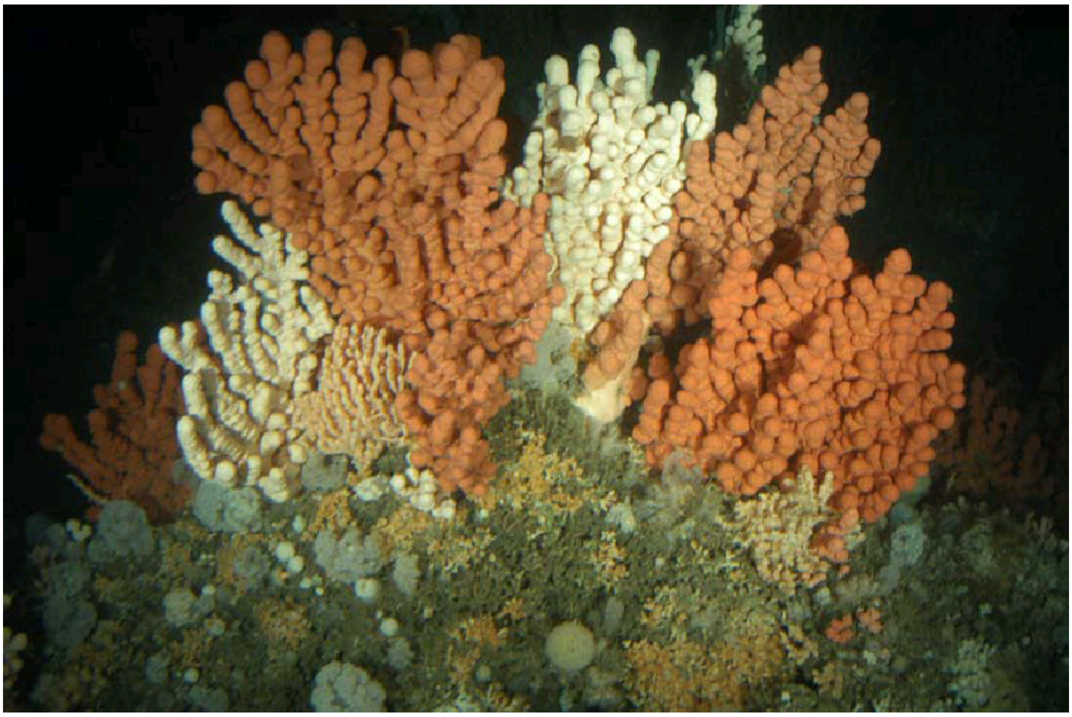
OSPAR COMMISSION

Background Document for Coral gardens



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.

Acknowledgement

This report has been prepared by Dr Sabine Christiansen for WWF as lead party. Contributions from Jason Hall-Spencer are gratefully acknowledged.

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Contents

Background Document for Coral gardens

Executive Summary

This background document on coral gardens 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 2008. The original evaluation used to justify the inclusion of coral gardens 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 coral gardens, 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 jardins de coraux mous 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 2008. L'évaluation d'origine permettant de justifier l'inclusion des jardins de coraux mous 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 jardins de coraux mous 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

Coral gardens

Definition of habitat

Coral garden (Reference Number 2008-07)

Habitat occurs within each of the following deep seabed EUNIS types:

A6.1 Deep-sea rock and artificial hard substrata

A6.2 Deep-sea mixed substrata

A6.3 Deep-sea sand

A6.4 Deep-sea muddy sand

A6.5 Deep-sea mud

A6.7 Raised features of the deep-sea bed

A6.8. Deep-sea trenches and canyons, channels, slope failures and slumps on the continental slope

A6.9 Vents, seeps, hypoxic and anoxic habitats of the deep sea

Where the communities found in the above EUNIS deep water habitats occur also in shallower water, such as in fjords or on the flanks of islands and seamounts (A6.7), they are included in this definition.

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

The main characteristic of a coral garden is a relatively dense aggregation of colonies or individuals of one or more coral species. Coral gardens can occur on a wide range of soft and hard seabed substrata. For example, soft-bottom coral gardens may be dominated by solitary scleractinians, sea pens or certain types of bamboo corals, whereas hard-bottom coral gardens are often found to be dominated by gorgonians, stylasterids, and/or black corals (ICES 2007).

The biological diversity of coral garden communities is typically high and often contains several species of coral belonging to different taxonomic groups, such as leather corals (Alcyonacea), gorgonians (Gorgonacea), sea pens (Pennatulacea), black corals (Antipatharia), hard corals (Scleractinia) and, in some places, stony hydroids (lace or hydrocorals: Stylasteridae). However, reef-forming hard corals (e.g. *Lophelia, Madrepora* and *Solenosmilia*), if present, occur only as small or scattered colonies and not as a dominating habitat component. The habitat can also include relatively large numbers of sponge species, although they are not a dominant component of the community. Other commonly associated fauna include basket stars (*Gorgonocephalus*), brittle stars, crinoids, molluscs, crustaceans and deep-water fish (Krieger and Wing 2002). Krieger and Wing (2002) conclude that the gorgonian coral *Primnoa* is both habitat and prey for fish and invertebrates and that its removal or damage may affect the populations of associated species.

Densities of coral species in the habitat vary depending on taxa and abiotic conditions, e.g. depth, current exposure, substrate). The few scientific investigations available indicate that smaller species (e.g. the gorgonians *Acanthogorgia* and *Primnoa*, and stylasterids) can occur in higher densities, e.g. 50 – 200 colonies per·100 m^2, compared to larger species, such as *Paragorgia*, which may not reach densities of 1 or 2 per 100 m^2. Depending on biogeographic area and depth, coral gardens containing several coral species may in some places reach densities between 100 and 700 colonies per·100 m^2. These densities merely indicate the biodiversity richness potential of coral gardens. In areas where the habitat has been disturbed, by for example, fishing activities, densities may be significantly reduced.

Currently, it is not possible to determine threshold values for the presence of a coral garden as knowledge of the in situ growth forms and densities of coral gardens (or abundance of coral by-catch in fishing gear) is very limited, due to technical or operational restrictions. Visual survey techniques will hopefully add to our knowledge in the coming years.

Non-reef-forming cold-water corals occur in most regions of the North Atlantic, most commonly in water with temperatures between 3 and 8ºC (Madsen, 1944; Mortensen et al., 2006) in the north, but also in much warmer water in the south, e.g. around the Azores. Their bathymetric distribution varies between regions according to different hydrographic conditions, but also locally as an effect of topographic features and substrate composition. They can be found as shallow as 30 m depth (in Norwegian fjords) and down to several thousand meters on open ocean seamounts. The habitat is often subject to strong or moderate currents, which prevents silt deposition on the hard substrata that most coral species need for attachment. The hard substrata may be composed of bedrock or gravel/boulder, the latter often derived from glacial moraine deposition, whilst soft sandy/clayey sediments can also support cold-water corals (mostly seapens and some gorgonians within the Isididae).

Notes on practical identification and mapping of the habitat: Given the diversity of possible appearances of the habitat across the North East Atlantic, a more precise description of the habitat as it occurs in relation to different substrates, depths and regions will need to be developed. For individual locations, expert judgement is required to distinguish this habitat from surrounding habitats, including an assessment of the appropriate densities of octocoral species to constitute this habitat. As a first step to further clarification a site-by-site description of coral gardens is required that will lead to further refinement of this habitat definition and its inclusion in national and European habitat classifications. The habitat definition above does not encompass shelf and coastal water habitats with seapen and octocoral communities (for example Alcyonium spp. *Caryopyllia* spp.), including the OSPAR habitat 'seapens and burrowing megafauna' or deeper-water habitats where colonial scleractinian corals (*Lophelia pertusa* reefs) or sponges (Deep-sea sponge aggregations) dominate.

Roberts et al. (2009) provide a comprehensive review of the taxonomy, biology and ecology of the habitat building species and the coral garden habitat, threats and impacts.

2. Original evaluation against the Texel-Faial selection criteria

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

OSPAR regions I, II, IV and V

Dinter Biogeographic zones: Boreal , Norwegian Coast (West Norwegian) , South Iceland - Faroe Shelf, Southeast Greenland, Arctic subregion (Deep sea), North Atlantic Abyssal Province (Deep sea). The full distribution not known

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

All where they occur (OSPAR 2008).

