OSPAR COMMISSION

Background document on Ecological Quality Objectives for threatened and/or declining habitats

Biodiversity Series

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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 Union 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 l'Union européenne et l'Espagne.

Acknowledgement

This report has been prepared by Norway in consultation with members of the Intersessional Correspondence Group on Ecological Quality Objectives and the Convenor of the Intersessional Correspondence Group on Coordination of Biodiversity Assessment and Monitoring (COBAM).

Photo: Oystercatcher's eggs © Sharpshot/Fotolia.

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Executive Summary

Threatened and declining habitats are obvious candidates in need of protection measures, and Ecological Quality Objectives (EcoQOs) can be used as management objectives supporting those measures. The OSPAR List of Threatened and/or Declining Species and Habitats contains 11 habitats occurring in the North Sea. Most of these habitats are present in intertidal and shallow subtidal parts of the North Sea.

A ***two-layered approach*** for setting EcoQOs for the threatened and/or declining habitats on the OSPAR list is suggested. The first layer is ***generic*** for all the habitats and comprises formulation of general EcoQOs for habitats. The second layer is ***specific*** for each separate habitat on the List and provides more detailed formulation of EcoQO elements and associated EcoQOs. The general EcoQOs for threatened and/or declining habitats are:

a. restore and/or maintain the areal extent and distribution of the habitat;

b. restore and/or maintain the quality of the habitat (e.g. water and sediment quality, condition of dominant or defining (e.g. habitat-forming) species, species composition, ecological functions).

The work on elaborating and setting operational EcoQOs for habitats on the OSPAR list should be linked closely to the further work on defining and mapping of these habitats in the waters of the Contracting Parties in the OSPAR Maritime Area, and to the development of appropriate management measures based on assessments of status of and threats to the habitats. Scientific and technical elements to consider in elaborating EcoQOs for specific habitats on the OSPAR List are included in annexes for seven selected habitats as examples and guidance for the further work.

Récapitulatif

Les habitats menacés et en déclin sont des candidats évidents appelant des mesures de protection et des Objectifs de qualité écologique (EcoQO) peuvent jouer le rôle d’objectifs de gestion étayant des mesures. La Liste OSPAR des espèces et habitats menacés et/ou en déclin comporte onze habitats présents en mer du Nord, la plupart se trouvant dans les parties intertidales et subtidales peu profondes de la mer du Nord.

On suggère d’appliquer une approche en deux couches à la détermination des EcoQO pour les habitats menacés et/ou en déclin de la Liste OSPAR. La première couche est générique pour tous les habitats et comporte la formulation des EcoQO généraux pour les habitats. La deuxième couche est spécifique à chaque habitat de la Liste et comporte une formulation plus détaillée des éléments d’EcoQO et des EcoQO correspondants. Les EcoQO généraux pour les habitats menacés et/ou en déclin sont les suivants:

a. rétablir et/ou maintenir l’étendue et la distribution géographiques de l’habitat;

b. rétablir et/ou maintenir la qualité de l’habitat (par exemple la qualité de l’eau et des sédiments, la condition des espèces dominantes ou définissant l’habitat (par exemple formatrices d’habitats), la composition des espèces, les fonctions écologiques).

Les travaux sur l’élaboration et la détermination d’EcoQO opérationnels pour les habitats de la Liste OSPAR devront être étroitement liés aux travaux supplémentaires sur la détermination et la

cartographie de ces habitats dans les eaux des Parties contractantes de la zone maritime OSPAR, et le développement de mesures de gestion appropriées basées sur l'état de ces habitats et les menaces auxquelles ils font face. Les éléments scientifiques et techniques à envisager lors de l'élaboration d'EcoQO pour des habitats spécifiques de la Liste OSPAR figurent dans les annexes pour sept habitats sélectionnés à titre d'exemple et d'orientation pour les travaux futurs.

Background

"Habitats" was one of the 10 issues for which Ecological Quality Objectives (EcoQOs) were to be elaborated, as agreed in the Bergen Declaration from the 5th North Sea Ministerial Conference in 2002. The general EcoQO element was formulated as: (s) ***Restore and/or maintain habitat quality***.

OSPAR 2005 adopted the Report to North Sea Ministers on the Review of the North Sea Pilot Project on Ecological Quality Objectives (EcoQOs), and agreed on a general strategic approach to the application of the EcoQO system to the Greater North Sea (OSPAR Region II) (OSPAR Agreement 2006-4). In the 2005 review report, it was concluded that the EcoQO should be refocused on the ***quality and extent of threatened and/or declining habitats***, and that further substantial development work was needed.

The OSPAR List of Threatened and/or Declining Species and Habitats was initially adopted in 2004. It was further updated by OSPAR 2006 and OSPAR 2008 (Agreement 2008-6) and now contains 16 habitats, 11 of them listed as occurring in the North Sea (Annex 1).

The 2005 OSPAR review noted that threatened and declining habitats are obvious candidates in need of protection measures, and that associated EcoQOs can be used as management objectives supporting those measures. OSPAR's Biological Diversity and Ecosystems Strategy gives priority to the identification of threatened and declining species and habitats.

This EcoOQ can contribute to the implementation of the Quality Descriptive Elements No. 1 and 6 of the Marine Strategy Framework Directive (MSFD):

- "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions."
- "Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected."

Scientific and technical assessments of these two GES descriptors (as well as the other 9 GES descriptors) were developed by Task Groups set up by the Joint Research Centre and the International Council on the Exploration of the Seas. Based on these assessments and broad consultations, the European Commission provided guidance on GES implementation in the Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (2010/477/EU).

Quantity and quality of habitats

ICES in their advice in 2004 noted that they had encountered problems with the definition of habitat quality, and recommended that the EcoQO element should be changed to: **Restore and/or maintain the extent of threatened habitats.**

Habitats in general can be characterized by their amount (quantity) and various other aspects or features that are quality aspects.

The ***quantity*** of a habitat can usually be given as area covered by the habitat, representing the areal extent. The concept of areal extent of a habitat is simple in principle, but in reality it can be difficult to determine the boundary, i.e. where one habitat ends and the next begins. This is related to the density of key habitat-forming features and how specific habitats are defined (see below). A habitat can also have a vertical dimension and thus have a 3-dimensional extent as volume. This is obvious for pelagic habitats in the water column (there are no such habitats on the OSPAR List) but applies also to benthic habitats, e.g. the height and volume of coral reef habitats.

The ***quality*** of a habitat is all those features that describe the condition or state of the habitat where it occurs. Many of the habitats on the OSPAR List are defined by dominant, habitat-forming organisms (e.g. *Lophelia pertusa* reefs, mussel or oyster beds (*Mytilus edulis*, *Modiolus modiolus*, *Ostrea edulis*), *Sabellaria spinulosa* reefs, *Zostera* beds). The condition of the habitat-forming species may be important quality aspects of the habitats, for instance size composition, and nutritional, reproductive, and health status of the individuals. A mussel bed of small individuals with poor growth and low reproduction represents a habitat of lower quality than one dominated by large, vigorous and healthy individuals. A lowered quality of a habitat might imply increased sensitivity to disturbance, potentially leading to habitat loss and decrease in habitat extent (quantity). Other habitats are made up of abiotic structures that facilitate an environment for certain species (e.g. intertidal mudflats, carbonate mounds, seamounts, etc.). The physical and chemical properties of the seafloor substrate (e.g. grain size, porosity, geomorphology, oxygen, contaminants etc.) represent important quality aspects that have consequences for the biota living in or at the seafloor.

The quality of a habitat can involve three main components:

(1) Habitat-forming or otherwise dominant species;

(2) Other species contributing to the species composition of the community inhabiting the habitat;

(3) Physical aspects of the habitat (e.g. oxygen, sedimentation, silting, etc.)

The distinction between quantity and quality of a habitat is not always clear. This is particularly the case for ***density*** aspects of habitats. A mussel bed may consist of a dense mat of mussels or a broken mat with larger or smaller patches of mussels with exposed sediment substrate in between. The density of mussels may be part of the definition and delineation of the habitat category. Thus density may be involved in determining the extent (quantity) of a habitat. However, the density will vary within a defined habitat and is therefore also a quality aspect of a habitat.

The ***geographical distribution*** of the habitats is also a feature that needs to be considered in the context of EcoQOs. Loss of a habitat from a geographical area represents loss in biodiversity character if the extremes of the geographical range of a given habitat are lost. Another issue is the spatial distribution patterns of habitats which are related to ecological connectivity and coherence. Loss of a habitat in one area could potentially affect the condition of habitats in other areas through for instance reduced availability of larvae and thereby lowered recruitment of key species of the habitat.

