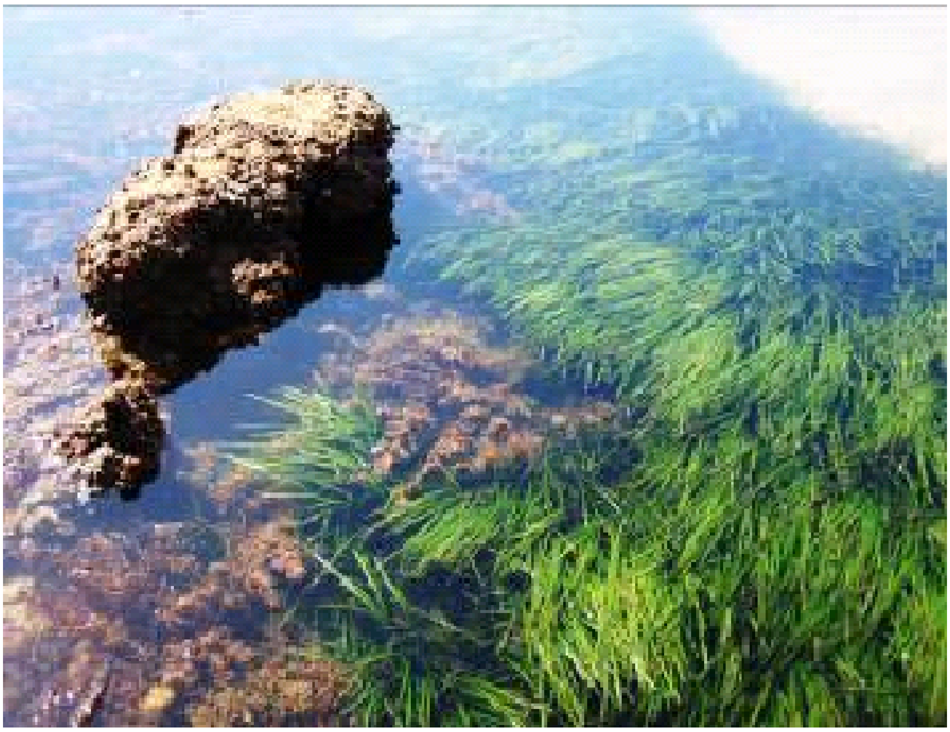
OSPAR COMMISSION

Background Document for *Cymodocea* meadows



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 document has been prepared by Beatriz Ayala for WWF as lead party.

Photo acknowledgement

Cover page: © Alexandra H Cunha, LIFE-BIOMARES

Contents

Background Document for *Cymodocea* meadows

Executive Summary

This background document on *Cymodocea* meadows 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 *Cymodocea* meadows 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 *Cymodocea* meadows, 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 Herbiers de cymodoce 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 Herbiers de cymodoce 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 Herbiers de cymodoce 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 habitat

Cymodocea beds, *Cymodocea* meadows, Seagrass beds (*Cymodocea nodosa* (Ucria) Ascherson, 1869)

EUNIS Code: A5.531, A5.5312, A5.53131 and A5.53132

Definition for habitat mapping

Cymodocea nodosa (Ucria) Ascherson, 1869

Cymodocea nodosa forms large and dense patches with green leaves than can reach 100 cm long and 8 mm wide in well shorted fine sands or on superficial muddy sands in sheltered waters and depths of 1-30 meters. Frequently is mixed with other habitat forming phanerogams (*Zostera noltii* and *Zostera marina*) at muddy sands rich in organic nutrients. Shallow meadows of *Cymodocea* and *Zostera* are usually found in sheltered bays close to harbours (e.g. Cadiz Bay), or in areas subject to human impact.

C. nodosa has a tropical origin, nowadays restricted to the Mediterranean and scattered locations in the North Atlantic from southern Portugal and Spain to Senegal, including Canary Island and Madeira. Southern Portugal constitutes the current northern geographic limit of its distribution.

2. Original Evaluation against the Texel-Faial selection criteria

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

OSPAR Regions: IV

Biogeographic zones: South European Atlantic shelf (IXa ICES Area); Benthic and neritic of the shelf and upper continental shelf (<1000 m depth) (from Dinter, 2001)

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

All where they occur.

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

Table 1: Summary assessment of *Cymodocea* meadows against the Textel-Faial Criteria

Criterion	**Comments**
Global importance	No
Regional importance	Yes. The distribution range of the Atlantic population fall entirely on Region IV, limited to Portugal and Spain
Rarity	The habitat is rare, as there are only a limited number of locations where it occurs, based on Red List of Spanish Vascular Flora (evaluation according to IUCN categories)

Sensitivity	Sensitive. *Cymodocea* meadows are much influenced by stress caused by hydrodynamic forces. Mayor disturbances such as dredging or water pollution cause extensive damage. Apparently healthy *Cymodocea nodosa* beds are know to exist in areas subject to low-level contamination using this bed as water-quality bio-indicators (Schneider *et al.* 2002). Because the buried origin of the seeds, usually germinate in the vicinity of the plant "mother", favouring the maintenance of the seagrass itself, but only under certain conditions of disturbance of the sediment, this seed can reach greater distances and give rise colonization of new spaces. Since sexual reproduction is not successful, disturbed areas will only recover by horizontal vegetative propagation from residual meadows (Alberto *et al.* 2001). It has a low resistance to turbidity that would reduce light penetration and prevent adequate photosynthesis. It has to be permanently submerged.
Ecological significance	Seagrass meadows constitute a complex ecosystem, which play a pivotal role in the coastal benthos. They strongly influence the local environment by amplifying the primary substrate, supplying nutrient to the seafloor and by providing a spatially diverse habitat structure and resources for rich algal and animal communities. Also contributes to global marine productivity. Seagrasses are an important source of primary production that may be exported to other adjacent ecosystems (beaches, mudflats, etc,) or may be buried in the sediment, contributing to the carbon removal of the system very long term. Seagrasses trapping the sediment and filtering particles from the water, either by a physical effect or due to contain a greater abundance of organisms that filter those particles. In a general way, seagrass meadows are one of the ecosystems that provide more features and services globally. When the habitat is well-developed algae, actinians, ascidians and hydroids as *Aglaophenia harpago* or *Plumularia oblique*, might colonize the leaves. The main taxonomic groups of macrofauna associated with the seagrass are generally similar to species occurring in shallow areas in a variety of substrata (e.g. amphipods, polychaeta, worms, bivalves and echinoderms). The molluscs gastropods are the most abundant within the community (Cancemi *et al.* 2002). The shelter provided by seagrass beds makes them an important nursery area for cuttlefish (*Sepia officinalis*) or the common octopus (*Octopus vulgaris*) and fishes as the gilthead seabream (*Sparus aurata*) or the stripped red mullet (*Mulus surmuletus*).

Status of decline	Significantly declined. It has been reported the decrease of *Cymodocea* at the Strait of Gibraltar during 30 years (Luque and Templado, 2004) as a result of industrial and coastal destruction that have increased turbidity to the system for a long-term period that estimated the decline by between 15% and 80% of its former natural distribution at the Gulf of Cadiz. There is a severe reduction in effective population size caused by habitat fragmentation and isolation. The absence of reproductive success of Ria Formosa Natural Park (Portugal) and its low genetic variability led to affect to the habitat quality. In other areas the decline is not well documented due to the lack of previous mapping studies. After *Cymodocea* regression, it may be replaced by invasive and opportunistic species such as *Caulerpa prolifera*, reducing significantly the seagrass associated fauna and produce great densities of the polychaete worm *Capitella capitata*. The main problem is that many of the previous functions and services rendered by *Cymodocea* meadows ecosystem are inherent characteristics of these habitats (resilience, stability, complexity, etc.) and can not be replaced by the functions and services provided by, for example, *C. prolifera* (exporting the primary production to other adjacent ecosystems, long-term withdrawal of atmospheric carbon, structural complexity and filtering water, etc.).

