Background Document for Deep-sea sponge aggregations

Biodiversity Series

2010

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d’Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l’Espagne.

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This document has been prepared by Dr Sabine Christiansen for WWF as lead party.

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Cover Photo: Sven/tauchprojekt

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Executive Summary

This background document on deep-sea sponge aggregations has been developed by OSPAR following the inclusion of this habitat on the OSPAR List of threatened and/or declining species and habitats (OSPAR agreement 2008-6). The document provides a compilation of the reviews and assessments that have been prepared concerning this habitat since the agreement to include it in the OSPAR List in 2003. The original evaluation used to justify the inclusion of deep-sea sponge aggregations in the OSPAR List is followed by an assessment of the most recent information on its status (distribution, extent, condition) and key threats prepared during 2009-2010. Chapter 7 provides recommendations for the actions and measures that could be taken to improve the conservation status of the habitat. In agreeing to the publication of this document, Contracting Parties have indicated the need to further review these proposals. Publication of this background document does not, therefore, imply any formal endorsement of these proposals by the OSPAR Commission. On the basis of the further review of these proposals, OSPAR will continue its work to ensure the protection of deep-sea sponge aggregations, where necessary in cooperation with other competent organisations. This background document may be updated to reflect further developments or further information on the status of the habitat which becomes available.

Récapitulatif

Le présent document de fond sur les agrégats d'éponges en eaux profondes a été élaboré par OSPAR à la suite de l'inclusion de cet habitat dans la liste OSPAR des espèces et habitats menacés et/ou en déclin (Accord OSPAR 2008-6). Ce document comporte une compilation des revues et des évaluations concernant cet habitat qui ont été préparées depuis qu'il a été convenu de l'inclure dans la Liste OSPAR en 2003. L'évaluation d'origine permettant de justifier l'inclusion des agrégats d'éponges en eaux profondes dans la Liste OSPAR est suivie d'une évaluation des informations les plus récentes sur son statut (distribution, étendue et condition) et des menaces clés, préparée en 2009-2010. Le chapitre 7 fournit des propositions d'actions et de mesures qui pourraient être prises afin d'améliorer l'état de conservation de l'habitat. En se mettant d'accord sur la publication de ce document, les Parties contractantes ont indiqué la nécessité de réviser de nouveau ces propositions. La publication de ce document ne signifie pas, par conséquent que la Commission OSPAR entérine ces propositions de manière formelle. A partir de la nouvelle révision de ces propositions, OSPAR poursuivra ses travaux afin de s'assurer de la protection des agrégats d'éponges en eaux profondes le cas échéant avec la coopération d'autres organisations compétentes. Ce document de fond pourra être actualisé pour tenir compte de nouvelles avancées ou de nouvelles informations qui deviendront disponibles sur l'état de l'habitat.

1. Background Information

Name of the habitat:

Deep-sea sponge aggregations.

Definition of habitat

OSPAR agreement 2008-7: Deep sea sponge aggregations are principally composed of sponges from two classes: Hexactinellida and Demospongiae. They are known to occur between water depths of 250-1300m* (Bett & Rice, 1992), where the water temperature ranges from 4-10°C and there is moderate current velocity (0.5 knots). Deep-sea sponge aggregations may be found on soft substrata or hard substrata, such as boulders and cobbles which may lie on sediment. Iceberg plough-mark zones provide an ideal habitat for sponges because stable boulders and cobbles, exposed on the seabed, provide numerous attachment/settlement points (B. Bett, pers comm.). However, with 3.5kg of pure siliceous spicule material per m^2 reported from some sites (Gubbay, 2002), the occurrence of sponge fields can alter the characteristics of surrounding muddy sediments. Densities of occurrence are hard to quantify, but sponges in the class Hexactinellida have been reported at densities of 4-5 per m^2, whilst 'massive' growth forms of sponges from the class Demospongiae have been reported at densities of 0.5-1 per m^2 (B. Bett, pers comm.). Deep-sea sponges have similar habitat preferences to cold-water corals, and hence are often found at the same location. Research has shown that the dense mats of spicules present around sponge fields may inhibit colonisation by infaunal animals, resulting in a dominance of epifaunal elements (Gubbay, 2002). Sponge fields also support ophiuroids, which use the sponges as elevated perches.

*Lundälv (pers. com) adds on the above that significant sponge habitats also occur in much shallower depths in fjords such as Trondheimsfjorden (below 30 m) and in the Koster- and Oslofjords (below 60 m).

Correlation with habitat classification scheme

EUNIS code: A6.62

National Marine Habitat Classification for UK & Ireland code: Not defined

2. Original Evaluation against the Texel-Faial selection criteria

List of OSPAR Regions and Dinter biogeographic zones where the habitat occurs

The OSPAR List (OSPAR other agreement 2008-6) recognises that deep sea sponge aggregations occur in OSPAR Regions; I, III, IV, V. Deep sea sponge aggregations also occur in the eastern Skagerrak in OSPAR Region II.

Biogeographic zones: Arctic subregion (Deep sea), North Atlantic Abyssal Province (Deep sea), Norwegian Coast (Skagerrak), South Iceland – Faroe shelf; Barents Sea

List of OSPAR Regions where the habitat is under threat and/or in decline

All where they occur.

Original evaluation against the Texel-Faial criteria for which the habitat was included on the OSPAR List

Deep sea sponge aggregations in OSPAR Region I, III, IV and V were nominated in 2001 in a joint submission by Iceland, Portugal and United Kingdom citing rarity, decline, and sensitivity, with information also provided on threat.

Table 1. Summary assessment of deep-sea sponge aggregations against Texel-Faial criteria (from OSPAR 2008)

Criterion	**Comments**	**Evaluation**
Global importance		Does not qualify
Regional importance		Does not qualify
Rarity	This habitat is restricted to particular areas where hydrographic conditions are favourable and is currently mapped as distinct patches often separated by wide distances. However, it is not clear at present in how far this is a record artefact.	Qualifies
Decline	No quantitative data on decline, however anecdotal reports from fishermen point to a decline of areas with sponge aggregations around the Faroe Islands	Qualifies
Sensitivity	Sponges are sensitive to increased turbidity and likely pollution. The dominant species are long-lived, slow growing and therefore slow to recover from impacts	Qualifies
Threat	Physical disturbance of the seabed from bottom fishing operations is the main threat, but extent of fishing in sponge areas unknown. Potential threat from bioprospecting	Qualifies

ICES (2002) consider it reasonable to expect that the vulnerability and threat to the habitat is high. This is consistent with the case being made on the basis of expert judgement. Later, ICES (2007a) has considered structural sponge habitat as being *"extremely vulnerable to commercial trawling suffering immediate declines through direct removal of sponges and further reductions in population densities of sponges due to delayed mortality (Freese, 2001"*).

3. Current status of the habitat

Distribution in OSPAR maritime area

Current information on deep-sea sponge aggregations in the OSPAR habitats database (retrieved 1 September 2009, Fig. 1). It is obvious that the majority of data delivered to the database so far stem from OSPAR Region I (Iceland, Norway). Published data from the Faroes, the UK Atlantic Margin, Ireland and further south are yet missing.

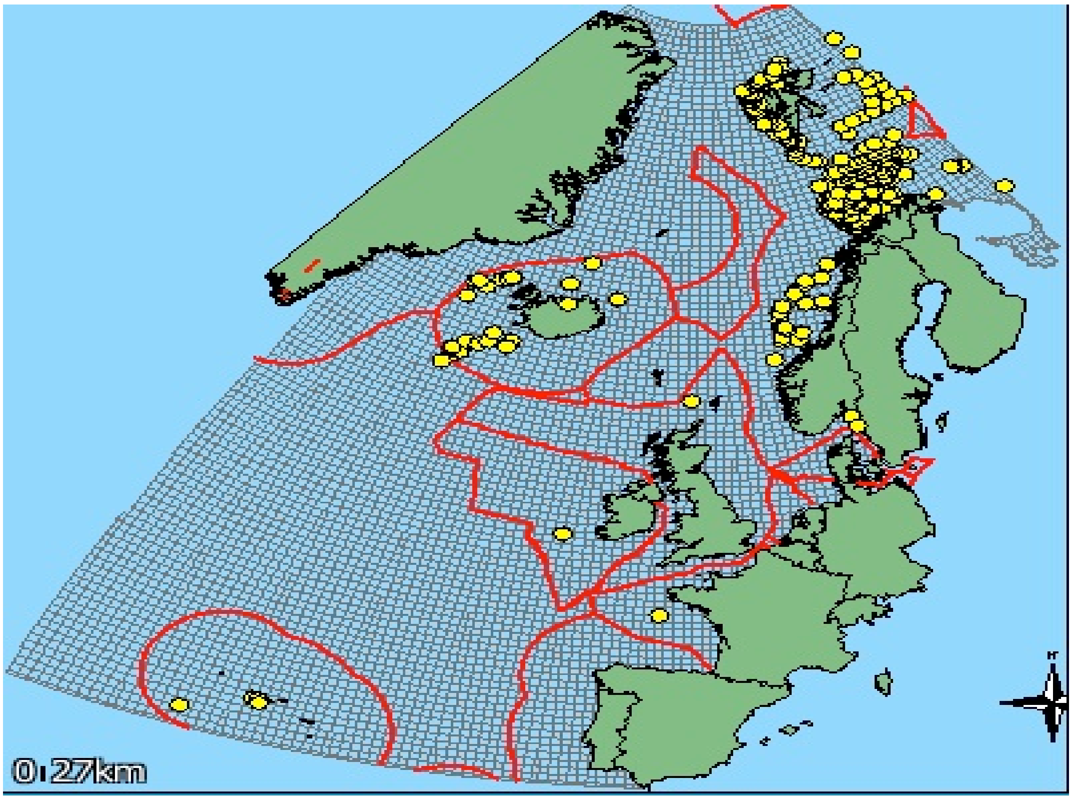

Figure 1: Deep-sea sponge aggregations. Records in the OSPAR habitats database (retrieved 1 September 2009).

The text below builds on the ICES (2007, 2008 and 2009) reviews of information on deep-sea sponge aggregations in the North Atlantic. Sponge grounds such as those described as "ostur" (Demospongiae, one of many fishermen names for this type of bycatch) are known to occur in the North East Atlantic in two different communities, depending on whether they occur in the flow paths of the warmer waters of the North Atlantic Current, or in the polar water of the Arctic Basin and outflow (Klitgaard and Tendal 2004).

Boreal "ostur" is dominated by *Geodia barretti, Geodia macandrewi, Geodia atlantica, Geodia (*former *Isops) phlegraei, Stryphnus ponderosus and Stelletta normani,* which occurs around the Faeroe Islands, Norway, Sweden, parts of the western Barents Sea and south of Iceland, and rarely occurring at temperatures lower than 3°C.

Cold water "ostur" is characterised by the same genera but represented by different species, viz. *Geodia mesotriaena, Geodia (*former *Isops) phlegraei pyriformis* and *Stelletta rhaphidiophora*, which is found north of Iceland, in most of the Danmark Strait, off East Greenland and north of Spitzbergen. A number of hexactinellid species are also represented in the cold water "ostur", the most frequently occurring being *Schaudinnia rosea.*

A clear difference between the boreal and the cold water "ostur" is in the average size of the dominant geodiid species. The local occurrence of "ostur" in the two bands is not continuous but represents a series of patches whose presence depends to a great extent on the local topography and hydrography. Therefore, the localities in which the highest concentrations of sponges occur may change over time (Barthel *et al* 1996; Klitgaard *et al*. 1997). These changes are most likely due to changes in water mass distributions (Klitgaard *et al.* 1997). Gutt and Starmanns (2003) discuss that patches of megabenthos in polar regions are seemingly unpredictable on a scale of 10 m, depending not only on current but also on past conditions. This is particularly relevant for long-lived species such as deepwater sponges, which integrate over long time scales.

Environmental conditions determining the distribution of Ostur:

Deep-sea demosponge aggregations tend to accumulate near the shelf break in regions where the bottom slope matches the slope of propagation of internal tidal waves. The causal link is thought to be an increase in the supply of food related to the incidence of internal waves which results in resuspension (Klitgaard *et al.* 1997). Therefore, the majority of the areas of “ostur“ known today are found:

- on the shelf plateau close to the shelf break (the Faroe Islands, the Karmoy area, and the western Barents Sea),
- on the upper slope (the Faroe Islands, the Karmoy area, and East Greenland),
- on the slope of the banks (the Faroe Islands, the western Barents Sea, and the Denmark Strait),
- on ridges (the Reykjanes Ridge), and
- on the rocky sides and on current-exposed sills of fjords especially off forelands and in narrow straits (the Trondheim Fjord, and the Koster- and Oslofjord areas).