GES descriptors for biodiversity (1) and seafloor integrity (6)

GES descriptor 1 (*Biological diversity is maintained*) is divided into three levels for the purposes of assessment and criteria for GES: species, habitat and ecosystem. At the habitat level there are three criteria specified in the EC guidance (Commission Decision 2010/477/EU):

- Distribution
- Extent

- Condition

For the ***habitat distribution*** criterion (1.4), there are two attributes listed as possible indicators: range and pattern. ***Habitat extent*** (criterion 1.5) can be expressed as area and volume, where relevant. For ***habitat condition*** (criterion 1.6), three attributes are listed:

- Condition of the typical species and communities;
- Relative abundance and/or biomass, as appropriate; and
- Physical, hydrological and chemical conditions.

At the ecosystem level for descriptor 1 the criterion is ***ecosystem structure*** (1.7). The attribute for this criterion is 'composition and relative proportions of ecosystem components (habitats and species)'. This may in principle include threatened and declining habitats.

GES descriptor 6 (*Sea-floor integrity*) has two criteria specified in the EC guidance:

- Physical damage, having regard to substrate characteristics;
- Condition of benthic community.

For the '***physical damage***' criterion (6.1) two attributes are listed:

- Type, abundance, biomass and areal extent of relevant biogenic substrate; and
- Extent of seabed significantly affected by human activities for the different substrate types.

For the criterion on ***condition of benthic community*** (6.2), four attributes are listed:

- Presence of particularly sensitive and/or tolerant species (6.2.1);
- Multi-metric indexes assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species (6.2.2);
- Proportion of biomass or number of individuals in the macrobenthos above some specified length/size (6.2.3);
- Parameters describing the characteristics (shape, slope and intercept) of the size spectrum of the benthic community (6.2.4).

Species and habitats are closely linked in ecological and GES contexts. For GES descriptor 1 this is explicitly recognized in the EC guidance. At the species level, it is stated that "The assessment of species also requires an integrated understanding of the distribution, extent and condition of their habitats, …", while at the habitat level it is stated that "The assessment of habitat condition requires an integrated understanding of the status of associated communities and species, …".

Ecosystem function is closely related to ecosystem structure. It is explicitly recognized in the EC guidance that "the interactions between the structural components of the ecosystem are fundamental for assessing ecosystem processes and functions for the purpose of the overall determination of good environmental status, …". GES descriptor 6 has as its objective "that human pressures on the seabed do not hinder the ecosystem components to retain their natural diversity, productivity and dynamic ecological processes, having regard to ecosystem resilience."

GES descriptor 4 (*marine food webs*) "concerns important functional aspects such as energy flows and the structure of food webs (size and abundance)." One of the criteria for this descriptor is:

- Abundance/distribution of key trophic groups/species (4.3).

An attribute for this criterion is 'habitat-defining groups/species', where appropriate.

GES descriptor 5 (*eutrophication*) has two attributes under the criteria for direct and indirect effects of nutrient enrichment (5.2 and 5.3) that are relevant for some of the habitats on the OSPAR list:

- Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities (5.2.4)
- Abundance of perennial seaweeds and seagrasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by decrease in water transparency (5.3.1).

Framework for setting EcoQOs for habitats

ICES (2002) recommended a four-step process for the evaluation of the usefulness of habitats on the OSPAR List of threatened and/or declining habitats in developing EcoQOs. The first step was to determine whether a habitat on the List occurred in the North Sea. The next steps were to address the following questions:

Step 2: Can the threatened or declining status of the habitat be quantified accurately?

Step 3: Can we establish why a habitat is threatened or declining?

Step 4: Can trends in habitat status be detected reliably on short timeframes (about five years) relevant to management?

Using this process, ICES in 2004 recommended that features of flat oyster beds, intertidal mudflats, and littoral chalk communities should be further developed as a basis for an EcoQO for habitats on the OSPAR List. ICES recommended that features of two other threatened and declining habitats in the North Sea, i.e., seapen and burrowing megafauna communities and seagrass beds, should not at present (2004) be used as a basis for EcoQOs. The reasons for this were that there is no strong evidence that seapen and burrowing megafauna communities are undergoing decline in the North Sea, while for *Zostera* beds there are insufficient data on the recovery rates, and a lack of clear causative links with a manageable human activity. This suggested that trends will not be readily identifiable on a reasonable time scale.

A ***two-layered approach*** for setting EcoQOs for the threatened and/or declining habitats on the OSPAR List is suggested. The first layer is ***generic*** for all the habitats and comprises formulation of general EcoQOs for habitats. The second layer is ***specific*** for each separate habitat on the List and provides more detailed formulation of EcoQO elements and associated EcoQOs.

The generic level of EcoQOs for habitats on the OSPAR List is described in following parts of this document. Some further considerations of the scientific and technical basis for specific EcoQOs for selected habitats are included in Annexes 2-9. The information in these annexes is drawn from background documents for the various habitats on the OSPAR List (ref. 2008-6), documents from the UK Habitat action plan (http://www.ukbap.org.uk/UKPlans.aspx?ID=34), work in the Wadden Sea, and other sources.

Annex 2 - *Lophelia pertusa* coral reefs

Annex 3 - Coral gardens

Annex 4 - Intertidal mudflats

Annex 5 - Intertidal *Mytilus edulis* beds on mixed and sandy sediments

Annex 6 - *Ostrea edulis* beds

Annex 7 - *Sabellaria spinulosa* reefs

Annex 8 - *Zostera* beds

Annex 9 - Sea-pen and burrowing megafauna communities

The elaboration and use of EcoQOs for threatened and/or declining habitats are obviously linked to two other OSPAR activities: mapping of habitats, and consideration of measures to improve the status of the listed habitats. The further work on the specific EcoQOs for each habitat on the list needs to be coordinated with these other activities, as well to the work on implementing the MSFD for the North Sea region.

Technical basis

EcoQO Issue: Habitats – threatened and/or declining habitats.

EcoQO Element:

a. Habitat extent and distribution

b. Habitat quality

EcoQO Objective:

a. Restore and/or maintain the areal extent and distribution of the habitat.

b. Restore and/or maintain the quality of the habitat (e.g. water and sediment quality, condition of dominant (habitat-forming) species, species composition, ecological functions).

Justification: Habitats on the OSPAR list are included there because they have been (and possibly still are) declining and/or are threatened, which could lead to decline in the future. Preventing or stopping decline, and/or restoring habitats, in terms of areal extent is the first objective (c). The second objective (d) is linked to the first, but considers quality aspects of the habitat which are important or critical to the health, integrity, and viability of the habitat. Such quality elements could be oxygen conditions, organic enrichment, silting, or other aspects of water and sediment quality, condition (size, growth, vigor, reproduction, etc.) of habitat-defining species, and the overall species composition, richness and diversity of the fauna and flora that inhabit the habitat. When determining the specific EcoQOs for each of the habitats on the OSPAR list, it will probably be possible and useful to set targets for the number of locations and areal extent of the habitats. EcoQOs for habitat quality could as an eventuality remain as a qualitative statement, with quantitative information used as assessment variables and criteria to determine whether the objective is achieved or not. This would be equivalent to the integrated set of EcoQOs for eutrophication, where the objective of “no eutrophication” (or status as “non-problem area”) is determined by using quantitative assessment criteria for several assessment variables that are included in the integrated set as EcoQO components.

Technical evaluation

		Comments	
a.	**ICES Criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Public awareness for protecting "habitat quality" is high.
	Sensitive to a manageable human activity	Usually, e.g. for oyster beds, littoral chalk communities, and intertidal mudflats	The decline is due to damage by fishing activities, and land reclamation and littoral structures. In general, many types of habitats can be sensitive to management activity, particularly in natural "low energy" environments (not exposed to frequent natural disturbance by waves, storms, strong currents, etc.).
	Relatively tightly linked in time to that activity	Occasionally	The status of oyster beds is closely linked in time with fishing and overexploitation. Littoral chalk community status is directly linked to land reclamation and littoral defence structures.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	The threats are significant primarily as a result of the relatively restricted distribution and small total area of these habitat types. *Zostera* beds were strongly impacted by wasting disease during the 1920s and 30s. Disease and severe winters may impact flat oyster beds.
	Easily and accurately measured, with a low error rate	Usually possible in principle but resource demanding in practice	Mapping procedures are well known. However, detailed mapping and sampling surveys may be required to determine the distribution and boundaries of habitats in relation to their definitions.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	There is good evidence of decline in the oyster beds and littoral chalk communities, and threats to intertidal mudflats in the North Sea. Overall habitat mapping is only partially completed for the North Sea area.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	An EcoQO to increase spatial extent may be valid even though accurate estimates of pre-impacted habitats do not exist.
b.	**Ecological relevance/basis for the metric**	Although generally of limited extent, many of the habitats specified by OSPAR are important parts of the coastal zone.	

c.	**Current and historic levels (including geographic areas)**	There is a good evidence for decline in the North Sea of many of the habitats on the OSPAR List. Historic data are in most cases not available.	
d.	**Reference level**	There is no quantitative basis for identifying historical abundances, but these habitats were known to be more extensive, and some quantitative information is available for many habitat types.	
e.	**Limit point (thresholds)**	To be developed where possible for specific habitats.	
f.	**Time frames**	*Detection of change*	Detection of impact can be rapid.
		Use in advice	Detection of response to remediation is likely to require at least five years.
g.	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
h.	**Monitoring regimes**	Detailed habitat mapping will be needed to record the current extent of the habitats. Monitoring of areas where management measures are in place can be tractable and cost-effective.	
i.	**Management measures to achieve EcoQO**	Cease or relocate disruptive activity. Sometimes habitat-specific rehabilitation may be possible. Management measures taken to ensure that the benthic environment is not significantly physically altered (e.g., by sediment deposition or trawling impacts) and ensure that water column quality is favourable to these habitats will promote the restoration/maintenance of habitat quality.	

