Joint OSPAR/NEAFC/CBD Scientific Workshop on the Identification of Ecologically or Biologically Significant Marine Areas (EBSAs) in the North-East Atlantic

Hyères (Port Cros), France: 8 – 9 September 2011

EBSA identification proforma for the North-East Atlantic - 9

Title/Name of the area - The Arctic Front - Greenland/Norwegian Seas

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

Contact: Sabine Christiansen sabine.christiansen@janthina.de

Abstract

The area proposed as EBSA reflects the meridional, interannual and seasonal variability of the **Arctic front** with adjacent Atlantic waters to the east (warm side) and Arctic waters up to the marginal ice zone to the west. The frontal processes are the power machine for the ecosystem, generating seasonally a huge biomass production on all trophic levels, but best visualized by the large schools of feeding pelagic fish.

Introduction

The ecology of the northern North Atlantic depends on the complex interplay with the water masses of Arctic and Atlantic origin, the degree of ice cover as well as the light regime. All these factors vary to a large extent on a seasonal and longer term scale as an expression of, among others, the North Atlantic Oscillation and the overall warming trend (Blindheim, 2004; Skjoldal and Sætre, 2004). Boreal ecosystems meet polar ecosystems here, and in particular frontal areas and marginal ice zones provide for production hotspots in pelagic waters (Joiris, 2011; Nøttestad *et al.*, 2007; Smith Jr *et al.*, 1987)

Hydrographically, three principal domains can be distinguished in the surface waters of the Greenland and Norwegian Seas (Swift and Aargaard, 1981): The polar domain in the ice-covered outflow of the Arctic Ocean on the East Greenland shelf, the Atlantic domain in the warm Atlantic waters in the Norwegian Sea, and the Arctic domain in the Greenland Sea in-between, bounded by the polar front to the west and the Arctic front to the east. Both the Arctic and polar fronts, smaller scale eddies and the physical phenomena in the marginal ice zone enhance locally the biomass production allover the respective food webs.

The seasonal latitudinal progression of increasing and diminishing light levels, respectively, is the determining factor for the timing of phytoplankton production. Therefore, the phytoplankton spring bloom and ice break up progress from south to north in spring, reaching the Arctic area by about June/July. Due to the different directions of the currents east (north bound) and west (south bound) of the Arctic front in relation to the latitudinal change in solar power there is a delay of about a month in the onset of the hydrological spring and summer between the cold Arctic and the warm Atlantic side of the Arctic front above Mohn´s Ridge (Kostianoy *et al.*, 2004), reflected in the biological patterns of distribution and seasonal development (Hirche *et al.*, 1991).

Polar and Atlantic waters both have their characteristic pelagic faunas, which are mixing to a variable degree in the surface water body of the Arctic domain (Gradinger and Baumann, 1991; Hirche *et al.*, 1991; Melle *et al.*, 2005). The Arctic front fish community of the Atlantic (warm) side is characterized by a large biomass of several medium-sized, highly migratory pelagic species, in particular blue whiting *Micromesistius poutassou*, NE Atlantic mackerel *Scomber scombrus* and Norwegian spring spawning herring *Clupea harengus,* which have their summer feeding area in the pelagic zone over large bottom depths. The Norwegian spring-spawning herring stock is considered to be the largest herring stock in the world, and it is the most important fish stock in the Norwegian Sea in both ecological and commercial terms (Norway Ministry of Environment, 2008-2009). The herring not only fuel the food web in the open sea but also transfer large quantities of energy to coastal waters during their seasonal migrations. These large stocks must be regarded key species in the ecosystem (ICES, 2008b). On the cold side of the front in the Arctic domain, the fish fauna counts fewer species and is characterized by cold water ones such as capelin *Mallotus villosus* (ICES, 2008a).

Feeding aggregations of top predators such as seabirds, seals or, for example, humpback whales can be used as indicators for such productivity hotspots (Joiris, 2011; Joiris and Falck, 2011).

Location

The Ecologically or Biologically Significant Marine Area (EBSA) focusses primarily on the Arctic front and its adjacent waters, including the broad range of the meridional, interannual and seasonal variability of its position (Blindheim, 2004). A central part of the proposed EBSA is in high seas waters, outside the 200 nm zones of Norway, Jan Mayen, Greenland and Svalbard (the „Banana Hole"). (see Fig. 1 attached). 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" has a mandate[1], and national/nationally administered waters within the 200 nm zone, within which the OSPAR Contracting Parties have committed to report candidate EBSAs to the Convention on Biodiversity EBSA repository (Convention on Biological Diversity, 2010). The coordinates of the overall area, as well as the high seas section are provided in Annex 1 (in decimals, shape files provided).

Around Jan Mayen and Spitsbergen/Svalbard, Norway has implemented 200 nm Fisheries Protection Zones. However, the Norwegian sovereignty over the 200 nm zone of Svalbard (outside territorial waters) is disputed (Molenaar and Oude Elferink, 2011), based on different interpretations of the Spitsbergen Treaty, which ensures non-discriminatory access to the resources for all currently 40 signatories of the Treaty (1920).

The delimitations of the extended continental shelves of Norway, Iceland and Denmark/The Faroes in the southern "Banana Hole" have not yet been finally agreed (Norway Ministry of Environment, 2008-2009).

All waters outside the Greenland Exclusive Economic Zone are included in the Norwegian Sea management plan of the Norwegian government (Norway Ministry of Environment, 2008-2009).

