OSPAR COMMISSION

Trend analysis of maritime human activities and their collective impact on the OSPAR maritime area

Biodiversity Series

2009

OSPAR Convention

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

Convention OSPAR

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

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Executive Summary

Cumulative effects of human activities have raised concern in the OSPAR maritime area

Human uses of the sea have the potential to impact on both coastal and offshore environments through a wide range of effects, both individually and cumulatively with other activities. They include fisheries, mariculture, shipping, offshore oil and gas activities, tourism, wind-farm development, cable laying, land reclamation, coastal defence, construction works, artificial reefs, sand and gravel extraction, dredging for navigational purposes and dumping of dredged spoil. Most human uses in the OSPAR maritime area have increased in the past decade and are expected to further increase in the future. This report gives an account of trends of human activities as input to the Quality Status Report 2010 and describes the process of developing approaches to cumulative effects assessment (CEA) in line with the requirements of the EU Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Habitats and Marine Strategy Framework (MSFD) Directives and the Espoo and OSPAR Conventions.

The biggest increase of human activities is in the North Sea and Celtic Seas (Region II and III)

This assessment has shown that the greatest increases in human activities since 1998 are in Region II (Greater North Sea) and Region III (Celtic Seas). Activities in Region V (Wider Atlantic) are limited. The assessment shows that whilst certain activities will decline in some areas in the future (for example oil & gas activities in Region II) others are expected to increase significantly (for example development of offshore wind-farms in Region II). This implies that the related environmental pressures will change accordingly.

Methodologies for cumulative effects assessments are still under development

Cumulative effects could derive from the effects of multiple instances of the same activity, the effects of more than one activity leading to the same disturbances or the effect of more than one activity leading to multiple disturbances.

Expert workshops, national case studies and the work of an OSPAR Intersessional Correspondence Group have provided the basis of information for this assessment and the development and partial testing of the approach for CEA. Two case studies included in this report describe the development and application of CEA approaches in Norway and the Netherlands.

Trend analyses of the human activities were extracted from the various assessments of the environmental impacts of human activities prepared under OSPAR's Joint Assessment and Monitoring Programme (JAMP). This showed whether these activities were increasing, decreasing or stable within each of the five OSPAR Regions. A series of pressure types were identified, including: habitat damage; habitat loss; contamination; siltation rate changes; removal of target species. These pressures were then matched with the associated activities. In the absence of data on the spatial and temporal extent, intensity and frequency of these pressures, data for the activities was used as a proxy.

Understanding the pressures provides the basis for understanding, studying and ultimately quantifying cause and effect relationships between the activities and impacts on the marine environment. The example of the pressure 'siltation rate change' is used to describe the CEA approach developed and trialled within this project. This example highlights the steps required and the limitations involved with the approach, including how uncertainty is factored into the analyses.

The approach used in this assessment has shown that by adopting a semi-quantitative methodology it is possible to establish relationships between human activities and pressures. This assessment

highlights the limitations of current data sets that need to be addressed if more quantitative assessments are to be undertaken in the future.

Commonly accepted methodologies for cumulative effects assessments are needed

This assessment recommends that OSPAR should:

- Continue to exchange information between Contracting Parties on methods and results of CEA methods currently being developed and applied by Contracting Parties;
- Develop commonly accepted methodologies for CEA;
- Exchange experience with other Regional Seas Conventions;
- Consider whether existing regulation and arrangements adequately cover transboundary cumulative impacts.

Recapitulatif

Les effets cumulatifs des activités humaines ont causé des inquiétudes dans la région maritime d'OSPAR

Les utilisations humaines de la mer ont la capacité d'impacter les environnements côtiers et offshore à travers une large gamme d'effets, à la fois de manière individuelle et en se cumulant avec d'autres activités. Elles comprennent la pêche, la mariculture, la navigation maritime, les activités offshore du pétrole et du gaz, le tourisme, les parcs éoliens, la pose de câbles, la reconquête des terres sur la mer, la défense des côtes, les travaux de construction, les récifs artificiels, l'extraction de sable et de graviers, le dragage pour la navigation et les immersions des déblais de dragage. La plupart des utilisations humaines dans la zone maritime d'OSPAR ont augmenté durant les 10 dernières années et sont prévus d'augmenter dans le futur. Ce rapport fournit un bilan des tendances des activités humaines en tant que contribution pour le bilan de santé 2010 et décrit le processus de développement des approches pour l'évaluation des effets cumulatifs (CEA) en ligne avec les exigences des directives européennes « Evaluation des impacts environnementaux (EIA) », « Evaluation stratégique environnementale (SEA) », « Habitats », « Stratégie pour le milieu marin (MSFD) » ainsi que les conventions Espoo et OSPAR.