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

The habitat was first nominated by WWF in 2006 and accepted for inclusion in the OSPAR List in 2008.

Table 1. Summary assessment of Coral Gardens against Texel-Faial criteria (from OSPAR 2008)

Criterion	Original assessment	Evaluation
Global importance		Does not qualify
Regional importance		Does not qualify
Rarity		Does not qualify
Decline	Probability of significant decline, based on evidence of damage and lack of recovery from research surveys and bycatch reporting of commercial fishermen	Qualifies
Sensitivity	Very sensitive based on longevity, unknown reproductive patterns , uncertain recovery and vulnerability to fishing impacts	Qualifies
Threat	Currently threatened. In particular considering the relatively high fishing pressure in deep waters in the OSPAR area, the probability of decline and the degree of threat may be higher than in other oceans.	Qualifies

3. Current status of the habitat

Distribution in OSPAR maritime area

In order to provide a complete assessment document, the detailed account of the known distribution of the coral garden habitat as of 2007 in the original case report (OSPAR 2008) has been included in this section, supplemented by new information provided by Spain (Cantabrian Shelf and Hatton Bank) and the Azores, and previously not used material from Ireland. the UK and the Bay of Biscay.

The occurrence and distribution of coral gardens in the North East Atlantic is insufficiently known at present. The current scientific information on the occurrence of non-reefal corals is patchy and is not based on systematic surveys, nor do characterisations of the density of occurrences exist for most of the sampling locations. The distribution cold-water corals (including non-reefal species) in the North Atlantic have been reviewed earlier by (Madsen 1944; Zibrowius, 1980; Cairns and Chapman, 2001; Watling and Auster, 2005; Mortensen *et al*., 2006). Grasshoff (in several publications 1972-1986, see ICES 2007) especially focused on the distribution of Gorgonaria, Anthipatharia and Pennatularia in the Northeast Atlantic. However recently, ICES (2007) compiled an initial and therefore incomplete review of soft coral records (octocorals, lace corals, black corals) from published literature, as an indicator of possible "coral garden" occurrences (see Figure 1). The description of the observed habitat preferences and the regional distribution of soft corals potentially occurring in coral gardens in the North East Atlantic is taken from this review.

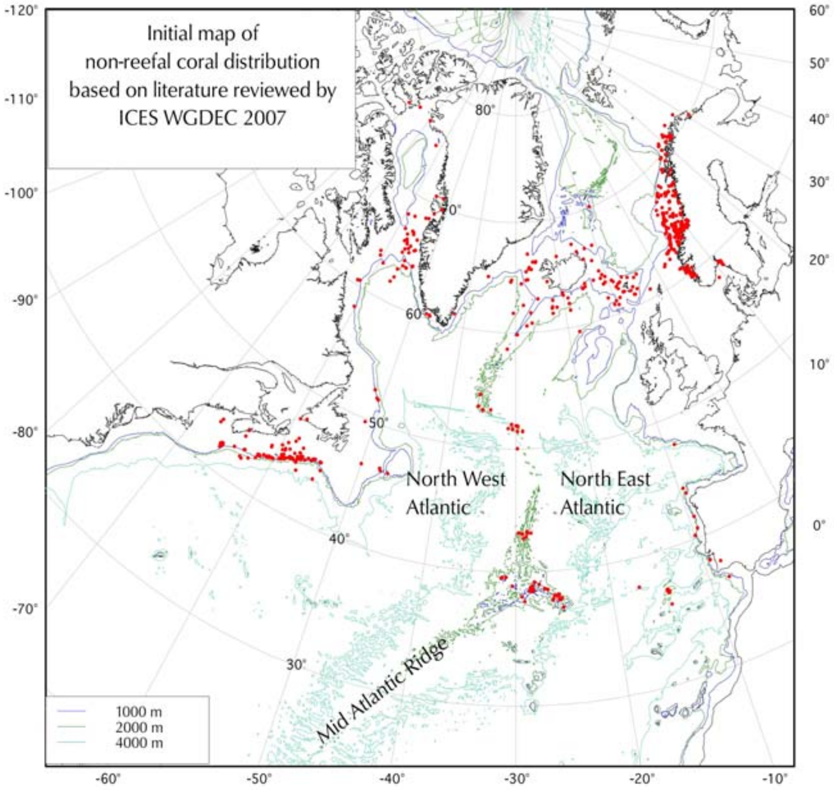

Figure. 1: Initial map of the currently known occurrence of soft corals in the North Atlantic Ocean. (Data compiled by ICES 2007).

Non-reefal coldwater corals occur in most regions of the North Atlantic, most commonly in water with temperatures between 3 and 8ºC (Madsen, 1944; Mortensen *et al*., 2006)) in the north, but also in much warmer water in the south, e.g. around the Azores. The bathymetric distribution of such cold-water corals varies between regions with different hydrological settings, but also locally as an effect of topographic features and substrate composition. On the Norwegian continental shelf corals occur mainly between 200 and 500 m depth restricted by seasonal hydrological variations above, and cold Arctic Intermediate Water below. In the Norwegian fjords, gorgonians such as *Paramuricea placomus* occur in waters as shallow as 30m due to stratification of the water column and good supply of Atlantic water. On the northern Mid Atlantic Ridge cold-water corals are found from 800 to 2100m, with the highest number of coral taxa observed shallower than 1400m depth (Mortensen *et al*., in press).

Such habitats are often subject to strong or moderate currents that prevent silt deposition on the hard substrates that most coral species need as an attachment. The hard substrate may be constituted of exposed bedrock or gravel/boulder, often from morainic deposition, but also soft sandy/clayey sediments can be used as substrate for cold-water corals (most seapens and some gorgonians within the Isididae). Also coral rubble (Roberts *et al*. 2008), coral mounds (Durán-Muñoz *et al*. 2009) and exposed reef framework (Freiwald *et al*. 2002) are locally colonised by small arborescent gorgonians (Primnoa, Paramuricea, Paragorgia) next to scleractinians and sponges. Areas with a high diversity of substrates support a higher diversity of corals. This is, for example, reflected in the depth distribution of coral taxa on the Mid Atlantic Ridge (Mortensen *et al*., 2008) where taxa like scleractinians predominantly occur in the shallower depths where the percentage of hard bottom in a variety of substrata is high, whereas the soft sediment flanks of the sampled seamounts were occupied by seapens (the distribution intervals reflect the discontinuous sampling effort).

Canyons may be particularly relevant as a megahabitat for the distribution of coral gardens. Off the Canadian east coast, fishermen identified canyons as sites where dense gorgonian coral assemblages were thriving (Breeze *et al*. 1997 in Reveillaud *et al*. 2008), possibly because of higher current flow and increased seston concentrations (Reveillaud *et al*. 2008, and literature therein). Submarine canyons are known to support elevated densities and diversity of megafaunal organisms compared to nearby slope areas and seem to be particularly important for deepwater fish also (Lorance et al. 2002, Uiblein et al. 2003) which may increase the threat from fishing to vulnerable habitats there.

OSPAR Region I

Norway

In their compilation of benthic macro-organisms in Norway, Brattegard and Holthe (1997) lists 38 cold-water coral species from the Norwegian coast. The majority of these (31 species) are octocorals. Of these, sea pens comprise most species rich (12 species). Species known to form habitats are represented among seven gorgonian species: *Paragorgia arborea*, *Primnoa resedaeformis* and *Paramuricea placomus* are known to occur in relatively high densities. These habitats have been referred to as ‘coral forest’ among fishers. Because of the abundant occurrence of *Lophelia* reefs off Norway, most recent research on cold-water corals has been directed to studies on the distribution, ecology and fisheries impact on reefs. The large gorgonians mentioned here are all typical components of the associated fauna on *Lophelia* reefs off Norway. The distribution of ‘coral forests’ or coral gardens, outside reefs is poorly known, but it is known that Trondheimsfjord has areas with such habitats (Strømgren, 1970). Indeed, there are coral gardens also offshore, indicated by local fishers off the coast of Finnmark and observed on the continental shelf break off mid-Norway during research cruises directed by the Institute of Marine Research (Pål Buhl-Mortensen pers. comm.).