Ecological relevance/basis for the metric: Habitats are the living areas of organisms, many of which are not properly known or their detailed occurrence not mapped in the North Sea. By protecting the habitats, the organisms are also being protected. The habitats on the OSPAR List have been declining and/or are threatened with decline in the future. These habitats also serve important ecological functions, such as feeding and nursery areas for fish and birds, and also a variety of invertebrates.

Definition and classification of habitats

Habitats need to be defined in any habitat classification system, as a necessary step if habitats are to be shown on maps. Habitats may be defined broadly or narrowly, and hierarchical classification systems such as the European Nature Information System (EUNIS; Davies et al. 2004) progress from broad to more narrowly defined habitats.

The seabed can be characterized and classified at different spatial scales ranging from fine-scale local environment with factors affecting individual organisms, to landscapes and large-scale ecosystems where the substrates, terrain and oceanographic settings influence biological communities and populations. There are several approaches to seascape and habitat mapping. Greene et al. (1999)

provide a classification scheme for deep seafloor habitats where the issue of scale is dealt with in a hierarchy of classes. The same approach is applied in EUNIS. Both classification systems take into account the biological components of the habitat classes. However, whereas the Greene et al. (1999) classification scheme use the biological components as modifiers of geological and geomorphological features at an intermediate level (macro and meso habitats) the EUNIS classification emphasizes taxonomic composition at the lower (finer) levels.

The habitats on the OSPAR List vary in the way they are defined (Table 1). Some of them are defined mainly by abiotic factors, such as terrain and geological features for carbonate mounds and seamounts, or depth and sediment features for intertidal mudflats. For most of the remaining habitats, species composition and density of habitat-forming species are used for their definition.

Table 1 provides an overview of the habitats in the EUNIS classification that correspond to the habitats on the OSPAR list.

The definition of habitats on the OSPAR list varies in broadness. 'Coral gardens' and 'Sea-pen and burrowing megafauna' communities are broadly (and to some degree vaguely) defined, while others such as *Sabellaria spinulosa* reefs, *Ostrea edulis* beds, and *Zostera* beds, are more narrow and precise in definition. The definition of habitats has implications for elaboration and setting of EcoQOs. Broadly defined habitats are generally more heterogeneous, and quality features may therefore be more difficult to select, or may have to be selected more generally or extensively. They may also be challenging in terms of setting objectives for extent, due to their heterogeneous nature and often imprecise definition.

While some of the more narrowly defined habitats may be simpler to deal with in terms of objectives, there are still difficulties related to determining their boundaries both in principle and practice. This can be illustrated using *Modiolus modiolus* beds as an example. This habitat is made up of dense beds of the horse mussel *Modiolus modiolus*. Horse mussel has a wide geographical distribution and occurs on a range of bottom substrates from the lower shore down to depths of several hundred meters on the shelves. Gradations occur from isolated individuals which may nest in the sediment, through well scattered small clumps, to near total coverage of the sea bed. The beds can be composed of mussels in isolated clumps, in ribbon like reefs with superimposed wave-like undulations, or in sheets. Patches extending over >10 m^2 with >30% cover by mussels and the epibiota attached to them should definitely be classified as "bed". Scattered populations of isolated full grown individuals or of spat at quite high densities are <u>not</u> classified as "beds". Somewhere in the gradation between these two cases lies the boundary between what is considered a bed and what is not. The *Modiolus modiolus* beds on the OSPAR list can be considered to include four different *Modiolus* bed habitat subtypes, as defined in both the European EUNIS habitat classification (2004 version; http://eunis.eea.eu.int/eunis/habitats.jsp) and the National Marine Habitat Classification for Britain and Ireland (Connor *et al*., 2004).

Table 1. OSPAR list of Threatened and/or Declining Habitats with corresponding codes for EUNIS classes and their main characteristic features.
* indicates weak descriptions that could lead to misclassifications.

	Eunis codes		**Defined by**					
Habitat	Equal to	Occurs in	Terrain	Geol feature	Depth	Sediment	Species composition	Density of habitat-forming species
Carbonate mounds	A6.75		X	X				
Coral Gardens	Not defined	A6.1 - A6.5, A6.7 - A6.9					X*	X*
Cymodocea meadows	A5.531, A5.5312, A5.53131, A5.53132						X	X*
Deep-sea sponge aggregations	A6.62				X		X*	X*
Intertidal *Mytilus edulis* beds on mixed and sandy sediments	A2.7211, A2.7212				X	X	X	X
Intertidal mudflats	Not defined	A2.3	X		X	X		
Littoral chalk communities	A1.126, A1.2143, A1.441, B3.114, B3.115			X	X			
Lophelia pertusa reefs	A5.631, A6.611						X	X
Maerl beds	A5.51						X	X
Modiolus modiolus beds	A5.621 - A5.624						X	X
Oceanic ridges with hydrothermal vents/fields	A6.94		X	X	X			
Ostrea edulis beds	A5.435						X	X
Sabellaria spinulosa reefs	A4.22, A5.611						X	X
Seamounts	A6.72		X					
Sea-pen and burrowing megafauna communities	A5.361, A5.362						X*	X*
Zostera beds	A2.611, A5.533, A5.545						X	X

Zostera beds are typically occurring with plant cover of 30% or more of the sediment surface. However, plant densities as low as 5% may qualify as a bed. In such cases of low densities, expert judgement may be required to define the bed. For flat oyster (*Ostrea edulis*) beds, there would generally be 5 individuals or more per m^2 to qualify as a bed, in addition to considerable quantities of dead oyster shells. In practice, therefore, the identification of boundaries to determine areal extent of habitats may require extensive and detailed studies. For *Zostera* there can also be marked fluctuations in the size and shape of local beds among years, presumably reflecting natural variability.

The majority of the habitats on the OSPAR list for the North Sea occur in the intertidal and/or shallow subtidal zones. These are:

- *Zostera* beds
- Intertidal mudflats
- Intertidal *Mytilus edulis* beds on mixed and sandy sediments
- *Ostrea edulis* beds
- *Sabellaria spinulosa* reefs
- Littoral chalk communities
- Maerl beds
- *Modiolus modiolus* beds

Several of these habitats are close in a spatial ecological sense and may through succession change from one to the other. Intertidal mudflats may provide the substrate where *Zostera* seagrass beds may develop, and if *Zostera* disappears, the habitat may change into an intertidal mudflat. Where stones and shells provide an initial attachment for byssus threads, beds of the common mussel *Mytilus edulis* occur.

Habitat mapping and the scale issue

Management of habitats generally requires maps showing their distribution within areas that are or could be impacted by human activities. Operational EcoQOs based on extent of habitats would depend on maps of sufficient quality to allow areas of habitats to be calculated. Depending on the distribution patterns of the habitat, suitable mapping methods may differ.

The scale issue is recognized as being very important in the context of assessment of status and objectives for habitats. Benthic ecosystem features (reflected in habitat classification) are patchy on many scales. Likewise, many human activities that affect the seafloor also operate at patchy spatial scales. While the initial impacts are usually local, their direct and indirect ecological consequences may dissipate widely by way of physical and biotic transport processes. All these features contribute to complex temporal and spatial relationships between human activities and habitats.

Broadly defined habitats are generally wider in extent than more narrowly defined habitats, which are nested within the former in a hierarchical classification system like EUNIS. In the context of maps one can 'zoom-in' to see the narrowly defined habitats and 'zoom-out' to get an overview of the broadly defined habitats.

Ideally, high resolution habitat maps should be used as a basis for good management to achieve objectives related to extent and quality of habitats. Such maps are costly to produce and exist only for selected and smaller parts of the OSPAR Maritime area. Given a strong correlation with environmental variables and other "predictors", habitat modeling represents an efficient way to reduce search area for 'ground-truthing' of sensitive habitats. However, targeted mapping of selected habitats thought to be threatened leaves a risk that other, as yet unknown threatened habitats are overlooked.