La croissance la plus forte des activités humaines se situe dans la mer du Nord et les mers celtiques (Région II et III)

Cette évaluation a montré que les croissances les plus fortes des activités depuis 1998 ont eu lieu dans la Région II (mer du Nord au sense large) et Région III (mers celtiques). Les activités dans la Région V (Atlantique au large) sont limitées. L'évaluation montre que pendant que certaines activités déclineront dans certaines zones dans le futur (par exemple les activités pétrolières et gazières dans la Région II) pour d'autres il est prévu une augmentation significative (par exemple les parcs éoliennes offshore dans la Région II). Les pressions environnementales qui y sont liées changeront en conséquence.

Les méthodologies pour l'évaluation des effets cumulatifs sont toujours en cours de développement

Les effets cumulatifs peuvent provenir des effets variés de la même activité : les effets de plus d'une activité menant aux mêmes perturbations ou les effets de plus d'une activité menant à de nombreuses perturbations.

Les ateliers d'experts, les études de cas nationales et le travail du groupe intersessionnel par correspondance d'OSPAR ont fourni la base d'informations pour cette évaluation, ainsi que pour le développement et l'examen partiel de l'approche pour la CEA. Deux études de cas incluses dans ce rapport décrivent le développement et l'application des approches de la CEA en Norvège et aux Pays-Bas.

Les analyses de tendance des activités humaines ont été tirées des différentes évaluations d'impacts environnementaux des activités humaines préparées dans le cadre du programme conjoint d'évaluation et de surveillance (JAMP) d'OSPAR. Cela a montré si ces activités ont augmenté, baissé ou se sont stabilisées dans chacune des cinq Régions d'OSPAR. Une série de type de pressions a été identifiée incluant : l'endommagement d'habitat, la perte d'habitat, la contamination, les changements du taux d'envasement, le retrait des espèces cible. Ces pressions ont été reliées aux activités associées. En l'absence de données sur l'extension spatiale et temporelle, l'intensité et la fréquence de ces pressions, les données pour ces activités ont été utilisées comme une procuration.

Comprendre les pressions fournit la base pour comprendre, étudier et finalement quantifier les causes et des effets des liens entre les activités et les impacts sur l'environnement marin. L'exemple de la pression « changement du taux d'envasement » est utilisé pour décrire l'approche de la CEA développée et testée pendant ce projet. Cet exemple reflète les étapes requises et les limitations impliquées par cette approche, incluant la manière dont l'incertitude est incluse en tant que facteur dans les analyses.

L'approche utilisée dans cette évaluation a montré qu'en adoptant une méthodologie semi-quantitative, il est possible d'établir des relations entre les activités humaines et les pressions. Cette évaluation souligne les limitations des données actuelles qui ont besoin d'être levées pour mener des évaluations plus quantitatives à l'avenir.

Les méthodologies communément acceptées pour les évaluations des effets cumulatifs sont nécessaires

Cette évaluation recommande à OSPAR de :

- Continuer à échanger des informations entre les Parties Contractantes sur les méthodes et résultats des méthodes de CEA actuellement développées et appliquées par les Parties Contractantes ;
- Développer des méthodologies communément acceptées pour la CEA ;
- Echanger les expériences avec les autres conventions de mers régionales ;
- Examiner s'il existe une régulation et des arrangements adéquats qui couvrent les impacts transfrontaliers et les impacts cumulatifs autres que les impacts environnementaux.

1. Introduction

1.1 Background

Human uses of the sea have the potential to impact on both coastal and offshore environments through a wide range of effects. They include fisheries, mariculture, shipping, offshore oil and gas activities, tourism, wind-farms development, cable laying, land reclamation, coastal defence, construction works, placement artificial reefs, sand and gravel extraction, dredging for navigational purposes and dumping of dredged material.

Cumulative effects of human activities taking place in the OSPAR maritime area have raised concern over the past few years and there are also specific impacts that result from more than one activity for example marine litter, microbiological contamination, introduction of non-indigenous species and underwater noise.

Cumulative effects can be defined as: “all effects on the environment which result from the impacts of a plan or project in combination with those overlapping effects from other past, existing and (reasonably foreseeable) future projects and activities” (OSPAR, 2008g).