Feature description

1 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 area proposed as EBSA reflects the meridional, interannual and seasonal variability of the **Arctic front** with adjacent Atlantic waters to the east (warm side) and Arctic waters up to the marginal ice zone to the west (cold side) (Blindheim, 2004). The Arctic front and the Jan Mayen front to the north and south of Jan Mayen, respectively, are the dominating hydrographic structures in the Atlantic north of Iceland. The frontal processes are the power machine for the ecosystem, generating seasonally a huge biomass production on all trophic levels, but best visualized by the large feeding schools of pelagic fish (e.g. Holst *et al.*, 2004; Melle *et al.*, 2005; Nøttestad *et al.*, 2007). The western part of the area is ice covered during winter, though decreasing in recent years, with the respective production-enhancing processes in the marginal ice zone taking place in spring (Johannessen *et al.*, 1987a; Smith Jr *et al.*, 1987).

Fronts are sharp horizontal gradients in water density, either due to differences in temperature, salinity or both, between adjacent water masses. The Arctic front separates Arctic surface water (temperature 0-3° C, salinity 34.4-34.9) from Atlantic waters (warmer than 3° C, salinity >34.4 , (Swift and Aargaard, 1981) (compare hydrographic cross section in Fig. 3, (Spall, 2010). On the western margin of the Greenland Sea, the Arctic basin outflow of polar water (temperatures less than 0° C, salinity <34.4) and ice moves southwards on the East Greenland Shelf to Danmark Strait and beyond. This surface current is bound to the east by the polar front. Arctic water is generated by a mixing of polar and Atlantic water, as well as freshening by ice melt, and it extends from the seasonally shifting marginal ice zone east of the polar front on the Greenland shelf to the Arctic front overlaying the Mohn´s and Knipovich Ridge in the Greenland Sea and Framstrait.

The western boundary of the proposed EBSA is therefore the summer marginal ice zone to the east of the polar front. The summer ice cover of the East Greenland Current usually coincides with the location of the polar front, however may be shifted east or west with strong westerly or easterly winds and varies with the weather/climate forcing (see e.g. Blindheim, 2004; Joiris and Falck, 2011). Cold core eddies are a common mesoscale feature along the marginal ice zone (Johannessen *et al.*, 1987b) which locally enhance the pelagic production available to top predators such as seabirds (Joiris and Falck, 2011). This could be also observed around Jan Mayen (Kostianoy *et al.*, 2004), explaining the huge productivity of its waters.

North of Jan Mayen, the location of the Arctic front and other characteristics of the regional hydrography (Spall, 2010) are to some extent determined by the subjacent section of the Mid Atlantic Ridge, the Mohn´s Ridge, at approximately 73.5° N, 8° E (Blindheim and Østerhus, 2005). Recirculating cold Arctic water is found in the Greenland Sea to the north and west of Mohn´s Ridge, the warm, northwards circulating Atlantic water remains to the south and east of the ridge in the Norwegian Sea. Therefore, the ridge corresponds to the location of the boundary between the Arctic and Atlantic biomes as defined by Longhurst (1998), reflected in the biogeographic boundary between cool Arctic and cool temperate waters in the deep benthal (down to 1000 m) set by Dinter (2001). South of Jan Mayen, on the other hand, no such topographic boundary exists, and variations in the volume of Arctic waters may result in relatively large shifts in the location of the Arctic front. Generally, strong westerly winds (as indicated by a high NAO index) will result in Arctic waters to occupy a larger portion of the western Norwegian Sea (Blindheim, 2004).

c.f. **Fig. 2**: Hydrographic cross-section of the Norwegian Sea in summer, between the Norwegian coast at about 65° N, across Mohn´s Ridge, and the East Greenland shelf at approx. 78° N (modified after Spall (2010) who used measurements of Oliver and Heywood (2003)).

The Arctic front is one of the **productivity hotspots** in the Norwegian Sea. The density gradients caused by the different temperatures and salinities of the water masses on both sides of the front, likely result in areas of sufficiently low mixing depth and consequently enhance a phytoplankton bloom earlier in the season than in open water. Following the seasonal latitudinal progression of the sunlight, the phytoplankton bloom proceeds from south to north, initiating the pelagic production of secondary producers (grazers) such as zooplankton (e.g. the copepod *Calanus finmarchicus*, the amphipod *Themisto abyssorum*, the euphausid *Thyssanoessa inermis* on the warm Atlantic side, *Calanus hyperboreus* on the cold Arctic side, the amphipod *Themisto libellula*, krill *Thysanoessa longicaudata;* (Melle *et al.*, 2005)). The physical forcing from the different directions of the currents may supply nutrients to the upper layers and therefore prolong the growth season. In addition, cold core eddies detach from the front and maintain for some time an enhanced food web (Rey, 2004).

Zooplankton production aggregates to highest biomass in the vicinity of the front (Nøttestad *et al.*, 2007), attracting planktivores such as herring *(Clupea harengus)*, blue whiting (*Micromesistius poutassou)*, mackerel (*Scomber scombrus)* and redfish (*Sebastes mentella)* on the warm eastern side of the front, capelin (*Mallotus villosus)* on the cold western side of the front, and blue *Balaenoptera musculus)*, fin and minke whales in ice-free waters (Holst *et al.*, 2004; Nøttestad and Olsen, 2004). Fin whales (*Balaenoptera physalus)*, and killer whales (*Orcinus orca)* follow the herring schools during their seasonal feeding migration (Nøttestad *et al.*, 2002), whereas sperm whales (*Physeter macrocephalus)* and Northern bottlenose whales (*Hyperodon ampullatus)* exploit the riches of the deep waters such as the large stock of the cephalopod *Gonatus fabricii* up to the edge of the pack ice (Holst *et al.*, 2004; Nøttestad and Olsen, 2004).