Faroe Islands and nearby Banks

Much of the information about the distribution of cold-water corals in the Faroe region comes from the research programme BIOFAR (Bruntse and Tendal, 2001; Tendal et al, 2005). Figure 2 shows the distribution of the gorgonians *Paragorgia arborea* and *Primnoa resedaeformis* around the Faroes (data not included in ICES 2007 database). Also the majority of the stylasterid samples are from the outer shelf and upper slope fauna zones of the Faroe plateau and outer banks, an area characterised by diverse hard substrate, good water movement, low fine sediment load and temperatures above 6 °C. This area also holds the greatest diversity of those coral groups that are slow-growing, long-lived and reliant on long-term environmental stability. Faroese fishermen reported colonies of *Paragorgia arborea* of 2.5 m height (estimated to be at least 1500 years old). *Primnoa resaediformes* is more widespread around the Faroes and was first recorded in 1906. Most records, including the present ones, come from 200-500 m depth, in North Atlantic water. Specimens of 1 m size were recorded, corresponding to an estimated age of about 500 years.

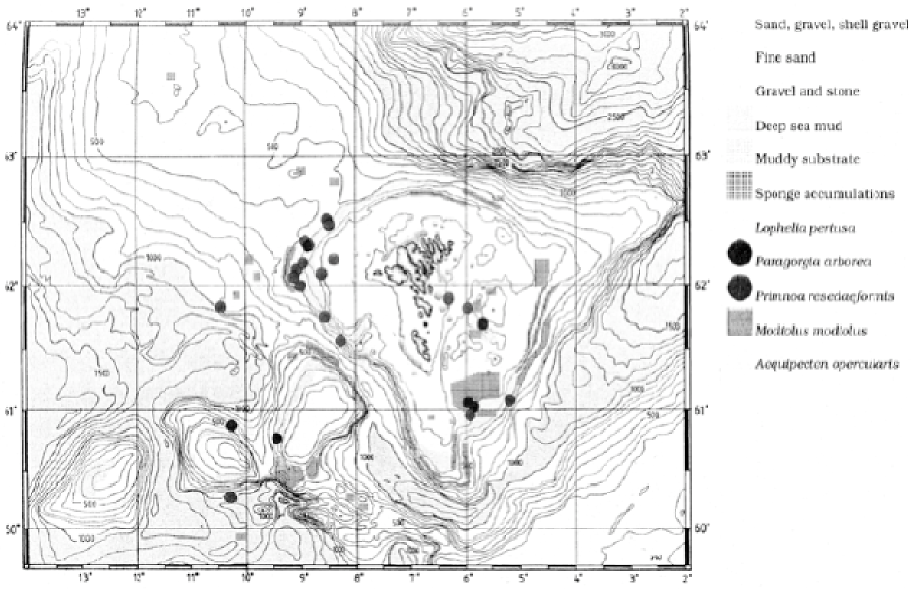

Figure 2: Locations of corals (see legend) around the Faroe Islands (from Bruntse and Tendal, 2001)

Iceland

Around Iceland, Ragnarsson and Steingrimsson (2003) mapped numerous occurrences of octocorals in relation to fishing pressure with otter trawl gear from trawl bycatch (Figure 3, data not in ICES 2007 database).

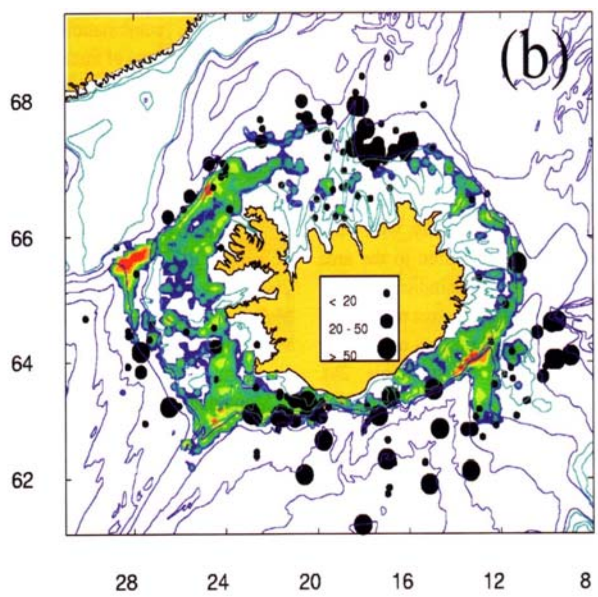

Figure 3: Iceland. Total number of octocorals per sample collected in the BIOICE project superimposed over otter trawling effort (Steingrimsson and López-Conzález, unpublished data in: Ragnarsson and Steingrimsson, 2003). The colour scale of fishing effort ranges from blue (low effort) to red (high effort). The size of the dots represents abundance.

OSPAR Region II

Sweden and southern Norway

In several locations in the Skagerrak, mostly in the channels connecting the Oslofjord proper with the open Skagerrak, and in one area (Bratten) in the open Skagerrak, Lundälv (2004), Lundälv & Johnsson (2005) and Sköld et al (2007) found rich communities of gorgonian corals (*Primnoa resedaeformis, Paramuricea placomus and Muriceides kuekenthali*) and basket stars

(*Gorgonocephalus caputmedusae*). New records of the gorgonian *Anthothela grandiflora* in the Skagerrak and Swedish waters were established.

OSPAR Region IV

France

Knowledge on the distribution and occurrence in the Bay of Biscay is sparse and fragmented. Recent enquiries revealed that indicator species associated with deep-sea coral reefs are occasionally collected by fishermen from active orange roughy fishery on the interfluves between canyons, including scleractinians corals and other reef engineer species including large antipatharians, gorgonians and sponges generally associated with scleractinanins on reefs (Le Guilloux; Olu unpubl.). The species reported from trawl bycatches confirm earlier accounts of LeDanois (1948) and include scleractinian corals, anthipatarians (*Leiopathes cf. glaberima, Bathypathes patula, Paranthipathes larix, Antipathes subpinnata*), and gorgonians (*Paramuriceidae, Placogorgia arborea, Acanella arbuscula*).

Continental slope and canyon investigations in the frame of the BIOGAS project of IFREMER revealed dense populations of gorgonians on soft bottoms in several canyons. *Acanella arbuscula* (Octocorallia, Gorgonacea) occur in denses of 2820 ind/104 m² (Sibuet *et al*. 1980) at 2000m (Grasshoff 1982, 1985, Sibuet & Segonzac 1985). Dense populations of various gorgonians on rocks, in particular *Isidella longifera*, also populations of Pennatularia *Distichoptilum gracile* occur on soft bottoms such as in Shamrock canyon, 1800-2900 m (photos with Cyana submersible) 47°41-8°31 (2980m, Grasshoff 1982, 1985).

Spain

From several locations in Spanish waters, at least 13 octocoral species are described and several coral associations can be recognised (see e.g. Aguirrezabalaga *et al*. 1984, Sánchez and Olaso 2004). These associations can include species of scleractinians mixed with gorgonians (e.g. *Paramuricea* spp) and stony hydroids. The composition of these associations is probably depth related. (e.g. on Galicia Bank, Spain).

A coral garden community lives in the northern area of the top of the Le Danois Bank, where the sediment coverage is lower due to the strong shelf break currents and there is a high presence of rocky outcrops (Sánchez *et al*., 2008). This benthic community (Figure 4), named *Callogorgia-Chimaera*, is mainly characterised by the presence of the gorgonian *Callogorgia verticillata* and the fish *Chimaera monstrosa*. The density of gorgonians, estimated using photogrammetric methodology, is of 299.5 individual by hectare on rocky grounds and 79.9 ind./ha on mixed sand and rocky grounds (Sánchez et al., 2009). Also, other vulnerable benthic species were identified in this community as big Hexactinellida and Geodid sponges (*Asconema setubalense* and *Geodia megastrella*) (Cristobo *et al*., 2008).