There are different types of cumulative effects interaction:

(i) Effects of multiple instances of the same activity (for example multiple wind-farms in a coastal area);

(ii) Effects of more than one activity leading to the same disturbances (for example accumulation of noise emissions caused by shipping, exploration drilling and construction of wind-farms); and

(iii) Effects of more than one activity leading to multiple disturbances (for example accumulation of the effects of noise of wind-farm construction and the effects of fisheries).

Despite all efforts by the international research community to further develop cumulative effects assessment (CEA) methodologies (for example Halpern *et al.*, 2008), considerable gaps in knowledge remain. To date no common methodology or understanding of CEA has been agreed, hampering the development of a transparent and widely accepted approach for the OSPAR maritime area. In the meantime, environmental impact assessments of projects and plans often attempt to address the issue of cumulative effects but mainly at a highly qualitative level and often it is difficult to compare the outputs with those of other environmental impact assessments. Although there is clear evidence that human activities in many parts of the OSPAR maritime area are increasing, there are gaps and limitations related to a paucity of data on spatial and temporal trends for some human activities and on their effects on the marine environment as well as the absence of an agreed harmonized approach.

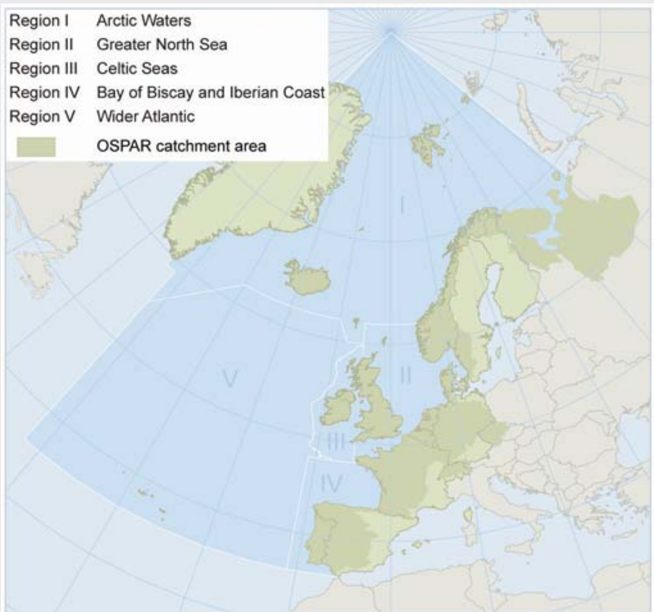
The purpose of this assessment is to prepare a trend analysis of all the different human activities listed in Appendix 3 of OSPAR’s Joint Assessment and Monitoring Programme (JAMP) (OSPAR Agreement 2003 – 22) and their collective impact on the OSPAR maritime area. This report provides input for the conclusions in the Quality Status Report 2010 in particular on the overall ecosystem quality and main pressures in the different OSPAR Regions. There might be differences, however, between the information presented in this assessment and the QSR 2010 syntheses report which has taken into account the results of additional source material. This report also supports the development of robust and widely-accepted methodologies for CEA. Two case studies from OSPAR Contracting Parties (the Netherlands and Norway) describe different approaches for CEA on a national level.

1.2 Preparation of the assessment

This assessment is mainly based on information on human activities and pressures extracted from OSPAR's different thematic JAMP BA-5 Assessments of the impacts of human activities on the marine environment (see Box 1). In addition, this assessment is based on the activity-pressure-ecosystem relationships described in the UK HBDSEG Regional Assessment Framework (Connor, 2009). The content of this report has been developed during workshops (Dublin/Ireland, 15 – 16 September 2008 and Lowestoft/UK, 3 November 2008), involving the task managers of the JAMP BA-5 Assessments of human activities and invited national experts and by an OSPAR Intersessional Correspondence Group under the OSPAR Biodiversity Committee (BDC).