Relevant additional considerations

Changes in relation to natural variability: The extent of seagrass beds may change as a result of natural factors as severe storms, exposure to air and freshwater pulses. Warm sea temperatures coupled with low level of sunlight may cause significant stress and mortality of seagrasses.

ICES Evaluation: in their review of the nomination for the inclusion of *Cymodocea* meadows on the OSPAR List (ICES 2007), ICES considered that there was good evidence of decline for this species on the edge of its distribution range. The interaction of *Cymodocea* beds with the spreading *Caulerpa prolifera* green algae would deserve further investigation. The evidence of threat from a variety of human activities (particularly from construction and associated changes in local water flow/chemistry) was considered reasonable for inclusion on the list.

3. Current status of the habitat

Distribution in OSPAR maritime area

Cymodocea nodosa is found in the Mediterranean Sea and in the warmer regions of the Atlantic Ocean, from southern Portugal to the northwestern African coasts. Considering the OSPAR area, the distribution range of the Atlantic population falls entirely in Region IV, limited to Portugal and Spain. The Sado Estuary is the northern limit of its distribution.

Figure 1: Global distribution of *Cymodocea nodosa* (in Espino *et al.* 2008)

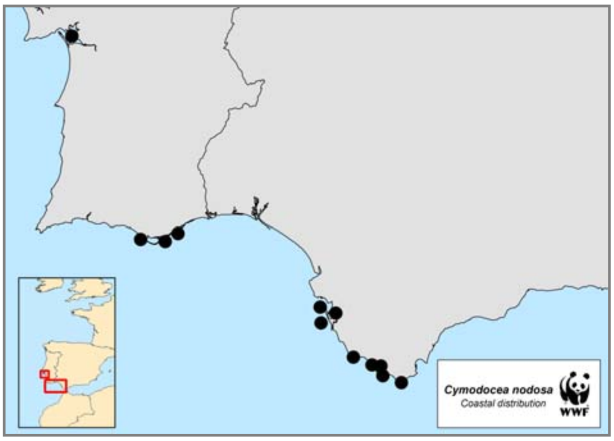


Figure 2: Geographical distribution of *Cymodocea meadows* in OSPAR maritime area

Spain: The occurrence of this species is well studied in the Bay of Cadiz, where it is fairly widespread and in acceptable condition. In the outer zone of the Bay of Cadiz, off the Cortadura beach, *Cymodocea nodosa* occurs in small patches of in sandy basins that form in the middle of the rocky intertidal zone, but it is unknown whether there are more continuous seagrass beyond the rocky area. There are also reported occurrences of *C. nodosa* meadows in the subtidal of different beaches near Tarifa (Cape Trafalgar, Valdevaqueros inlet, Bolonia inlet, western slope of the island of Tarifa), but these meadows are less developed than those of the Bay, because naturally they are exposed to increased hydrodynamic energy connected with a strong sediment dynamics which causes light limitation and burial. It is also believed that there must be *C. nodosa* in Huelva. Recently some scattered seagrasses have been found in the estuary of the Guadalquivir River, opposite Chipiona, and are present in the Corrales of Rota.

Portugal: *Cymodocea* meadows in the Ria Formosa widespread along the lagoon channels (Ponte, Caçôes, Daniel, Culatra, Areais and Moinho). Moreover, there are some meadows outside in some beaches. This species is also present in the south coast, rocky beaches like Santa Eulália, Arrifes, Marinha Galé, Senhora da Rocha; these areas are small, but are very important since it is a unique feature. *Cymodocea nodosa* is also present in Sado Estuary in small areas, being this place its northern limit of distribution along the Altlantic coasts. In any of theses places it goes below 5 meters depth.

Geographical extent

The distribution and abundance of seagrasses have declined during the last century, and the main cause is reduced water quality. Its progressive disappearance has provoked that in some places the species occurs only in isolated patches, disabling its sexual reproduction, worsening the genetic variability of the species and provoking slowly its disappearance.

The very low dispersal capacity of the seeds implies that recolonization processes are largely dependent on horizontal spread as well as new path formation from occasional seeds or vegetative fragments that may colonise the area. The recolonization could be possible if the disturbance causing the seagrass declined is limited in time and space. Observations on the dynamics of *Cymodocea nodosa* landscapes indicate that gap recolonization occurs within a year, and the meadow development takes place in less than a decade (Borum *et al.* 2004).

Condition

Spain: The conservation status of *Cymodocea nodosa* in the Bay of Cadiz (the only site from which data are available) is good, and the tendency is to remain so long as they control the main sources of impact on this ecosystem, such as harvesting and other fishing practices, the anchorage and movement of vessels, sewage disposal, etc..

In the exposed area of the Cadiz coast (area of Tarifa), *Cymodocea* meadows are poorly developed, and existing data of the Andalusian show a notable decline in the Valdevaqueros beach. However, the lack of information in this area can not determine the causes that have led to the disappearance of seagrass, and both may be due in part to natural causes (currents, storms, sediment dynamics, etc.), without excluding other anthropogenic causes which might aggravate the situation. The trend in this area is that seagrasses will disappear completely if the necessary studies will not be carried out to determine their exact extent and distribution, identify potential pressures and impacts on the ecosystem, and implement the appropriate conservation and management measures.

Portugal: There is only information available for habitats of the Ria Formosa and the Sado Estuary. It's sure that populations are decreasing, but there are historical data to compare with actual cover. Nevertheless, many actions such as channel dredging, fish and recreative harbours, have been constructed in some areas over *Cymodocea* meadows. This was the case in the Sado Estuary (new ferry boat pontoon in Tróia in 2008) and Ria Formosa (e.g. Culatra fishing harbour in 2007). Especially bad is the permission for big clam dredging boats to dredge below 5 meters depth along the Ria Formosa coast and Tróia Peninsula. Here there is the possibility that more pontoons will be constructed over *Cymodocea* meadows. In Sado Estuary the population of *Cymodocea nodosa* is very ephyphited; there is a big industrial pollution and is suspected that Cymodocea meadows have decreased a lot over the last 30 years. As *C. nodosa* is present in the coastal and rocky beaches, a possible threat would be the infilling of beach with sand to increase the beach size. That's occurring today in some beaches. Because of this, the coverage of *C. nodosa* is decreasing, but could recuperate if proper management actions are implemented.

The geographic isolation from other populations of *Cymodocea nodosa* in the south-western Iberia disables its sexual reproduction and provokes a low genetic variability (the nearest populations are located more than 300 km away, in northern Africa and the Mediterranean Sea). Both factors are important in the conservation of this species since colonization can only occur through vegetative growth. Major disturbances such as dredging, construction works, eutrophication or increased water turbidity due to shell-fishing, cause extensive damage to *Cymodocea* meadows. Since sexual reproduction is not successful, disturbed areas will only recover by horizontal vegetative propagation from residual meadows. Consequently, all plans and management affecting the seagrass habitat in this area should consider *C. nodosa* dynamics in a metapopulation perspective (i.e. the seagrass patch extinction and recolonization) with selected patches preserved to allow vegetative recolonization in disturbed areas (Alberto *et al.* 2001)

Limitations in knowledge

There are many studies on seagrass beds, and mostly general mapping of their extent and of the associated communities has been carried out in particular locations. Despite this, there is still a poor spatial analysis of the habitat.