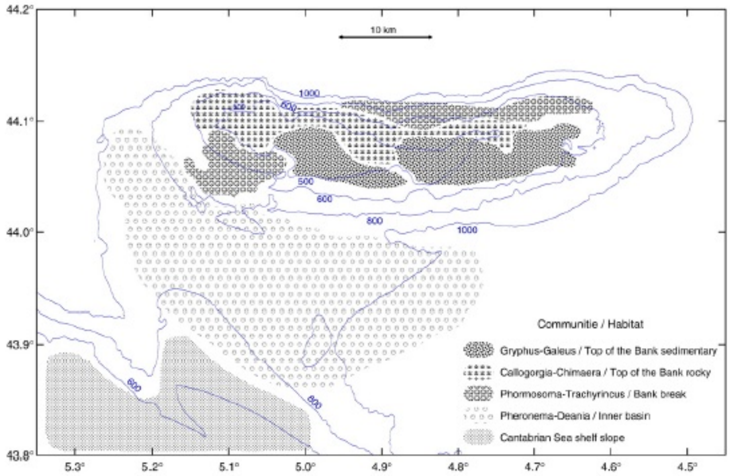

Fig. 4. Coral gardens distribution on Le Danois Bank area, as indicated by the Callogorgia-Chimaera community. The dominant species is the gorgonian *Callogorgia verticillata* (Sánchez et al. 2008)

OSPAR Region V

UK

Smith and Hughes (2008) conclude from studies of octocoral forests around the British Isles that these habitats may harbour a treasure-trove of intricate interactions between undescribed species, which increases concern that unregulated trawling remains a major threat to these habitats (Myers and Hall-Spencer, 2004). The gorgonian soft coral *Acanella arbuscula* is high in abundance between 2000-3500 m to the west of the British Isles (Duineveld *et al.,* 1997a; Hughes and Gage, 2004; Davies *et al*., 2006). This species has also been found at shallower depths (~1300 m), where it is associated with fine sediment and strong current regime (Roberts *et al*. 2000, Davies *et al*., 2006). Most recent surveys identified coral garden habitat at around 1500 m water depth at the base of Anton Dohrn seamount (Golding pers. comm.).

Ireland, Porcupine Seabight

Extensive octocoral forests have recently been described along the continental shelf break off Ireland at 1km depth (Hall-Spencer and Brennan, 2004). At least 9 species were recorded between 650 -1200 m depth, occurring in greatest densities on topographically high hard substrata such as on coral rubble, large glacial boulders and on eroded carbonate rock. They were scarce in areas disturbed by strong sand scour or demersal trawling.

Hatton Bank

Durán Muñoz *et al. (*2007) recorded gorgonians and antipatharians as part of the bycatch occurring in the Spanish bottom trawl and bottom longline cooperative surveys on the Hatton Bank and adjacent waters and in the Spanish bottom trawl commercial fishery on the Hatton slope (1000-1500m). The frequency and volume in the catches was low on the regularly-used fishing grounds. Most of the gorgonian records were obtained at shallow depths (<1000m approx.), but antipatharians were found over a wide depth range.

Durán Muñoz *et al*. (2009a) studied the habitats in the Hatton Bank outcrop, a hard and uneven area at the top of the bank located on the western slope (Sayago-Gil *et al*., 2009a). Based on the results of such studies (Durán Muñoz, 2009), the European Commission presented a proposal to protect vulnerable marine ecosystems of the Hatton Bank outcrop, from significant adverse impacts (NEAFC, 2009). The seabed outcrop on the western slope of Hatton Bank is a suitable platform for most cold-water corals (Sayago-Gil *et al.*, 2009b) and glass sponges (Durán Muñoz *et al*., 2009b). Certain parts of the outcrop were slightly covered by sediments (Drift) that formed a suitable soft substrate for other species such as seapens (Durán Muñoz *et al*., 2009b). The area can be subdivided into three sites of special scientific and ecological interest, termed the Northwestern Area, the Ridges and Mounds Area, and the Central Area (ICES, 2008). In the Northwestern Area (Durán Muñoz *et al*., 2009a), the multibeam bathymetry showed an irregular relief, with irregular alignments (700–1740 m deep). Dredge samples suggested that this outcrop forms suitable substratum for coral gardens. Live stony corals (*Solenosmilia variabilis*) and dead octocoral skeletons were found in the samples. Information obtained from trawl and longline surveys also provide evidence for the presence of stony corals in the area (*Lophelia pertusa, Madrepora oculata, S. variabilis*), gorgonians such as *Callogorgia verticilata,* black corals, pennatulaceans (Durán Muñoz *et al*., 2009b) along with dead fragments of corals, with great associated biodiversity. In the Ridges and Mounds Area (Durán Muñoz *et al*., 2009a), the multibeam data, revealed elongate and parallel ridges some 5 km apart extending for more than 40 km. They are located at depths of 700–1600 m with heights of 5–45 m. Dozens of small mounds (carbonate reefs) have been identified on the crest of the ridges. Analysis of the dredged samples from the area suggested that this type of substratum is suitable for coral gardens. Samples collected contained live colonies of scleractinians and black corals, skeletons of dead scleractinians and octocorals with a rich associated biodiversity, and the remains of cirripedes and molluscs. Data from longline surveys supported this interpretation, showing the presence of *M. oculata, L. pertusa,* seafans (Family Plexauridae), bamboo corals and soft corals (Durán Muñoz *et al*., 2009b) black corals, lace corals, and glass sponges. Dead coral was also found. In the Central Area (Durán Muñoz *et al*., 2009a), multibeam data show an irregular surface with no specific direction of the relief in depths of 800–1600 m. Seismic information reveals that it is an area of the bank outcrop (probably basalts), and that it can locally be covered by sediments from the Drift. Dredge samples confirm the presence of live cold-water corals (colonies of *S. variabilis*), and longline survey data support this through the presence of *L. pertusa, M. oculata,* seafans, bamboo corals (*Acanella* sp.), soft corals (Durán Muñoz *et al.*, 2009b), black corals, lace corals, and glass sponges. Skeletons of dead colonial scleractinians were found, along with a broad associated biodiversity.

North-east Atlantic south of 60°N

Hall-Spencer *et al*. (2007) reviewed the literature and compiled a database of deep-water (> 200m) anthipatharians, scleractinians and gorgonians of the north-east Atlantic south of 60°N, including 2547 records from benthic sampling expeditions between 1868 and 1985 (the data are part of the ICES 2007 database). The majority of records came from steeply-sloping seabed types around seamounts, oceanic islands and the continental slope and confirmed the importance of the Mid-Atlantic Ridge as a biogeographic boundary between corals characterising the American boreal continental slope to the west and the European continental slope communities to the east (see e.g. Cairns and Chapman 2001, Watling and Auster 2005, Schröder-Ritzrau *et al*. 2005). North Atlantic antipatharians appear to be restricted to open ocean areas, with *Antipathes erinaceus, Distichopathes sp., Phanopathes sp. and Stauropathes punctata* only recorded on Josephine seamount, the Azores and Cape Verde Islands (Molodtsova 2006).

Josephine Seamount

The summit region of Josephine Seamount, a seamount rising from more than 4000m to less than 200m depth is characterised by dense gorgonian beds on gravelly substrate (Gage and Tyler 1991, compare their Figure 8). The species-rich fauna of Josephine Seamount is typical for the eastern Atlantic, more closely related to the islands than to the continental shelf. This particularly well investigated summit region offers a wide variety of substrates which are readily populated by sometimes high densities of mostly sessile filter feeding species. Sixteen species of horny and black corals, thirteen species of stony corals, but no pennatulids and neither shelf nor deep sea benthic species were found. Dense beds of the gorgonian *Callogorgia verticillata*, coincide with large sponges on the summit of Josephine, quite different from other seamounts (Grasshoff 1985).

Azores

A high number of coral species have been recorded in the Azores over the last 5 years (81 species) providing a strong indication of the high diversity displayed by those communities (Braga-Henriques *et al*., 2008). These collections, along with the data from historical campaigns, such as those promoted by Prince Albert I of Monaco, contributed to a checklist of deep-water corals in the Azores that currently includes around 150 species. These occurrences spread throughout the area on the steep volcanic island slopes and offshore seamounts (e.g.: Condor, Mar da Prata, Princesa Alice, Açores, Sedlo or Cavala) but coral gardens have been recorded only for few of those areas. No fine-scale predictive maps exist yet for cold water coral distribution.

The most common species in the Azores upper bathyal zone include large Leiopathes spp., Callogorgia verticillata, Errina dabney, Dentomuricea sp., Acanthogorgia armata, Paracalyptrophora josephinae and Viminella flagellum. Some of these species form aggregations of considerable density as revealed by the discovery of a large and dense gorgonian garden dominated by Dentomuricea sp. and V. flagellum at the Condor de Terra (Braga-Henriques et al., 2006) and Mar da Prata seamounts (Sampaio et al., 2009). Coral gardens at the Condor da Terra were patchily distributed over the seamount summit and showed variations associated to changes in substrate composition (Braga-Henriques et al., 2006; Tempera et al., 2009). The community included other less abundant Primnoidae gorgonians, sponges, hydrarians, crustaceans, sea urchins, molluscs and fishes.