Detailed mapping of habitats is generally simpler in the intertidal and shallow subtidal zones since observations from satellites, air planes, shorelines and underwater by Scuba divers may help us to record habitat features, occurrence and extent. Even then, monitoring, mapping and assessment may be demanding since the habitats may undergo complex changes due to natural climate variability and change and ecological interactions, as well as due to anthropogenic factors.

The work on elaborating and setting of operational EcoQOs for habitats on the OSPAR list should be linked closely to the further work on defining and mapping of these habitats in the waters of the Contracting Parties in the OSPAR Maritime Area.

Assessment and management of habitats

The habitats on the OSPAR list have been identified as being under threat and/or in decline in some parts of the OSPAR area. The purpose of listing them is to consider appropriate measures to remove the threat and stop or reverse the decline so that the habitats hopefully and eventually can be taken off the list because they are in satisfactory conservation status.

EcoQOs are objectives that are to be used in a management context to help us define what desirable status for the identified habitats is. Measures need to be tailored to deal with the threats in specific cases and informed by assessments of the status of the habitats on the OSPAR list. A first version of such assessments has been carried out as reported in a series of draft background documents (ref. MASH 08/4/1), as a contribution to JAMP BA-4 and the OSPAR QSR 2010. We have used information from these draft background documents to compile some information relevant to the issue of setting EcoQOs for these habitats.

The further work on EcoQOs for the habitats on the OSPAR list should be linked closely to the ongoing work to consider appropriate management measures based on assessments of status and threats. A list of threats as identified factors that affect the various habitats on the OSPAR list is given in the table below.

Table 2. OSPAR list of Threatened and /or declining Species and Habitats that occur in the North Sea and main affecting factors

DESCRIPTION	**Affecting factors**	**North Sea countries where such habitats occur**
Coral Gardens	Bottom fisheries, physical disturbance	Norway, Sweden
Intertidal *Mytilus edulis* beds on mixed and sandy sediments	Fisheries, bait digging, pollution, physical disturbance (coastal development, dredging, anchoring)	All except Belgium (?)
Intertidal mudflats	Land claim (for agricultural and industrial use), effluent discharges (pollution, eutrophication), oil spills, dredging, fishing, bait digging, sea level rise, erosion and sedimentation from altered hydrodynamics	All

Littoral chalk communities	Physical disturbance, pollution	UK, France, Denmark and Germany
Lophelia pertusa reefs	Bottom fisheries	Sweden, Norway and UK
Maerl beds	Removal, physical disturbance, pollution	UK, France and Sweden (?)
Modiolus modiolus beds	Fisheries, physical disturbance	UK, Sweden (?)
Ostrea edulis beds	Pollution, temperature variation, bottom trawling, dredging, sand and gravel extraction	All, but in some countries extinct
Sabellaria spinulosa reefs	Physical disturbance, pollution	All except Belgium (?)
Sea-pen and burrowing megafauna communities	Bottom fisheries, pollution, hypoxia	UK, Norway, Denmark (?)
Zostera beds	Physical disturbance, competitive exclusion, pollution	All except Belgium

Annex 1 OSPAR List of Threatened and/or Declining Species and Habitats

Part II - Habitats

DESCRIPTION	**OSPAR Regions where the habitat occurs**	**OSPAR Regions where such habitats are under threat and/or in decline**	**Date of inclusion in the list**
Carbonate mounds	I, V	V[1]	2003
Coral Gardens	I, II, III, IV, V	All where they occur	2008
Cymodocea meadows	IV	All where they occur	2008
Deep-sea sponge aggregations	I, III, IV, V	All where they occur	2003
Intertidal *Mytilus edulis* beds on mixed and sandy sediments	II, III	All where they occur	2004
Intertidal mudflats	I, II, III, IV	All where they occur	2003
Littoral chalk communities	II	All where they occur	2003
Lophelia pertusa reefs	All	All where they occur	2003
Maerl beds	All	III	2004
Modiolus modiolus beds	All	All where they occur	2004
Oceanic ridges with hydrothermal vents/fields	I, V	V	2003
Ostrea edulis beds	II, III, IV	All where they occur	2003
Sabellaria spinulosa reefs	All	II, III	2004
Seamounts	I, IV, V	All where they occur	2003
Sea-pen and burrowing megafauna communities	I, II, III, IV	II, III	2003
Zostera beds	I, II, III, IV	All where they occur	2003

[1] To be confirmed in the light of further survey work being undertaken by Ireland

Annex 2: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – *Lophelia pertusa* reefs

Biological and ecological features

1. There is only one reef-building stone coral (Scleractinia) in European Atlantic waters, *Lophelia pertusa*. Its close relative, *Madrepora oculata*, does not form reefs in the Northeast Atlantic, but commonly occurs together with *L. pertusa* as scattered smaller colonies. *M. oculata* seems to be more common in the Mediterranean. The same EcoQOs should apply for both species.

2. Coral “health” and coral associated community is very difficult to monitor in a standardised way. Growth is slow (for coral polyps: 7 mm/yr on average, with maximum rates up to ca 2.5 cm/yr; for reefs: ca 1.5 mm/yr in height increment on average [Mortensen 2000; Brooke and Young 2009]).

Threats

3. The extension of such reefs has been documented to be reduced locally due to physical impacts from bottom trawling in certain areas of European shelf areas (Fosså et al 2002; Hall-Spencer 2002).

4. Other causes of reduced Ecological Quality are poorly known, but changes in coral “health” (e.g. mortality, growth, and recruitment) and community composition may occur as a result of climatic changes, increased sedimentation, replacement by invading species, etc.

Aspects related to objectives, monitoring and assessment

5. The coral skeleton structures represent a habitat with a complex 3D architecture, where the variation is very high between samples (Mortensen & Fosså 2006). Sampling of coral habitat for the purpose of detecting changes in composition of macrofauna would need to be more extensive than could be recommended as an environmentally sustainable method.

6. The following variables are suggested as indicators relevant for monitoring the Ecological Quality of cold-water coral reefs:

a. Destruction of coral structures: Occurrence or relative area of damaged (clearly distinguished from natural fragmentation) coral colonies (monitored by standardized visual inspection).

b. Proportion of live coral: Percentage cover of live coral (relative area of living [bright white] coral to total area of coral, which includes dead corals) (monitored by standardized visual inspection).

c. Mortality and growth: changes in proportion live coral over time (monitored by standardized visual inspection).

d. Loss of biodiversity: Composition and richness of megafaunal organisms observed with visual inspection tools (ROV, submersible, or tethered video platform)

e. Presence and extent of threatened and declining species (e.g. red-listed species)

f. 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.

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Annex 3: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area - Coral gardens

Biological and ecological features

1. There are around 10 species of Alcyonacea and Gorgonacea in the OSPAR area II that contribute to forming coral garden habitats. The most common of these are the gorgonians *Primnoa resedaeformis*, *Paragorgia arborea*, *Paramuricea placomus*, *Swiftia pallida* and *S. rosea*. The distribution and habitat characteristics of coral gardens are less well known than for *Lophelia* reefs in the same area.

2. The coral colonies represent a habitat with a complex 3D architecture (Mortensen & Buhl-Mortensen 2005). 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 mutualists). This fauna is almost impossible to monitor without removing or damaging the coral.

Threats

3. From Canada and Italy (Bavestrello et al. 1997; Mortensen et al. 2005) it has been documented that fishing (both bottom trawling and long-lining) has reduced the extent and colony density of such habitats. The habitat is therefore assumed to be threatened in the North Sea.

4. Other causes of reduced Ecological Quality are poorly known, but changes in coral "health" (e.g. mortality, growth, and recruitment) and community composition may occur as a result of climatic changes, increased sedimentation, replacement by invading species, etc.

Aspects related to objectives, monitoring and assessment

5. Coral "health" and coral associated community is very difficult to monitor in a standardised way. Growth varies between species but is generally slow (1 - 45 mm/yr).

6. The following variables are suggested as indicators relevant for monitoring the Ecological Quality of coral gardens:

a. Destruction of coral structures: Occurrence or relative area of damaged coral colonies (area with broken or tilted colonies)

b. Proportion dead coral: Percentage cover of dead, exposed coral skeleton (relative area of dead coral to total area of coral) or area covered by parasitic anemones

c. Mortality and growth: changes in proportion live/dead coral over time

d. Loss of biodiversity: Composition and richness of associated megafaunal organisms observed with visual inspection tools (ROV, submersible, or tethered video platform)

e. Presence and extent of threatened and declining species (e.g. red-listed species)

f. 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

7. References

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Annex 4: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – Intertidal mudflats

Biological and ecological features

1. Intertidal mudflats can be defined as shallow-sloped shorelines, with expanses of fine sediment that are flooded with each high tide. They form typically in calm coastal environments and are of two sub-types:

- marine intertidal mudflats, and
- estuarine intertidal mudflats.