Klitgaard et al. (1997) indicate that the best developed sponge growths around the Faroes are found where water temperatures are greater than 5°C. Nonetheless, the band of ostur in the eastern Faroe-Shetland Channel in around 500 m depth may at least occasionally be subject to subzero temperatures, possibly representing the extreme of the habitat (Bett 2001).

Southern type of mass occurrences

Further south in more Iberian waters off Morocco and the west of Ireland and Scotland large aggregations of the hexactinellid (glass sponge) *Pheronema carpenteri* (“Holtenia grounds“, Thomson, 1869) have been reported from 740 to 1300 m depth (Carpenter *et al*., 1870; Rice *et al*., 1990; Barthel *et al*., 1996). There are indications that this species may also be common to the west of the Faroe Islands and south of Iceland, at depths from between 800 and 1160 m (Burton, 1928; Copley *et al.,* 1996) and in the Bay of Biscay from 1000 to 2000 m (Le Danois, 1948, Cristobo et al, 2008; Sánchez et al., 2008). In the south of the Bay of Biscay and in north of Spain the structure-forming hexactinellid *Asconema setubalense* is encountered from 800 to 1500 m (Le Danois, 1948, Sanchez et al., 2009).

Hexactinellid sponges form aggregations in areas of open sediment and create a very distinct habitat (see Smith and Hughes 2008). Analysis of the abundance and taxonomic composition of the macrobenthos suggests the presence of sponge spicule mats at the sediment surface substantially modifies the fauna by increasing the numerical abundance of macrobenthos with increasing spicule abundance (Bett and Rice, 1992). Spicule mats indicate longterm stable environmental conditions and stabilise the sedimentary slopes of seamounts and continental shelves. Henrich et al. (1992) found that the dense and stable spicule mats made up of sponge spicules and bryozoan fragments not only provide an ideal substrate for microbes and other sessile benthic organisms but also for the settlement of sponge larvae which then grow on these mats.

Environmental conditions determining the distribution of *Pheronema carpenteri*

Already Le Danois (1948) considered *Pheronema* to be typical of an "infra-corallien" community which was to be found at the base of the coral patches thriving particularly well in regions of enhanced current flow. Le Danois observed *Pheronema* and other suspension feeders to occur particularly down-slope of cold water coral reefs associated to "coral mud" not only in the Porcupine Seabight, but also beneath similar patches off La Chapelle Bank, off the Armorican Shelf and smaller patches along the northern coast of Spain.

Here, aggregations of *Pheronema carpenteri* were found on sedimentary grounds (800-1200 m depth) located between the Cantabrian Sea continental shelf and the Le Danois Bank (Sánchez et al., 2008). This habitat, the inner basin, where the bottom topography in combination with shelf break current and tidal effects enhances the organic matter re-suspension processes, is favourable for the presence of the sponges.

This pattern was also described by Rice *et al* (1990) who clearly showed that the sponges are not found within the region of highest current flow on the continental slope but in a narrow band down-slope of it. Van Soest *et al.* (2007) discuss the type of association between hexactinellid sponges and coral reefs, and argue whether these sponges simply have the same environmental demands than corals and therefore tend to be found in the same places - profiting in addition of any hard substrate provided by coral fragments.

Figure 2 collates all available information on sponge aggregation type and occurrence as described below.

1. Polar “band”: OSPAR Region I

North of Spitsbergen: At about 1000 m depth (bottom T around -1° C), in a place of a thick, muddy mat of sponge spicules, rich assemblages of sponges have been recorded with dominant species of the genera *Geodia*, *Isops*, *Stelletta* and others (Klitgaard and Tendal 2004 and literature quoted therein). They conclude from reviewing the literature that “ostur“ may be widely distributed over large parts of the Arctic Ocean, especially on the eastern shelf and slope areas.

East Greenland and Denmark Strait: On the slope of East Greenland in about 750 - 800 m depth (bottom T around 0°C) , large occurrences of sponges were found, consisting of *Geodia mesotriaena, Isops p. Pyriformis, and Stelletta rhaphidiophora*, and *Tenea valdiviae* with several hexactinellid species typical of the polar “band“ Barthel pers. com. In Klitgaard and Tendal 2004).

On the Vesteris seamount, sponges (most common *Geodia* spp., *Stelletta* sp., and others, are abundant between 133 and 260 m depth (Henrich *et al.* 1992). Below 400 m, where the slope inclination increases drastically, sponge-bryozoan mounds with very large bryozoans and large demosponges (*Geodia* sp. and *Thenea cf. muricata*) prevail. Contrary to the mid slope, hexactinellids (*Schaudinnia* spp., Hyalonema sp) settle on lava blocks on the deep slope below 750 m.

“Ostur“ occurs either on the slopes of the banks or on the northern slope of Denmark Strait Channel in Arctic intermediate water (<2° C, Klitgaard and Tendal (2004). Denmark Strait seems to be particularly rich in large-sized sponge species of the orders Demospongiae and Hexactinellida, with e.g. all Atlantic Geodia species present. The dominant species are *Geodia mesotriaena, Isops p. Pyriformis, and Stelletta. Rhaphidiophora*. The most common hexactinellid sponge is *Schaudinnia rosea*. Locally, a relatively old, established Geodia community was found.

Witte and Graf (1996) observed very high densities of the golfball sized Tetilla cranium on Kolbinsey Ridge in their only sampling station there (20-24 Ind*m^{-2}). The species was found on sponge spicule mats. It is a typical deepwater sponge, known also from Ireland.

Also in the deep Fram Strait (78° N, 6° W; 1000 m, -0.4° C) massive sponge occurrences are known with the typical polar “band“ species composition (Koltun 1964 in Klitgaard and Tendal (2004).

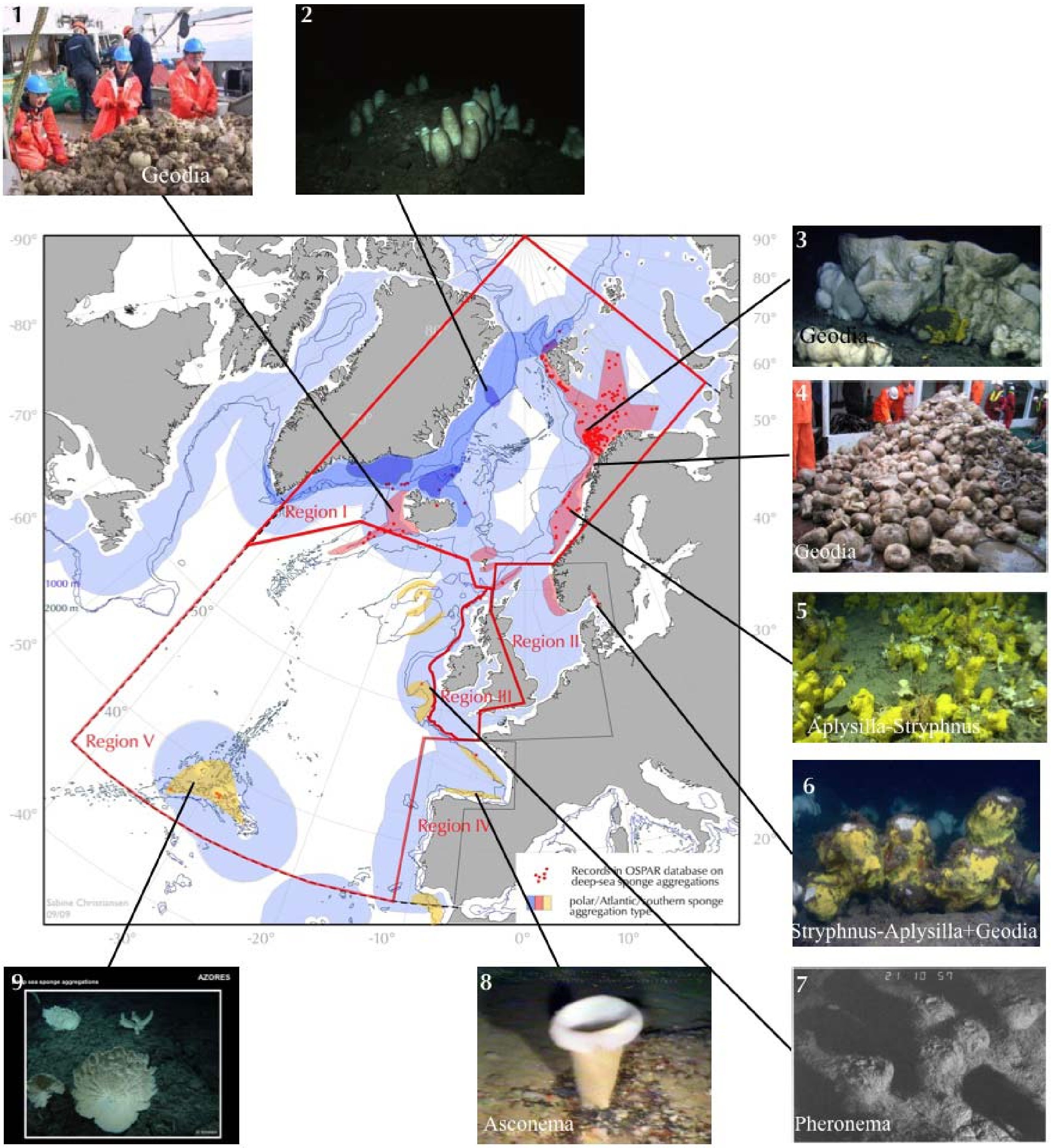

Figure 2: General distribution of habitat-forming sponges in the NE Atlantic and Nordic Seas as indicated by records in the OSPAR habitats database (red dots, 2008) and the sponge areas (darker colours) indicated in ICES (2009, Figure 8.2.2.1.) and further literature reports as described in the text below. Concentration of sponges vary considerably within these areas. The three biogeographic bands of deep-sea sponge aggregations are superimposed as blue (polar), red (atlantic) and yellow (Iberian) shading. The photos stem from ICES (2009), Rice *et al.* (1992), Tempera (pers. com), Lundälf (pers. com), Gutt (pers. com.) and Sànchez (pers. com).

2. Atlantic “band“: OSPAR Region I

Barents Sea: The western Barents Sea is well known for mass occurrences of sponges from numerous scientific and fishermen sources (reviewed by Klitgaard & Tendal 2004). Between 150 and 350 m depth, sponges of up to 1 m diameter and contributing up to 95-98 % of the local total biomass samples and up to 5-6 kg*m^{-2} were found to occur on sandy and sandy-silty bottom with good water movement. The species composition corresponds to the “Atlantic“ band group as described by Klitgaard and Tendal (2004, see above) and includes *Geodia barretti, G. macandrewi, Geodia (*former *Isops) phlegraei, I. pyriformes*, and other species.

On the edge of the Tromsøflaket particularly mixed sediments generate a high benthic species diversity with large sponges (Geodia spp.) being typical of these areas (MAREANO[1] results). Figure. 3 shows a clear concentration of high sponge bycatch volumes on Tromsøflaket as well as south and west of Svalbard/Spitsbergen (Norway Min. Env. 2005-2006).

During the MAREANO mapping it was observed that on Tromsøflaket in many places the trawl-door ruts are closely spaced, and traces of trawling were seen in about 90% of the video recordings. In some places with a large number of trawl tracks, large quantities of sediments were observed on the surface of sponges, and unattached sponges had collected in the trawl ruts.