4. Evaluation of threats and impacts

A number of the threats to *Cymodocea* beds are directly linked to human activities. There are extraction of sediments, dumping of solid waste and dredged spoils, constructions, land-based activities, placement of submarine cables and pipelines, anchoring and mobile fishing gears or fish cage farms. In Cadiz Bay, *Cymodocea* meadows are suffering from different impacts, including construction works, eutrophication, dredging and increased water turbidity due to shell-fishing and direct physical damage on the populations of the intertidal and shallow subtidal zone. Another potential threat to *Cymodocea* beds comes from the spreading of *Caulerpa prolifera*, however the ecological links are not yet established (I. Hernandez, pers. Com. in ICES review of habitat). Channel dredging is a common activity in the Ria Formosa which cause extensive damages to *Cymodocea nodosa* meadows. Moreover, this area supporting an intense mollusc fishery (about 95% of the tidal Portuguese clam production is obtained from this system), and receives urban wastewaters inputs from the adjacent cities which cause a water quality deterioration. In the case of the Sado Estuary, the main impacts on the populations of *Cymodocea* are related with channel dredging, harbour construction, industrial pollution and fishing seines.

5. Existing Management measures

The ecological importance of *Cymodocea* meadows is such that it is nowadays protected by the European legislation:

Bern Convention: Annex 1 (Council Decision of 3 December 1981 concerning the conclusion of the Convention on the conservation of European wildlife and natural habitats)

Habitat Directive: Annex 1 (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora)

Seagrass meadows are included in the following habitat types:

1110 Sandbanks which are slightly covered by sea water all the time.

1140 Mudflats and sandflats not covered by seawater at low tide (*Cymodocea nodosa* populations of the intertidal zone).

Conclusion: the provisions of the Habitats Directive protect *Cymodocea* sp. hosted in designated *Natura 2000* sites.

Table 2: Competent authorities and their role in the management of seagrass meadows

Competent Authorities	Role in the management of seagrass meadows
European Commission	European directives (direct and indirect): Nitrates, Urban Wastewater, Water Framework Directive, Bird and Habitat Directive
European Commission	Designation of *Natura 2000* Sites
National Authorities, Provincial Authorities, National Park Administration	Protection, surveillance and monitoring on MPAs for the species (National legislation, *Natura 2000* Sites and/or OSPAR MPAs)
Other organisations (e.g. WWF)	Protection, communication
OSPAR	Designation of OSPAR MPAs, nutrient reduction programmes

6. Conclusion on overall status

Marine seagrass meadows represent one of the most important habitats existing in the soft-bottom of the coastal waters around the world. This importance lies in the major richness and animal density that they support in comparison with the adjacent unvegetated bottoms.

In the North Atlantic *Cymodocea* meadows occur exclusively in waters of the Gulf of Cadiz and in southern Portugal. The habitat is threatened by diverse human activities (e.g. construction works, eutrophication, dredging and increased water closet turbidity due to shell-fishing).

Due to genetic isolation in some areas all plans and management affecting the seagrass habitat should consider *C. nodosa* dynamics in a metapopulation perspective (*i.e.* the seagrass patch extinction and recolonization) with selected patches preserved to allow vegetative recolonization in disturbed areas. Management could also include the establishment of protected areas, restoration and the control of substratum removal or physical damage to the habitat. Research actions might be implemented. Promoting awareness of the importance of seagrass beds could assist in minimizing anchor damage. Protected areas could be designated under the proposed OSPAR MPA network although the EU Habitats Directive and the Bern Convention cover seagrass.

Spain: The status of *Cymodocea* meadows in the Cadiz Bay is good, but in the rest of the sites is vulnerable or is at risk of disappearing.

Portugal: *Cymodocea nodosa* has very low genetic diversity in the Portuguese coast, which increases its vulnerability and the need for protection.

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.

Background considerations

The most important actions to prevent seagrass loss are (Borum *et al*. 2004):

a) Protection of *Cymodocea* meadows and potential seagrass areas.

b) Control and treatment of urban and industrial sewage to reduce the loading with nutrients, organic matter and chemicals.

c) Regulation of land use in catchments areas to reduce nutrient runoff and siltation due to soil erosion.

d) Regulation of land reclamation, coastal construction and downscaling of water exchange between open sea and lagoons.

e) Regulation of aquaculture, fisheries and clam digging in or adjacent to seagrass beds.

f) Create awareness of the importance of seagrasses and implement codes of conduct to reduce small-scale disturbances.

Management programmes could be designated under both national and international levels and measures could directly or indirectly benefit seagrass meadows. Protected areas should be designated under the EU Habitats Directive and included in both the Natura 2000 network and the envisaged OSPAR network of MPAs.

Possible recommendations for further measures and activities:

National and international legislation

- Enforcement of the legislation of protection.
- Include Cymodocea nodosa in the list of priority species in the Natura list of species.
- Protection of areas which have a potential for seagrass development.
- Improve and speed up nutrient reduction.

Communication

- Improve the links between local, national and international works.
- Overcome unrealistic timescales for targets.
- Long-term of continuous surveillance/monitoring including surrounding abiotic factors.

Research, gaps of knowledge

- More research in order to improve sufficient habitat and ecological information.
- (Inter)national exchange of data.

Proposals for actions and measures

Role of OSPAR:

It is proposed that the OSPAR Commission should:

a) inform the European Commission of OSPAR work to ensure that ongoing work is linked with the Habitat Directive (*Natura 2000*), Water Framework Directive and the Marine Strategy Framework Directive to avoid duplication of work;

b) agree arrangements, in conjunction with other authorities, for the coordinated implementation of the monitoring and assessment system for *Cymodocea* meadows for the OSPAR area, which co-ordinate activities at the national level for data collation, monitoring and management and build on work undertaken under existing mechanism such as biodiversity plan and *Natura 2000*.

It is proposed that OSPAR should recommend that Contracting Parties should:

a) designate areas which are important for *Cymodocea* meadows as protected areas with management plans that ensures the protection of *Cymodocea* meadows under the OSPAR MPA programme as well as within *Natura 2000*;

b) intensify efforts to reduce nutrient input into the marine environment in accordance with relevant European Community legislation;

c) implement the monitoring and assessment system in the OSPAR area.

d) avoid damaging fishing techniques over *Cymodocea* meadows, such as bottom trawling or clams dredging

e) ensure the compliance of the established conservation measures such as the 50 meters deep trawling ban through an appropriate monitoring and strong infraction penalties

f) mapping and characterization of identified *Cymodocea* meadows for fishing conservation measures purposes

g) establish and implement appropriate management measures for permitted fishing techniques such as gillnets, traps or hooks over *Cymodocea* meadows.

h) promote fishing reserves and other spatial management tools in biologically most important *Cymodocea* meadows given its importance in fish and shellfish stocks recruitments and conservation.

It is proposed that OSPAR should establish a mechanism by which Contracting Parties report back on the implementation of the above recommendations and the implementation of the monitoring and the assessment strategy so that the progress can be evaluated in conjunction with the future assessment of the status of the species.