2. Mudflats are sedimentary intertidal habitats created by deposition in low energy coastal environments, particularly estuaries and other sheltered areas. Their sediment consists mostly of silts and clays with a high organic content. Towards the mouths of estuaries where salinity and wave energy are higher the proportion of sand increases. The wide extent of many mudflats is revealed when the tide goes out and they may seem to stretch to the horizon. Despite their empty appearance, mud flats are valuable as habitat and feeding grounds for many species of wildlife.

3. Mudflats are characterised by high biological productivity and abundance of organisms, but low diversity with few rare species. Together with other intertidal habitats, they support large numbers of predatory birds and fish. They provide feeding and resting areas for internationally important populations of migrant and wintering waterfowl, and during neap tides provide the only readily available food source. At high tide they are also important nursery areas for flatfish.

4. Mudflats are intimately linked by physical processes to, and may be dependent on, other coastal habitats such as soft cliffs and saltmarshes (UK Habitat action plan; http://www.ukbap.org.uk/UKPlans.aspx?ID=34). They commonly appear in the natural sequence of habitats between subtidal channels and vegetated saltmarshes. In large estuaries they may be several kilometres wide and commonly form the largest part of the intertidal area of estuaries.

5. The surface of the sediment is often apparently devoid of vegetation, although mats of benthic microalgae (diatoms and euglenoids) are common. These produce mucilage (mucopolysaccharides) that binds the sediment. Under nutrient-rich conditions, there may be mats of the macroalgae *Enteromorpha* spp or *Ulva* spp. On the landward side, intertidal mudflats grade into saltmarshes which are intertidal flats colonized by salttolerant vegetation. In slightly coarser areas, seagrass (*Zostera* spp) beds may develop. Where stones and shells provide an initial attachment for byssus threads, beds of the common mussel *Mytilus edulis* occur and accrete material through faecal deposition. Occasional stones or shells may also provide suitable attachment for stands of fucoid macroalgae such as *Fucus vesiculosus* or *F. spiralis*.

6. Mudflats, like other intertidal areas, dissipate wave energy, thus reducing the risk of eroding saltmarshes, damaging coastal defences and flooding low-lying land. The mud surface also plays an important role in nutrient chemistry. In areas receiving pollution, organic sediments sequester contaminants and may contain high concentrations of heavy metals.

Threats

7. The main threats to this habitat are land claim for agricultural and industrial use, effluent discharges, oil spills, dredging, fishing, bait digging and sea level rise. Land claim, for urban and transport infrastructure and for industry, has removed about 25% of Great Britain estuarine intertidal

flats and up to 80% in some estuaries. Barrage schemes for water storage, amenity, tidal power and flood defence continue to pose a threat to the integrity and ecological value of mudflats in estuaries and enclosed bays.

8. Diffuse and point source discharges from agriculture, industry and urban areas, including polluted storm-water run-off, can create abiotic areas or produce algal mats which may affect invertebrate communities. They can also remove embedded fauna and destabilize sediments thus making them liable to erode.

9. Within estuaries, mudflats deposited in the past may erode due to changed estuarine dynamics, and remobilized sediment may be redeposited elsewhere in the same littoral sediment cell. Higher sea level and increased storm frequency, resulting from climate change, may further affect the sedimentation patterns of mudflats and estuaries.

Aspects related to objectives, monitoring and assessment

10. Possible EcoQOs for intertidal mudflats can be illustrated by the following objectives and targets from the UK Habitat action plan (http://www.ukbap.org.uk/UKPlans.aspx?ID=34):

- Maintain at least the present extent and regional distribution of the UK's mudflats. This target will require compensating predicted losses to development by the restoration of mudflats. Whilst this may not be possible in the same location, it should be within the same littoral sediment cell.
- Create and restore enough intertidal area over the next 50 years to offset predicted losses to rising sea level in the same period. Predicted losses in the next 15 years should be offset in the next 10 years.
- Restore estuarine water quality to ensure that existing mudflats fulfil their important ecological and conservation role.

11. In terms of monitoring and assessment of this habitat, the work currently underway for the Water Framework Directive and for the Natura2000 sites has been summarised by two key elements:

- a regular surface area assessment of this habitat in order to evaluate its destruction, erosion or accretion,
- an assessment of the conservation status of the benthic macrofaunal and microphytobenthos communities.

12. A survey of the fish and bird populations linked to this habitat could also be used to evaluate its functional value, with the help of one or several EcoQO's developed on certain aspects. Monitoring of waders and flatfish nurseries at a national level should be created or amplified in order to complement the habitat mapping with qualitative measures of the functional value of this habitat.

13. Variables for monitoring the environmental quality or conditions could include:

- Sediment particle size distribution
- Organic content
- Redox potential
- Concentrations of contaminants
- Water quality (turbidity, nutrients, organic load, chlorophyll, and others)
- Various aspects of the hydrological regime.

14. The imagery that needs to be acquired in order to assess the surface area coverage of this habitat should be done in synergy with those habitats which form biogenic structures overtop of

intertidal mudflats (e.g. intertidal *Mytilus edulis* beds on mixed and sandy sediments; *Ostrea edulis* beds; *Zostera* beds).

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Annex 5: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – Intertidal *Mytilus edulis* beds on mixed and sandy sediments

EUNIS code: A2.7211 and A2.7212

Biological and ecological features

1. Dense aggregations of the blue mussel *Mytilus edulis* on the mid and lower shore, on mixed substrata (mainly cobbles and pebbles on fine sediments), on sand, or on sheltered muddy shores.

Threats

2. Current and potential threats to this habitat are:

– *Commercial fisheries:* Targeted removal of mussels, physical damage and smothering from use of mobile fishing gear.

– *Water Quality: Mytilus edulis* bioaccumulates pollutants in seawater which may lead to sublethal, and in some cases, lethal responses.

– *Coastal developments:* Physical damage and displacement from infrastructure development, dredging, trenching and cable/pipe-laying.

– *Anchoring:* Physical damage can arise from sustained anchoring and mooring chains.

– *Bait digging*: Removal of mussels as fishing bait and physical damage from associated trampling in the intertidal.

Aspects related to objectives, monitoring and assessment

3. Aspects of monitoring, assessment of status, and setting objectives for this habitat can be informed by work within the tri-lateral agreement for the Wadden Sea. With respect to the "Tidal Area" (intertidal and subtidal), the following Target applies to blue mussel beds (Wadden Sea Plan):

An increased area of, and a more natural distribution and development of, natural mussel beds.

4. The following parameters that reflect extent and quality aspects of *Mytilus* beds have been agreed:

5. Mandatory parameters

– Area and distribution of intertidal blue mussel beds: size of intertidal blue mussel beds (km^2), coordinates of mussel beds (GIS polygon)

– Biomass: tons fresh weight

– Coverage: mussel coverage of the beds (%)

6. Additionally, parameters for individual beds should be monitored (not mandatory) such as:

– abundance

– length frequency distribution,

– condition index,

- structure of bed

- primary settlement

7. Changes in the abundance of blue mussels *Mytilus edulis* may reflect natural fluctuations (including climate, weather, predation), and/or changes may be caused by fishing, nutrient loads and contaminant levels, or by combinations of these factors. The assessment of status therefore requires that the monitoring provides information on these impacts. Further, the general ecological targets, as agreed at the Trilateral Governmental Conference in Stade (1997), will be used for the assessment in the Wadden Sea:

- A natural dynamic situation in the tidal area.
- An increased area of geomorphologically and biologically undisturbed tidal flats and subtidal areas.
- An increased area and more natural distribution and development of natural mussel beds, *Sabellaria* reefs and *Zostera* fields.

9. The table below provides criteria and objectives for the monitoring and assessment of blue mussel beds in the Wadden Sea.

Table. Assessment of intertidal blue mussel beds.

Parameters		**Assessment**	**Objective**
Area and distribution of intertidal blue mussel beds:	size of blue mussel beds (km²), coordinates of mussel beds (GIS polygon)	Trends in area covered over 6 years (total area and sub-areas)	Stable or increasing (taking into account natural fluctuations).
Biomass	Tons fresh weight	Trends in biomass over 6 years (total area and sub-areas)	Stable or increasing (taking into account natural fluctuations).
Coverage	mussel coverage of the beds (%)	Trends in coverage over 6 years (total area and sub-areas)	Stable or increasing (taking into account natural fluctuations).

Source: Anon 2008. TMAP Monitoring Handbook. Tidal Area – Blue mussel beds (version 15.5.2008).

Annex 6: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – *Ostrea edulis* beds

Biological and ecological features

1. The native or European flat oyster (*Ostrea edulis* L.) is a sessile, filter-feeding, bivalve mollusk. It is associated with highly productive estuarine and shallow coastal and open sea habitats with sediments ranging from mud to gravel. *Ostrea edulis* is widely distributed around the British Isles, the North Sea, Mediterranean and Black Seas. This was still an abundant species in the southern North Sea and the Channel up to the 18th and 19th centuries, with numerous large offshore oyster grounds producing up to 100 times more than today's 100-200 tonnes (Source: UK Habitat action plan; http://www.ukbap.org.uk/UKPlans.aspx?ID=495).