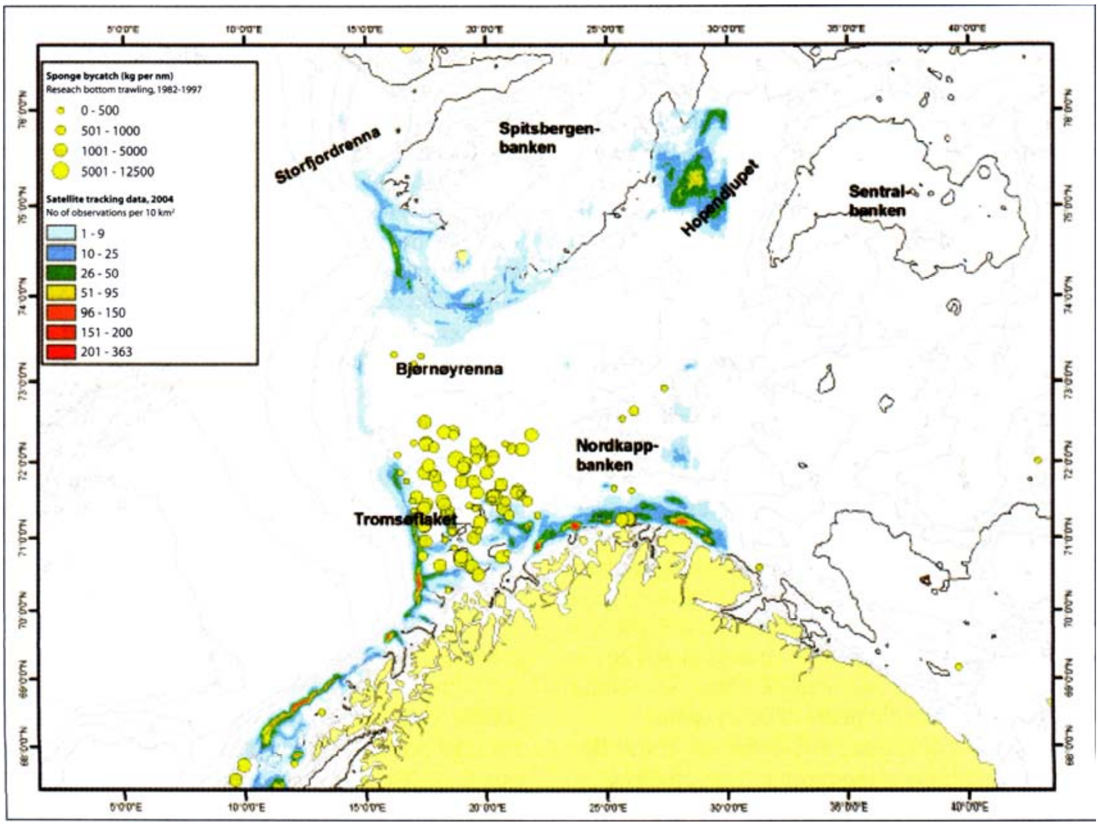

Figure 3: Barents Sea. Sponge bycatch in research bottom trawling 1982-97 superimposed on fishing effort 2004 (as density of VMS data points, Norway Min. Env. 2005-2006).

[1] http://www.mareano.no/english/results

Norwegian continental slope and fjords: Ostur is described also from the Norwegian fjords, such as Trondheim Fjord, where *Geodia barretti* is the most frequent species encountered (Klitgaard and Tendal 2004).

Iceland: The waters around Iceland, at least down to 500 m depth, are very rich in habitat forming sponge communities, "ostur", dominated by *Geodia* spp.. Klitgaard and Tendal (2004) describe the composition of "ostur" from sampling sites all around Iceland, the community south of Iceland being comprising *Geodia atlantica, G. Mesotriaena* and *G. barretti* as well as *Geodia (*former *Isops) phlegraei.* Very large catches of sponges (up to >20000 kg) were reported to Klitgaard and Tendal (2004) from the eastern and western flanks of the northern part of Reykjanes Ridge at more than 1000 m depth in Atlantic water.

Bycatch analysis carried out during the 2002 groundfish survey enabled the estimation of the distribution of mass sponge occurrences on the Iceland shelf (Ragnarsson and Steingrimsson 2003). The authors suspect that sponge bycatch is lower in areas of high fishing effort as indicated in Figure 4.

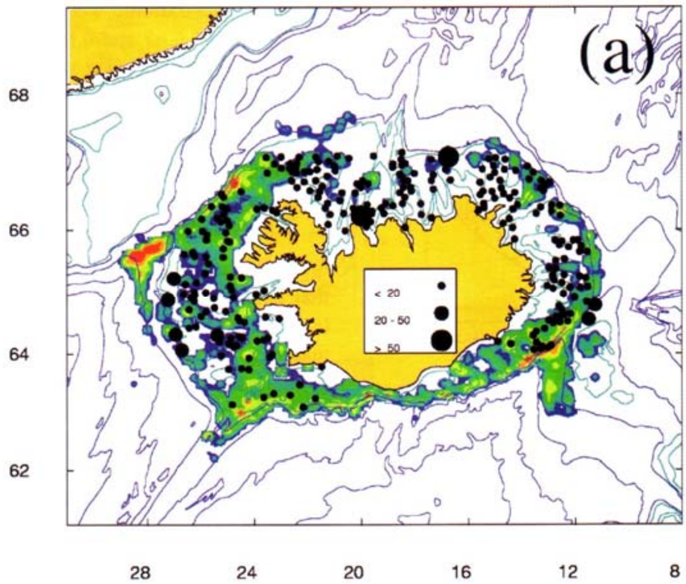

Figure 4: Iceland. Biomass of sponge bycatch in 2002, superimposed on fishing effort as mean annual swept area (nm^2 per 1° latitude x 1° longitude cell). Black dots indicate total biomass (kg/h otter trawl haul) of sponges in 2002 groundfish survey by Marine Research Institute.

Faroe Islands Eleven sponge species constitute the main part of the biomass of sponge dominated areas, “ostur“ (Klitgaard *et al.,* 1997; Klitgaard and Tendal, 2004). Ostur occurs all around the Faroes, generally on coarse gravel bottom with some current. It appears to be particularly well developed as narrow bands along the shelf break, at depths of about 250 to 500 m, in areas where the energy from internal waves is the basis for, at least tide-wise, increased water movements, resuspension and perhaps also convection of fine particulate matter. Originally it probably covered several thousands of km^2 but trawling seems to have reduced the size of the distribution areas (Tendal and Dinesen 2005).

Klitgaard et al. (1997, see Figure. 5) present a detailed account of all known “ostur“ areas around the Faroes:

- Faroe Shelf (southeast, between 200 and 300 m): several large patches of very large “ostur“ areas, constituted of *Geodia* spp., *Isops phlegaei and Stryphnus ponderosus*, the latter being dominant in weight. Individual bodyweights up to 20 kg. This is continued on the eastern shelf edge, with additional sponge belts being reported by fishermen from 300, 400 and between 291 to 600 m, coinciding with the respective depth of the critical slope.
- Faroe shelf (northern edge): two narrow bands of sponge dominated megafauna at 385-400 m and 180 - 215 m depth. Dominant species *Stryphnus ponderosus*
- Faroe Shelf (southern and western edge): reported bands along 300, 400 and 500 m isobaths, however not verified during BIOICE investigations. In other places large sponge catches of mainly Geodia barretti and other Geodia species between 300 and 400 m.
- Faroe Bank: ostur has only been reported from the northern (450 - 500 m) and southern slopes (207-470 m), the western slope does not meet the criteria for a critical slope.

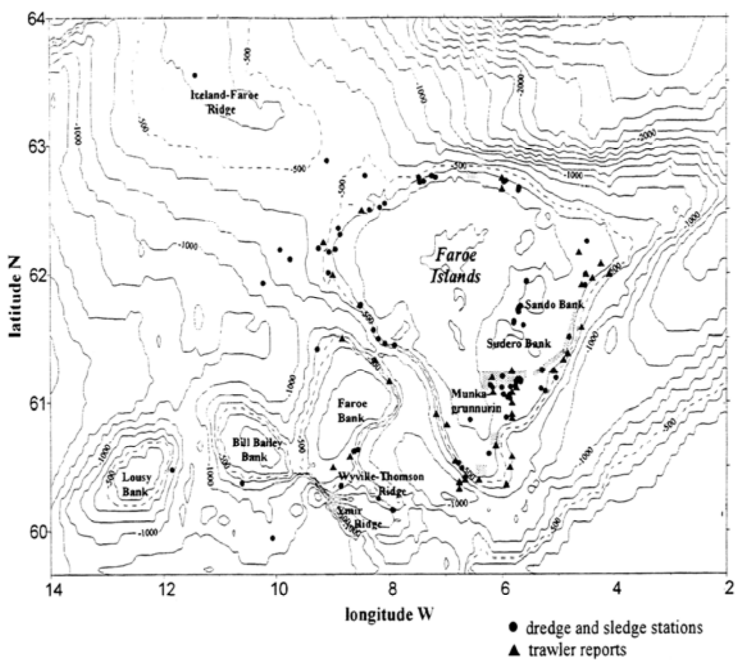

Figure 5: All known occurrences of ostur at the Faroe Islands. Shaded areas mark occurrences known from fishermen’s reports (Klitgaard *et al.* 1997).

Wyville Thomson Ridge: The southern slope of the Wyville Thomson Ridge has a critical slope in 550 to 600 m depth and somewhat deeper on the northern side. A few samples revealed five species with *Geodia phlegaei* as most abundant species (one station) in 600 - 650 m. However, no sponge aggregations comparable to those on the West Shetland continental shelf were found (Howell *et al*. 2007).

OSPAR Region II

Skagerrak: Investigations of the offshore cold water coral reefs in the eastern Skagerrak revealed massive sponge occurrences in several locations (Lundälv 2004, Hvalerrapport1):

- Fjellknausene: sponge-dominated communities with *Geodia spp.*, *Phakellia ventilabrum Antho dichotoma, Stryphnus ponderosus, Geodia (*former *Isops) phlegraei, Stelletta normani* and several others as biotope-forming species. The dead coral reef areas have a rich sponge fauna, dominated by *Geodia* spp., *Mycale lingua* and *Phakellia spp.*).
- Søstrene: the rich fauna is dominated by sponges (*Phakellia ventilabrum*, *Axinella rugosa, Geodia baretti, Mycale lingua* and *Antho dichotoma)*
- Tisler Reef: the sponge *Mycale lingua* occurs frequently in places with *Lophelia pertusa* and can outgrow the corals. Some places are sponge-dominated with *Geodia barretti*, *Stryphnus ponderosus, Geodia (*former *Isops) phlegraei, Stelletta normani* and several others as biotope-forming species
- Bratten: (Skjöld *et al.* 2007) indicate that Bratten holds deep-sea sponge aggregations corresponding to the OSPAR definition
- Kosterfjord: *Geodia baretti* occurs in numerous localities between 50 and 220 m depth, sometimes forming mass occurrences on the western flank of the fjord (Klitgaard and Tendal 2004)
- Norwegian shelf off Jomfruland and Finsbåene (between 9°38 and 9°50´E): Historic records (Alander 1942 in Klitgaard and Tendal 2004) show mass occurrences of mainly *Geodia barretti* and *Stellatta normani* at 100-300 m depth.

North Sea: Deep-sea sponge beds occur on the Norwegian slope of the Norwegian Trench between 375 and 145 m, mostly between 200 and 300 m (Karmoy area, Klitgaard and Tendal 2004), probably extending at least between Bergen and Kristiansand (Fosså and Tendal 2005). The dominant species are *Geodia* spp. and *Stryphnus ponderosus.*

Faroe-Shetland Channel: On the northern Scottish slope into the Faroe-Shetland Channel, “ostur“-like sponge grounds occur in a narrow band at about 500 m depth, coinciding with iceberg ploughmark terrain (Bett 2001, Axelsson 2003, see Figure. 6) in regions where the currents are elevated and resuspension and transport of particles are enhanced (Klitgaard *et al*., 1995). Recent surveys confirm the patchy presence of a structural sponge habitat between 400 and 600 m depth, being the dominant faunal community at approximately 450m depth (Howell *et al*., 2007). The structural sponge communities of the west Shetland Channel are characterised by a high diversity of sponge morphospecies including branched, cup, lamellate, globose, erect and encrusting sponges.

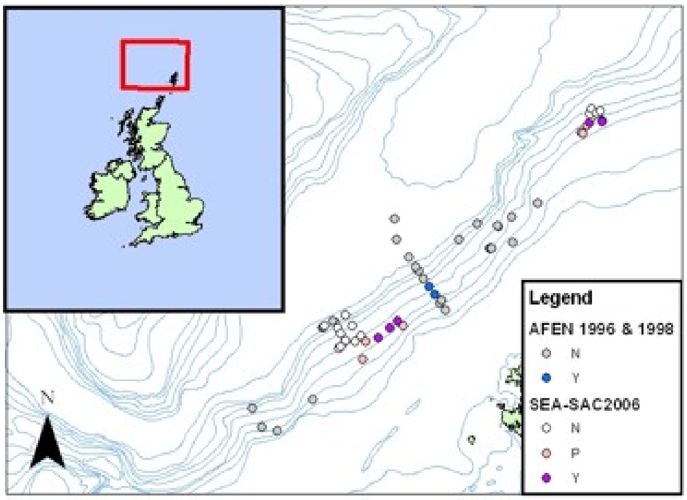

Figure 6: West Shetland Slope. Presence/absence of structural sponge communities (from ICES 2007, Figure 6.2.2)

Bett (2000) documented lost fishing gear and impacts of deepwater trawling on the seafloor and its communities allover the Atlantic Margin, on practically all sites investigated during several large scale regional seabed surveys. Most but not all observations came from the upper continental slope (300-600m), coinciding with the occurrence of well developed epifauna communities, in particular deep water sponges (see above). Consequently, Bett (2001) suggest that the environment described "*may, in part, already be influenced by the actions of deep-sea trawling as the impacts of deep-sea trawling may be encountered practically anywhere within the UK Atlantic Margin*". Evidence of human activities (trawl marks and discarded fishing gear) was also observed at all sites investigated by Howell *et al*. (2007). These observations support ICES (2006) studies concluding on a moderate to high impact of otter trawling on benthos, a very high impact on elasmobranchs (> 70 % fishing mortality), and a relatively high impact on non-target fish species.