As far as the antipatharian fauna is concerned, *Antipathella wollaston*i, which typically occurs beyond 20m depth, is the most common species in deep infralittoral and circalittoral grounds and is known to form dense stands. In bathyal areas, the black corals *Leiopathes* spp. are common between 200 and 600m and can grow to 2.5 m heights.

Gulf of Cadiz:

Dendrophyllia ramea with gorgonians (*Paramuricea clavata*) occurs below 20 m in the Gulf of Cádiz, south-west Spain (Templado *et al*. 1993).

Mid-Atlantic Ridge

The non-hydrothermal hard bottom areas of oceanic ridges are often colonised by erect megafauna such as gorgonians, sponges, hydroids, and black corals (Grigg, 1997). Mortensen *et al*. (2008) observed corals on all sites surveyed with ROVs at depths between 800 and 2400 m on the northern Mid-Atlantic Ridge. The species richness of corals was high with a total of 40 taxa. Octocorals (Alcyonacea, Gorgonacea, Pennatulacea) were taxonomically richer than hexacorals (Antipatharia and Scleractinia) with 27 versus 14 taxa. Gorgonacea was the most diverse order comprising 14 taxa, whereas Antipatharia and Alcyonacea were represented with the lowest number of taxa (two and three taxa, respectively).

Habitat extent and condition (current/trends/future prospects)

Current extent: The current extent of the habitat as defined by OSPAR is unknown, in particular the definition does not specify a particular density of organisms or species composition. However, more and more observations are made on the occurrence of the habitat, such as lately from the Le Danois Bank off the Cantabrian coast. With more deepwater surveys being made, the description of coral gardens will become more concrete.

Trends in extent and condition: Fishing in areas with structural habitats, in this case with tall, branched corals which easily snag to fishing gear, has caused substantial damage already, although this is known more in anecdotal terms (see below). However, many of the commercially targeted fish species prefer structural habitats and repeated fishing gradually degrades the habitat.

As long as no further fisheries management measures are taken to avoid coral gardens to be impacted by trawling and bottom longlining, the extent of the habitat is expected to shrink further. It is highly likely that the suitable habitat for the species composing a coral garden will be narrowed in the future by rising aragonite saturation depth limits and an overall temperature increase in the upper water layers (Guinotte *et al*. 2006).

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 hydrological 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.

Limitations in knowledge

As mentioned above, the distribution, characteristics, and extent of the habitat are only locally known. More and better surveys would improve the knowledge, in particular when employing visual techniques.

4. Evaluation of threats and impacts

Threats to the coral garden habitat come on different scales and from different sources:

Global warming and the associated fast changes in temperatures, current and stratification patterns, food availability and seawater acidity may in the long run pose the most significant threat to the existing distribution of calcifing organisms (e.g. Guinotte *et al*. 2006), starting with those in shallower waters. Roberts *et al*. (2009) emphasize the high sensitivity of coldwater corals to temperature change, along with changes affecting the food supply. Octocorals of the suborder Calcaxonia (Chrysogorgidae, Primnoidae, Isididae) and some Stylasterids with a carbonate skeleton are in addition highly sensitive to the acidification of seawater as a consequence of rising CO_2-levels in the atmosphere.

Within the upper 2000 m, the most prominent present large scale threat is **fishing** with gear that comes into contact or in the vicinity of the seafloor. Bottom trawling is here the most significant threat on soft and mixed sediments (see for impacts e.g. Bett 2000, Roberts *et al*. 2000, Davies *et al*. 2007). However, the habitat preferentially occurs also in areas of boulders and otherwise complicated topography which are not (easily) accessible to trawling. Here, the primary threat comes from longlining. Video transects e.g. off Nova Scotia, Canada, and bycatch analysis from the Azores revealed longlines entangling in corals and bringing them (only a fraction?). to the surface. This was confirmed by fishermen. Secondary damage may occur from the long free end of a snagged long-line (Mortensen *et al*. 2005).

Around Iceland, Ragnarsson and Steingrimsson (2003) mapped the present occurrence of octocorals in relation to fishing pressure from otter trawl gear (see Fig. 3). Trawling and occurrence of corals mostly did not coincide, which either indicates that no trawling occurs in boulder areas, or that decades of trawling may have diminished the previously wider distribution of these corals. An indication for the latter hypothesis comes from evidence given by German fishermen who targeted redfish around Iceland in the 1970s. They reported having caught as a bycatch huge fragments of "bubble gum trees" (*Paragorgia*), for example in an area called "Rosengarten" to the south east of Iceland. Fishing in this area continued for many years with decreasing catches of both fish and coral bycatch (pers. com. to S. Christiansen, WWF, in 2004).

Apart from directly smashing or tilting the gorgonians, fishing also weakens the structure of individual colonies by damaging the tissue resulting in a higher rate of epibiont and parasite colonisation, increasing the mortality and lowering the fertility (ICES 2007).

Collecting: The degree of threat posed by collection of corals is unknown. Many species of black corals (Anthipatharia) which are collected for jewellery, e.g. the gold coral Gerardia and bamboo corals (Isidids), also occur in the deep North Atlantic, In particular Anthipatharia are extremely long-lived, recorded ages go up to 4000 years (*Leiopathes* sp., Roark pers. com. in Roberts *et al.* 2009).

Silting: The degree of impact on the coral physiology from siltation is not known. Probably, up to a certain level, at least those coral garden coral species found in shallower waters and e.g. in the canyons of the Bay of Biscay are able to tolerate the relatively high seston levels prevailing there. Exceeding the threshold is probably followed by reduced growth rates and other physiological stress reaction, possibly too subtle to be recognized. The real deep sea species are likely even more sensitive to changes in their ambient environment.

Research: Generally research sampling takes place on a small scale. However fisheries trawl surveys are periodically carried out with commercially sized gear and can reveal coral or sponge bycatch of substantial volume (see e.g. Edinger *et al*. 2006, Klitgaard and Tendal 2004).

Relevant human activity	Degree of threat	Relevant human category
Fishing Bottom trawling Longlines Gillnets Traps	 Large scale, very high Medium scale, very high Medium scale, high small scale, minor?	biological – physical damage to species
Co_2 Emission	Large scale, very high	Large scale, very fast modification of temperature and current regimes as well as carbonate household
Oil and gas exploration	local	deep-sea mineral resources 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	nutrient changes (eutrophication)
Collecting	?	
Research	Can be substantial (bycatch in fisheries surveys)	scientific sampling

Bay of Biscay

Reveillaud *et al*. (2008) report that a small, but non-permanent deep-sea fishery (e.g. for orange roughy, Hoplostethus atlanticus) is established off France in the Bay of Biscay (Koslow *et al*. 2000). Fishermen, looking for orange roughy, mainly within the vicinity of canyon heads in the northern part of the Bay of Biscay (47° N/ 49°N), report living *L. pertusa* bycatch until 1100 m (Le Guilloux personal observation). Anthropogenic impact on this area, e.g. in terms of fishery has not yet been addressed so far. The degree of threat may be substantial because the fishing activity occurs within a narrow continental margin. Yet the steep topography could partially protect the coral communities by their inaccessibility for benthic trawling. Unpublished expert knowledge reports that coral gardens and sponge aggregations have been locally very damaged by fisheries (OSPAR 2009/468).

Azores

Despite bottom trawling being forbidden in the Azores, there is evidence that corals are accidentally damaged and captured during bottom longline fisheries operations. During four bottom longline fisheries surveys (2007 and 2008) a total of 19095 fish and 883 benthic organisms were caught by 77 fishing sets (ca. 3000 hooks each), deployed between 26.8m and 1793.7m (Sampaio *et al.*, 2009). Sessile organisms were entangled on the fishing gear. Deepwater corals were the most representative group (231 colonies), but sponges and hydrozoans were also common. More than 50% of all long-line sets, in all surveys, retrieved deepwater corals. They were caught almost everywhere on islands and seamounts slopes. The overall CPUE was 0.98 corals per 1000 hooks.