The warm side of the Arctic front is a well-known feeding area of Norwegian Spring-spawning **herring** during its seasonal migration (Nøttestad *et al.*, 2007). After spawning, the herring schools move northwards parallel to the front. The western boundary of the herring schools coincides with a zooplankton biomass maximum at the Arctic front in surface waters, but the herring also appear to consume larger zooplankton in the cold subjacent water masses at more than 300 m depth (Nøttestad *et al.*, 2007), such as hibernating *Calanus hyperboreus* (Hirche *et al.*, 2006). The area of the proposed Arctic front EBSA covers the full extent of the seasonal herring feeding migration starting in the south in May/June, and arriving at the northern part of the Arctic front in July/August (Skjoldal *et al.*, 2004), when the larger herring also start feeding on the large, lipid-rich copepod *Calanus hyperboreus* in Arctic surface water (Holst *et al.*, 2004). In recent years, the seasonal feeding migration of herring has been observed to expand in northerly direction, due to, among other factors, the recent warm period (high NAOI) (Holst *et al.*, 2004). If the warming continues or even amplifies, the northerly section of the Arctic front is likely to gain importance for the herring stock and other plankton feeders.

Apart from Norwegian Spring-spawning herring, NE Atlantic **mackerel** (*Scomber scombrus)* and **lumpsucker** (*Cyclopterus lumpus)* also belong to the epipelagic fish community (from the surface down to about 150-200 m, Bjelland and Holst, 2004) and have their summer feeding areas associated with the warm side of the Arctic front (Iversen, 2004; Monstad, 2004). Mackerel is a surface feeder which may benefit from occasional stronger inflows of Atlantic water into the Norwegian Sea for moving its northern distribution limit further to the north (Monstad, 2004).

The **mesopelagic** community (200 - 1000 m) in the vicinity of the Arctic front is dominated by large stocks of blue whiting (*Micromesistius poutassou)* and, among others, pearlsides (*Maurolicus muelleri)* and lanternfishes (*Benthosema glaciale)* (Bjelland and Holst, 2004). Pelagic redfish (*Sebastes mentella),* classified as vulnerable (Norway Ministry of Environment, 2008-2009)*,* undertake feeding migrations from the continental shelf into the Norwegian Sea and form (exploitable) aggregations in the zone of the Arctic front at 150-450 m depth in the summer-autumn season (Vinnichenko, 2007).

The gonatid **squid** *Gonatus fabricii* occurs over large areas of the Norwegian Sea but with highest biomass along the Arctic front in summer (interpretation of Fig. 14.3 in Bjørke and Gjøsæter, 2004). It is estimated to produce annually some 20 million tons of biomass in the Norwegian Sea (Bjørke and Gjøsæter, 2004). These squids are another important link between the secondary producers (mesozooplankton like *Calanus finmarchicus* and *C. hyperboreus*, amphipods and krill) and large predators such as northern bottlenose whales, pilot whales, sperm whales, but also several seal species, seabirds, and predatory fish, including Greenland sharks (Bjørke and Gjøsæter, 2004).

On the **cold side of the Arctic front**, the mesozooplankton community includes several species adapted to the colder waters over the deep sea such as the large, lipid-rich copepod *Calanus hyperboreus* and the amphipod *Themisto libellula* (e.g. Melle *et al.*, 2005). These are the prey of capelin (*Mallotus villosus),* which has its main feeding area of adults in the oceanic waters from about 68 to 72°N, between the Jan Mayen Ridge and the East Greenland continental shelf, i.e. between the Polar and Arctic fronts (ICES, 2008; Vilhjálmsson, 2002). Capelin spawn in shallow coastal waters south and west of Iceland and at the heads of numerous fjords on the eastern coast of Greenland.

Jan Mayen lies within or at least very close to the Arctic front (Kostianoy *et al.*, 2004) and therefore provides superior feeding conditions for seabirds breeding on the island, exploiting the enhanced frontal productivity. Some 300000 pairs of northern fulmars *Fulmarus glacialis)*, little auks *Alle alle*, Brünnich's guillemots *Uria lomvia* and kittewakes *Rissa tridactyla* breed here in several colonies (Norway Ministry of Environment, 2008-2009).

Additional information: **Mohn´s Ridge** (lying beneath and determining the location of the Arctic Front)

The Mohn´s Ridge is one of three distinct parts of the Mid Atlantic Ridge north of Iceland and south of the Arctic Basin. It extends from the Jan Mayen Fracture Zone at 71° N to approximately 73°30´N, 8° E, from were the ridge turns north and continues as the Knipovic Ridge (Blindheim, 2004). Blindheim and Østerhus (2005) describe the Mohn Ridge as having depths between 1000 and 2000 m on either side of a rift valley, with a rather complex topography characterized by many isolated elevations. Some banks rise to approximately 600 m below sea level (Myrseth, Boyd, B. Schultz Banks, see map of Eggvin (1963).

A number of seamounts (elevations higher than 1000 m above surrounding) have been identified along the ridge (see Fig. 3). Little is known about the fauna of these seamounts or the level of fishing activity, but ICES (Report WGDEEP, 2011) recalls that such habitats are known to be generally areas with often higher levels of productivity and associated dense aggregations of fish.