OSPAR Region V

Mid Atlantic Ridge: The sponge fauna of the Mid Atlantic Ridge is poorly known. However, video dives and sampling in 750 - 3000 m depth revealed rich hexactinellid sponge communities or “garden“ around the Charlie Gibbs Fracture Zone and the associated seamounts down to 3000 m depth, and depending more on the availability of hard substrate than an depth (Felley *et al.,* 2008; ICES 2007a; Tababachnick and Collins, 2008). Several species belonging to the typical North Atlantic deepwater sponge fauna were determined (Tababachnick and Collins, 2008).

Southern group/Iberian waters: OSPAR Region IV

Bay of Biscay: From Ireland to Spain, in the muddy sediments below the coral reefs (“Infracorallien“, Le Danois 1948) at the base of the continental slope (1000-2000 m), there is a hexactinellid sponge belt characterised by high densities of *Pheronema* sp. and *Hyalonema* sp. in the north, and by *Asconema setubalense* south of Cap Breton Canyon. ICES (2007) quote Le Danois (1948) who reported aggregations of the large Hexactinellid sponge *Asconema setubalense* (”one of the most characteristics species of the Iberic waters"), being frequently collected by fishing trawls, between 500-1000 m, on soft bottoms, from Cap Breton canyon to the south. This species was also collected deeper (1000 – 2000 m) where it could form "sponge facies on muddy bottoms" as it is uniformly distributed along the deep slope of Northern Spain. Communities characterised by *Asconema setubalense* have been associated with 'coral muds'. Other sponge communities composed of *Asbestopluma pennatula* and *Cladorhiza abyssicola* are also thought to be linked to the 'coral mud' but also colonise deeper areas. Le Danois (1948) also described muddy facies characterised by the occurrence of Elasiopod holothurians and hexactinellid sponges of genus *Hyalonema* from 2000-3000m.

Le Danois Bank (El Cachucho): Spain (2008) in their nomination of the Danois Bank to OSPAR indicate all of the inner Bank to be an area of deep-sea sponge aggregation-occurrence in the sense of the OSPAR habitat definition (see. Figure 7).

Pheronema carpenteri constitutes most of the biomass among the approx. 40 species of sponges (Demospongiae and Hexactinellida) identified on Le Danois Bank (ECOMARG project, Sánchez *et al*., 2008, Cristobo *et al.*, 2008). Two different benthic communities including deep-sea sponge aggregations where described and cartographied on Le Danois Bank (El Cachucho MPA). In the rocky outcrops of the northern area of the top of the bank (400-600 meters depth), with medium to high habitat complexity, live a community characterized by the gorgonians *Callogorgia verticillata*, including also large-sized Geodidae and Hexactinellida (*Geodia megastrella*, up to 15 kg individual weight, and e.g. *Asconema setubalense*, larger than 1 m (Sánchez *et al*., 2008). The density of the *Asconema*, estimated using photogrammetric methodology, is of 119.8 individual by hectare on rocky grounds (Sánchez *et al*., 2009). This area is characterised by the strong water currents. On the inner basin located between the Cantabrian Sea continental shelf and the Le Danois Bank aggregations of *Pheronema carpenteri* were found on sedimentary grounds (800-1200 m depth) at a mean density of 37.2 individuals by hectare (estimated using beam trawl and otter trawl). The high variability associated to the samples suggest a patchy distribution of aggregates, were in some areas *Pheronema carpenteri* occurs in considerable densities of up to 750 individuals per hectare. Figure 7 show the spatial distribution of the two different sponge aggregations.

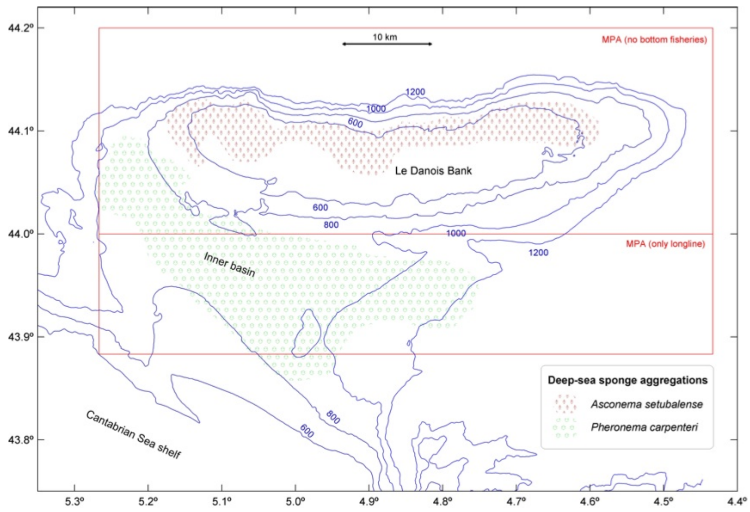

Figure 7: Le Danois Bank (El Cachucho MPA). Distribution of deep-sea sponge aggregations (*Asconema setubalense* and *Pheronema carpenteri*) in relation with MPA management measures (Sanchez, pers.com. based on Sánchez *et al.,* 2008)

OSPAR Region V

UK, Hebrides Slope: Photographic transects down the slope of the continental shelf to the northwest of Scotland revealed high densities of the hexactinallid (glass) sponge *Hyalonema* spp. in particular in the fine silt/clay sediments at 1295 m depth. At this depth, trawl marks were noticed on 12% of the photographs taken. Trawl marks following the depth contours photographed 10 years previously were still visible when visiting the same location a decade later (Roberts. *et al*. 2000).

Ireland, Porcupine Seabight: Mass occurrences of what was then named *Holtenia carpenteri* ("Holtenia ground") were first described from a region on the edge of the Hebridean Terrace by Thomson (1873). Stephens (1915, 1921 in van Soest *et al*. 2007) reported on sponges (91 species) on the continental slope of West Ireland (Porcupine Bank) and the opposite eastern slope of Rockall Trough at 396-1350 m depth in trawl and dredge samples.

Rice *et al*. (1990) observed dense aggregations (> 1.5 Ind*m^{-2}) of *Pheronema carpenteri* in the Porcupine Seabight at depths betwen about 1000 and 3000 m (see Figure 8).

Bathyal sponge communities co-occurring with the coral reefs on the northwestern slope of Porcupine Bank, to the west of Ireland (500 – 900 m), were found to have a combined sponge species richness of 191 species, however none of them forming mass occurrences (van Soest *et al*., 2007), The largest number of sponge species were found in the lower live coral cover range, Certain abundant sponge species, *e.g., Hexadella dedritifera*, appear to be closely associated with the presence of live coral.

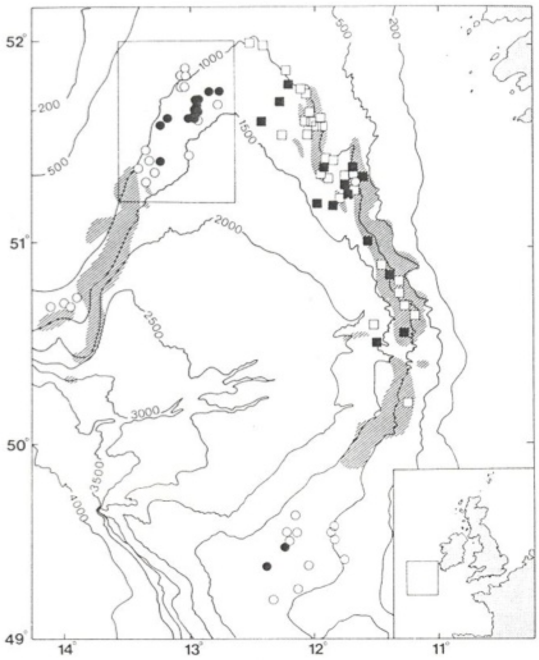

Figure 8: Distribution of *Pheronema carpenteri* in the Porcupine Seabight. Closed symbols represent presence and open symbols absence of the sponge. Circles: IOS (now NOCS) stations, squares Irish Fishery Investigation Stations (from Rice *et al.,* 1990).

Rockall Bank and Rockall Trough: High density patches of Hexactinellid cup sponge *Rosella nodastrella* (previously identified as *Asconema* aff. *setubalense* (cup height up to 30 cm) with up to 6 Individuals m^{-2} over a distance of more than a km were observed in a video transect across a coral mound at 500-800 m depth on SW Rockall Bank (van Soest and Lavaleye 2005).

Hatton Bank: The fishing grounds on the sedimentary western flank of the Hatton Bank (Sayago-Gil *et al*., 2009) frequented by the deep-water bottom fishing fleets (ICES, 2008) did not reveal large bycatch of sponges (Durán Muñoz *et al.*, 2007) except some hauls recorded by the observers of the Spanish Institute of Oceanography (IEO) on board commercial trawlers, particularly in the northern part (ECOVUL/ARPA data, Durán Muñoz, pers. comm). However, large bycatches of sponges (estimated > 500 kg) have been recorded in several hauls carried out during a cooperative bottom trawl deep-water survey developed in 2005 by the IEO on less frequented eastern flanks of Hatton Bank and in the Hatton-Rockall Basin, south to Rockall (Durán Muñoz *et al.*, 2007). The large structural sponges identified in the Hatton Bank and surrounding areas were the Hexactinellida *Pheronema carpenteri* and specimens of Demospongiae, Family Geodiidae (*Geodia* spp., ICES, 2007). In the aforementioned eastern flank of the Hatton Bank, P. carpentieri and Porifera indet, was also captured as a part of the bycatch during a cooperative bottom longline deep-water survey developed by the IEO in 2008 (Durán Muñoz *et al.*, 2009a). This suggests the presence of benthic communities dominated by large structural sponges in deep-sea bottoms of the eastern flank of the Hatton Bank.

The 2007 Spanish multidisciplinary research survey (Durán Muñoz *et al*., 2009b), sampling the Hatton Bank outcrop (western slope of the bank), came up with a provisional list of 28 species of deep-water sponges of the genera *Aphrocallistes, Phorbas, Craniella*, and others (Cristobo *et al.*, 2008). In the same outcrop area (Durán Muñoz *et al.*, 2009b), specimens of small glass sponges (*Aphrocalistes sp* and *Eupectella* sp) were collected during the 2008 bottom longline cooperative survey, suggesting that the outcrop of the Hatton Bank in the western slope, is a suitable substrate to small sponges settlement (Durán Muñoz *et al.*, 2009). In 2009, the European Commission presented a proposal to protect vulnerable marine ecosystems of the outcrop area in the western slope of the Hatton Bank, from significant adverse impacts (NEAFC, 2009).

A B C

Figure 9: Hatton Bank. Specimens of large structural sponges collected by the Spanish Institute of Oceanography (IEO) during cooperative deep-sea surveys (A, *Pheronema carpenteri;* B *Geodia* spp; C, *Isops* sp - Attention: *Isops* sp. is now also *Geodia* sp., Tendal pers. com.).

Seamounts off Portugal (Gorringe Bank, Josephine): The Gorringe Bank exhibits a diverse sublittoral demosponge fauna with a total of 36 recorded species down to 120 m depth, some of which occur in high abundances (Xavier and van Soest 2007). Previous investigations recorded another 9 deepwater species (Lévi and Vacelet 1958). The two neighbouring peaks Gettysburg and Ormonde share only six out of 23 species, a pattern of regional distinctness, and partly endemism which was observed also for other taxa. In addition to 9 species identified by Topsent (1928) in a depth of 200 m on Josefine Bank, *Asconema setubalense* is the only hexactinellid sponge identified from trawl resp. dredge catches in 300 and 400 m depth on Gorringe Bank and Josephine Bank (Gebruk *et al*. 2004).

Azores: Early records of Topsent (1892, 1904, 1913, 1928) established the first knowledge on the bathyal sponge fauna of the Azores. Saldanha (1991) reported of *Hyalonema* sponge aggregations on slopes and flanks of the Azores Islands. Today, more than 137 species and subspecies are recorded for the Azores EEZ in the review made by the World Porifera Database[2]. The visual survey of bottom habitats is slowly progressing, having already established that sponges are the dominating elements in the composition of circalittoral and bathyal biotopes of the Azores islands slopes (e.g., Faial island), seamounts (e.g., Baixo de São Mateus, Formigas Bank), and the Mid Atlantic Ridge.

[2] http://www.marinespecies.org/porifera/index.php

A few biotopes have already been identified both on soft and hard bottoms that are noticeably dominated by sponges. In some of them, sponges grow very large and play a major role as habitat builders for demersal fish species as well as for various epibenthic organisms and endofauna. Some of the sponges in these areas can attain diameters of up to 80 cm and weights of more than 50 kg(!). The reference collection programme maintained by the Department of Oceanography and Fisheries of the University of the Azores (DOP/UAç) in collaboration with fishermen indicates these species are common in exploited grounds on the Mid-Atlantic Ridge and associated seamounts.