Box 1
Electronic navigator to the JAMP Assessments of the impact on the marine environment of the following human activities:

- Tourism and recreational activities (OSPAR, 2008a)
- Dumped conventional and chemical munitions (OSPAR, 2008b)
- Offshore wind-farms (OSPAR, 2008c)
- Dumping of wastes at sea (OSPAR, 2009a)
- Dredging for navigational purposes (OSPAR, 2008d)
- Placement of artificial reefs (OSPAR, 2009b)
- Construction or Placement of Structures (other than Oil and Gas and Wind-farms) (OSPAR, 2008e)
- Land reclamation (OSPAR, 2008f)
- Cables (OSPAR, 2009c)
- Sand and gravel extraction in the OSPAR maritime area (OSPAR, 2009d)
- Coastal defence (OSPAR, 2009e)
- Mariculture (OSPAR, 2009f)
- Fisheries (OSPAR, 2009g)
- Shipping (OSPAR, 2009h)
- Offshore oil and gas activities in the North-East Atlantic (OSPAR, 2009i)
- Marine litter (OSPAR, 2009k)



OSPAR maritime area and its five Regions

During the workshops all available information on human activities was entered into a spreadsheet[1], to obtain the activity-related information per pressure per region. The aim was to provide information on the relative contribution of each activity to a specific pressure and the relative contribution of a pressure to the collective pressure. For every OSPAR Region the following information on human activities was extracted from the JAMP BA-5 Assessments and entered into the spreadsheet or used otherwise to support the assessment:

- Determination of the spatial extent (% of the area) of each activity per region (coastal zone/shelf/deep sea) and representation of the spatial footprint on maps;
- Selection of priority pressures (based on pressure list in United Kingdom Framework matrix (Connor, 2009);
- Description of the intensity, frequency, seasonality, geographical variation of the various activities across regions[2];
- Description of trends (2000 – 2020, or longer, if possible).

It should be noted that OSPAR's work on CEAs is still work in progress. This report has been partly based on unpublished expert judgement obtained during the workshops for those areas where there is incomplete information on the extent and environmental impacts of human activities in the OSPAR maritime Area.

All outputs of the BA-6 assessment process were also made available to a Regional Assessment Workshop (Utrecht, the Netherlands; 9 – 13 February 2009; OSPAR 2009j) that also supported the development of the Quality Status Report 2010.

2. What has been done?

The Ecosystem Approach is the main tool of the OSPAR Commission for the management of human activities. This requires a thorough understanding of their cumulative effects on the marine environment. However, to date, there are very few examples of large-scale assessments of the cumulative effects of human activities in the OSPAR maritime area (see case studies in Annexes 3 and 4) and no common methodology has been agreed for the OSPAR maritime area.

In the OSPAR maritime area CEAs are required for new projects, plans and programmes through the Espoo Convention (incl. Kiev Protocol), the EU EIA Directive (Directive 85/337/EEC, as amended by Directives 97/11/EC and 2003/35/EC) and SEA Directives (Directive 2001/42/EC) and the EU-Habitats Directive (Council Directive 92/43/EEC).

The need for robust CEAs has also been taken up by the European Marine Strategy Framework Directive (2008/56/EC) which requires an assessment of cumulative and synergistic effects in the initial assessment of current environmental status of waters and environmental impact of human activities by 2012. The work carried out by OSPAR Contracting Parties for this assessment will be an important input to the process of implementing the Directive.

A detailed overview of relevant legislation on CEAs in the OSPAR maritime area and gaps in understanding, including recommendations on the implementation of CEAs, are given in OSPAR 2008g.

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[1] The spreadsheet was based on the methodology used for the case study on cumulative effect assessment of the Dutch EEZ (see Annex 4).
[2] See Annex 1 for a clarification of these terms.

3. Trends of human activities and pressures

In total 27 potential main types of pressures were identified by the expert workshops and the process for the preparation of the BA-6 Assessment. Some have been regrouped subsequently leaving a total of 21 types of pressures (see Table 3.1).

Table 3.1 *Potential main pressures of human activities in the OSPAR maritime area.*

** Original types of pressures (see below)*

Habitat damage* Habitat loss* Introduction of microbial pathogens (disease) Introduction or spread of non-indigenous species & translocations (competition) Contamination* Removal of target species (lethal) Removal of non-target species (lethal) Underwater noise disturbance Siltation rate changes Hydrological changes* Atmospheric climate change	Barrier to species movement (behaviour, reproduction) De-oxygenation Electromagnetic changes Input of nitrogen & phosphorus Litter Mortality of mobile species (collision) Organic enrichment Temperature changes – local Visual disturbance (behaviour) Wave exposure changes – regional/national
Habitat damage (i.e. reversible effects expected): - *Habitat damage* - *Habitat structure changes - abrasion & other physical damage* - *Habitat structure changes - removal of substratum (extraction)*	*Habitat loss (i.e. permanent effects expected):* - *Habitat change (to another substratum)* - *Habitat loss (to land)* - *Habitat loss*
Contamination - *Non-synthetic compound contamination - Heavy metals, Hydrocarbons (+produced water)* - *Synthetic compound contamination (inc. pesticides, antifoulants, pharmaceuticals)*	*Hydrological changes* - *Emergence regime changes (inc. desiccation) - local* - *Water flow (tidal currents) rate changes – local* - *Wave exposure changes – local*