Recently, hydrothermal vent fields and sulfide deposits have been discovered all along the ridge . (see e.g. Pedersen *et al.*, 2010).

c.f. Figure 3: Ocean ridges in the Norwegian Sea with elevations of more than 1000 m above the surrounding (seamounts) indicated by red dots (Norway Ministry of Environment, 2008-2009).

Little is known about the benthos at Mohn´s Ridge (see e.g. Bluhm *et al.*, 2011) , but 7 photographic transects between 900 and 3000 m indicate patchy, but relatively species- and biomass-rich megabenthos communities (Santos, 2010). The author identified 66 disparate taxa and three distinct hard substrate communities, represented by the basket star *Gorgonocephalus* spp., Crinoidean species and Anthozoan species, respectively. Hexacorallia were the most common group, observed during all dives but one, with the anemone *Hormathia digitata* being the most abundant species and occurring in dense colonies on exposed rock surfaces, followed by Porifera (18 species), Tunicata (3 species), and Crinoidea. One cartilaginous fish species (*Amblyraja hyperborea*) and six bony fish species were identified (*Lycodes* sp., *Gaidropsarus argentatus, Macrourus berglax*, *Reinhardtius hippoglossoides, Rhodichthys regina*, *Paraliparis* sp.).

Additional information on the fauna of Mohn´s Ridge was provided by Schander *et al*. (2010), who investigated the fauna of the Jan Mayen hydrothermal vent fields (see also EBSA proposal by J. H. Fosså). With a few exceptions of specialized vent taxa, the fauna observed at the vent fields was considered to be representative for the non-vent conditions at Mohn´ s Ridge at 71° N latitude and related to the regional faunal pool at similar depths. On vertical surfaces away from the vents dense aggregations of the motile crinoid *Hormathia* sp. and several anthozoans were found. Among the sponge fauna, calcareous sponges represented 8 out of 14 taxa and are likely to be considered pioneer fauna. No larger erect or massive demosponges or hexactinellids were observed, but dense aggregations of the echinoderms *Heliometra glacialis* and *Gorgonocephalus eucnemis* were seen.

Feature condition, and future outlook

The actual locations and hydrographic regimes of the Arctic and polar fronts, and consequently the biological regime in the Arctic domain in-between are highly dependent on large scale atmospheric pressure oscillations and long-term climate trends. The large-scale atmospheric pressure fields in the North Atlantic are closely linked to the general oceanic circulation patterns, and their variation is reflected in changing patterns of zooplankton biomass production (Skjoldal and Sætre, 2004). During periods of a high NAO index (NAOI) the zooplankton biomass, in particular that of *Calanus finmarchicus,* is high, during periods of a low NAOI the biomass is low (Skjoldal and Sætre, 2004). The transition from one to the other NAO state is suspected to trigger particularly successful recruitment for the most important pelagic fishes: herring respond positively to the switch from low to high NAOI, blue whiting to a switch from high to low NAOI (Skjoldal and Sætre, 2004).

Recent studies reveal that sea surface warming in the Northeast Atlantic is accompanied by significant latitudinal shifts in the size distribution of phytoplankton (Richardson and Shoeman, 2004), and in the species distribution of zooplankton (Beaugrand *et al.*, 2002) and fish (Brander *et al.*, 2003). In addition, due to different control mechanisms (light, temperature, food) for the various ecosystem components, a variable trophic match (or mismatch) may contribute to these distribution shifts, in the end affecting also the commercially important species, primarily fish, and dependent predators such as marine mammals and sea birds (Edwards and Richardson, 2004).

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.

CBD EBSA Criterion	**Description**	**Ranking of criterion relevance (please mark one column with an X)**			
		Don't Know	**Low**	**Some**	**High**
Uniqueness or rarity	**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**				
Explanation for ranking					
Special importance for life-history stages of species	**Areas that are required for a population to survive and thrive**				**x**

Explanation for ranking

Feeding on the plankton, cephalopod and mesopelagic fish production along the Arctic front is essential for, among others, the Norwegian spring-spawning herring and blue whiting populations, for several baleen and toothed whale species, including blue whales, fin whales, northern bottlenose whales, pilot whales, sperm whales, but also several seal species and predatory fish, including Greenland sharks. The productivity of the Arctic front is essential for the millions of breeding seabirds on the cliffs of Jan Mayen, for feeding their young, and during their pelagic life outside the breeding season.

Importance for threatened, endangered or declining species and/or habitats	**Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species**				**x**

Explanation for ranking

Several of the top predator species listed above are considered vulnerable on the IUCN Redlist (2011): Blue, fin and sperm whale, hooded seal.

Vulnerability, fragility, sensitivity, or slow recovery	**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**				

Explanation for ranking

Sensitivity to large scale climate oscillations (NAO) and trends

Norway Ministry of Environment (Norway Ministry of Environment, 2008-2009) characterise the Arctic front as a particularly valuable and vulnerable area in the Norwegian Sea because „High biological production makes this an important feeding area for several whale species, including blue whale, fin whale, minke whale and northern bottlenose whale. Further north, the marginal ice zone stretching further northwards to the Fram Strait north-west of Svalbard is also important for the same species, and also for species that are more permanently associated with ice-covered waters, such as the bowhead whale.

Seabirds and marine mammals are vulnerable to oil spills and substances that are liable to bioaccumulate. Different species may vary in their vulnerability at different times of year (see further details on seabird vulnerability in section 3.2)."