Gulf of Cadiz: Overall, 78 species of sponges have been recorded from the ibero-morrocan gulf, the sponge community composition being similar between Alboran Sea and the Atlantic (Boury-Esnault *et al*. 1994). Barthel *et al*. (1996) found a relatively dense band of *Pheronema carpenteri* (up to 6 Ind*m-2) in 740-850 m depth on the Maroccan slope. The second most abundant species, the sponge *Hyalonema* as well as crinoids showed the same habitat preferences.

Habitat extent

Current extent: ICES (2009) concludes that it is highly likely that much of the habitat occurences are yet undiscovered. Currently, no systematic surveys of deepwater habitats take place, and the existing knowledge is based to a large extent on individual research programmes. The BIOFAR and BIOICE programmes where particularly important for developing the knowledgebase on deep-sea sponge aggregations. Nonetheless, the full extent of the habitat is not known.

ICES (2009) emphasize the patchiness of occurrence of deep-sea sponge aggregations. Individual colonies can have a range of sizes as summarised in Table 2. The typical extent of the habitat however, is rarely known as most samples stem from trawl by-catch investigations or research trawl and dredge sampling. Only visual observations will provide more detailed knowledge on the spatial extent of deep sea sponge aggregations.

As shown above, it is highly likely that deep-sea sponge aggregations occur in sites with very particular sediment, slope and current conditions. A further investigation of such a likely causal relationship will enable predictive modelling of potential further occurrences.

Trends in extent: As long as no further fisheries management measures are taken to avoid deep-sea sponge aggregations to be impacted by trawling, the extent of the habitat will shrink further. It is highly likely that from shallow to deep the deep-sea sponge aggregations will be impacted by global warming and its consequences for local to regional environmental conditions in the sea.

Future Prospects: In order to have a clear view on future prospects of the habitat, it is necessary to know to what extent the habitat will be affected by potential climate-induced shifts in hydrographic conditions and what the sensitive triggers are. Apart from the observed effects of rising temperatures on boreal species such as in the Skagerrak (Lundälv pers. com), any modification of the current and seston conditions may locally improve or degrade the growing conditions. Barthel *et al*. (1996) and Klitgaard and Tendal (2004) noted that the high density band of sponges may shift to some extent and may even react to climatically induced changes in current patterns.

Table 1: Current knowledge on deepwater sponge aggregations with respect to bathymetric occurrence, structural species, colony size, habitat occupied and relation to EUNIS classification (extracted from ICES 2009 WGDEC report, Tab. 10.1)

Geogr. Region	Bathymetric Zone	Structural species	Class	Typical size of Colonies	Typical Size of Habitat	EUNIS classification
NEAtlantic	Shelf/upper slope	*Geodia spp, Stryphnus ponderosus, Geodia* (former *Isops) phlegraei, Aplysilla sulfurea*	Demospongiae	10-100 cm	1-100 m	A5.1, A5.2, A6.62 Deep-sea sponge aggregations
		Phakellia ventilabrum , Axinella infundibuliformis, Axinella dissimilis, Stelligera stuposa		10-30 cm	?	A4.12 Sponge communities on deep circalittoral rock
		Hyalonema spp., Stylocordyla spp.	Hexactinellida	10-20 cm	?	
	slope	*Caulophacus arcticus*	Hexactinellida	10-20 cm	?	A6.62 Deep-sea sponge aggregations
		Hyalonema spp.,	Hexactinellida	10-20 cm	?	A4.12 Sponge communities on deep circalittoral rock
		Pheronema carpenteri	Hexactinellida	10-20 cm	?	A6.621 Facies with (Pheronema grayi)

Condition

Current condition: The quality of deep-sea sponge aggregations in terms of density, species composition, overall biomass etc. Is highly variable not only among different biogeographic regions, and depths but may also vary on a local scale. However, so far too few investigations provide a complete picture of the in situ habitat to be able to qualify even the natural condition of the habitat.

Table 3 summarises density estimates published for the dominating species in various types of "deep-sea sponge aggregations". The units reported vary widely and depend on the type of gear used.

Table 3: Compilation of literature data on the density of megabenthic sponges.

location	depth	Dominant species	density	Gear type	source
Kolbinsey Ridge (north of Iceland)	840 m	*Tetilla cranium*	20-24 Ind./m^2	Box core	Witte and Graf 1996
Faroes		*Geodia spp.*	1 large Indiv/30m^2	Trawl and dredge	Klitgaard and Tendal 2001
West Shetland slope	500 m			Photosledge, video	Bett 2001 Axelsson 2003 Howell et al. 2007
Hebridean Slope	721 m		0,05/m^2 (+/- 0.22)	Photographs	Roberts *et al.* 2000
Hebridean Slope	1295 m	*Hyalonema* spp.	0,11/m^2 (+/- 0.33)	Photographs	Roberts *et al.* 2000
Slope of Porcupine Bank	1283 - 1327m	*Pheronema carpenteri*	1 Ind/6 m^2, max. 1.5-5 Ind/m^2	Photosledge	Rice *et al.* 1990
Porcupine Seabight, coral mound		*Rosella nodastrella*	3-4 large Ind/m^2, max. 6 Ind./m^2	Box core	Van Soest and Lavaleye 2005
Le Danois Bank "El Cachucho"	400-600	*Asconema setubalense*	119.8 Ind./ha	Photosledge	Sánchez *et al.*, 2009
Le Danois Bank "El Cachucho"	800-1200	*Pheronema cerpenteri*	37.2 Ind./ha	Beam trawl, otter trawl	Sánchez *et al.*, 2008
Gulf of Cadiz, Maroccan slope	740-820 m	*Pheronema carpenteri*	0.17 Ind./m^2, max. 6 Ind./m^2	Photosledge	Barthel *et al.* 1996
Gulf of Cadiz, Maroccan slope		*Pheronema carpenteri*	1 Ind/31 m^2, max. 3 Ind. /m^2	Box core	Van Soest pers. com. (in van Soest and Lavaleye 2005)

location	depth	Dominant species	density	Gear type	source
Mid Atlantic Ridge	Between 3000 and 1700 m		Up to 80 Ind./1 min dive	Video-submersible	Felley *et al.* 2008
Mid Atlantic Ridge	2500-2000		Sponges abundant	Video-submersible	Felley *et al.* 2008

Trends in condition: Most of the data on deep-sea sponge aggregations stem from either commercial or research trawl and dredge operations. These gears not only remove biomass from the seafloor, but can also alter the sediments as shown by Bett (2000, Figure. 10) who encountered a toppled sediment structure with the remnants of sponge fauna being buried underneath an oxygenized new surface. Given the high intensity of bottom trawling carried out on the continental margins it is highly likely that not only the extent but also the condition of the habitat for deep-sea sponge aggregations will be affected. A similar but larger scale effect can be expected of the scouring of icebergs off Iceland, Greenland and Spitsbergen (Klitgaard and Tendal 2004 and literature therein).

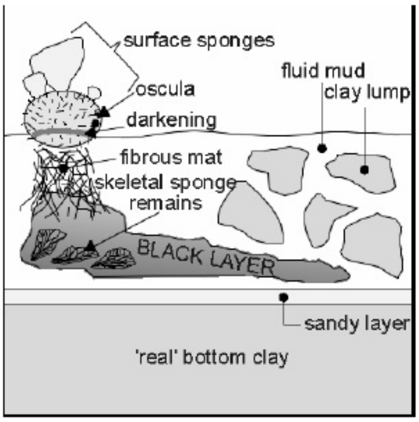

Figure 10: Schematic representation of profile through a disturbed sediment core collected on the West Scotland slope (Bett 2000, Figure 4)

Future Prospects: Unless measures are taken to protect the habitat from further degradation the condition of the habitat will not improve.

Sanchez *et al.* (2009) have modelled the effect of a 10 years fishery management regime in the El Cachucho MPA off the Cantabrian coast of Spain. The bank itself was considered fully closed to all bottom gears, and the innerbasin closed to trawling with longlining permitted. The simulation shows an important increase of biomass (in orange) of fish (anglerfish, deepwater elasmobranchs, catshark, thornyhead, etc.) and vulnerable species (corals & gorgonians, sponges, gastropods) is observed on the appropriate habitats of the MPA. The spillover effect increases the biomass of commercial species (anglerfish, megrim, squids) on the near continental shelf of Cantabrian Sea.

Limitations in knowledge

Van Soest (pers. com) qualifies the current knowledge of the sponge aggregations in the OSPAR region - though probably the best known area in the world for this - as “incidental and in need of much more ground work“ (collecting and identification). In particular to the south data are incidental, but there is reasons to assume that many more of those sponge fields occur along the continental margins, on seamounts and along major banks such as Rockall and Hatton Bank. The exact knowledge where and how many is woefully scanty and needs to be greatly expanded by more research.

Within the OSPAR Maritime Area, ICES (WGDEC2009) considers the eastern side of the Faroe/Shetland Channel as an area requiring further investigation. This is an important geographic zone as it represents the convergence of two water masses. Evaluation of the sponge fauna there will assist in the determination of the environmental factors influencing species distribution.

ICES (WGDEC2009) proposes to investigate the distribution of the species listed in their Table 8.2.1.2.1 (Annex 4 of this document) and their abundance/biomass remains a high priority. Efforts toward improving the quality and quantity of information on sponges, in particular also below 1500 m depth should be encouraged.

It is necessary to obtain a detailed cartography of spatial distribution of sponge aggregations using modern sampling techniques (side scan sonar, ROVs, photogrammetric sled, etc.) and adequate analysis (geostatistics, BPIs, GIS, etc.). It will allow to justify and define suitable measures of protection in order to avoid conflicts with the fishing activities. These necessary surveys and studies are very expensive and the necessary means in many cases are not available for some areas.

Research and monitoring into the vulnerability of the various types of the OSPAR deep-sea sponge aggregations are required to obtain a clear view on future large scale prospects for the conservation of the habitat.

4. Evaluation of threats and impacts

Threats to the deep-sea sponge aggregation habitat come on different scales and from different sources:

Global warming may in the long run pose the most significant threat to the existing distribution of deep-sea sponge aggregations and others, starting with those in shallower waters. Observations in the Koster- and Oslofjords showed dramatic declines in populations of *Geodia baretti* over the last 2-year period, most likely as a result of increasing water temperatures (Lundälv pers. com). Sponges with a carbonate skeleton of the order of Hexactinellids are in addition highly sensitive to the acidification of seawater as a consequence of rising CO_2-levels in the atmosphere.

The other large scale threat is bottom trawling wherever the habitat occurs on accessible grounds. As shown above, deep-sea sponge aggregations exist in various forms in all OSPAR regions except likely Region III. Wherever they occur, the range of distribution is within fishing depth, usually on the continental slopes, though some rocky outcrops may not be easily accessible to fishing gear. Due to the wide and large scale effort of bottom trawling fisheries, the threat from this type of activity was ranked highest (Hughes *et al*., 2003; Shepard, 2006 in Smith and Hughes 2008); see Table 4). Roberts *et al*. (2000) documented a persistence of trawl marks of at least 10 years in 1300 m depth off the Hebrides shelf. The long lasting effects of trawling on sponge grounds have been reviewed by e.g. Freese (2001) and Klitgaard and Tendal (2004). These authors also report of fishermen reporting of “improving“ the fishing ground by first removing with the bobbins the sponges, corals and any other fauna.

OSPAR (2005), the UN Secretary General (UNGA, 2006) and the International Council for the Exploration of the Seas (ICES, 2005) are agreed that the most threatened and easily impacted systems are ones that are both readily disturbed and are very slow to recover, or may never recover. ICES (2007a) has considered structural sponge habitat as being *"extremely vulnerable to commercial trawling suffering immediate declines through direct removal of sponges and further reductions in population densities of sponges due to delayed mortality (Freese, 2001)"*.