Threats

2. During the 20th century its abundance declined significantly in European waters. The dramatic reduction is attributed mainly to over-exploitation but also to impacts from introduced species. The American oyster drill *Urosalpinx cinerea* and the slipper limpet *Crepidula fornicata* were introduced with the oyster *Crassostrea virginica* from North America around 1900. *Urosalpinx* is a predator alongside indigenous species such as crabs, starfish, dog whelks, shell boring worms and sponges. *Crepidula* is a filter feeder that deposits pseudofaeces and creates `mussel mud`. This mud degrades the grounds and hinders recruitment, but dead *Crepidula* shell provides culch upon which oyster settle. The impact of *Crepidula* on deeper oyster beds is possibly limited.

3. Severe winters, such as those experienced in 1947 and 1963, caused high mortalities in the UK, particularly on the east coast where stock levels have not recovered to the pre-1963 levels.

4. The parasitic protozoan *Bonamia ostreae* has caused massive mortalities in France, from whence it was introduced, and in the Netherlands, Spain, Iceland and England. Another protozoan parasite, *Marteilia refringens*, has also been found in French stocks.

5. TBT (tri-butyl tin) in anti-fouling paints used on ships and leisure craft in the early 1980s caused stunted growth and probably affected reproductive capacity.

6. There are many other factors that affect oyster stock abundance, most contributing to the high variability of recruitment: temperature, food supply, hydrodynamic containment in a favourable environment, anthropogenic effects (e.g. coastal development, waste disposal). Also spawning stock density or biomass may be too low in many areas to ensure synchronous spawning or sufficient larval production for successful settlement. (Source: UK Habitat action plan; http://www.ukbap.org.uk/UKPlans.aspx?ID=495).

7. The former distribution of offshore deeper beds remains largely unknown. Coastal populations may be more exposed to severe weather conditions (see point 3 above) than beds in the open-sea, making it likely that survival rates are higher in open-sea beds than in inshore waters. This aspect of the ecology of the species remains unknown, as oyster science in the 20th century was largely driven by cultivation needs. It seems logical that after mass mortalities experienced by inshore beds, a recolonization of the habitat must take place, and it is plausible that most of released propagules originated from less affected neighboring populations. In the historic literature of the 19th century, many references mention that these beds were populated with large oysters named 'horseshoe oysters'. The occurrence of such very old specimens, probably over 20 years, indicates that the population was producing large amounts of propagules, probably more than coastal beds, where the

maximum age of oysters was much lower, especially in exploited beds. It seems thus likely that these offshore beds may have been more important for the regional population dynamics than previously considered. Offshore beds might have acted as a source of propagules for inshore beds after mass mortality events in inshore beds.

8. Even though the historical distribution has not been drawn up and summarized in the literature yet, there is a lot of information on the historical beds in the open-sea. These previous occurrences may be considered as disappeared reef structures. In Belgian waters, dominated by sand and mud, such wild beds existed in open-sea gravel grounds between large sand banks. These beds were destroyed in the late 1860s by a targeted fishery. While reviewing the historic literature, it was found that such was the case for all open-sea beds in the southern North Sea and Channel (Jean-Sebastien Houziaux, MUMM, Belgium).

Aspects related to objectives, monitoring and assessment

9. Heterogeneity is a typical feature linked to the tri-dimensional structure of the substratum in oyster beds. This is accompanied by high species richness. A species inventory would be very labour-intensive and require destructive sampling. However, indicator species can be identified.

10. The UK Habitat Action Plan has set the following objectives and targets:

- Maintain the existing geographical distribution of the native oyster within UK inshore waters.
- Expand the existing geographical distribution of the native oyster within UK inshore waters, where biologically feasible.
- Maintain the existing abundance of the native oyster within UK inshore waters.
- Increase the abundance of the native oyster within UK inshore waters, where biologically feasible.

11. Other targets include:

- Ensure adequate recruitment to maintain stock abundance. Target to be defined following a review
- Endeavour to stop the spread of the introduced pests *Urosalpinx cinerea* and *Crepidula fornicata* beyond their existing distribution.
- Control stock density to reduce the risk of transmission of disease.
- Endeavour to prevent the introduction of the oyster disease *marteiliosis*, and limit the spread of *bonamiosis*.
- Maintain genetic variability. Target to be defined.

Annex 7: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – *Sabellaria spinulosa* reefs

Biological and ecological features

UK Habitat action plan (http://www.ukbap.org.uk/UKPlans.aspx?ID=38):

1. *Sabellaria spinulosa* reefs comprise dense subtidal aggregations of this small, tube-building polychaete worm. *Sabellaria spinulosa* can act to stabilise cobble, pebble and gravel habitats, providing a consolidated habitat for epibenthic species. They are solid (albeit fragile), massive structures at least several centimetres thick, raised above the surrounding seabed, and persisting for many years. As such, they provide a biogenic habitat that allows many other associated species to become established. This includes a range of epibenthic species with their associated fauna and a specialised 'crevice' infauna, which would not otherwise be found in the area.

2. *Sabellaria spinulosa* requires only a few key environmental factors for survival in UK waters and presumably also elsewhere. Most important seems to be a good supply of sand grains for tube building, put into suspension by strong water movement (either tidal currents or wave action). *Sabellaria spinulosa* appears to be very tolerant of polluted conditions. The worms need some form of hard substratum to which their tubes will initially be attached, whether bedrock, boulders, artificial substrata, pebbles or shell fragments. However, the presence of extensive reefs in predominantly sediment areas indicates that, once an initial concretion of tubes has formed, additional worms may settle onto the colony enabling it to grow to considerable size without the need for additional 'anchorage` points. Published work has noted that the planktonic larvae are strongly stimulated to settle onto living or old colonies of *Sabellaria spinulosa*, although they will eventually (after two or three months in the plankton) settle onto any suitable substratum in the absence of other individuals.

3. Given its few key requirements, and its tolerance of poor water quality, *Sabellaria spinulosa* is naturally common around the British Isles. It is found in the subtidal and lower intertidal/sublittoral fringe with a wide distribution throughout the north-east Atlantic, especially in areas of turbid seawater with a high sediment load. Recent research in the Wash using remote video, identified very extensive areas of reef rising up to 60 cm above the seabed and almost continuously covering a linear extent of 300 m. However, in most parts of its geographical range *Sabellaria spinulosa* does not form reefs, but is solitary or in small groups encrusting pebbles, shell, kelp holdfasts and bedrock. It is often cryptic and easily overlooked in these habitats. Where conditions are favourable, much more extensive thin crusts can be formed, sometimes covering extensive areas of seabed. However, these crusts may be only seasonal features, being broken up during winter storms and quickly reforming through new settlement the following spring. These crusts are not considered to constitute true *Sabellaria spinulosa* reef habitats because of their ephemeral nature, which does not provide a stable biogenic habitat enabling associated species to become established in areas where they are otherwise absent.

4. There have been no studies of the longevity of individual worms, and the longevity and stability of colonies or reefs of *Sabellaria spinulosa* are poorly known.

5. Consideration of the present and historical status of this habitat in the Wadden Sea area is useful because it has been much better studied than in the UK. Large subtidal *Sabellaria spinulosa* reefs in the German Wadden Sea, which provided an important habitat for a wide range of associated

species, have been completely lost since the 1920s. *Sabellaria spinulosa* now appears in the Red List of Macrofaunal Benthic Invertebrates of the Wadden Sea.

Threats

6. The greatest impact on this biogenic habitat is considered to be physical disturbance from fisheries activities. Dredging for oysters and mussels, trawling for shrimp or fin fish, net fishing and potting can all cause physical damage to erect *Sabellaria spinulosa* reef communities. The impact of the mobile gear breaks the reefs down into small chunks which no longer provide a habitat for the rich infauna and epifauna associated with this biotope. Research has attributed the loss of the large *Sabellaria spinulosa* reefs in the Wadden Sea to the long-term effects of fishing activity. Published work has also identified crustacean shellfisheries and potting, and molluscan shellfisheries, as the activities to which *Sabellaria spinulosa* accretions are most sensitive.

7. Aggregate dredging often takes place in areas of mixed sediment where *Sabellaria spinulosa* reefs may occur. Such dredging may affect some reefs but the impacts of this activity on the long-term survival of the reefs are unknown. However, suspension of fine material during adjacent dredging activity is not considered likely to have detrimental effects on the reef habitat. Aggregate extraction is not considered to be as significant a threat as commercial fisheries, provided that environmental assessments identify reefs, exclude licenced areas and/or establish 'refuge' zones, avoid other reef habitats while dredging, and carry out appropriate monitoring and biological study.