It is highly likely that the megabenthos communities of Mohn´s Ridge, lying beneath the Arctic front, as described by Santos (Santos, 2010) and partially by Schander *et al*. (2010), are as vulnerable to physical impact as similar communities in other regions. However, there does not seem to be any bottom fishery in the area at present (Norway Ministry of Environment, 2008-2009). The North East Atlantic Fishery Council considers the area to be a new fishing area to bottom fishing (NEAFC AM2008/53 rev1), any developing fishery being subject to an Exploratory Bottom Fisheries Protocol (NEAFC, 2010). Other activities in relation to the seabed are not known.

Biological productivity	**Area containing species, populations or communities with comparatively higher natural biological productivity**				**x**

Explanation for ranking Frontal areas are generally characterised by high productivity and relatively low diversity. The Arctic Front is the production machine of the northern North Atlantic. One expression of this pelagic productivity is the huge biomass of among others the herring, blue whiting and since recently in the south also the mackerel stocks which exploit the plankton and mesopelagic fish production during their seasonal feeding migration along the Arctic front.					
Biological diversity	**Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity**				**x**
Explanation for ranking The area proposed comprises three ecologically relevant types of production systems in the water column, the cold Arctic domain to the west of the front, the frontal zone itself and the warm Atlantic water east of the frontal zone. Each system is characterized by typical pelagic communities. In addition, the winter ice cover, and therefore ice-related biota enrich the species pool. The frontal system and its associated plankton production is extensively used for feeding by highly migratory species such as baleen whales and schooling pelagic fish.					

Sharing experiences and information applying other international criteria (Optional)

CBD EBSA Criterion	**Description**	**Ranking of criterion relevance** **(please mark one column with an X)**			
		Don't Know	**Low**	**Some**	**High**
Dependency:	**An area where ecological processes are highly dependent on biotically structured systems (e.g., coral reefs, kelp forests, mangrove forests, seagrass beds). Such ecosystems often have high diversity, which is dependent on the structuring organisms. Dependency also embraces the migratory routes of fish, reptiles, birds, mammals, and invertebrates.**		**x**		
Explanation for ranking Frontal areas are physically, not biologically structured.					
Representativeness:	**An area that is an outstanding and illustrative example of specific biodiversity, ecosystems, ecological or physiographic processes**				**?**

<table>
<tr><td colspan="6">Explanation for ranking
The proposed boundaries enclose all the Arctic front with respect to its meridional, seasonal and interannual variablility. As such, the area is an outstanding example of specific frontal processes in a subpolar region with strongly varying environmental drivers.</td></tr>
<tr><td>Biogeographic importance:</td><td>An area that either contains rare biogeographic qualities or is representative of a biogeographic “type” or types, or contains unique or unusual biological, chemical, physical, or geological features</td><td></td><td></td><td></td><td>?</td></tr>
<tr><td colspan="6">Explanation for ranking
The proposed area covers a unique set of physical and biological properties and marks the separation and interaction of two distinct biogeographic regions</td></tr>
<tr><td>Structural complexity:</td><td>An area that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features.</td><td></td><td></td><td></td><td>x</td></tr>
<tr><td colspan="6">Explanation for ranking
Frontal zones separate distinct water masses and create complex physical structures (density, either due to temperature and/or salinity differences) in the water column. This structure enhances productivity (but likely, this was not meant by this point)</td></tr>
<tr><td>Natural Beauty:</td><td>An area that contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td colspan="6">Explanation for ranking</td></tr>
<tr><td>Earth’s geological history:</td><td>An area with outstanding examples representing major stages of Earth’s history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td colspan="6">Explanation for ranking</td></tr>
</table>

References

1920. Treaty between Norway, the United States of America, Denmark, France , Italy, Japan , the Netherlands, Great Britain and Ireland and the British Overseas Dominions and Sweden concerning Spitsbergen, signed in Paris 9th of February 1920.

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A., Edwards, M., 2002. Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. Science 296 (5573), 1692-1694.

Bjelland, O., Holst, J.C., 2004. Other fish species and fish communities. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 357-370.

Bjørke, H., Gjøsæter, H., 2004. Cephalopods in the Norwegian Sea. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 371-394.

Blindheim, J., 2004. Oceanography and climate. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 33-64.

Blindheim, J., Østerhus, S., 2005. The Nordic Seas, main oceanographic features. 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. 11-.

Bluhm, B., Ambrose, W., Bergmann, M., Clough, L., Gebruk, A., Hasemann, C., Iken, K., Klages, M., MacDonald, I., Renaud, P., Schewe, I., Soltwedel, T., Wlodarska-Kowalczuk, M., 2011. Diversity of the arctic deep-sea benthos. Marine Biodiversity 41 (1), 87-107.

Brander, K., Blom, G., Borges, M.F., Erzini, K., Henderson, G., MacKenzie, B.R., Mendes, H., Ribeiro, J., Santos, A.M.P., Toresen, R., 2003. Changes in fish distribution in the North Atlantic: Are we seeing a coherent response to changing temperature? ICES Marine Science Symposia 219, 261-270.

Convention on Biological Diversity, 2010. Marine and coastal biodiversity. COP 9 Decision X/29.

Dinter, W.P., 2001. Biogeography of the OSPAR Maritime Area. A Synopsis and Synthesis of Biogeographical Distribution Patterns Descibed for the NE Atlantic. Federal Agency for Nature Conservation, Bonn, Germany.

Edwards, M., Richardson, A.J., 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature 430, 881-884.