Brief summary of the proposed monitoring system

The proposed monitoring system (see Annex 2) includes monitoring of *Cymodocea* meadows distribution and abundance from coarse assessments of presence/absence or area distribution of seagrasses in large areas to fine-scale diver assessments of depth limits and of cover, biomass or shoot density along depth gradients. These indicators all respond to changes in water quality. The upper and deep depth limits of the meadows deliver robust indications of overall status, and these are easily detectable and occur where stresses are most likely. The lower depth limit of seagrasses and their abundance in deep water are the indicators most directly coupled to water clarity as they are primarily light regulated. These indicators should therefore have high priority in monitoring programs aimed at assessing effects of changes in levels of eutrophication and siltation. Cover and density estimates are highly seasonal and should be monitored during peak vegetation period.

The selection between different monitoring options is dependent on the structure and resources available. Seagrass monitoring programmes can benefit from including variables on habitat quality in addition to seagrass indicators e.g. occurrence of epiphytes and macroalgal blooms indicate high nutrient concentrations. Such variables affect the seagrasses, and information on their level may therefore help identify reasons for status and changes in seagrass indicators and suggest corrective measures. Relevant key fauna to measure in connection with seagrass monitoring programmes may differ between regions. Water transparency, measured with Secchi disc, provides the most robust and simple indication of water quality (Borum *et al.* 2004).

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

Cymodoces meadows were nominated for inclusion in the OSPAR List in 2006 by WWF.

Expert input to the development of this background document was received from Ignacio Hernández and colleagues of the research group "Structure and Dynamics of Aquatic Ecosystems" (EDEA) of the University of Cadiz, and from Alexandra Cunha (University of Algarve).

Summaries of country-specific information provided

National overview of the distribution and extent of *Cymodocea nodosa*

The natural range *Cymodocea nodosa* spans the Mediterranean and the Atlantic south of the Iberian Peninsula, also including the island of Madeira, the Canary Islands and down to Senegal, which is its southern distribution limit. Strictly considering the OSPAR Region IV, distribution in Spain is limited to the provinces of Huelva and Cadiz (until Tarifa) and the provinces of Algarve and Setúbal in the case of Portugal.

Spain: The presence of *Cymodocea nodosa* is well studied in the Bay of Cadiz, where it is fairly widespread and in an acceptable state of preservation. In the outer zone of the Bay of Cadiz, off the Cortadura beach, small specimens of *C. nodosa* have been found, in sandy basins that form in the middle of the rocky intertidal zone, although it is unknown whether there are continuous meadows beyond the rocky area. *Cymodocea* meadows have also been located on sandy sediment in the area of the Bajo of the Cabezuela, in the Bay of Cadiz; in the rocky intertidal zone of Corrales of Rota; and at the mouth of the Guadalquivir River, front of Chipiona. Also aware of the existence of this species in the subtidal of different beaches near Tarifa (Valdevaqueros, Bolonia, etc.), but these fields are less developed than those of the Bay, because they are naturally exposed to increased hydrodynamic energy connected with a strong sediment dynamics mainly caused light limitation and burial (Garcia Gomez *et al.* 2003).

As for the province of Huelva, due to the mouth of several rivers (Guadiana, Piedras, Odiel, Tinto and Guadalquivir) also has an important sediment dynamics, making it difficult for this species could colonize the seabed. It is considered that there should be *Cymodocea nodosa* in Huelva.

Portugal: *Cymodocea nodosa* form extensive meadows in Ria Formosa in southern Portugal, which, together with scattered patches along the southwestern Portuguese coasts, represents the known northern limit of the species in the Atlantic Ocean. *Cymodocea* meadows in the Ria Formosa widespread along the lagoon channels (Ponte, Caçôes, Daniel, Culatra, Areais and Moinho). Moreover, there are some meadows outside in some beaches. This species is also present in the south coast, rocky beaches like Santa Eulália, Arrifes, Marinha Galé; Senhora da Rocha; these areas are small, but are very important since it is a unique feature. *Cymodocea nodosa* is also present in Sado Estuary in small areas, being this place its northern limit of distribution along the Altlantic coasts. In any of theses places it goes below 5 meters depth.

National information on the status and trends in condition of *Cymodocea* meadows

Spain: Information on the conservation status and trends regarding the future development of Cymodocea meadows comes mainly from the Andalusian, EGMASA or research groups located in the area. Except for the work developed by the EDEA group in the Bay of Cadiz, there is little information on this species on the Atlantic coast of Andalusia, because it has always paid more attention to the study of the Mediterranean part.

The conservation status of *Cymodocea nodosa* in the Bay of Cadiz (the only site from which data are available) is good, and the tendency is to remain so long as they control the main sources of impact on this ecosystem, such as shellfish and other fishing practices, the anchorage and movement of vessels, sewage disposal, etc.

In the exposed area of the Cadiz coast (area of Tarifa), seagrass are poorly developed, and existing data of the Andalusian showing a notable decline in the Valdevaqueros beach. However, the lack of information in this area can not determine the causes that have led to the disappearance of seagrass meadows, and both may be due in part to natural causes (currents, storms, sediment dynamics, etc.), without excluding other anthropogenic causes which might aggravate the situation. The trend in this area is that *Cymodocea* meadows will disappear completely if not carry out the necessary studies to determine their exact extent and distribution and identify potential pressures and impacts on the ecosystem there, after which it would be necessary implement conservation and management measures that are suited to this case.

Portugal: There is only information available for habitats of the Ria Formosa and the Sado Estuary. It's sure that populations are decreasing, but do not exist historical data to compare with actual cover. Nevertheless, many actions such as channel dredging, fish and recreative harbours, have been constructed in some areas over *Cymodocea* meadows, both in Sado Estuary (new ferry boat pontoon in Tróia in 2008) and Ria Formosa (e.g. Culatra fishing harbour in 2007). Especially bad is the permission for big clam dredging boats to dredge below 5 meters depth along the Ria Formosa coast and Tróia Peninsula. Here there is the possibility of construction of more pontoons over *Cymodocea* meadows. In Sado Estuary the population of *Cymodocea nodosa* is very ephyphited; there is a big industrial pollution and is suspected that Cymodocea meadows have decreased a lot over the last 30 years. As *C. nodosa* is present in the coastal and rocky beaches, a possible threat would be the infilling of beach with sand to increase the beach size. That's occurring today in some beaches. Because of this, the coverage of *C. nodosa* is decreasing, but could recuperate if proper management actions are implemented.

National information on the existing management measures in OSPAR Contracting Parties

Spain: The competent authority in the management of the seagrass meadows in Andalusia is the Autonomous Government of Andalusia, which can operate through EGMASA, but so far there is no known specific plan aimed at the management and / or conservation *Cymodocea nodosa* meadows in the Atlantic zone of Andalusia. There are some general projects mapping the coastal area of species identification and determination of the conservation state.

Studies developed by the research group "Structure and Dynamics of Aquatic Ecosystems" (EDEA; University of Cadiz) in the Bay of Cadiz have into account environmental monitoring of these meadows, which could be a good tool for developing management plans and conservation of *Cymodocea nodosa* meadows in this area.

Portugal: Regular monitoring activities in Portuguese coastal and transitional waters are described in the "Monitoring plan for Portuguese coastal waters", but it is not known whether an overview of all marine monitoring activities exists in Portugal. There is not a specific monitoring system implemented for *Cymodocea nodosa* in Portugal.

Annex 2: Description of the proposed monitoring and assessment strategy

Rationale for the proposed monitoring

Cover and density of seagrass meadows in order to observe abundance and detect changes are the most widely used parameters in seagrass monitoring programmes. The methods used are either direct observations of the distribution of the meadows, often along transects, or by remote sensing (satellite or airborne remote photography, or side scan sonar) (Borum *et al.* 2004).