Table 4: Overview of the main threats and impacts to *deep-sea sponge aggregations*

Relevant human activity	**Degree of threat**	**Relevant human category**
Fishing	Large scale, very high	biological – physical damage to species
Co_2 Emission	Large scale, very high	Large scale, very fast modification of temperature and current regime as well as carbonate household
Minerals exploration	local	deep-sea mineral mining hydrocarbon exploitation physical - substratum change;
Dumping of solid waste and dredged soils	local	increased siltation (deposited sediment).
Land-based activities (emissions and input from agriculture, forestry, industry, urban waste water	Probably minor, only affecting coastal and near-coastal sites	nutrient changes (eutrophication)
Harvesting	?	Bioprospection
Research	Can be substantial (bycatch in fisheries surveys)	scientific sampling

ICES (2009) summarise the sensitivity of different sponge species to impact and disturbance: Due to their upright structure, the sponges listed in ICES (2009, Table 8.2.1.2.1) are especially vulnerable to the impacts of bottom tending gear (Freese *et al*., 1999). The degree of damage is crucial to evaluating the impact of this type of disturbance. Sponges have a certain ability to regenerate tissue, which depends upon the size of the wound and the size of the sponge, with larger sponges showing an increased ability for regeneration (Henry and Hart, 2005). Smaller sponges tend to be younger and age is complexed with size in determining recoverability. Juvenile sponges may not be able to regenerate tissue (Simpson, 1984; Henry and Hart, 2005). Gross morphology also seems to influence regeneration ability and sponges with decreased morphological complexity are expected to regenerate less well than more complex forms. However, recoverability depends on the size of the wound relative to the amount of uninjured tissue and if this ratio is small, other factors may not be important. The key aspect of the wound in determining recovery rate is the wound perimeter, which positively correlate. The depth of the wound does not appear to be a major determinant (Henry and Hart, 2005).

Sponges are also vulnerable to smothering as they are unable to alter current inflow. Clearing accumulated sediments is energetically demanding and in extreme cases may disrupt the aquiferous system. Sponges which have been subject to smothering are also less able to regenerate wounded tissue (Henry and Hart, 2005).

Level of threat from Fishing: The level of threat from bottom trawling on the continental slope can be illustrated by a study of Roberts *et al.* (2000): Off the west of Scotland between 900 and 1300 m depth, the authors noticed trawl marks in 2- 12 % of all photographs from a camera system which covers less than 100 m^2 per deployment. The deepest (physically most stable) stations had the highest frequency of trawl marks per deployment (12 %) at the deepest sites (1300 m). A nearby site in 600-883 m depth which was revisited after a decade, revealed the old and fresh trawl marks in up to 47 % of the pictures taken. Also Bett (2000), surveying the West Shetland slope found trawl marks in almost all of the photographs analysed.

The type of damage that may occur to an individual sponge through fishing disturbance is listed in Table 5, together with a subjective evaluation of the recovery potential. ICES (2009) points out that habitat recovery is very different from the ability of an individual to regenerate tissue. Trawling can impose very extensive damage to coldwater sponge grounds which may take decades or even centuries to recover. Klitgaard and Tendal (2004) suggest that the dominant ostur species are slow growing and take at least several decades to reach the sizes commonly encountered. In general, they are found in relatively constant environmental conditions, suggesting that they are dependant on a certain stability with respect to water mass characteristics, kinds and amount of particles in the water, and on low physical disturbance.

Experimental trawling on sponge communities in the Gulf of Alaska demonstrated that damage is significant (30 to 60% of the remaining sponges of the principle species were damaged). No damaged sponges in the trawl paths showed signs of repair or regrowth after 1 year and damage to some had been so severe that necrosis, probably as a result of bacterial or fungal agents, had led to subsequent death (Freese, 2001). No sign of recovery of the community a year after trawling was observed.

Table 5: Summary of the prognosis for recovery of structure-forming cold water sponge species according to various disturbance types associated with fishing activities. Recovery assessment is individual-based as opposed to community-based (ICES 2009, Table 8.4.1.).

Disturbance type	Comments	Prognosis for recovery
Mechanical Damage		
Minor tearing of body wall	Sponges showing tissue repair have been collected; increased risk of infection; distal wounds appear to heal faster than wounds on lateral surfaces	Excellent
Large wounds relative to body size	Incomplete regeneration; increased risk of infection; impaired reproduction and growth	Moderate
Breakage at base	No signs of recovery after 1 year during experimental trawling in Alaska	Very Poor or No Recovery
Dislodgement		
Minor change to orientation, position relative to currents not strongly affected	Sponges can lay new growth down to adapt to minor change in current direction	Unaffected

Disturbance type	Comments	Prognosis for recovery
Significant change to orientation, position relative to currents strongly affected	Sponges likely to die if food availability is restricted as a result of dislodgement	Poor
Sponge dislodged on bottom, free-floating		No Recovery
Sponge brought up on deck and returned	When the aquiferous system is drained very few sponges can fill it up again; air in the chambers cause the sponges to float	No Recovery
Crushing	Turning over of substrate commonly seen in trawl tracks	No Recovery
Sedimentation		
Light accumulation of sediments in incurrent aquiferous system, no serious damage to aquiferous system	Ability to clear sediment; sediment accumulation can be viewed in cross sections with concentrations near ostiole	Very Good
Repeated accumulation of sediments in incurrent aquiferous system	Sponge death or impairment	No Recovery

5. Existing Management measures

OSPAR Region I: There are no targeted measures in place to protect deep-water sponge aggregations from human impacts. However, in Norway several sites have been closed to trawling for the protection of cold water coral reefs. It is unknown to what extent these closures have beneficial effects on deep-sea sponge aggregations. In any case the habitat seems to be more widely distributed in the Barents Sea compared to cold water coral reefs.

Around Iceland and the Faroes (Act on Commercial Fisheries 1994) a number of seasonal and annual closures to bottom trawling exist which might have beneficial effects on the deep-sea sponge aggregations occurring there. However, this has not been assessed. In the case of the Faroe Bank for example, only the plateau of the bank is closed to trawling whereas the slopes, where the habitat occurs, are not.

OSPAR Region II: There are no measures in place to protect deep-water sponge aggregations from human impacts on the West Shetland slope, the Karmoy area off the Norwegian coast and the Bratten area in the Skagerrak. In the latter area trawling effort is said to increase (Sköld *et al*. 2007)

OSPAR Region IV: The implemented management measures in the new MPA of the El Cachucho (Le Danois Bank), in which is prohibited the use of bottom gears, can contribute effectively to the recovery of the sponge aggregations in the zone. Spain has initiated in 2009 a big research project (LIFE-INDEMARES) for the study of zones with vulnerable deep ecosystems as potential candidates to be declared MPAs and to be integrated in Natura 2000 network. This project will finalize in year 2013 and three of the study zones are in the OSPAR area: Avilés Canyon, Galicia Bank and the submarine volcanoes of the Gulf of Cadiz.

In addition to a general prohibition to bottom trawling in waters shallower than 100 m several seasonal and annual closures to bottom trawling exist on the Cantabrian shelf (Rodriguez-Cabello et al. 2008), which may also cover the occurrence of deep-sea sponge aggregations. The use of rockhopper is banned in all the Atlantic coast of Spain (Fishing Ministry order 06/03) based on a study on rockhopper effects on benthic communities (www.ecomarg.net).

OSPAR Region V: Until 2003 (Azores regional legislation), and since 2005, the waters around the Azores are permanently closed to bottom fishing activities ((EC) No 1568/2005).

Since 2008, several small SACs for the protection of coldwater corals in economic exclusive Zone of Ireland are fully closed to fishing with bottom contacting gear (EC) No 40/2008). Several closures for the protection of cold water corals exist on Rockall (both within and beyond national waters) and Hatton Bank, regulated by EU TAC decisions since 2007 and NEAFC recommendations since 2007. It is uncertain whether the habitat seep-sea sponge aggregations will benefit of these measures.

In areas beyond national jurisdiction the first coral closures on seamounts and the northern Mid Atlantic Ridge came into force in 2005 (NEAFC AM 2004/57) together with a 30% reduction in fishing pressure. Since April 2009, these closures have been amended to deliver actions requested by UNGA 61/105 to protect vulnerable marine habitats and species from fishing impacts. It is uncertain whether the habitat seep-sea sponge aggregations will benefit of these measures.

OSPAR (2008) agreed on a code of conduct for scientific research in open ocean and deep water (2008) with the goal to avoid unnecessary damage to species and habitats from scientific research sampling.

Hydrocarbon exploration and exploitation takes place in the EEZs of Norway, the UK, the Faroes and in the future of Ireland which poses a potential threat to the deep-sea sponge occurrences. National regulatory authorities for these industries require Strategic Environmental Assessment (SEA) and Impact Assessment (IA) in advance of new developments. There are no agreed standards at to what level of impact is not acceptable.

Figure 11 maps the spatial extent of the 2009 regulations restricting fishing wit h bottom-contacting fishing gear outside territorial waters in national, European and international waters of the OSPAR Maritime Area.

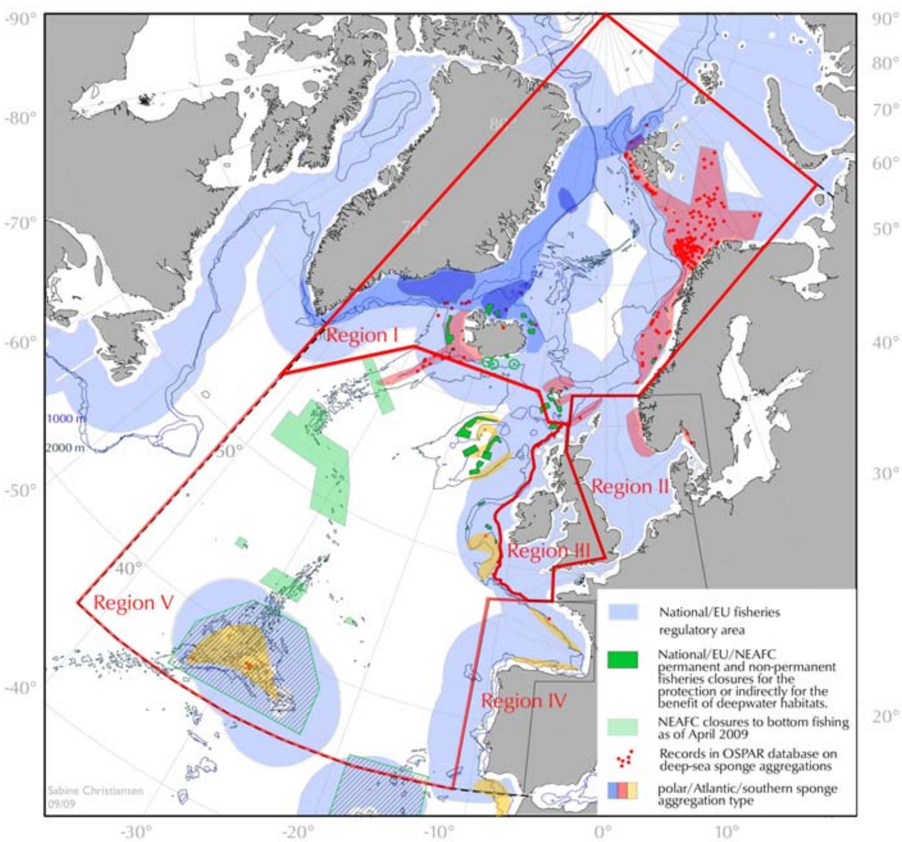

Figure. 11: Spatial extent of the 2009 regulations restricting fishing with bottom-contacting fishing gear in national, European and international waters of the OSPAR Maritime Area superimposed on known and likely distribution of deep-sea sponge aggregations (legend see Fig. 2).

6. Conclusion on overall status

The following sections draw on parts 3-5 of this report to provide an updated evaluation of deep-sea sponge aggregations against the Texel-Faial criteria. For summary see Table 6.

Table 6: Summary of 2009 evaluation of “deep-sea sponge aggregations“ against the Texel-Faial selection criteria

The Texel-Faial selection criteria	Updated evaluation (2008)
Global importance	Globally important
Regional importance	Regionally important
Rarity	
Sensitivity	‘very sensitive’ to the effects of demersal trawling ‘sensitive’ to the localised effects of oil and gas
Ecological significance	‘very important’
Decline	‘significant decline’
Threat	‘currently threatened’

Global and regional Importance: Although deep-sea sponge aggregations have been found in many parts of the world ocean, the community composition of these habitats is very different. Even within the OSPAR area the there are several types of deep-sea sponge aggregations. The habitat is not linked to the occurrence of a particular species, but rather to particularly favourable long-term growth conditions. Therefore, probably, the species associations characterising the deep-sea sponge aggregations in the OSPAR area are unique and as such globally and regionally important.

Rarity: Deep-sea sponge aggregations of different types are described from all OSPAR areas but Region III, and from all depths. Klitgaard and Tendal (2004) make clear, that the occurrence of the habitat might follow a relatively predictable pattern of environmental conditions and as such may not occur (or be rare) outside these favourable conditions. Overall, this type of habitat is not (yet) rare in the OSPAR area.

Sensitivity: ICES (2009) clearly summarized the very high sensitivity of the habitat to human impacts based on longevity, slow growth, unknown reproduction patterns and slow if any recovery from physical damage. Only minor injuries or a low degree of siltation can be repaired. In addition, the habitat is vulnerable to temperature increases (Lundälv pers. com) and to some extent to acidification of seawater.

Ecological significance: Sponge aggregations *per se* are not necessarily places with high sponge diversity, but rather places of high abundance or relative dominance of a few large species (which can be identified by visual survey). The vast majority of sponge diversity lies within the small, encrusting specimens that go unnoticed on video and have therefore been highly overlooked.