Eggvin, J., 1963. Bathymetric Chart of the Norwegian Sea and Adjacent Areas. Fiskeridirektorats Havforskningsinstitutt Norway, Bergen.

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.

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., 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.

Holst, J.C., Røttingen, I., Melle, W., 2004. The herring. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 203-226.

ICES, 2008. Report of the ICES Advisory Committee In: ICES Advice, Book 2, Iceland and East Greenland. pp. 1-112.

Iversen, S.A., 2004. Mackerel and horse mackerel. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 289-300.

Johannessen, J.A., Johannessen, O.M., Svendsen, E., Shuchman, R., Manley, T., Campbell, W.J., Josberger, E.G., Sandven, S., Gascard, J.C., Olaussen, T., Davidson, K., Van Leer, J., 1987a. Mesoscale eddies in the Fram Strait marginal ice zone during the 1983 and 1984 marginal ice zones experiments. Journal of Geophysical Research 92 (C7), 6754–6772.

Johannessen, J.A., Johannessen, O.M., Svendsen, E., Shuchman, R., Manley, T., Campbell, W.J., Josberger, E.G., Sandven, S., Gascard, J.C., Olaussen, T., Davidson, K., Van Leer, J., 1987b.

Mesoscale eddies in the Fram Strait marginal ice zone during the 1983 and 1984 marginal ice zones experiments. Journal of Geophysical Research 92, 6754–6772.

Joiris, C., 2011. A major feeding ground for cetaceans and seabirds in the south-western Greenland Sea. Polar Biology, 1-11.

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.

Kostianoy, A.G., Nihoul, J.C.J., Rodionov, V.B., 2004. Physical oceanography of frontal zones in the subarctic seas. Elsevier Amsterdam.

Longhurst, A., 1998. Ecological Geography of the Sea. Academic Press, San Diego.

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.

Molenaar, E.J., Oude Elferink, A.G., 2011. The Regulation of Fishing Activities in the Maritime Zones of Spitsbergen. Utrecht University, School of Law, Netherlands Institute for the Law of the Sea (NILOS), Utrecht, Netherlands, pp. 1-81.

Monstad, T., 2004. Blue whiting. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 263-288.

NEAFC, 2010. Information on the protection of biodiversity and mitigating impact of fisheries in the North East Atlantic. A report prepared by the NEAFC Secretariat for CBD COP 10 Agenda item 5.2 and 5.4, Nagoya October 2010 North East Atlantic Fisheries Commission, p. 6 pp.

Norway Ministry of Environment, 2008-2009. Integrated Management of the Marine Environment of the Norwegian Sea. Report No. 37 to the Storting. (in English). pp. 1-151.

Nøttestad, L., Fernö, A., Mackinson S., Pitcher, T., Misund, O.A., 2002. How whales influence herring school dynamics in a cold-front area of the Norwegian Sea. ICES Journal of Marine Science 59, 393-400.

Nøttestad, L., Misund, O.A., Melle, W., Hoddevik Ulvestad, B.K., Orvik, K.A., 2007. Herring at the Arctic front: influence of temperature and prey on their spatio-temporal distribution and migration. Marine Ecology 28, 123-133.

Nøttestad, L., Olsen, E., 2004. Whales and seals: top predators in the ecosystem. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 395-434.

Oliver, K.I.C., Heywood, K.J., 2003. Heat and freshwater fluxes through the Nordic Seas. Journal of Physical Oceanography 33, 1009-1026.

Pedersen, R.B., Rapp, H.T., Thorseth, I.H., Lilley, M.D., Barriga, F.J.A.S., Baumberger, T., Flesland, K., Fonseca, R., Früh-Green, G.L., Jorgensen, S.L., 2010. Discovery of a black smoker vent field and vent fauna at the Arctic Mid-Ocean Ridge. Nature Communications 1124, 1-6.

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.

Richardson, A.J., Shoeman, D.S., 2004. Climate impact on plankton ecosystems in the northeast Atlantic. Science 305, 1609-1612.

Santos, E.d., 2010. Community analysis of large epibenthos in the Nordic Seas. Master´s thesis, University of Iceland, Reykjavik, Iceland.

Schander, C., Rapp, H.T., Kongsrud, J.A., Bakken, T., Berge, J., Cochrane, S., Oug, E., Byrkjedal, I., Todt, C., Cedhagen, T., Fosshagen, A., Gebruk, A., Larsen, K., Levin, L., Obst, M., Pleijel, F., Stöhr, S., Warén, A., Mikkelsen, N.T., Hadler-Jacobsen, S., Keuning, R., Petersen, K.H., Thorseth, I.H., Pedersen, R.B., 2010. The fauna of hydrothermal vents on the Mohn Ridge (North Atlantic). Marine Biology Research 6 (2), 155 - 171.

Skjoldal, H.R., Dalpadado, P., Dommasnes, 2004. Food webs and trophic interactions. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 447-504.

Skjoldal, H.R., Sætre, R., 2004. Climate and ecosystem. In: The Norwegian Sea Ecosystem. Skjoldal, H.R. (Ed.)Tapir Academic Press, Trondheim, Norway pp. 507-534.

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.

Spall, 2010. Non-local topographic influences on deep convection: An idealized model for the Nordic Seas. Ocean Modelling 32, 72-85.

Swift, J.H., Aargaard, K., 1981. Seasonal transitions and water mass formation in the Iceland and Greenland seas. Deep Sea Research 29A (10), 1107-1129.