The taxonomic composition of coral bycatch changed along depth. Gorgonians were the dominant bycatch group in the upper layers to 500 m depth. *V. flagellum, Dentomuricea sp., Bebryce mollis* and *C. verticillata* were the most abundant species. Colonies of *Leipathes* spp. were also common. Stony corals, namely *M. oculata*, were the dominant species on the deeper strata.

The bycatch composition is likely related to coral morphology and community composition on the fishing ground. Longlines predominantly capture colonies that are morphologically more conspicuous, branched and tri-dimensional in structure, which are more easily entangled by fishing lines.

The impact of longline fisheries on coral communities is not as large as the impact of bottom trawling, which destroys everything along the trawling path (Freiwald *et al*., 2004). But at intermediate temporal scales (*i.e.,* decades) longlines may also have a relevant destructive impact and mitigation measures should be planned.

As fishing goes on, it is expected that larger colonies become progressively less abundant in coral garden communities. The loss of these structurally complex colonies may have important bottom-up effects in the community, as they provide a large portion of microhabitats and food for associated invertebrate and fish species. Moreover, the impacted coral species have low capacity to recover from destruction or disturbance, because they have low growth rates, long life spans and supposedly low levels of recruitment, requiring long time periods for habitat building (Edinger *et al*., 2006; Rogers *et al*., 2007; Roark *et al*., 2009).

5. Existing management measures

Neither coral garden habitats as defined by OSPAR nor any of the species which characterise coral gardens are subject to a directed national or international protection regime in the OSPAR area. However, *Antipatharia* spp., *Scleractinia* spp. and *Stylasteridae* spp. (except fossils) which are listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) as „species not necessarily now threatened with extinction but that may become so unless trade is closely controlled“.

OSPAR Region I

There are no targeted measures in place to protect coral garden habitats from human impacts unless they occur in conjunction with *Lophelia* reefs in the few sites closed to bottom fishing activities (Norway, Iceland). In addition, in Norway the deliberate damage to cold water corals is prohibited (FOR 1999-03-11 Nr. 299), however, as long as coral occurrences are not mapped on fishery and navigational charts, this provides only insufficient protection.

Around Iceland and the Faroes a number of seasonal or annual closures to bottom trawling exist which might have beneficial effects on the coral garden habitats occurring there. However, this has not been assessed.

OSPAR Region II

There are no measures in place to protect coral gardens from human impacts in the offshore Skagerrak (e.g. Bratten), where trawling effort is said to even increase (Sköld *et al*. 2007).

OSPAR Region IV

The implemented management measures in the new Spanish MPA of the Le Danois Bank (El Cachucho), in which the use of bottom gears is prohibited, can contribute effectively to the recovery of the coral garden habitat in the zone. In 2009, Spain has initiated a big research project (LIFE-INDEMARES) for the study of zones with vulnerable deep ecosystems as potential candidate areas for MPAs and future components of the Natura 2000 network. This project will finalize in 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 coral gardens.

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). In addition, there are several smaller permanent (Formigas Bank) or temporary (Condor Seamount) fisheries closures implemented. Further measures are being developed for a number of SACs and OSPAR MPAs where the habitat occurs (Faial-Pico Channel, Corvo island, Sedlo seamount and the Menez Gwen and Lucky Strike hydrothermal fields. The vent fields are surrounded by seamount-like structures also to be protected. Abundant scleractinian corals occur on the Menez Gwen hydrothermal field in association with a diverse assemblage of gorgonians and sponges (Santos *et al.* 2003). It is likely that limitations on the use of bottom-tending gear will be established when the designation and regulation of these MPAs occur (see for details Annex 5).

Since 2008, several small SACs for the protection of coldwater corals in Exclusive Economic 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 the 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 coral gardens 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). 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 to what extent the habitat coral gardens will benefit of these measures. For large scale spatial overlap see Figure 5.

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 occurrences of coral gardens. 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.

OSPAR (2008) agreed on a code of conduct for scientific research in high and deep seas of the OSPAR maritime area (OSPAR other agreement 2008-1) with the goal to avoid unnecessary damage to species and habitats from scientific research sampling.

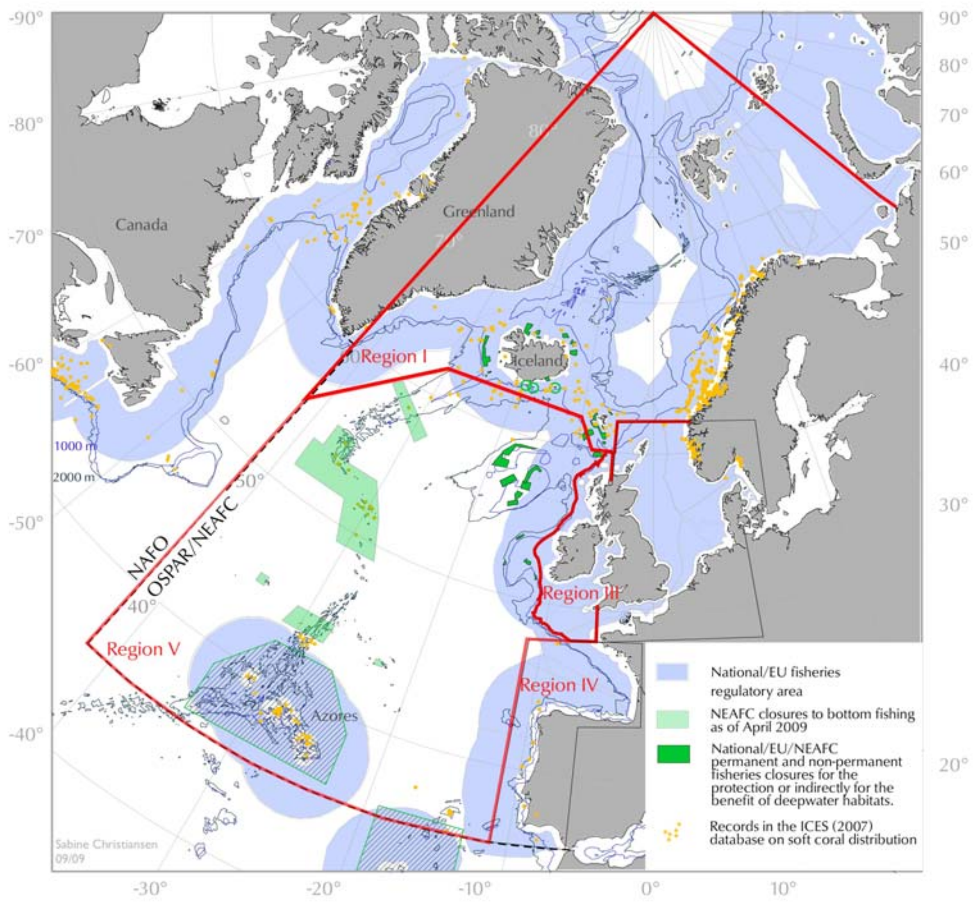

Fig. 5. Known distribution of soft coral records in the OSPAR area (ICES 2007 database) and current permanent fisheries closures to fishing operations with bottom touching gear of potential benefit to coral gardens. The actual overlap is not known.

6. Conclusion on overall status

The habitat “Coral Garden” was added to the OSPAR List in 2007 (OSPAR 2008), based on a case description agreed in 2007/2008. Little further evidence of the habitat has been reported and the degree of threat from fishing has remained the same. The threat from global climate change has been added. Therefore the 2009 evaluation does not differ from the original evaluation.

Global and regional importance: Many of the habitat forming taxa of coral gardens, e.g. *Paramuricea, Paragorgia or Primnoa* , but also most of the anthipatharians and stylasterid corals have a cosmopolitan distribution. Therefore the OSPAR area does not have specific global or regional importance for their occurrence. However, due to the high fishing pressure in deep waters in the OSPAR area, the probability of decline and the degree of threat may be higher than in other oceans.