However, sponges as individuals and as a habitat builder increase the physical heterogeneity of habitat and the number of available microhabitats in deep marine ecosystems through their morphology by adding structure and complexity to the physical habitat. This creates additional space for fish and invertebrates to utilize for shelter and other needs. An enhanced level of structure and complexity has been demonstrated to be of particular importance during times of reproduction, and for juvenile life-stages (Auster, 2005), or at night for daytime-active species (Brodeur, 2001).

The fauna associated with the sponge grounds is rich and has a higher diversity compared to surrounding bottoms. The associated fauna is dominated by epifaunal groups such as encrusting sponges, hydroids, zoanthrians, bryozoans, and ascidians that use the sponges as a substratum (Klitgaard, 1995; Klitgaard and Tendal, 2004). For example Klitgaard (1995) found at least 242 species of epi-and infauna, among these 115 species of obligate sponge associates, to occur with eleven sublittoral sponges of the genera *Geodia, Isops, Strychnus, Thenea, Phakellia* and *Tragosia* in Faroese waters. The spicule mats associated with the sponge communities' support increased biomass of macrofaunal species (Bett and Rice, 1992).

ICES (2009) notes that rockfish, especially *Sebastes* species, live in openings and in between sponges. Young redfish (*Sebastes* spp.), are regularly observed on sponge grounds sometimes seeking shelter inside the cavities of large sponges. In samples taken using fishing gear there are often several species of groundfish represented, such as cod and ling, along with the sponges in the catch.

Decline: The degree of decline of deep-sea sponge aggregations cannot be quantified, neither locally nor for the OSPAR area. It is however very likely that much of the habitat has been removed in the course of fishing operations, as the sponges usually occur on trawlable ground on the slopes of offshore banks, islands and the European continent. These are the prime trawl fishery areas, and eyewitnesses confessed to “clean“ the ground of these biota in order to make the ground accessible to trawling.

Threat: The habitat is considered 'currently threatened' as the likely rate of decline linked directly to human activity exceeds that which can be expected to regrow. Spatially detailed assessments of fishing effort is needed to determine the conflict areas with the habitat and whether any of the coral protection areas provides any protection to the deep-sea sponge aggregations as well.

7. Action to be taken by OSPAR

Action/measures that OSPAR could take, subject to OSPAR agreement

As set out in Article 4 of Annex V of the Convention, OSPAR has agreed that no programme or measure concerning a question relating to the management of fisheries shall be adopted under this Annex. However where the Commission considers that action is desirable in relation to such a question, it shall draw that question to the attention of the authority or international body competent for that question. Where action within the competence of the Commission is desirable to complement or support action by those authorities or bodies, the Commission shall endeavour to cooperate with them.

When adding the deepwater habitat "deep-sea sponge aggregations" to the OSPAR List of threatened and/or declining species and habitats, OSPAR recognised the seriousness of the threat in conjunction with bottom fisheries. So far no targeted measures exist to protect the habitat in areas under national/EU jurisdiction, although some fisheries management measures may benefit the status of the habitat indirectly (see above).

Although OSPAR is not entitled to take or decide upon any measures related to fishing, as the regional environmental convention OSPAR does have the task to monitor and assess the health of the marine ecosystems of the North East Atlantic. Any need for fisheries measures to protect particular species or habitats (in this case the deep-sea sponge aggregations) from destructive impacts has to be communicated to the responsible national, European and international fisheries management bodies.

A staged process of communication is proposed with the responsible fisheries management bodies of Iceland, The Faroes, Greenland, Norway, the EU and NEAFC through intranational, OSPAR-national and OSPAR-international communications channels:

Phase 1: Secure the known occurrences of the habitat - (see chapter 3 above). This means to close to fishing the sensitive areas already known (where the critical slope provides favourable conditions). Deep-sea sponge aggregations are normally avoided by fishermen, so charting the known occurrences will likely provide some, though likely not sufficient, protection from interaction with fishing gear even without legal measures being taken.

Phase 2: Investigate systematically the occurrence of the habitat, as well as the quality of the known habitat occurrences by means of deepwater habitat surveys (though a lot is being done already, this is a long-term action) and support with predictive modelling (and vice versa).

Phase 3: Then propose further area closures - or in the long term eventually the exchange of good/less good sites.

Setting an ecological quality objective for deep-sea sponge aggregations (EcoQOs) is an important task for OSPAR to direct the management effort towards conservation and recovery of the habitat. The EcoQO could be formulated as "*maintain the habitat extent and quality and provide opportunity for regeneration in areas which have been impacted by human activities*". It seems unrealistic to aim at a certain proportion of the habitat to be conserved as the full extent of the habitat is not likely to be known in the near future.

Table 7 provides a list of actions that it proposed OSPAR, and/or its Contracting Parties should take forward.

Table 7: Summary of key priority actions and measures which could be taken for deep-sea sponge aggregations. Where relevant, the OSPAR Commission should draw the need for action in relation to questions of fisheries management to the attention of the competent authorities. Where action within the competence of the Commission is desirable to complement or support action by those authorities or bodies, the Commission shall endeavour to cooperate with them.

Goal	Action	Who	Adressee
1	Protect the known occurrences of deep-sea sponge aggregations from further degradation		
1.1.	Develop a regional approach to reducing the interaction of fishing gear with vulnerable habitats in cooperation with the fisheries management bodies	OSPAR	National fisheries ministries of Iceland, The Faroes, Greenland, Norway, the EU and NEAFC
1.2.	Communicate the locations of deepwater sponge aggregations in the OSPAR area and the need for measures arising from the most recent assessment.	OSPAR	National fisheries ministries of Iceland, The Faroes, Greenland, Norway, the EU and NEAFC
1.3.	Communicate the locations of deepwater sponge aggregations and the need for measures to the respective national fisheries ministries	Iceland, Denmark/The Faroes, (Greenland), Norway,	National fisheries ministries
1.4.	Initiate measures in the responsible fisheries management bodies - Contracting Parties to sign up for lobbying the relevant own national and international fora	EC and EU Member States in EU, NEAFC Contracting Parties in NEAFC and own national government	EU, NEAFC, national waters of Norway, Iceland, the Faroes, Greenland
1.5.	Select and designate as MPAs an ecologically coherent and representative set of deep-sea sponge aggregations	Contracting Parties (except D, NL, B)	
1.6.	Select and designate as MPAs an ecologically coherent and representative set of deep-sea sponge aggregations in areas beyond national jurisdiction.	OSPAR	

2	Improve systematically the spatial coverage of data on distribution, quality and extent of the habitat		
2.1.	Initiate deepwater habitat surveys (including visual and sampling survey as well as a range of physical factors)	All Contracting Parties individually and jointly	
2.2.	Chart locations of the habitat as precise as possible and enter into fishing and navigation charts as areas to be avoided.	All Contracting Parties individually and jointly	
2.3.	Assess the regional differences of the habitat in terms of community characteristics, biomass, patchiness and establish thresholds for "move-on rules" for fishing vessels hitting upon so far unknown habitat occurrences.	ICES on behalf of OSPAR	
2.4.	Invest in predictive habitat modelling	International research project	
2.5.	Initiate a reform of the bycatch rules in all relevant fisheries: Obligation to land subsample of invertebrate bycatch for scientific investigation	OSPAR, CPs, in particular EC, Norway, Iceland, Faroes	EC, Norway, Iceland, Faroes
3	Improve the OSPAR database and habitat map to complete the current knowledge base on this habitat.		
3.1.1.	Contracting Parties to provide the missing (existing) data	Faroes, Ireland, France, Spain, mainland Portugal, UK	
3.1.2.	Initiate a programme to retrieve and map knowledge from fishermen (building on work in Norway, the Faroes and Iceland); initiate cooperation on bycatch recordings.	EU research project?	
3.1.3.	Compile bycatch information from deepwater research trawl surveys	ICES?	
3.1.4.	Improve the OSPAR habitat mapping with bathymetry and seafloor characteristics.	UK	
3.1.5.	Provide an annually updated report and map of known and expected locations of the habitat for information to the fishing sector.	OSPAR	National fisheries ministries of Iceland, The Faroes, Greenland, Norway, the EU and NEAFC

4	Elaborate an EcoQO for deep-sea sponge aggregations in the frame of the „EcoQO for threatened and declining habitats in the OSPAR Maritime Area“. This will set a conservation target communicable to management bodies.	OSPAR	All management bodies and the public
5	Periodically provide an integrated assessment of threats and impacts on the habitat together with the trend analysis of EcoQO indicators, deduce effectiveness of measures and improvements required.	OSPAR	
6	Ensure that commercial use/harvesting and international trade in deepwater sponges is sustainable	OSPAR	
7	Provide outreach and public information	OSPAR	
8	Communicate to national/European research and funding agencies on the need for budgeting further habitat mapping and deep water habitat research	OSPAR	national/European research and funding agencies

Brief summary of the proposed monitoring system (see annex 2)

ICES (2009, Chapter 8.2.1. Habitat-based management vs. species management) endorses a habitat-based approach to management (as opposed to conservation of individual species) and recommends to use a list of 25 structure-forming sponge species as a basis for monitoring (see Annex 4). It is necessary to carry out biological “state“ monitoring of distribution, extent and quality of the habitat, as well as “pressure“ monitoring of the extent, intensity and type of conflict with human activities.

Biological survey is required for getting a better understanding of habitat distribution, quality and extent, whereas monitoring will deepen the knowledge for a number of representative cases over time.

For biological survey and monitoring a wide array of well developed field techniques is available - usually however expensive and time-consuming. Monitoring potentially damaging human activities on the other hand is a desk activity which will help outline the main areas of conflict.

Annex 1: Overview of data and information provided by Contracting Parties

Contracting Party	Feature occurs in CP's Maritime Area	Contribution made to the assessment (e.g. data/ information provided)	National contact point (acc. Updated OSPAR MASH 07 Annex 8)	National reports References or weblinks
Belgium	N	N	A. Vanreusel	
Denmark	N			
Faroes	Y			
France	Y	Y	A. Curd, B. Guillaumont (in MASH07 Annex 8)	B. Guillaumont , N. Boury-Esnault provided some comments
Germany	N	N		
Iceland	Y	N	Steingrimsson - Ragnarsson	
Ireland	Y	N	E. Kelley	
Netherlands	N	N		
Norway	Y		J. H. Fosså	
Portugal	Y	Y	R. S. S. Santos	Azores: Text provided by F. Tempera, P. Porteiro, comments T. Morato
Spain	Y	Y	Pantoja J. Cristobo	MASH08/4/Info 2, Text and comments by F. Sanchez, A. Serrano and P. Durán-Muñoz (Instituto Español de Oceanografía)
Sweden	Y	Y	T. Lundälf	Comments provided
UK	Y	N	D. Connor	

Annex 2: Detailed description of the proposed monitoring and assessment strategy

Rationale for proposed monitoring

The proposed approach is designed to provide an appropriate assessment of extent, distribution and condition of deep-sea sponge aggregations and associated macrofauna, to yield information on current and future extent of the habitat, as well as present and future qualities. If possible damage and/or recovery of deep-water sponge aggregation and adjacent substrate types from human impacts and the effects of ocean acidification need to be studied, however this will require a complementary larger scale research programme investigating the spatial distribution of fishing effort, and bycatch analysis. The monitoring programme will in the future serve also to assess the effectiveness of management measures in place.

Use of existing monitoring programmes

At present there are no monitoring programmes established for deep-sea sponge aggregations, and currently no data on temporal or spatial change of the habitat quality and extent exist. Records of occurrence have come from research sampling, bycatch analysis of research trawls and fisher's knowledge. In the Azores, an observer programme covering all of the EEZ is delivering information on biota through bycatch analysis.

Synergies with monitoring of other species or habitats

Deep-sea surveys are usually expensive due to their remote location so *deep-sea sponge aggregation* monitoring should be combined with assessments of other deep-sea habitats and species where possible. Monitoring of other OSPAR features, such as cold water coral occurrences, the complex fauna of carbonate mounds, canyons and seamounts could be synergized. It is important to obtain as many physical and chemical data as possible in addition to habitat -specific assessments to maximise the use of ship-time. In addition, extensive observer programmes and bycatch retention programmes for the commercial fisheries could greatly enhance the knowledge base.

Assessment criteria

Visual surveys need to quantify the extent of the habitat, the density of habitat-structuring species and the quality of the site (compare table A2.1 below). This includes mapping of properties with modern means, quantification and qualification of eventual impacts, and evolving modelling of physical-biological relations in order to approach predictive mapping of the habitat. For taxonomic and other baseline studies, scientific sampling will be necessary supplementary to visual surveys. There are presently no indicators available to address the issue of ecosystem function directly, which also limits the assessment of the impacts of human activities on the ecosystem (Smith and Hughes 2008). Some of the status descriptors for habitat extent and quality may act as proxies, however indicators for ecosystem function should be developed.