The proposed monitoring system includes monitoring of seagrass distribution and abundance from coarse assessments of presence/absence or area distribution of seagrasses in large areas (with remote sensed data) to fine-scale diver assessments of depth limits and of cover, biomass or shoot density along depth gradients. These indicators should therefore have high priority in monitoring programs aimed at assessing effects of changes in levels of eutrophication and siltation. Seagrass abundance and area distribution in shallow waters are more subjected to physical disturbance like wind- and wave exposure and sediment redistribution and by human impact. Area distribution of entire seagrass populations therefore responds less predictably to changes in water quality than do deep population, but distribution maps have the advantage of providing large-scale overviews of entire populations and are useful and easily eligible supplements to the more detailed monitoring (Borum *et al*. 2004). Cover and density estimates are highly seasonal and should be monitored during peak vegetation period.

The selection between different monitoring options is dependent on the structure and resources available. Seagrass monitoring programmes can benefit from including variables or habitat quality in addition to seagrass indicators. Such variables affect seagrasses, and information on their level may therefore help identify reasons for status and changes in seagrass indicators and suggest corrective measures. Suggested quality indicators are occurrence of epiphytes and macroalgal blooms and information on key fauna species associated with seagrass meadows. Epiphytes and macroalgal blooms indicate high nutrient concentrations.

Many programmes, especially in the USA, combine seagrass monitoring with the monitoring of water, and sometimes, sediment quality, such information can help ascertain the causes of trends detected on seagrass meadows, thereby facilitating action. Among the environmental properties monitored, water transparency, measured with the Secchi disc, provides the most robust and simple indication of water quality (Borum *et al*. 2004).

Use of existing monitoring programmes

The European Environment Agency (EEA) works at the moment with two types of actions: *Increasing efficiency of monitoring* by simplifying, streamlining and making comparable existing marine monitoring data and *Convergence of assessments* by leading work towards the development of a common set of pan-European marine indicators to be complemented regionally, in order to support the implementation of the European Marine Strategy (EMS) and proposed Marine Strategy Directive's (MSD) as well to further develop its own pan-European marine assessments (Anon, 2006).

Below is a brief overview of biological elements covered by OSPAR, compared to requirements for biological elements under the Water Framework Directive and the proposed Marine Strategy Directive (Anon, 2006).

***OSPAR Common Procedure* –** Macrophytes including macro-algae; Shifts from long-lived to short-lives nuisance species. Angiosperms and macroalgae are not used as indicators at the regional sea level but OSPAR does some monitoring in the context of its eutrophication effects under the Eutrophication Monitoring Programme (OSPAR agreement 2005-4) as part of the CEMP: Macophytes, including macroalgae and angiosperm: Biomass, species composition, coverage and reduced depth distribution. Annual monitoring of biomass and species composition of macrophytes (including macroalgae and angiosperms) in (potential) problem areas relating to eutrophication (applied as an assessment parameter). In OSPAR, where the parameter in monitored only for (potential) problem areas; there are currently limited data available reported by Contracting Parties. Angiosperms are also used to evaluate the consequence on eutrophication.

***Water Framework Directive* –** The Water Framework Directive requires Member States to monitor angiosperms in transitional and coastal waters. For angiosperms, the most important parameter is distribution extension and variation in time and space (WFD Guidance Document). Monitoring frequencies are related to the degree of risk that a water body will fail to meet good ecological status.

Transitional waters: composition and changes in abundance of angiosperms.

Coastal waters: Presence of disturbance-sensitive macro-algal and angiosperm taxa. Macroalgal cover and angiosperm abundance.

Marine Strategy Directive – A description of the biological communities associated with the predominant habitats. This would include information of

- The typical phytoplankton and zooplankton communities including the typical species, seasonal and geographical variability and estimates of primary and secondary productivity;
- The invertebrate bottom fauna including species composition, biomass, productivity and annual/seasonal variability.

The structure of fish populations including the abundance, distribution and age/size structure of the population.

***Global biodiversity monitoring* –** Under the CBD no specific monitoring is required. The state of the marine environment will be evaluated through a global assessment, based on regional assessments.

***Others* –** Some seagrass meadows of the OSPAR area are included in different protected areas:

Spain: Part of *Cymodocea nodosa* meadows are included in the protected areas of the Regional Network of Protected Areas of Andalusia (Strait Natural Park). The Bay of Cadiz and the Coastal Front of the Strait of Gibraltar are considered important for biodiversity on a European scale and have been classified as sites of special interest for nature conservation under the protection of the Habitats and Birds Directives (Community Directive 79/409/EEC). Cadiz Bay has also been designated RAMSAR site for the protection of wetlands.

Portugal: The Ria Formosa and some of its hinterland were included in a 78.000 ha National Park, in recognition of its environmental value. The Ria is considered of European importance for biodiversity and has been classified as a site of special interest for nature conservation under the protection of the Habitats and Birds Directives (Community Directive 79/409/EEC). It is an Important Bird Area (IBA) and has been designated RAMSAR site for the protection of wetlands. The Sado Estuary is an important nature reserve and has been classified as a site of special interest for nature conservation under the protection of habitats and as a RAMSAR site for the protection of wetlands.

Synergies with monitoring of other species or habitats

Nutrient concentrations and light attenuation in the water column are the most important water quality parameters affecting seagrass growth. Another habitat characteristic, salinity, may also play a role. These variables therefore constitute the primary list of variables to measure in connection with seagrass monitoring programmes. Knowledge on sedimentation rate of total and organic suspended particles will also help to assess the status of seagrass meadows. These parameters are measured in monitoring programmes of eutrophication.

Trends in seagrass health can act as alarm indicators of trends in the environment, since health of seagrass meadows is closely linked to the health of the wider marine environment (Borum *et al*. 2004).

The proposed monitoring system includes monitoring of seagrass distribution and abundance from coarse assessments of presence/absence or area distribution of seagrasses in large areas (with remote sensed data) to fine-scale diver assessments of depth limits and of cover, biomass or shoot density along depth gradients. These indicators all respond to changes in water quality. The lower depth limit of seagrasses and their abundance in deep water are the indicators most directly coupled to water clarity as they are primarily light regulated. These indicators should therefore have high priority in monitoring programs aimed at assessing effects of changes in levels of eutrophication and siltation. Seagrass abundance and area distribution in shallow water are the most subjected to physical disturbance like wind- and wave exposure and sediment distribution, and by human impact. Area distribution of entire seagrass populations therefore responds less predictably to changes in water quality than do deep populations, but distribution maps have the advantage of providing large-scale overviews of entire populations and are useful and easily eligible supplements to the more detailed monitoring (Borum *et al*., 2004).

The proposed monitoring system would also be a complement of the monitoring of rocky habitats.

Assessment criteria

Suggestion of indicators

Monitoring programmes can benefit from including variables on habitat quality in addition to seagrass indicators. Such variables affect the seagrasses, and information on their level may therefore help identify reasons for status and changes in seagrass indicators and suggest corrective measures. The table below show suggested indicators for basic and enhanced monitoring and suggestion at what status the enhanced monitoring (on habitat quality) could be required.