Table 2 Summary of 2009 evaluation of "coral gardens" against the Texel-Faial selection criteria

The Texel-Faial selection criteria	Updated evaluation (2008)
Global importance	
Regional importance	
Rarity	
Sensitivity	**very sensitive'** to the effects of demersal trawling and longlining, temperature change and acidification **'sensitive'** to the localised effects of offshore energy–related activities
Ecological significance	**'very important'**
Decline	**'significant decline'**
Threat	**'currently threatened'**

Sensitivity: Very sensitive – for several reasons:

- ***Longevity**:* Analysis of the life span of octocorals indicates that some of the large colony-forming species, such as *Primnoa resedaeformis*, can live for centuries (Risk *et al.* 2002, Andrews 2002). In Faroese waters, *Primnoa resaediformes* specimens of 1 m size were recorded, corresponding to the maximum size for the species all over the North Atlantic. Specimens of that size are at least 500 years old (all acc. to literature quoted by Bruntse & Tendal 2001). However, gorgonian corals are difficult to age. Growth rate estimations indicate that off Nova Scotia a *Primnoa resaediformes* of 80 cm is an estimated 46 years old (Mortensen and Buhl-Mortensen 2005b). Acc. to Bruntse and Tendal (2001), Faroese fishermen reported of *Paragorgia arborea* colonies of 2.5 m hight, which is assumed to correspond to an individual age of at least 1500 years.
- ***Unknown reproductive patterns**:* Knowledge on recruitment patterns is very limited. Bruntse & Tendal (2001) reviewed the literature finding that *Primnoa resaediformis* was reported to be viviparous (Strömgren 1979, Risk *et al*. 1989). Acc. to their review, the reproduction frequency of both *Primnoa resedaeiformis* and *Paragorgia arborea* is unknown . A single series of observations in the Gulf of Alaska suggest that recruitment of *Primnoa* sp. is patchy and aperiodic (Krieger 2001).
- ***Uncertain recovery**:* Knowledge on recovery patterns is sparse: Krieger (2001) observed no recruitment of new colonies in an area where *Primnoa* was removed by trawling after seven years. However, six new colonies were observed at a second site one year after trawling. Four of these colonies were attached to the bases of colonies removed by trawling. Recruits of *Primnoa* were also observed on two 7 cm diameter cables (>15 colonies each). On the other hand, in the Gulf of Maine and in submarine canyons limited observations have revealed abundant new recruits of both *Primnoa resedaeformis and Paramuricea* spp. (Watling, Auster,

and France, unpublished observations, in Watling & Auster 2005). Whether these young colonies were produced by larval recruitment or branch dropping (as in shallow-water gorgonians) "is impossible to say at this time" (Watling and Auster 2005). However, studies from deep water, high latitudinal, hard bottom communities are lacking (Mortensen *et al*. 2005).

- ***Large size perpendicular to the seafloor**:* The most prominent gorgonian coral species can grow to a size of several meters up into the water column, their delicate branches being highly susceptible to physical damage (Bruntse & Tendal 2001). Probert *et al*. (1997) examined benthic invertebrate bycatch from a deep-water trawl fishery off New Zealand, and found that Gorgonacea was one of the best represented groups in the catch. They concluded that large sessile epibenthic species were among taxa especially vulnerable to impacts from commercial trawling, and that large gorgonians such as *Paragorgia arborea* would be unlikely to recover “within a foreseeable future”.

Ecological significance: Norway (2009, BDC 9/4/4) notes that the coral colonies represent a habitat with a complex 3D architecture. A review of symbiosis in cold water corals (Buhl-Mortensen & Mortensen 2004) conclude that the associated fauna of cold water gorgonians is comparable rich on species with warm water gorgonians. Furthermore, the associated fauna of cold water octocorals contain several examples of obligate species relationships (parasites, commensalists and mutuialists). This fauna is almost impossible to monitor without removing or damaging the coral.

Among other species, redfish live associated with corals in the boulder fields which they use for rest and shelter. Decreasing availability of such three-dimensional current-reducing structure may have an effect on the competitiveness/success of redfish.

Decline: Probability of significant decline.

There are no known scientific records or time series about decline in this habitat due to bottom trawling. Unlike scleractinian reefs, the corals which make up the coral garden do not leave clear evidence of trawling damage so it is not possible to determine their historical distribution and abundance based on post-fishing surveys (Hall-Spencer *et al*. 2007). Pooling data on the distributions of sensitive benthic species with data on the distribution of deepwater trawling to highlight areas where pristine habitats are likely to still be found, are only beginning.

However, fishermen’s experience indicates a significant decline in areas where bottom trawling occurs, with observations off Iceland and the Faroes (Bruntse and Tendal 2001 quote fishermen) and in the Skagerrak (off Sweden/Norway, Lundälf pers. com), as well as probably on all the "good" fishing places for redfish which lives within the habitat. This is also known from Canada, where fishermen reported significant changes to the seafloor over the duration of their fishing careers, including a decrease in the size and number of corals they caught (Gass & Willison 2005). Mortensen et al. (2005) observed broken live corals, tilted corals, scattered skeletons and lost fishing gear entangled in corals off Nova Scotia.

In other regions, the volume of gorgonian bycatch in bottom fisheries was estimated (e.g. off Alaska 200 000 kg of mostly gorgonian and antipatharian corals between 1990 and 2002) giving a further indication for the likely significant decline of this habitat caused by bottom fisheries. Long-line gear is also noted to tip and dislodge corals (Krieger 2001). Bycatch data from a long-line survey in the Gulf of Alaska and Aleutian Islands showed Primnoa and other coral taxa were caught on 619 of 541,350 hooks fished at 150-900 m depths (Krieger 2001). This bycatch rate of almost 1 coral/1000 hooks was also derived from longlines in the Azores, demonstrating the high risk to corals from this fishing technique.

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.

- **Fishing**: There are indications that all the most frequently-used fishing gears (gill nets, trawls, long lines) cause damage to the corals. Coral gardens on soft bottoms within fishing depths are subject to the highest threat, however, advances in fisheries technology such as "rock hopper" gear on bottom trawls have eliminated some of the areas that would have been refuges from trawling (Watling & Norse 1998). Bottom longlining may pose the highest risk to large erect species such as gorgonians.
- **Global warming** may in the long run pose the most significant threat to the existing distribution of deep-sea coral habitats and others, starting with those in shallower waters. Roberts *et al*. (2009) emphasize the high sensitivity of coldwater corals to temperature change, along with changes affecting the food supply. In addition, octocorals of the suborder Calcaxonia (Chrysogorgidae, Primnoidae, Isididae) and some Stylasterids with a carbonate skeleton are in addition highly sensitive to the acidification of seawater as a consequence of rising CO_2-levels in the atmosphere.
- **Collection**: The degree of threat from collection of corals in the OSPAR area is not known. However, some of the species used for jewellery also occur in the deep North Atlantic.

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 „Coral Gardens“ 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 improve the status of the habitat indirectly (see above).

Although OSPAR is not entitled to take or decide upon any measures related to fishing (OSPAR Annex V, Art. 4.1), 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 coral gardens) from destructive impacts has to be communicated to the responsible national, European and international fisheries management bodies.

A staged process of communication is required 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 vulnerable areas already known. Coral gardens do not protect themselves by posing obstacles to fishing nets or hooks and they primarily occur on mixed substrates which are fished at relatively low risk.

- **Phase 2.** Investigate and map 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 longterm 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.

It is proposed that setting an ecological quality objective (EcoQOs) for Coral gardens 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 3 below provides a list of actions to be taken forward by OSPAR, and/or its Contracting Parties.