3.1 Trends in the OSPAR Regions

The different JAMP Assessments of human activities (see Box 1) show that human activities and related pressures are increasing in most parts of the OSPAR maritime area. Relevant information on trends of human activities and related pressures has been extracted from these assessments and is presented in Annex 2 of this report, together with complementary information obtained during the expert workshops. The main trends and pressures are summarized in Table 3.2 and described in the following paragraphs. There may be discrepancies between the content of this report (Table 3.2 and Annex 2) and summaries provided in the QSR 2010 synthesis report which has taken into account the results of additional assessments and source material.

In Region I, since 1998, there has been an increase in shipping, oil and gas activities, mariculture, tourism and the placement of artificial reefs. Fisheries have decreased. A further increase is expected until 2020 for shipping, oil and gas activities, mariculture, tourism and wind-farms. Fisheries are expected to decrease (see Table 3.2).

In Region II, since 1998, there has been an increase of many activities and related pressures, mainly shipping, construction of coastal defence and other coastal structures, construction and operation of wind-farms, placement of telecommunication and power cables and artificial reefs, as well as an increase of oil and gas exploration and exploitation and tourism. Sand and gravel extraction, land reclamation, dredging for navigational purposes and related dumping of dredged material as well as encounters with munitions have remained more or less constant. Mariculture activities and fisheries have decreased (see Table 3.2).

A further increase is expected until 2020 for many activities, especially wind-farm developments. Due to climate change, an increase in coastal defence is expected including sand and gravel extraction, and land reclamation. Due to increasing sizes of ships, dredging for navigational purposes and related dumping of dredged material is also expected to increase. Tourism and encounters with munitions are expected to remain more or less constant, oil and gas activities as well as fisheries are expected to decrease (see Table 3.2).

In Region III, since 1998, there has been an increase of many human activities and related pressures: shipping, construction of coastal defence and other coastal structures, construction and operation of wind-farms, placement of telecommunication and power cables and artificial reefs, as well as an increase of oil and gas exploration and exploitation. Sand and gravel extraction, land reclamation, dredging for navigational purposes and related dumping of dredged material as well as mariculture, tourism and encounters with munitions have remained more or less constant while fisheries have decreased (see Table 3.2).

A further increase is expected until 2020 for all activities, especially wind-farm developments. Furthermore, due to climate change, an increase in coastal defence is expected including sand and gravel extraction, land reclamation as well as, due to bigger ships, dredging for navigational purposes and related dumping of dredged material. Mariculture is also expected to increase. Oil and gas activities as well as artificial reef constructions, tourism and encounters with munitions are expected to remain more or less constant, while fisheries are expected to further decrease (see Table 3.2).

In Region IV, since 1998, there has been an increase in many activities and related pressures: shipping, fisheries, construction of coastal defence and other coastal structures, construction and operation of telecommunication and power cables, as well as tourism. Oil and Gas exploration and exploitation, land reclamation and encounters with munitions have remained more or less constant. There has been a decrease in mariculture and artificial reef construction (see Table 3.2).

A further increase is expected until 2020 for many activities such as shipping, the construction of coastal defence and other coastal structures and cables. Aslo land reclamation, tourism, placement of artificial reefs and mariculture are expected to increase. Encounters with munitions are expected to remain more or less constant. Oil and gas activities, as well as fisheries, are expected to decrease (see Table 3.2).

In Region V, since 1998, there has been an increase of the following activities and related pressures: shipping, oil and gas activities, tourism and probably fisheries. A further increase is expected for these sectors until 2020, except for fisheries (decrease) (see Table 3.2).