Table 3: Suggestion of indicators for basic and enhanced monitoring

Indicator	***Basic Monitoring***	***Enhanced Monitoring***	***Status***
Presence/absence	X		High-Good
Cover	X		High-Good
Seagrass species	X		High-Good
Depth limit	X	X	High-Good
Biomass		X	Moderate-Poor
Shoot density		X	Moderate-Poor
Filamentous algae		X	Moderate-Poor
Abundance of epiphytes		X	Moderate-Poor
Key fauna		X	Moderate-Poor
Genetic diversity		X	Moderate-poor, additional information

Techniques/approaches:

Baseline monitoring programme

Indicators of seagrass distribution
Presence/absence and area distribution of seagrasses are commonly used indicators of status and change in seagrasses at the landscape scale. Presence/absence is the simplest of all seagrass indicators.

Presence/absence and area distribution of Cymodocea meadows

Definition: A seagrass meadow is defined when seagrass cover a bigger area than 2x2 meter, when patchy it is still a meadow if it is less than 10 meters between the patches, if bigger than 10 m between patches it should be counted as a new meadow.

Method description: Presence/absence and area distribution of seagrasses can be assessed using various methods of seagrass mapping, ranging from diver observations or survey using aqua scope and differential GPS from a small boat to remotely sensed data from satellites or airborne sensors. In general areas of less than 1 ha (1:100) and up to 1 km^2 (1:10,000) can be investigated by divers, aqua scope and drop down video, but in larger areas the remote sensing methods are more appropriate. Aerial photography is the most common remote sensing method for seagrass mapping studies and for monitoring over time, while satellite are valued for large-scale localisation investigations (Borum *et al.* 2004).

In clear shallow waters with seagrasses occurring on a light, sandy bottom, the contours of the meadows can be easily be distinguished in remotely sensed images such as aerial photos. Ground surveys, are essential to make sure that other underwater such as macroalgae, reefs or mussel banks are not mistakenly identified as seagrass meadows. Ground surveys alone, however, are often too costly and inconvenient for mapping large coastal areas. Short and Coles (Short & Coles, 2001) gives a summary of available and appropriate techniques for mapping seagrasses in areas of different size and water depth.

Method evaluation: The choice of method depends on the purpose of the monitoring. When the objective is to catalogue the presence/absence of seagrasses or coarsely asses the area distribution, the choice is for macro-scale maps of low resolution. By contrast, when the objective is to provide detailed data on distribution and change in seagrass areas or to estimate the biomass, the best choice is high resolution maps. If a finer scale mapping is necessary, a differential GPS can be used to delineate at patch level. Results from the assessments can be visualized in maps showing changes in seagrass distribution. These maps can be created in e.g. Arc View, a geographical information system (GIS) program, which also can be used for calculation of seagrass changes (Güllström, 2006).

Explanation: Status and changes in seagrass beds are important in order to overview the extent of the decline and recovery. Presence and area distribution of seagrasses may be reduced by human impact. Eutrophication primarily increases shading because of phytoplankton blooms and increased growth of epiphytes and thereby reduces depth limits, abundance and area distribution of the seagrasses. Physical impacts, such as construction of harbours and dredging, have more direct and drastic effects at least in the directly impacted areas (Borum *et al.* 2004).

Colonisation depth of Cymodocea

Colonisation depth is one of the best-known seagrass indicators of water quality, due to its well-described relationship with water clarity and the relative ease with which it can be estimated precisely.

Definition: Colonisation depth is defined as the maximum water depth at which seagrasses grow. The maximum depth of well-defined meadows or as the depth of the deepest growing shoots (Borum *et al.* 2004).

Method description: Colonisation depth can be determined by scuba diving or drop down video along a depth gradient to the maximum depth of the population. Several subsamples (e.g. with transects) within each site and coastal area are needed due to the considerable variation (Borum *et al.* 2004). Instead of having one observation per depth gradient, the diver may swim along the lower limit of the meadow and record depth limits at several points. The diver records the depth limit using a high-precision depth recorder. The water depth must be corrected to average water levels. Determination should be carried out in the growth season and preferably at the same time of the year in multi-year comparisons.

Method evaluation: Depth limits can be estimated with relatively high precision if good depth sensors are used and if water depth is corrected depending on the tidal level at the sampling time. Other advantages are that the method is non-destructive and allows repeated measurements at the same location. It must be clear, however, whether sampling refers to the depth limit of meadows or of individual shoots and, if the former is the case, the depth limit must be defined precisely e.g. as the maximum depth where seagrasses cover a given fraction (e.g. 10%) of the bottom (Borum *et al.* 2004).

Explanation: The depth limit is primarily determined by water clarity, and hence closely related to nutrient levels. Different investigations shown that reductions on colonisation depths of seagrasses is partly caused as a consequence of poorer light conditions, and that eelgrass depth limits increase significantly as nitrogen concentrations decline and water clarity increases.

Indicators of seagrass abundance

The abundance of seagrasses shows a characteristic depth dependence, the highest abundance typically being found at intermediate waters depths where level of exposure and light are moderate. A seagrass abundance changes markedly on an annual basis, it is important of all indicators of abundance that comparisons between years are based on samplings performed at the same time of the year, at biomass maximum. Seagrass abundance can be measured as cover, biomass and shoot density.

Cover

Seagrass cover describes the fraction of sea floor covered by seagrass and thereby provides a measure of seagrass abundance at specific water depths. Depending on sampling strategy, seagrass cover may reflect the patchiness of seagrass stands or the cover of seagrass within the patches, or both aspects.

Definition: The fraction of sea floor covered by seagrass, measured as a cover of seagrass leaves on a 0-100% scale.

Method description: As cover is depth dependent, any measure of cover must be related to water depth. The study area can be either coarsely defined as a corridor through which the diver swims, or be more precisely defined as quadrates of a given size. Percent cover of seagrasses is usually estimated visually by a diver as the fraction of the bottom area covered by seagrass. The cover can be estimated directly in percent or assessed according to a cover scale. A recommendation is to standardize the estimates using an existing guide or by making a photo calibration guide with photos on representative quadrats from 1-100% (Duarte & Kirkman, 2001).

Method evaluation: A visual estimate of percent cover is a simple, non-destructive way of quantifying seagrass abundance. Cover estimates are coarse but well suited for surveys at the landscape level. It is however a risk that they may be made subjectively, as cover estimates are based on visual observation and it is important, therefore, that the divers making them are trained.

Explanation: Light climate and exposure levels are the main factors regulating seagrass cover along depth gradients. Seagrass cover is a more sensitive indicator of eutrophication at intermediate water depths and in deep water, where light plays a major regulating role, than in shallow water, where physical exposure has a marked influence. Both shoot density and shoot length affect this estimate and, consequently, meadows consisting on dense, short shoots may have the same cover as meadows of sparser but longer shoots. Cover is therefore less sensitive to changes in light climate than is shoot density (Borum *et al.* 2004).

Biomass of Cymodocea

The indicator is useful for detailed analyses of changes in seagrass abundance. The method can also be used in connection with area distribution measures to estimate the standing stock of seagrasses in a given area (Borum *et al.* 2004).

Definition: Biomass is the weight (dry weight, fresh weight or ash-free dry weight) of *Cymodocea* leaves per unit area (m^2) and thereby provides a measure of seagrass abundance along depth gradients. The measure refers to either the total biomass or the aboveground biomass of the seagrasses.

Method description: Biomass is measured by divers harvesting within sampling frames. It is recommended that samples be taken randomly within stands rather than including samples from bare areas, because this sampling strategy reduces the variability of the estimates (Borum *et al.* 2004). Some sampling programmes even recommend that samples be taken randomly within the densest stands; others recommend standardized depth, in order to reduce the variability further. The number of sub-samples and monitoring sites needed depends on the spatial variability of seagrasses in the area. In the laboratory, the samples are rinsed, dried to constant weight, weighed and related to the area of the sampling frame. As biomass is depth dependent, any measure of biomass must be related to water depth.