Vilhjálmsson, H., 2002. Capelin (Mallotus villosus) in the Iceland–East Greenland–Jan Mayen ecosystem. ICES J. Mar. Sci. 59 (5), 870-883.

Vinnichenko, V.I., 2007. Russian investigations and fishery of the pelagic redfish in the Norwegian Sea. Working Document for ICES Arctic Fisheries Working Group, pp. 1-19.

Maps and Figures

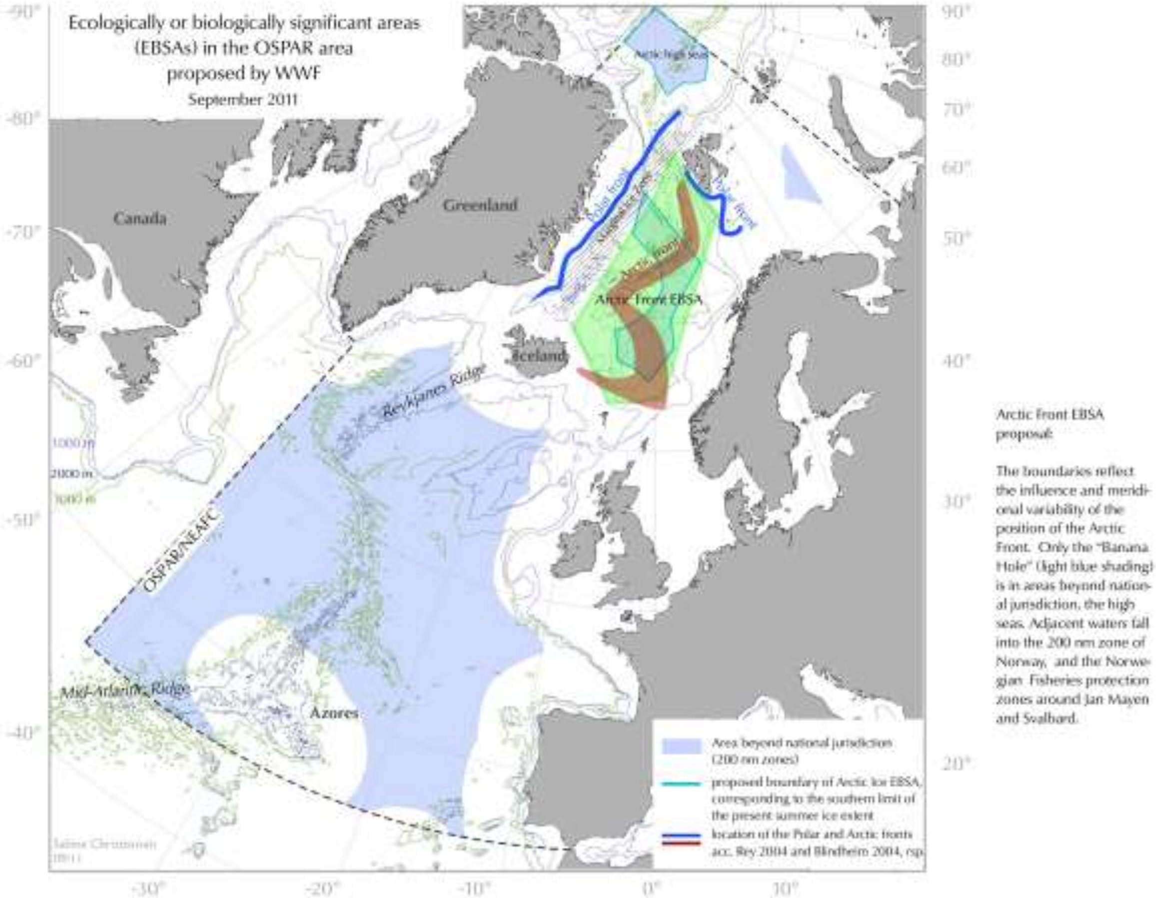


Figure 1: Location of the Ecologically or biologically significant areas (EBSA) proposed by WWF in September 2011. The position of the Arctic and polar fronts was redrawn after (Rey, 2004, Fig. 5.7).