Table 3.2 *Trends and pressures of human activities in the OSPAR maritime area (Source: Annex 2).*

Activity	Historic trend since 1998	Future trend until 2020	Main pressures
Mariculture	↑ : I ↓ : II and IV ↔: III	↑: I, II, III, IV	Removal of target species, introduction/spread of non-indigenous species, genetic modification, habitat damage, habitat loss, contamination, siltation rate changes, input of nitrogen & phosphorus, organic enrichment
Munitions	↔: I, II, III, IV	↔: I, II, III, IV	Habitat damage, contamination
Land reclamation	↔: I, II, III, IV	↑: (I), II, III, IV	Habitat loss, barrier to species movement, local hydrological changes, siltation rate changes, (underwater noise)
Coastal defence	↑: II, III, IV	↑: II, III, IV	Habitat damage, habitat loss, local hydrological changes, siltation rate changes, (underwater noise), Introduction/spread of non-indigenous species
Construction of structures	↑: (I), II, III, IV	↑: (I) II, III, IV	Habitat damage, Habitat loss, local hydrological changes, wave exposure changes – regional/national, siltation rate changes, (underwater noise)
Sand and gravel extraction	↔: II, III, (IV)	↑: II, III, (IV)	Habitat damage, siltation rate changes, underwater noise, de-oxygenation
Dredging	↔: (I), II, III, (IV)	↑: (I), II, III, (IV)	Habitat damage, siltation rate changes, contamination, (underwater noise)
Dumping of wastes	↔: (I), II, III, (IV)	↑: (I), II, III, (IV)	Habitat damage/loss, siltation rate changes, contamination, organic enrichment, de-oxygenation
Cables	↑: (I), II, III, IV, (V)	↑: (I) II, III, IV, (V)	Electromagnetic changes, temperature changes, habitat loss, habitat damage, siltation rate changes, (underwater noise)
Wind-farms	↑: II, III	↑: I, II, III	Habitat loss, barrier to species movement, underwater noise, habitat damage, electromagnetic changes, visual disturbance
Artificial Reefs	↑ : I, II, III ↓ : IV	↔: I, III ↑: II, IV	Habitat loss, organic enrichment, hydrological changers – local
Tourism	↑ : I, II, IV, V ↔: III	↑ : I, IV, V ↔: II, III	Habitat damage, habitat loss, litter, organic enrichment, underwater noise
Oil and Gas	↑ : I, II, III ↔ : IV, V	↑ : I, V ↓ : II and IV ↔: III	Habitat loss, contamination, underwater noise, barrier to species movement, temperature changes
Shipping	↑ : I, II, III, IV, V	↑ : I, II, III, IV, V	Underwater noise, litter, introduction of non-indigenous species and microbial pathogens, contamination, mortality due to collision
Fisheries	↑ : IV, (V)* ↓: I, II, III	↓: I*, II*, III*, IV*, V*	Removal of target and non-target species and fishing effort. (Other issues: habitat damage, litter, underwater noise, barrier to species movement)

↑ increase, ↓ decrease, ↔ no increase/decrease, ( ) minor presence or change

(underwater noise) : during construction phase only

* low confidentiality

4. Cumulative pressures of human activities – the example of siltation rate changes

Different human activities will have one or more associated pressures on the marine environment. Understanding these pressures provides the linkage to identifying impacts. Concentrating on the pressures therefore provides a basis for understanding, studying and ultimately quantifying cause and effect relationships between the activities and impacts on marine environmental parameters. The majority of the work in OSPAR to date has focussed on the pressures from individual activities to generate conclusions on how an activity affects the quality status of the OSPAR maritime area. The development of collective pressure approaches allows for marine environmental managers and custodians to develop a holistic vision of how pressures from different activities may be associated to facilitate ecosystem based management options.

The associations and relationships within and between pressures and ecosystems are complex and it is unlikely that one tool or approach will suffice for environmental management purposes. However, drawing on case studies prepared for the BA-6 assessment and utilising the experiences of contracting parties, one way of considering this problem has been developed. As such, this section of the report does not describe a definitive approach to assessing collective pressures but describes a step in the process towards this goal.

An added complication is that different ecosystem components will respond to pressures differently. As such, the same pressure can be exerted at different spatial extents depending on the component under consideration, for example for the pressure habitat damage/disturbance (if associated with wind-farm construction) for benthos and sediments this pressure could be confined to the foundations, scour pits and cable corridors; for fish and mammals it could be the whole array plus a buffer zone to account for underwater noise; for birds it could be the total footprint of the wind-farm. Pressures also have different temporal scales, with some being continuous, some being intermittent, some frequent and others infrequent. Also, as has been demonstrated within this assessment, the resolution, format and coverage of spatial data of human activities and their associated pressures are variable. Consequently, it is necessary to apply some generalisations and assumptions in any attempt to assess collective pressures, otherwise the process becomes too complicated.