Method evaluation: The method provides a relatively precise measure of seagrass abundance, and is repeatable if the sampling strategy is well defined. The method has the disadvantage of being destructive and is relatively costly, requiring sampling in the field as well as subsequent laboratory work (Borum *et al.* 2004). The between-year variation is often large and therefore it is recommended to carry out measurements for at least three years (Duarte & Kirkman, 2001).

Explanation: Biomass is a measure of seagrass abundance along depth gradients, which are related to water clarity. Changes in seagrass meadows will likely be shown by changes in biomass (Duarte & Kirkman, 2001). Seagrass biomass tends to decline exponentially from the depth of maximum abundance towards the depth limit, thus paralleling the decline in light availability with increasing depth.

Shoot density

The clear exponential decline in maximum shoot density with depth suggests that shoot density responds faster than biomass and cover to changes in light climate and consequently is the more sensitive of the seagrass abundance indicators. It should therefore be possible to forecast seagrass shoot density under future water quality regimes with higher precision than cover and biomass (Borum *et al.* 2004).

Definition: Shoot density is the number of seagrass shoots per m^2 and thereby provides a measure of seagrass abundance along depth gradients.

Method description: Shoot density can be measured in connection with biomass measurements by counting the number of shoots in the harvested samples before the samples are dried (see above). Shoot density can also be measured in a non-destructive manner by counting the number of shoots within given sub-areas in the field. As shoot density is depth dependent, any measure of shoot density must be related to water depth.

Method evaluation: The method provides a relatively precise measure of seagrass abundance. Counting shoots in harvested samples requires less laboratory work than processing of biomass samples but the method is still relatively time-consuming. Counting shoots in the field increases the sampling time in the field but requires no laboratory work.

Explanation: The maximum shoot density at given water depths shows a clearer exponential decline with depth than do biomass and cover, indicating that shoot density is regulated in a more direct and deterministic manner than the other abundance variables (Borum *et al.*2004).

Enhanced monitoring programme

Indicators of seagrass quality

Seagrass monitoring programmes can benefit from including variables on habitat quality in addition to seagrass indicators. Such variables affect the seagrasses, and information on their level may therefore help identify reasons for status and changes in seagrass indicators and suggest corrective measures.

Presence and amount of filamentous algae

Macroalgal blooms may be an obvious component of seagrass ecosystem when ambient nutrient concentrations are high.

Definition: Abundance of filamentous algae, either as cover (%) or as biomass (dry weight, fresh weight or ash-free dry weight) per unit area (m^2).

Method description: The abundance of macroalgal blooms can be measured either as cover or as biomass using the same methods as described for seagrasses. Percent cover of the seafloor of filamentous algae can be measured either with aerial photos or by using quadrates randomly placed at the samples sites.

Method evaluation: Macroalgal blooms may vary markedly over time both because they grow fast and because it is regulated by wind exposure and can be decimated after a storm. Sampling must therefore be repeated several times during the growth season to represent the site properly (Borum *et al*. 2004).

Explanation: The amount of filamentous algae can be used as a proxy of nutrient richness in coastal waters. The presence of the genera *Ulva, Cladophora* and *Enteromorpha* which thrive under nutrient rich conditions can be used as an indicator of deterioration of sediment quality for seagrass growth. Eutrophication-gained filamentous algae (mainly ephemeral) may shade seagrasses, hamper water exchange and cause a decline in associated faunal communities, e.g. shrimps and crabs (Borum *et al*. 2004). In shallow stagnant waters with limited oxygen pools, as well as in deeper stratified waters, the oxygen-consuming decomposition of ephemeral algae and detritus may lead to anoxia and formation of hydrogen-sulfide in the bottom sediment. High water temperature also simulates microbial decomposition rates and thereby further increases the risk of anoxia.

Abundance of epiphytes

Epiphytes may be a prominent component of seagrass ecosystem when ambient nutrient concentrations are high.

Definition: Abundance and species composition of seagrass epiphytes.

Method description: Sampling shoots with associated epiphytic assemblages with a net bag attaches to a frame. The epiphytes are rinsed from the shoots, taxonomically identified and the dry weight is measured.

Method evaluation: sampling of epiphytes is costly. Epiphytic biomass may vary markedly over time because the organism grow fast and because epiphyte biomass is regulated by wind exposure and can be decimated after a storm. Sampling must therefore be repeated several times during the growth season to represent the site properly (Borum *et al.* 2004).

Explanation: Epiphyte abundance and species composition in seagrass meadows can be used as a proxy of nutrient richness in coastal waters (Borum *et al*. 2004).

Key fauna

Seagrass meadows host a large number of animal species. When the habitat is well-developed actinians, ascidians and hydroids as *Aglaophenia harpago* or *Plumularia oblique*, might colonize the leaves. The main taxonomic groups of macrofauna associated with the seagrass are generally similar to species occurring in shallow areas in a variety of substrata (e.g. amphipods, polychaeta, worms, bivalves and echinoderms). The molluscs gastropods are the most abundant within the community (Cancemi *et al.* 2002). The shelter provided by seagrass beds makes them an important nursery area for cuttlefish (*Sepia officinalis*) or the common octopus (*Octopus vulgaris*) and fishes as the gilthead seabream (*Sparus aurata*) or the stripped red mullet (*Mulus surmuletus*).

Information of the fauna species associated with seagrass meadows often reflect plant health and may also add to the general understanding of the importance of seagrass beds for coastal biodiversity. Relevant key fauna to measure in connection with seagrass monitoring programmes may differ between regions, but examples are:

- Fish – there are fish species that are “permanent residents” in the seagrass meadows. Examples are pipefish and sea sticklebacks. Exclusive feeding on living seagrass leaves is rare; in general fishes that feed fresh leaves also depend on other food resources, such as epiphytes or small invertebrates. Fish can be sampled with underwater visual census (Borum *et al.* 2004).
- Sea urchins – are often important grazers of seagrasses. Herbory by sea urchin occasionally (overgrazing events) can be so intense that it may even result in the elimination of extensive seagrass patches. The density of sea urchins increases with increasing nutrient concentrations in plant tissues, and, hence, in the environment. Sea urchins can be sampled with underwater visual census (Borum *et al.* 2004).

The underwater visual census is a quantitative estimation of the abundance of fishes and large epibenthic invertebrates by transects in clear waters environments. There are other techniques available for assessing the abundance and biomass of fishes and epibenthic invertebrates, such as gill nets, drop nets, etc., in turbid waters (Borum *et al.* 2004).

Genetic diversity

Genetic diversity also provides important information about the status, susceptibility and change within a seagrass community. Seagrass habitat degradation may cause loss of genetic diversity, consequently lowering the potential for populations to survive and to adapt to changing environmental conditions. However, this indicator requires relatively great man power and advanced and expensive equipment. Hence, it should only be applied where important specific questions have been clearly defined (Borum *et al*. 2004).

Definition: Genetic diversity is the combination of different genes found within a population of a single species, and the pattern of variation found within different populations of the same species.

Method description: Measurement of genetic diversity with molecular markers can be used to understand not only the genetic composition of each population but also at what scales there is dispersal of seeds, and what is an appropriate management unit (population genetically differentiated from others). A pilot study is necessary to be able to estimate the number of samples needed for a representative sample of the population but is often suggested that 50 samples per population are sufficient to give a reliable estimate of the genotypic diversity (Borum *et al*. 2004).

