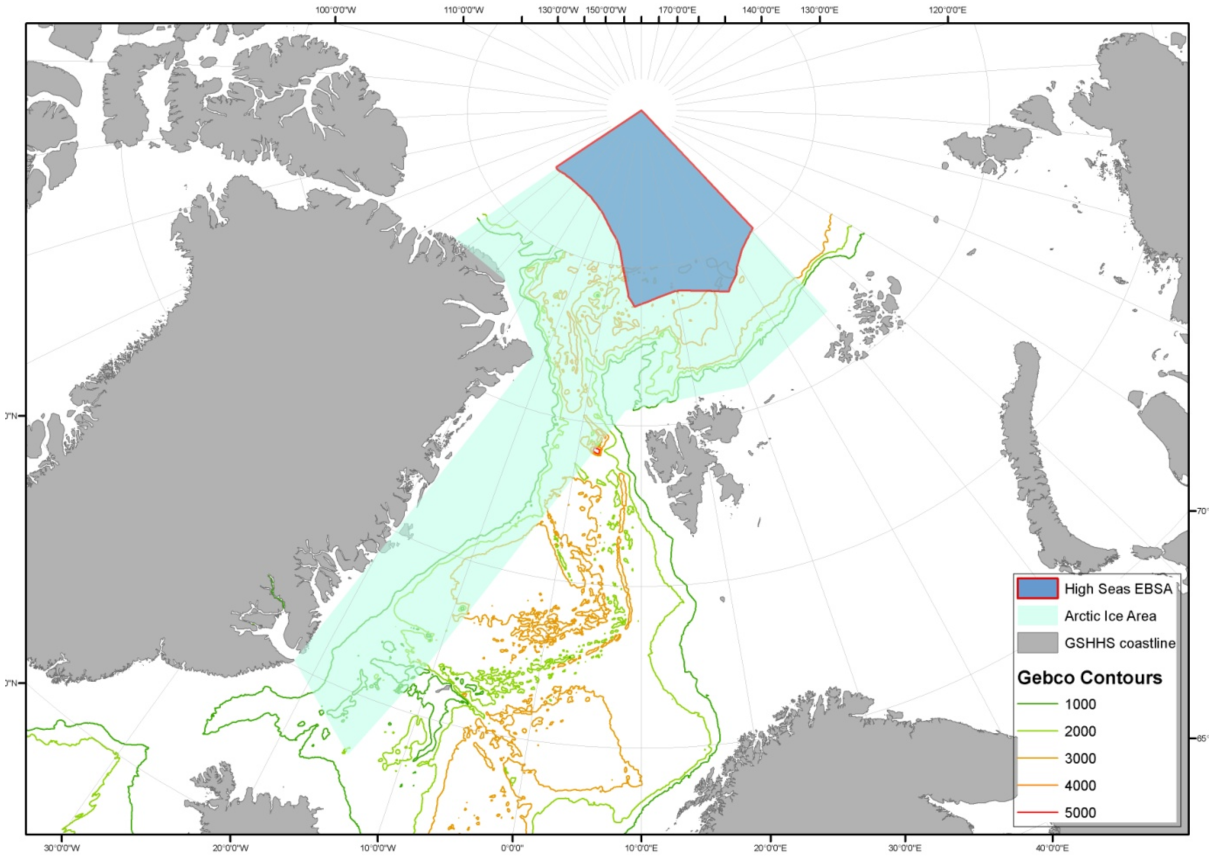

Figure 1 Location of the Ecologically or Biologically Significant Area (EBSA) in the High Seas of the Arctic, proposed initially by WWF in September 2011. No account has been taken of claims for extensions of the continental shelf[5].

[5] Version 2: Map updated