8. Pollution is listed as one of the major threats to *Sabellaria spinulosa* in the Wadden Sea. *Sabellaria spinulosa* reefs in this area, destroyed by fishing activities, have been replaced by beds of mussel *Mytilus edulis* and sand-dwelling amphipods *Bathyporeia* spp. This is partly attributed to an increase in coastal eutrophication, favouring *Mytilus*.

9. The risk to *S. spinulosa* from trawling and dredging has been considered high. Other research has assigned scores of moderately high to very high for damage, fragility, longevity and stability to *Sabellaria* accretions, but a low intolerance score (these species are considered to be tolerant to a moderate variety of environmental changes). Recovery was considered to be unlikely within ten years. Regeneration of this habitat is classified as 'difficult` (15-150 years) in the Wadden Sea Red List.

Aspects related to objectives, monitoring and assessment

10. <u>The following are action plan objectives and targets in the UK:</u>

By 2004 maintain the extent and distribution of existing *S. spinulosa* reefs in the UK.

By 2004 maintain the quality of existing *S. spinulo*sa reefs in the UK.

By 2004 establish and ensure necessary habitat conditions required for the re-establishment of *S. spinulosa* reef where formerly found, for example in the Essex Estuaries and Morecambe Bay.

11. Hendrick and Foster-Smith (2006) suggest that the conservation priority of a *S. spinulosa* aggregation could be determined using a scoring system based on a series of physical, biological and temporal characteristic reef features, weighted according to the perceived importance of each feature and augmented with a further score indicating the confidence in the feature score.

12. The extent and state (following the scoring system by Hendrick and Foster-Smith (2006) of *S. spinulosa* aggregations are essential ecological quality indicators for monitoring.

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Annex 8: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – *Zostera* beds

Biological and ecological features

1. Seagrass beds develop in intertidal and shallow subtidal areas on sands and muds. They may be found in marine inlets and bays but also in other areas, such as lagoons and channels, which are sheltered from significant wave action.

2. Three species of *Zostera* occur in the UK, and all are considered to be scarce (present in 16-100 ten km squares). Dwarf eelgrass *Zostera noltii* is found highest on the shore, often adjacent to lower saltmarsh communities, narrow-leaved eelgrass *Zostera angustifolia* on the mid to lower shore, and eelgrass *Zostera marina* predominantly in the sublittoral. The plants stabilise the substratum, are an important source of organic matter, and provide shelter and a surface for attachment by other species. Eelgrass is an important source of food for wildfowl, particularly brent goose and widgeon which feed on intertidal beds. Where this habitat is well developed, the leaves of eelgrass plants may be colonised by diatoms and algae such as *Enteromorpha* spp, *Cladophora rectangularis*, *Rhodophysema georgii*, *Ceramium rubrum*, stalked jellyfish and anemones. The soft sediment infauna may include amphipods, polychaete worms, bivalves and echinoderms. The shelter provided by seagrass beds makes them important nursery areas for flatfish and, in some areas, for cephalopods. Adult fish frequently seen in *Zostera* beds include pollack, two-spotted goby and various wrasses. Two species of pipefish, *Entelurus aequoraeus* and *Syngnathus typhie* are almost totally restricted to seagrass beds while the red algae *Polysiphonia harveyi* which has only recently been recorded from the British Isles is often associated with eelgrass beds. Source: UK Habitat action plan (http://www.ukbap.org.uk/UKPlans.aspx?ID=35).

3. Five different community types have been identified for seagrass beds from the southern North Sea and the Channel and 16 microhabitats including the seagrass itself, sessile epifauna, infauna and free swimming animals not confined to a special part of the community. The diversity of species will depend on environmental factors such as salinity and tidal exposure and the density of microhabitats, but it is potentially highest in the perennial fully marine subtidal communities and may be lowest in intertidal, estuarine, annual beds.

Threats

4. Throughout the world, the degradation of coastal ecosystems continues at an alarming rate and estuaries may be some of the most degraded environments because they have been the focus points for human colonisation for centuries (Beck et al., 2001; Edgar et al., 2000). Loss of seagrass abundance occurs in many coastal environments due to natural causes such as wasting disease or high energy storms. However, human activities have also led to hydro-morphological changes in seagrasses. These include: fishing activity, e.g. dredging, benthic trawling or rhizome disturbance during shellfish picking or bait digging; vessel mooring, e.g. anchor-chain scour, moorings or beaching of boats; coastal defense engineering, e.g. building groynes, sea walls or breakwaters, beach replenishment, dredging for coastal/harbour development; industrial development, e.g. land reclaim, harbor construction/maintenance, artificial reefs; and, waste dumping, e.g. sewage discharge, cooling water discharge, storm water discharge, spoil dumping, nutrient runoff (Foden & Brazier, 2007).

5. Dredging is required in many ports, to deepen and maintain navigation channels, and commercial extraction of sand and gravel takes place to meet an increasing demand for sand and gravel for construction and land reclamation (Erftemeijer & Robin Lewis, 2006). Excavation,

transportation and disposal of soft bottom material may lead to adverse impacts on the marine environment, and these aspects can be especially significant when dredging or disposal occurs in the vicinity of sensitive marine environments such as seagrass beds. Damage may occur due to a temporary decrease in water transparency, increased concentrations of suspended matter and increased rates of sedimentation, physical removal of substratum and associated plants and animals from the seabed, and burial due to subsequent deposition of material (Erftemeijer & Robin Lewis, 2006).

6. Seagrasses are very sensitive to nutrient enrichment. In temperate estuaries, areas of eelgrass habitat have been found to decrease and percentage loss of habitat to increase as nitrogen loading rates increase (Hauxwell et al., 2003). Nutrient enrichment may lead to excessive growth of opportunistic epiphytic algal species such as *Enteromorpha*, *Ulva*, *Chaetomorpha* and *Ectocarpus* on seagrass beds. Descriptive field studies have found that such algae appear to inhibit or eliminate eelgrass by overlying and smothering (e.g. Dennison et al., 1993) and excessive growth can cause serious deterioration or even the eradication of seagrass. Decline in eelgrass has also been observed, not as a consequence of shading by increased algal growth, but as a direct effect of increased nitrogen in the form of nitrate and ammonium (Burkholder et al., 1992; van Katwijk et al., 1997).

7. A wasting disease was responsible for die-back of large areas of seagrass in the UK and other places in western Europe in the 1930s. The fungus and slime mould which colonised the weakened seagrass have recently reappeared in seagrass beds around the Isles of Scilly.

8. The extent of seagrass beds may change as a result of natural factors such as severe storms, exposure to air, and freshwater pulses. Grazing by wildfowl can have a dramatic seasonal effect with more than 60% reduction in leaf cover reported from some sites. Warm sea temperatures coupled with low level of sunlight may cause significant stress and die back of seagrass.

9. Physical disturbance from a number of activities, for example by trampling, dredging, cockle picking, use of mobile bottom fishing gear, land claim and adjacent coastal development, may all impact *Zostera* beds. This is also the case for changes in the hydrological regime from various constructions and alterations of the coastal zone. Introduction of alien species such as *Spartina anglica* and *Sargassum muticum* may influence *Zostera* beds through completion and replacement.

10. Eelgrass is known to accumulate Tributyl tin and possibly other metals and organic pollutants. Several heavy metals and organic substances have been shown to reduce nitrogen fixation which may affect the viability of the plant, particularly in nutrient poor conditions. Accumulated pollutants may become concentrated through food chains.

11. Frost et al. (1999) found that bed fragmentation of seagrass had an influence on macrofauna community composition via modification of both the physical nature of the habitat and possibly the biological interactions that take place within. The authors noted that infaunal invertebrates may be the component of the seagrass ecosystem least likely to be affected by fragmentation and therefore, any significant effect noted for this community may be magnified for larger organisms such as fish which may be more dependent on patch size. Indeed, Pihl et al. (2006) found a significant reduction in fish species and a change in species structure in areas where seagrass had disappeared. *Z. marina* beds are therefore essential habitats in the recruitment process for fish, and losses of seagrass will most likely reduce the nursery function of the coastal zone for a number of commercially important species including cod and plaice. Seagrass beds are easily disrupted by environmental change and are vulnerable to damage by human activities.

Aspects related to objectives, monitoring and assessment

12. The following are action plan objectives and targets in the UK:
    - Maintain extent and distribution of seagrass beds in UK waters.
    - Assess feasibility of restoration of damaged or degraded seagrass beds. Until surveys assess the extent of the seagrass resource, it will not be possible to assess whether restoration is necessary, or to specify a final target. An interim target of 1,000 ha has been costed.

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Annex 9: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – Sea pens and burrowing megafauna

Biological and ecological features

1. This habitat typically consists of plains of fine mud, at water depths ranging from 15-200 m or more, which are heavily bioturbated by burrowing megafauna. Burrows and mounds may form a prominent feature of the sediment surface with conspicuous populations of seapens. The burrowing activity of megafauna creates a complex habitat, providing deep oxygen penetration. The habitat occurs extensively in sheltered basins of fjords, sea lochs, voes and in deeper offshore waters such as the North Sea and Irish Sea basins and the Bay of Biscay.