To compensate for the data inconsistencies, Eastwood *et al*., 2007 used estimates of the spatial extent or footprint of each activity as a proxy for direct, physical pressure and a similar approach has been applied here in the investigation of collective pressures.

Siltation (or sedimentation) is the settling out of silt/sediments that are suspended in the water column. Taking the example of the pressure "siltation rate changes" the descriptions in the various JAMP assessments have associated this pressure with mariculture, land reclamation, dredging for navigational purposes, dumping of wastes and other materials, sand and gravel extraction, placement of cables and pipelines, construction and placement of structures and coastal defence. Table 4.1 summarises the information on this pressure extracted from Annex 2.

Table 4.1 *Description and extent of siltation rate changes due to different activities.*

Activity	**Description of pressure**	**Extent of pressure**
Mariculture	Operation: • Structures may reduce water flow • Harvesting (dredging) • Faeces / uneaten food	• Year round • Persistent activity • Coastal regions
Land reclamation	Dredging: • Predominantly caused by overflow • Finer particles than with sand and gravel extraction Construction: • Predominantly coarse sand generating less siltation	Frequency: • Occasional in terms of number of sites • Coastal habitats Dredging: • Short period (few hours) • Very local Construction: • Persistent
Coastal defence	Dredging: • Changes in the water regime • Changes in sediment, transportation • Scouring	• Coastal areas. Construction: • Soft defences - (probably) in spring • Hard defences – year round Operation • Year round Maintenance • Soft defences - between once per year and every five years • Hard defences – unknown
Construction of structures	Dredging: • Changes in the water regime • Changes in sediment, transportation • Scouring	• Persistent • Coastal • Construction – seasonal • Operation – year round
Sand and gravel extraction	During extraction: • Predominantly caused by overflow	During Extraction: • Short period (few hours) • Very local General Activity: • Persistent • Year round • Discrete coastal and offshore areas
Navigational dredging	Dredging: • Predominantly caused by overflow • Finer particles than with sand and gravel extraction	• Short period (few hours), • Very local • Coastal area Capital dredging: • Occasional activity Maintenance dredging: • Persistent • Year round
Dumping of wastes	• Local and temporal (re)suspension of sediments • Increased turbidity • Affects phytoplankton production due to decreased light penetration	• Coastal areas. Capital dredging: • Occasional activity Maintenance dredging: • Persistent • Year round
Cables	Burial of cables: • Local and temporal (re)suspension of sediments • Increased turbidity	• Construction – seasonal • Coastal areas and offshore waters

Some of the above activities will cause sediment to fall out of suspension, whereas others will mobilise sediments into suspension from which they will ultimately settle on the seabed. From all of the above descriptions it can be seen that siltation is predominantly associated with specific phases rather than a permanent feature, *i.e*. the period during and immediately after cable laying, deposit of wastes, dredging, extraction of sand and gravel, construction of structures, the act of reclaiming land, construction of mariculture facilities and dredging at mariculture sites.

Cable laying, dumping of wastes, navigation dredging, sand and gravel extraction, and construction activities will all mobilise sediment into suspension that will ultimately settle out of suspension (siltation). This would include sediments mobilised by scouring. However, once equilibrium is reached no further material will be scoured. Mariculture and construction activities could produce structures that reduce water flow resulting in siltation. It is only the faeces and uneaten food associated with mariculture activities that could be described as an ongoing persistent pressure associated with that activity.

It can be seen that there is a direct relationship between the extent and duration of the activity and the extent and duration of siltation rate changes. This pressure will be confined to a relatively small area around the activity (dependant on hydrodynamic energy and sediment transport pathways) and numerical models can be used to predict the extent of these areas. These parameters will also control the time required for the sediments to settle out of suspension.

There is no pattern in the spatial and temporal extent of the activities listed in Table 4.1. Whilst we have maps showing where these activities (and therefore the associated pressures) are located, the specific phase of the activity that will cause siltation rate changes occurs at different times, some synchronous but some not. At present there is no data presented in the JAMP assessments on the precise timing of each activity, for example for sand and gravel extraction sites an area for each site is marked on the map, however, at any one time only a fraction of that site will be worked, there are also likely to be times when the site is not being worked at all. Unless this detailed information on timing and active areas is known we can only make assumptions. A worst case would be to assume that each pressure, associated with each activity is continuous, persistent, has comparable characteristics and is prevalent across the whole footprint. This is clearly not the case and will generate an overestimation of the extent of the pressure but with detailed spatial and temporal data currently lacking this is the only option that can be used at present. Figures 4.1 to 4.4 therefore represent the maximum spatial and temporal extent of siltation rate change pressures, *i.e.* the area in which sediment is disturbed and re-deposited.