Table A2.1 presents recommendations made by Smith and Hughes (2008) evaluating indicators for monitoring deepwater habitats in UK waters.

Indicator	Quantitative	Nominal	Qualitative	Monitoring Frequency
Extent, density and biology of Reefs/ Seamounts/ Carbonate Mounds	Spatial extent, density (features per unit area), community parameters (abundance, biomass, diversity, composition …)	Ranking of ecological status (e.g. 0=completely destroyed, 5=pristine)	Skilled 'eye' appraisal	Total removal of ecosystem structure technically possible within a matter of hours. Technically possible to monitor demersal trawling via VMS
	Recommendations: photo / video surveys at nominal / qualitative scale; annually for high value sites and others as discovered or where monitoring (e.g. VMS) suggests impact or new threat. Physical samples required for 'ground-truthing' species identification and biomass measurements.			
Extent, abundance/ density of Deep-sea Demosponges and Hexactinellid aggregations	Spatial extent, density (features per unit area), community parameters (abundance, biomass, diversity, composition …)	Ranking of ecological status (e.g. 0=completely destroyed, 5=pristine)	Skilled 'eye' appraisal	Total removal of ecosystem structure technically possible within a matter of hours. Technically possible to monitor demersal trawling via VMS
	Recommendations: photo / video surveys at nominal / qualitative scale; annually for high value sites and others as discovered or where monitoring (e.g. VMS) suggests impact or new threat.			
Extent, abundance/ density Octocorals (soft corals)	Spatial extent, density (features per unit area), community parameters (abundance, biomass, diversity, composition …)	Ranking of ecological status (e.g. 0=completely destroyed, 5=pristine)	Skilled 'eye' appraisal	Total removal of ecosystem structure technically possible within a matter of hours. Technically possible to monitor demersal trawling via VMS
	Recommendations: photo / video surveys at nominal / qualitative scale; annually for high value sites and others as discovered or where monitoring (e.g. VMS) suggests impact or new threat.			

Techniques/approaches

Given the overall deficiencies in knowledge on distribution, quality and extent of deepwater habitats in the OSPAR area, it is advisable to build as a backbone a systematic, multidisciplinary survey programme of benthic habitats offshore ("state monitoring"). Regionally, priorities should be set on continental, island and offshore bank and seamounts slopes within fishing depth as these are the locations most vulnerable to impacts from fishing as the main threat to deepwater habitats. A second backbone of the monitoring programme will have to be the "pressure monitoring" in the form of surveillance of fishing effort by various means, obligatory bycatch analysis programmes and conflict analyses evolving over time. Rogers et al. (2008) set out recent and emerging techniques available for monitoring human impacts to *L. pertusa* reefs (e.g. satellite surveillance, electronic vessel logbooks). As a minimum these should be used to closely monitor and manage all human activities (demersal fisheries, oil & gas development and marine scientific research) likely to affect protected areas of vulnerable deepwater habitats such as deep-sea sponge aggregations. For example, fisheries should be continuously monitored remotely, using satellite technology, ideally in combination with onboard observers, patrol vessels and overflight surveys where required. Smith and Hughes (2008) evaluate the functionality of various biodiversity indicators vs. several pressures impacting on the deepwater habitats (Table in Annex 5).

The technical design and execution of biological monitoring programmes have to depend upon the particular site depending on depth, location, available technologies and prevailing threats. Given the small spatial range of visual surveys (for techniques see Roberts *et al*. 2006), these have to be complemented by acoustic surveys of bathymetry, roughness of the seafloor and sedimentary characteristics. With growing experience, acoustic techniques my help locate and determine various deepwater habitats, such as already experienced for cold water coral reefs (see Fosså et al. 2005). New techniques for transferring visual observations into quantitative expressions of quality and extent have been developed in recent years, including habitat (e.g. Roberts *et al*. 2008) facies classification and mapping (e.g. Foubert *et al.* 2005, Wienberg *et al*. 2007), and photogrammetry (e.g. Sánchez *et al*. 2009) in combination with GIS mapping (e.g. de Mol *et al*. 2008).

Selection of monitoring locations

Other than reconnaissance surveys, monitoring involves the repeated visit to particular sites in order to address temporal changes in habitat quality and quantity. As a first step, the monitoring of the already existing cold water coral protection areas should assess whether and to what extent the measures in these areas also protect deep-sea sponge aggregations, and whether such habitats occur in the vicinity (see chapter 2). In addition, it is necessary to reassess the status of deep-sea sponge occurrences already Faroe described in the literature - a number of representative examples should be selected for long-term monitoring. Only after considerable survey efforts, it will be possible to build a network of monitoring sites which allows to inform systematically about trends in extent, quality and threats of the habitat.

Timing and Frequency of monitoring

Monitoring in deep waters is inevitably restricted by funding, vessel and scientist capacity, but also by whether conditions and vessel availability. Probably a multi-layered approach is required with a few sites visited at a high frequency (e.g. annually, as proposed by Smith and Hughes 2008), and a larger number of sites visited at greater intervals. Monitoring should be combined with ecological research of the habitat, such as into regeneration patterns, which will demand long term high frequency observations. Establishing observatories in several particular places may help deliver some of the required information at relatively low cost (see e.g. Condor Seamount Azores).

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Annex 4: List of species frequently reported from Sponge Grounds in the NEA

Table A4.1: Large-sized (> 5 cm maximum dimension) sponge species frequently reported from sponge grounds in the North Atlantic. The nature of occurrence is different from one species to another: D = dominating on the ground; M = one of several dominating species on the ground; A = found on sponge ground in abundance, but not dominating as to biomass (ICES 2009, Table 8.2.1.2.1.)

TAXON	SUBSTRATE	SIZE (RANGE OF ADULT)	ASSOCIATED WITH DENSE GROUNDS	GROWTH FORM
Hexactinellida				
Pheronema carpenteri (Thomson, 1869)	Mud	25 cm	D	Barrel-shaped, thick-walled
Asconema setubalense Kent, 1870	Gravel, stones	60 cm	M	Funnel-shaped, thin-walled
Vazella pourtalesi (Schmidt, 1870)	Mud	10 cm	D	Barrel-shaped, thin-walled
Schaudinnia rosea (Fristedt, 1887)	Gravel	20 cm	A	Barrel-shaped, thin-walled
Demospongiae				

Geodia barretti (Bowerbank,1858)	Gravel, stones	50 cm (100 cm)	D, M	Globular, often irregular
Geodia macandrewi Bowerbanki, 1858	Gravel, stones	45 cm	D,M	Globular, often faintly flattened
Geodia mesotriaena (Hentschel, 1929)	Gravel, stones	15 cm	M	Spherical
*Geodia (*former *Isops) phlegraei* (Sollas, 1880)	Gravel, stones	20 cm	M	Globular to funnel-shaped
Stryphnus ponderosus (Bowerbank, 1866)	Gravel, stones	50 cm	D, M	Lumpy, often irregular
Stelletta normani Sollas, 1880	Gravel, stones	20 cm	A	Spherical
Stelletta rhaphidiophora Hentschel,1929	Gravel, stones	15-20 cm	A	Spherical
Thenea muricata (Bowerbank, 1858)	Mud, sand	20 cm	D, A	Spherical
Thenea levis Von Lendenfeld, 1903	Mud, sand	15 cm	A	Oblong to crescent
Tetilla infrequens (Carter, 1876)	Gravel, other sponges	5 -10 cm	A	Spherical
Tetilla cranium (Müller, 1776)	Gravel, other sponges	10 cm	A	Spherical
Polymastia mammillaris (Müller, 1806)	Gravel, stones	20 cm	A	Encrusting, cushion-shaped
Polymastia uberrima (Scmidt, 1870)	Gravel, stones	10-15 cm	A	Spherical to cushion-shaped
Polymastia thielei (Koltun, 1964)	Gravel, stones	5-10 cm	A	Lumpy to spherical
Phakellia robusta Bowerbank, 1864	Stones	10-15 cm	A	Upright, foliate
Phakellia rugosa (Bowerbank, 1866)	Stones	20 cm	A	Upright, branched
Phakellia ventilabrum (Linnaeus, 1767)	Stones	45cm (60 cm)	A	Foliate, funnel-shaped
Mycale lingua (Bowerbank, 1866)	Sand, gravel	25-30 cm	A	Lumpy
Antho dichotoma (Esper, 1794)	Gravel stones	30-40 cm	A	Upright, branches
Petrosia crassa (Carter, 1876)	Gravel, stones	15cm (25 cm)	A	Lumpy
Oceanapia robusta (Bowerbank, 1866)	Sand	20cm (40 cm?)	A	Partly buried

Annex 5: Review of Pressures vs. Indicators

(Smith and Hughes 2008)

Pressure (Impact)	**Indicators**	**Comments**
Fishing - demersal trawling (habitat structure changes – abrasion; removal of target species)	- reef extent and density - reef biology - extent and biology of carbonate mounds - Seamount diversity; evidence of destruction - Extent/ density/ biology of deep-sea sponge aggregation (hexactinellid and demosponge aggregations) - Extent and abundance of octocorals	The only protected habitats in UK deep water from demersal fishing are the *Darwin Mounds*, which are home to *Lophelia pertusa* bushes and their associated fauna. There are currently no regulations or monitoring programmes in place to assess and monitor demersal trawling in UK deep water habitats.
Oil and gas industry (habitat transformation by smothering or sealing)	- Community change around oil and gas industry drill sites - Cold seep/pockmark extent and biology - Extent/density/biology of deep-sea sponge aggregation (hexactinellid and demosponge aggregations)	Impact from the oil and gas industry will be localised around the drilling structure. Regulations are in place for initial environmental impact assessment, but little or no monitoring and assessment work is carried out during and after the impact. More research is required on the location/extent/biology of lesser known habitats (cold seeps/ pockmarks) and the resulting impact from the oil and gas industry
Oil and gas industry (contamination by hazardous substances)	- Community change around oil and gas industry drill sites - Bioaccumulation of contaminants - Molecular biomarkers - Oxidative stress biomarkers - Other biochemical and molecular biomarkers	Oil and gas industry regulations prohibit oil- or synthetic-based drillings muds. These have been replaced with water-based muds that are thought to disperse quickly, therefore being less toxic to the environment. Research is being undertaken to examine the toxicity of water-based mud on deep-water fauna.
Land-based pollution and shipping (physical disturbance)	- litter/ debris/ lost fishing gear abundance and distribution	No system is currently in place to monitor the extent and impact of litter/debris/lost fishing gear on the UK deep water habitat.
Climate Change (temperature/ water flow)	- Porcupine Abyssal Plain - Temperature - salinity - acidity	This set of indicators should be fully covered and critically reviewed by Theme 10, ocean processes. The impact of climate change on deep-sea organisms remains unknown

Land-based pollution (Contamination from hazardous substances – synthetic and non-synthetic compounds)	- Bioaccumulation of contaminants - Molecular biomarkers - Oxidative stress biomarkers - Other biochemical and molecular biomarkers	While bioaccumulation of land-based contaminants is known to occur in deep-sea fauna, the effects on the organisms are unknown. Biomarkers will help to determine the response and health of the sentinel organisms.
Land based pollution (contamination by hazardous substances - heavy metals)	- Bioaccumulation of contaminants - Other biochemical and molecular biomarkers (metallothioneins)	Bioaccumulation of heavy metals has been shown in deep-sea fauna, although the effects are unknown. Metallothioneins have been used as biomarkers of heavy metal exposure in shallow-water animals. This could be developed for monitoring deep-sea habitats.
Shipping (contamination by hazardous substances)	- Bioaccumulation of contaminants - Molecular biomarkers - Oxidative stress biomarkers - Other biochemical and molecular biomarkers	While bioaccumulation of shipping-based contaminants is known to occur in deep-sea fauna, the effects on the organisms are unknown. Biomarkers will help to determine the response and health of sentinel species.
No specific or single impacting activity (Changes in species or community distribution, size/ extent or condition)	- reef extent and density - reef biology - extent and biology of carbonate mounds - Seamount diversity; evidence of destruction - Extent/ density/ biology of deep-sea sponge aggregation (hexactinellid and demosponge aggregations) - Extent and abundance of octocorals - Porcupine Abyssal Plain (PAP) time series	To be able to cover comprehensively (using indicators) the impacts from non-specific pressure, all deep-sea habitats should be included in a regular assessment and monitoring programme. Baseline levels and natural fluctuations need to be understood and determined for monitoring programmes to be of value. The PAP time series is the only deep-sea time series station in the Atlantic and it offers the closest (to UK deep-water) and longest temporal data set on ecosystem change over time.

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OSPAR's vision is of a clean, healthy and biologically diverse North-East Atlantic used sustainably

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