2. The 'Sea pens and burrowing megafauna' biotope complex is found on sandy and muddy substrata in sheltered, fully marine conditions. According to Hughes (1998) it is characterized by three species of colonial anthozoans (*Virgularia mirabilis*, *Pennatula phosphorea* and *Funiculina quadrangularis*), and a functionally-defined grouping of animals ('burrowing megafauna') which construct large, long-lasting burrows in the bottom sediments. The burrowing megafauna is a taxonomically-diverse assemblage of crustaceans (e.g. *Callianassa subterranea*, *Calocaris macandreae*, *Nephrops norvegicus*), worms (e.g. *Maxmuelleria lankesteri*) and fish (e.g. *Cepola rubescens*, *Lesueurigobius friesii*). Burrowing megafauna are difficult to sample using traditional ship-borne equipment, and most of our information on their ecology has been obtained in the last two decades using SCUBA diving and underwater video. It is clear that there are other species compositions of sea pens and burrowing megafauna that have the same characteristics as the above described associations. *Kophobelemnon stelliferum* and *Balticina christii* are other species occurring in the North Sea and elsewhere that should be considered as part of this habitat.

3. Sea pens are colonial cnidarians belonging to the Class Anthozoa, which also includes the corals and sea anemones. The sea pens (Order Pennatulacea) are the only octocoral order adapted for life on soft substrata. Each animal consists of a colony of polyps arising from a central stiffened axis, or rachis. The rachis ends in a basal stalk which anchors the colony in the sea bottom, with the polyp-bearing section held upright above the sediment. The animals are suspension-feeders, living on plankton and organic particles trapped by the polyp tentacles.

Threats

4. Bottom-trawling is considered to have the greatest impact on this habitat. The Great Mud Bank (Grande Vasière) in the centre of the Bay of Biscay is heavily trawled especially by the *Nephrops* trawler fleet. On average, the northern part is swept six times a year and this is suspected to have changed the sediment grain size through resuspension of fine materials, causing a decrease in the proportion of muds found on the Grande Vasière grounds (Bourillet *et al*., 2005). Such changes to the physical habitat have the potential to cause substantial and long-term changes to benthic ecosystems, including negative impacts on burrowing animals such as *Nephrops* (ICES, 2008). Fishing effort is currently so high that the once flagship species of seapen *Pennatula phosphorea* is now virtually absent. In the southern North Sea, the *Nephrops* habitat exists but without seapens. This is possibly due to the extensive bottom trawling activities that have taken place here over long time.

5. Organic enrichment such as from marine fish farms can also potentially impact this habitat in sea lochs and fjords. Heavy organic pollution excludes large, active megafauna such as *Nephrops norvegicus*, and probably also sea pens. Oxygen depletion is probably the most damaging consequence of organic enrichment. Deep-burrowing megafauna may also be excluded from heavily-impacted areas by hypoxia, physical burial or changes in sediment properties unfavourable to burrow maintenance. The critical thresholds of organic pollution causing changes in megafaunal communities have rarely been identified. Around the Garroch Head sludge dumping ground in the Clyde, burrowing megafauna were common where the sediment organic carbon content was < 4%, but were absent where this exceeded 6%. In semi-enclosed sea lochs, cage aquaculture of Atlantic salmon is the most common source of organic enrichment. The area of sea floor impacted by fish faeces and uneaten food will depend on the size and tonnage of the farm, on water depth, and on the local hydrodynamic conditions.

6. There are only scattered observations of the effects of other forms of pollution on this biotope complex. In the North Sea, *Callianassa subterranea* appears to be highly sensitive to sediment contamination by oil-based drilling muds. Ivermectin, an anti-parasite chemical now coming into use in the Scottish salmon farming industry, is also toxic to some benthic organisms, and may potentially affect sea loch biotopes. The introduction of non-indigenous species is an increasing cause of concern in coastal ecosystems generally, but so far there are no known examples in the biotope complex under discussion here.

Aspects related to objectives, monitoring and assessment

7. Parameters for monitoring, assessment and potential EcoQOs for quality aspects for this habitat include:

- Sediment grain size distribution
- Oxygen conditions
- Redox potential in sediments
- Macrofauna community composition
- Abundance, size composition and recruitment of key burrowing megafauna species
- Abundance, size composition and recruitment of seapens

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Annex 10: Development of Ecological Quality Objectives for Threatened and Declining Habitats in the OSPAR Maritime Area – *Modiolus modiolus* beds

Biological and ecological features

1. The horse mussel *Modiolus modiolus* forms dense beds (biogenic reefs), at depths up to 70m, mostly in fully saline conditions and often in tide-swept areas. *M. modiolus* is a widespread and common species, but the bed habitats have a more limited distribution. *M. modiolus* is an Arctic-Boreal species, with a distribution ranging from the seas around Scandinavia (including Skagerrak & Kattegat) and Iceland south to the Bay of Biscay.

2. Biological and ecological features of *M. modiolus* “beds” are reviewed by Rees (2009), Holt et al. (1998) and Anwar et al. (1990). Individuals can grow to lengths >150mm and can live for >45 years (Anwar et al. 1990). Growth, longevity and maximum sizes vary with environmental stresses in different localities (Anwar et al, 1990). Off the Faeroes *M. modiolus* occur to about 200m depth, being densest at 65-95m (Tendal & Dinesen, 2005).

There is typically a diverse fauna of epoibiota associated with *Modiolus* beds.

3. The total extent of *Modiolus* beds in the OSPAR area is unknown. Individual *Modiolus* beds usually extend over only a few square kilometres and and several semi-discrete beds may occur within a limited area. In some the beds can be mapped by acoustic survey methods (Lindenbaum, et al, 2008).

4. Beds that may have once had discrete edges will often show open tracks through them and be degraded to patchy clumps at the margins after disturbance by towed fishing gear. Bed extent is then open to differing interpretations.

Threats

5. Table. Summary of the key activities which can cause impacts to *Modiolus modiolus* beds (Rees 2009).

Type of impact	Cause of threat	Comment	Scale of threat
Destruction or degradation through extensive physical impacts	Dredge fisheries for scallops, beam and otter trawling	A previously substantial bed south of the Isle of Man was eliminated by intensive dredging for scallops in the 1970s and 1980s. In Strangford Lough Northern Ireland beds that used to cover extensive areas were reduced to isolated small clumps by trawling for scallops. With other biogenic features beds are damaged by towed fishing (Jennings & Kaiser, 1998).	Very High

Habitat loss or degradation through site specific physical damage	Infrastructure development (dam construction, coastal development, oil & gas exploitation)	Infrastructure developments such as oil platform installation, temporary placing of exploratory rigs, burial of pipelines and cables all cause local impacts. Other site specific developments such as tidal energy barrages or major port dredging could have wider effects but would be subject to EIA.	Medium - Low
Pollution: terrestrial run-off or organic overload	Agriculture, forestry and aquaculture. Dumping at sea of dredge spoil, pipe discharges of effluent or cooling water	Potential effects where enclosed water bodies suffer temporary hypoxia in bottom waters. Local effects around licensed dumping grounds, some wrecks, and effluent pipes. Effects of discharges are often mitigated by EIA and controls.	Low and local
Removal of species (mussels)	Harvesting of mussels	Take for both human consumption and bait is thought to be small. Some *Modiolus* beds can have *Mytilus edulis* seed settling on them and may have been affected by dredging the seed for mussel cultivation.	Low and local
Non-native species	Introductions for aquaculture or inadvertently	Possible effects from the spread of the King Crab *Paralithodes* which was transferred by Russia from the Pacific have been suggested (Jorgensen, 2005) but not studied in detail. Potential always exists for non-native species introduced for aquaculture to bring with them diseases or pests that cause significant impacts, although regulation reduces risks in most countries bordering the north-east Atlantic. Accidental introductions by shipping are frequent but to date no species has been reported as significantly affecting *Modiolus* beds.	Uncertain

Aspects related to objectives, monitoring and assessment

6. Rees (2009) summarizes the recommended monitoring and assessment strategies for *M. modiolus* beds. The following types of information should be obtained to monitor their status and condition:

Information on the presence of beds and their locations including changes in geographic range.

- Estimates of the overall extent of beds by the relevant Contracting Parties.
- Surveys at intervals to monitor the extent and integrity of selected beds of a range of types and throughout the geographical range. A re-survey interval of 6 years is suggested, unless specific damaging activities are known to have occurred.

- Targeted sampling to monitor the age and size frequency distribution of the mussels and whether recruitment has taken place.
- Assessment of the associated epibiota in a selected range of beds by video or diving methods. Assessment of the associated infauna by targeted sampling.
- Monitoring those activities and developments likely to be most detrimental to the beds.

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