From the samples DNA is extracted. From every sample genetic markers are used to determine the genotype of the sample at each locus (i.e. determining the multilocus genotype). The genetic markers yielding the best resolution to identify distinct clones on the basis of their multilocus genotypes are usually microsatellite loci, because there are hyper-variable markers. Having this data, various population genetic parameters are estimated (genetic diversity, population differentiation and gene flow at various scales), for which a variety of software packages are available. To avoid erroneous conclusions it is essential to choose markers that are capable of distinguishing different genotypes as opposed to clonal repeats (Borum *et al*. 2004).

Method evaluation: Microsatellite markers are very sensitive for determination of genotypic diversity and its spatial and temporal variability. However this requires a large number of polymorphic microsatellite loci to be used, and therefore high costs. Moreover, the feasibility of the method is limited by the requirement of rather specialised expertise and equipment, and it is destructive in the sense that cells must be obtained (and therefore destroyed) from the organisms, but is non-destructive for the whole organism, because only a small portion of material is sufficient for the analysis of genotype. Due to the high cost in equipment, consumables and man-power, and the high level of specialised training that this indicator requires, it is not recommended as a general use indicator, but only when more thorough population studies are needed / possible.

Explanation: Characterisation of the geographic differentiation of populations is critical for understanding whether meadow recovery can rely of the neighbouring populations as sources for recovery, or to choose source populations for restoration. A recent reduction in genetic diversity or in gene flow between populations can be indicative of deterioration environmental conditions (Borum *et al*. 2004).

This indicator is useful in any meadow at any time, depending on what population parameters are required to be understood, for example, within population genetic diversity (e.g. if it has been reduced or increased following some perturbation), or scales of gene flow (e.g. if barriers to dispersal have been created). The forecasting power on the indicator is poor in terms of short term predictions, because the genetic composition reflects events that took place over a long time scale, and the factors shaping it may have changed considerably for the time period for which one is attempting to make predictions. It is more an indicator of the past history. However, understanding past history can certainly be helpful in predicting what will happen in the same factor / events that took place in the past will continue to occur (Borum *et al*. 2004).

Indicators of the environment

Water quality and climatic variables: Nutrient concentrations and light attenuation in the water column are the most important water quality parameters affecting seagrass growth. Another habitat characteristic, salinity, may also play a role. These variables therefore constitute the primarily list of variables to measure in connection with seagrass monitoring programmes (Borum *et al.* 2004):

- *Light attenuation* – can be measured simply by using a Secci disc or more precisely using a light meter to measure actual light levels at different positions in the water column and then calculate the light attenuation per meter water column.

- *Nutrient concentrations* – inorganic concentrations are often low and difficult to detect in summer so it may be a better choice to measure inorganic nutrient concentrations in winter and/or total nutrient concentrations in summer.
- *Salinity* – can e.g. be measured automatically using a probe or using a refractometer.

Sedimentation: Human activities in the littoral zone increase the inputs of organic matter to the sediment and the growth and survival of seagrasses decrease as this input increases. Knowledge on sedimentation rate of total and organic suspended particles will help to assess the status of seagrass meadows. The rate of suspended particle deposition on seagrass sediments can be measured by deploying benthic sediment traps (Borum et. al. 2004). Details on sampling methods can be found in e.g. Gacia *et al.* (Gacia *et al.* 2003).

Selection of monitoring locations

Whenever possible it is advisable to sample all the localities where the species is found. If this is not possible, consider at least one or two sites that can serve as reference for their good state of preservation, and will have to monitor closely those sites which are most likely to suffer a significant degradation of seagrass meadows.

In order for the monitoring to be efficient in detecting possible changes in seagrass distribution and abundance it is important that the variability of the estimates is a low as possible. The lower the variability of the estimate, the smaller the identifiable year-to-year differences in seagrass parameters.

Timing and Frequency of monitoring

Timing
Mapping of seagrass presence and abundant should therefore be performed at the annual biomass maximum and preferably at the same time of the year in multi-year comparisons.

The best time to carry out monitoring programmes of *Cymodocea nodosa* meadows is in summer, because it is when that species reaches its maximum potential development in nature.

Frequency
The sampling rate, once established baseline values or reference can be annual, though, if should have sufficient resources, it is always preferable seasonal frequency. In cases where severe impacts are identified which may lead to drastic changes in the ecosystem in a short time, it is preferable to increase the frequency to monitor the influence of these impacts on *Cymodocea nodosa* meadows.

In areas with no knowledge about the distribution and status of *Cymodocea* meadows one suggestion is to start monitoring with an intense sampling to conduct a baseline assessment and thereafter when variability is known decide and continue with a full monitoring programme.

Data collection and reporting

Data recorded from the samplings should include date, time, site or transect description, quadrate size, number of replicates, GPS location, tide condition and water depth. Below is an example:

1. General
   1.1. Institutes
   1.2. Title: Seagrass monitoring
   1.3. Aim: Documentation of the development of seagrass *Cymodocea nodosa*
2. Sites
   2.1. Area and frequency
      ·Mapping area
      ·Frequency and time of the year
   2.2. Parameters

      Basis:
      - Location of seagrass beds: coordinates of seagrass beds (GIS polygon)
      - Coverage of seagrass-species: Seagrass coverage of the beds (%)
      - Area: size of seagrass beds (km^2)
      - Depth limit: single shoots or bed extent (m)

      Additional:
      - Biomass of seagrass species per unit area (m^2)
      - Number of seagrass shoots per m^2
      - Cover (%) or biomass (per m^2) of eutrophication-related algae
      - Species composition (*Cymodocea nodosa*)
   2.3. Methods
      - Remote sensing
      - Ground survey/Field mapping, GPS (transects, sampling plots)

   Field surveys should be carried out:
      - as ground truth in conjunction with remote sensing.
      - to monitor areas with scattered occurrence of seagrass (<20% coverage) including potential seagrass areas.
      - to get more detailed information (quantitative and qualitative) to be able to characterize the ecological status of the seagrass beds.

   The surveys should be carried out during peak vegetation period (in summer).
   2.4. Analyzing methods
3. Data handling

All data obtained from aerial and field surveys should be transferred to a geographical information system (GIS) for the analysis and assessment of the data (spatial and temporal development) and in combination with other GIS based information.

4. Quality assurance

Appropriate monitoring protocols should be developed on national level. Intercalibration exercises should be carried out nationally and in the framework of OSPAR.

Quality assurance

A sampling programme should include the following:

1. a predetermined sampling plan that takes into account the specific purpose of the investigations, including the parameters to be determined, and the type of analyses to be performed:
2. sample collection by personnel trained in the sampling techniques and procedures specified;
3. maintenance of the sample integrity by using sampling devices that have been found to be suitable for the particular purpose, avoiding confusion of samples;
4. using transportation procedures that ensures that the composition of the sample or the concentrations of the variables are nor altered;
5. instructions for labelling the sample specifying its identity;
6. a record that demonstrates an unbroken control over the sample from collection to its final deposition.

Necessary documentation includes:

- a clear description of sampling equipment
- a clear description of all steps in the sampling procedure
- a clear description of the methods used
- protocols for sample identification and analyses
- clear labelling of samples and signature of the person responsible

Appropriate monitoring protocols need to be developed on national level. Intercalibration exercises are suggested to be carried out nationally and in the framework of relevant EU directives.

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WFD intercalibration technical report, Part 3 – Coastal and Transitional Waters, Section 5 – Angiosperms, Final Draft/Final April 08 NEA.

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ISBN 978-1-907390-28-9
Publication Number: 487/2010