Table 3: Summary of key priority actions and measures which could be taken for coral gardens. 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 and likely occurrences of coral gardens 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 coral gardens 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 coral gardens and the need for measures to the respective national fisheries ministries	Iceland, Denmark/The Faroes, (Greenland), Norway,	National fisheries ministries

Goal	Action	Who	Adressee
1.4.	Initiate measures in the responsible fisheries management bodies	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 coral gardens and other vulnerable habitats	Contracting Parties (except D, NL, B)	
1.6.	Select and designate as MPAs an ecologically coherent and representative set of coral gardens 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 (so far no data in database).		
3.1.1.	Contracting Parties to provide any existing and new data on coral gardens	Faroes, France, Iceland, Ireland, Norway, Portugal, Spain, Sweden, UK	UK (running the habitat database and mapping)

Goal	Action	Who	Adressee
3.1.2	Initiate a regional project to identify and describe the individual biotopes which make up the coral garden complex to feed into habitat classification and mapping	EU research project?	
3.1.3.	Improve the OSPAR habitat mapping with bathymetry and seafloor characteristics from national and regional mapping projects.	UK with contributions from contracting parties Or Project to collate data and enable predictive modelling	
3.1.4.	Initiate a periodic analysis of the risk from fishing (derived from VMS signals) to the known and predicted (modelled) occurrences of coral gardens	ICES?	
3.1.5.	Initiate a programme to retrieve, collate and map knowledge and logbook data from fishermen (building on work in Norway, the Faroes and Iceland); initiate cooperation on bycatch recordings.	EU research project?	
3.1.6.	Compile bycatch information from deepwater research trawl surveys	ICES?	
3.1.7.	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	Agree on an EcoQO for „coral gardens“ along the lines of BDC 09/4/4 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 corals is sustainable	OSPAR	

Goal	Action	Who	Adressee
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 proposed monitoring system (see annex 2)

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 CPs 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		A. Vanreusel	
Denmark	N			
Faroes	Y			
France	Y		S. Derrien	
Germany	N			
Iceland	Y			
Ireland	Y		E. Kelley	
Netherlands	N			
Norway	Y		P. B. Mortensen	
Portugal	Y	Y	R. S. S. Santos	Azores: Text provided by F. Tempera, P. Porteiro, comments T. Morato
Spain	Y	Y	Pantoja	MASH08/4/Info 2, Text and comments by F. Sanchez, F. Serrano and P. Durán-Muñoz (Instituto Español de Oceanografía)
Sweden	Y	Y		Comments provided by T. Lundälv
UK	Y	Y	D. Connor	Information on new coral garden finding Anton Dohrn Seamount by Neil Golding Comments after MASH09

Coral gardens were nominated for inclusion in the OSPAR List in 2006 by WWF

Annex 2: Description of the recommended monitoring and assessment strategy

Rationale for proposed monitoring

The proposed approach is designed to provide data for an appropriate assessment of extent, distribution and condition of coral gardens 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 coral gardens and adjacent substrate types from human impacts and the effects of climate change-induced alterations of the ecosystem need to be studied, however this will require a complementary larger scale research programme investigating the spatial distribution of fishing effort, bycatch analysis and physical-biological coupling. 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 coral gardens, 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.

Synergies with monitoring of other species or habitats

Deep-sea surveys are usually expensive due to their remote location so coral garden monitoring should be combined with assessments of other deep-sea habitats and species where possible. Monitoring of other OSPAR features, such as scleractinian 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. Table A2.1 presents recommendations made by Smith and Hughes (2008) evaluating indicators for monitoring deepwater habitats in UK waters.

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.

At the meeting of OSPAR's Biodiversity Committee in 2009 (see BDC 9/4/4) proposals were made for variables which could act as indicators relevant for monitoring the Ecological Quality of coral gardens:

- Destruction of coral structures: Occurrence or relative area of damaged coral colonies (area with broken colonies)
- Proportion dead coral: Percentage cover of dead, exposed coral skeleton (relative area of dead coral to total area of coral)
- Mortality and growth: changes in proportion live coral over time
- Loss of biodiversity: Composition and richness of megafaunal organisms observed with visual inspection tools (ROV, submersible, or tethered video platform)
- Presence and extent of threatened and declining species (e.g. red-listed species)

- Occurrence of opportunistic/invasive species: Changes in abundance of megafaunal organisms observed with visual inspection tools, and sampled with manipulator or videograb for species identification if possible

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: 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“). Rogers *et al*. (2008) set out recent and emerging techniques available for monitoring human impacts to vulnerable marine ecosystems (e.g. observer programmes, acoustic and scientific surveys) and emerging predictive modelling techniques. Smith and Hughes (2008) evaluate the functionality of various biodiversity indicators *vs*. several pressures impacting on the deepwater habitats (Table in Annex 4). 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.

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, these have to be complemented by acoustic surveys of bathymetry, roughness of the seafloor and sedimentary characteristics (for techniques see Fosså et al. 2005). Benthic landers can provide data on the longterm environmental conditions such as temperature, current speed and direction and pigment concentration (Roberts et al. 2005). With growing experience, acoustic techniques my help to locate and determine various deepwater habitats, such as already experienced for cold water coral reefs (see Fosså et al. 2005). New techniques for transfering 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. 2008), and photogrammetry (e.g. Sánchez et al. 2009) in combination with GIS mapping (e.g. de Mol et al. 2008).

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, supplemented by obligatory bycatch analysis programmes and conflict analyses evolving over time. As a minimum all human activities (demersal fisheries, oil & gas development and marine scientific research) likely to affect vulnerable deepwater habitats such as coral gardens have to be monitored and managed. For example, fisheries should be continuously monitored remotely, using satellite technology, ideally in combination with onboard observers, patrol vessels and overflight surveys where required (see e.g. Davies *et al*. 2007, Rogers *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 “coral garden“ habitat, and whether such habitats occur in the vicinity (see chapter 2). In addition, it is necessary to reassess the status of coral garden sites already described in the literature - a number of representative examples should be selected for longterm 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 weather 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). The monitoring of fishing activities, and fishing pattern changes in response to new regulations should be carried out on an annual scale, whereas pressures from less variable uses and further policy response could be monitored at greater intervals.

Data collection and reporting

Table A2.1 and the proposed assessment criteria in this Annex inform about the overall categories of information required, however this is neither systematic nor exhaustive. The further development of the habitat classification for deepwater habitats is important and will, once provided with a strong basis, reduce the amount of survey and data required to determine occurrences of the coral garden habitat. Matching the scale of the habitat occurrence with the scale of investigation and classification is the most important issue in this context.

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Annex 4: 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.

Annex 5: National/regional contribution: Azores

Summary of measures beneficial to the conservation of coral gardens already taken in the Azores

Prohibition of bottom trawling and deep-sea netting around the Azores through Council Regulation (EC) N°1568/2005 of 20 September 2005.

Temporary closure of Condor seamount: Temporary protection is presently being implemented on the Condor seamount, located to southwest of Faial island (Morato et al., in press), which is known to support rich assemblages of deep-sea corals, abundant sponges, sea urchins, crabs and commercial fishes. A deep-sea scientific observatory is currently being installed in this location that will provide unique interdisciplinary monitoring and experimental opportunities to study oceanographic and biological patterns. The closure of the seamount to bottom fisheries activities will also allow the assessment of fisheries impacts and further analysis on the recovery of fished seamount populations from decades of local artisanal bottom fishing. This knowledge is instrumental to enhance the quality of advice regarding seamount management and promote general public awareness on marine conservation and sustainable development.

Formigas Bank: This is an important seamount located on the eastern part of the Azores archipelago that is known to hold hidrarian gardens and sponge aggregations. Its summit is designated as an SAC (Natura 2000) and the whole seamount is a Nature Reserve since 1988 and an OSPAR MPA since 2006. For management purposes, the reserve has been integrated in the Natural Park established in 2008 on the neighbouring Santa Maria Island (DLR 47/2008/A of 7th November).

No bottom-tending fisheries are allowed on this seamount. Exuberant hidrarian gardens that provide habitat for a variety of nekto-benthic fishes are recorded for this protected area.

Faial-Pico Channel: Protected areas were designated in the Faial-Pico Channel by DLR 20/2008/A of 9th July and DLR 46/2008/A of 7th November that extend to depths in excess of 700m. Coral gardens are recorded in the southern deeper areas of these MPAs. It is possible that management measures regarding boat size and bottom tending gear will be established when the fine regulations of the MPAs, including a zoning scheme, are established.

Corvo island: A protected area was designated around the island of Corvo (DLR 44/2008/A of 5th November) that encompasses the whole island shelf and slopes down to depths in excess of 1000m. Coral gardens occur in the area. It is possible that management measures regarding bottom tending gear will be established when the fine regulation of the area, including a zoning scheme, is established.

Other seamounts and seamount-like features: There are ongoing efforts to confer statutory protection to the OSPAR MPAs of Sedlo seamount and the Menez Gwen and Lucky Strike hydrothermal fields, which are surrounded by seamount-like structures also to be protected. Sedlo seamount is known to hold coral assemblages (Santos et al. 2009). Abundant scleractinian corals occur on the Menez Gwen hydrothermal field in association with a diverse assemblage of gorgonians and sponges (Santos et al. 2003).It is likely that limitations on the use of bottom-tending gear will be established when the designation and regulation of these MPAs occur.

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