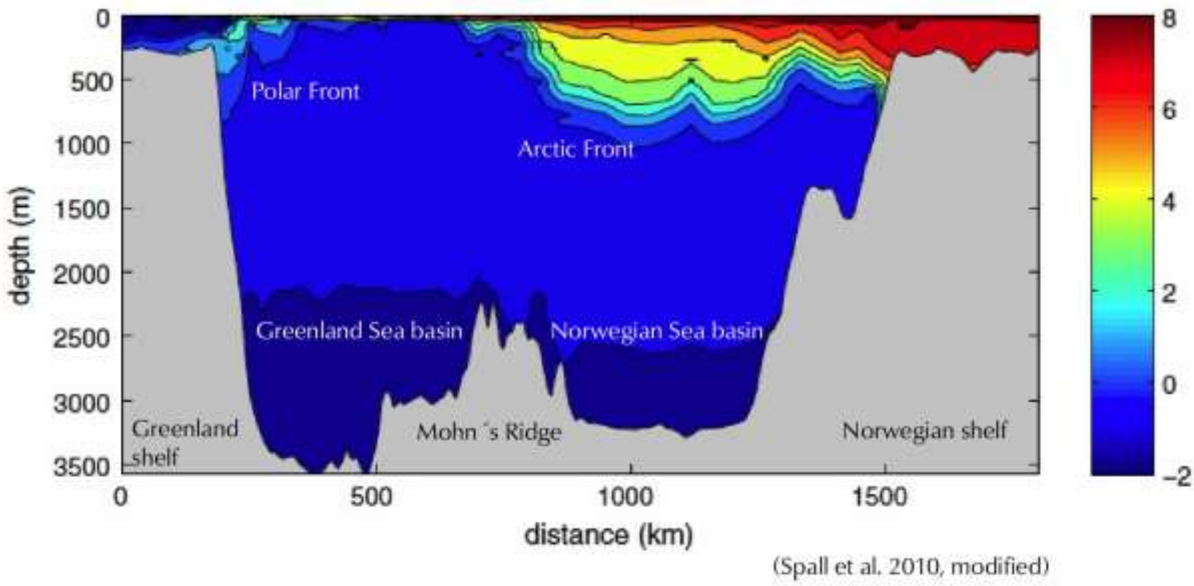
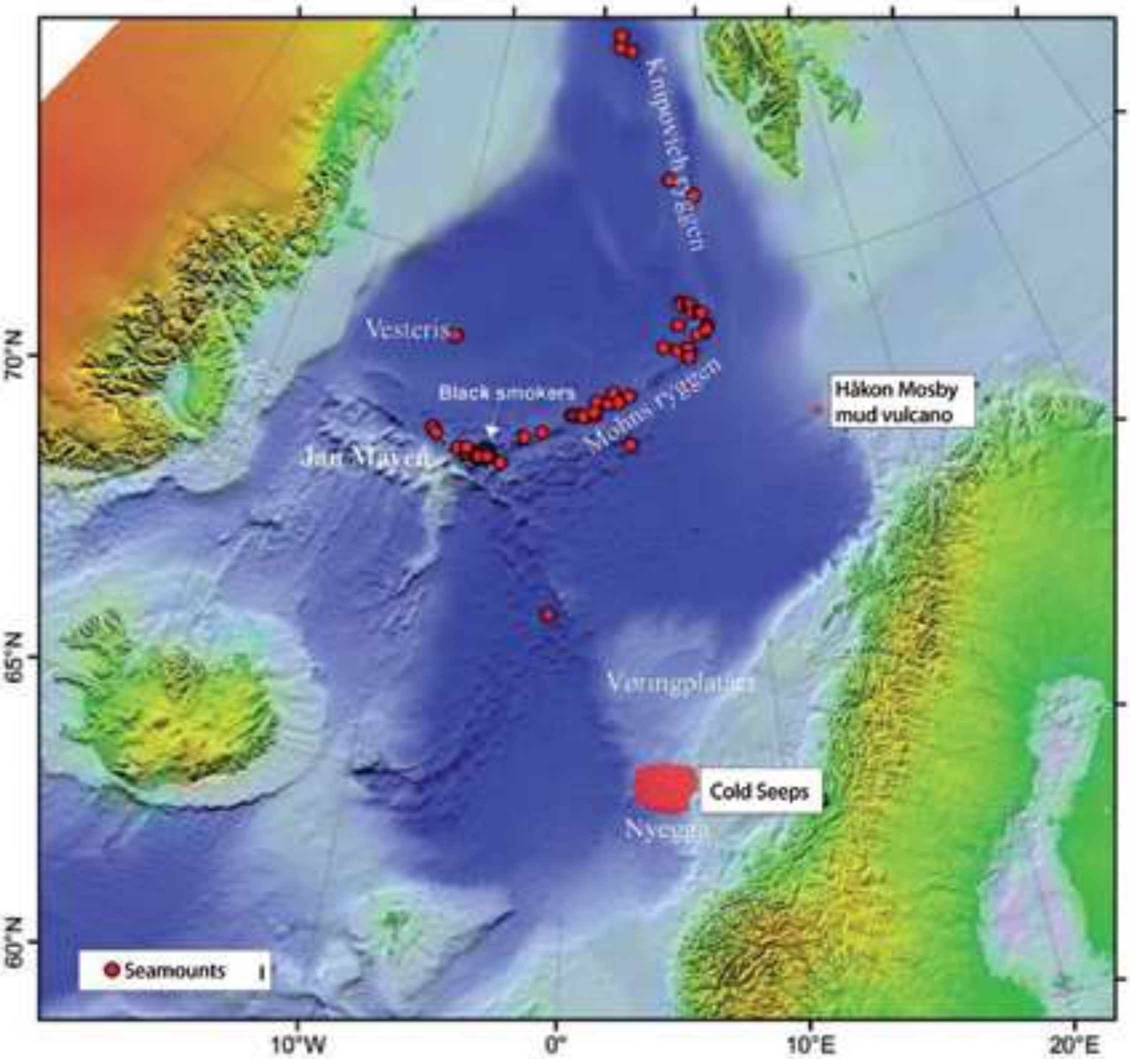


Fig. 2: Hydrographic cross-section of the Norwegian Sea in summer, between the Norwegian coast at about 65° N, across Mohn´s Ridge, and the East Greenland shelf at approx. 78° N (modified after (Spall, 2010) who used measurements of (Oliver and Heywood, 2003).



Ocean ridges in the Norwegian Sea (higher than 1000 m). The mud vulcano "Håkon Mosby" and a gas flow area on Nyegga are also marked.

Figure 3: Ocean ridges in the Norwegian Sea with elevations of more than 1000 m above the surrounding (seamounts) indicated by red dots (Norway Ministry of Environment, 2008-2009).

Rights and permissions – [indicate here there are any known issues with giving permission to share or publish these data and what any conditions of publication might be; provide contact details for a contact person for this issue].