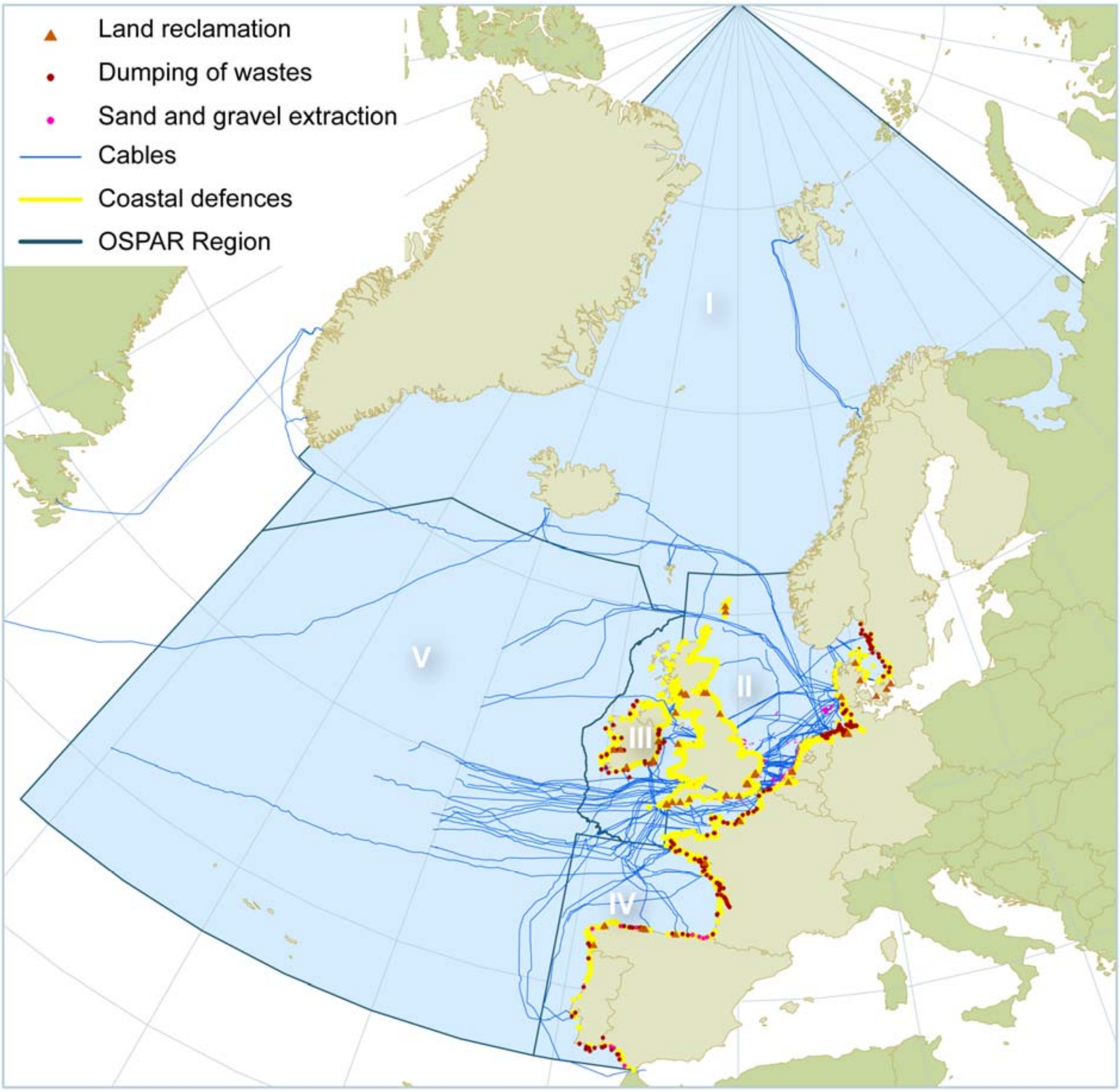

Figure 4.1 *Map showing collective human activities contributing to the pressure of siltation rate changes for the NE Atlantic Region (mariculture activities and dredging for navigational purposes are not displayed on the map).*

Source: Based on shapefiles submitted by OSPAR Contracting Parties for the preparation of JAMP assessments (see Box 1).

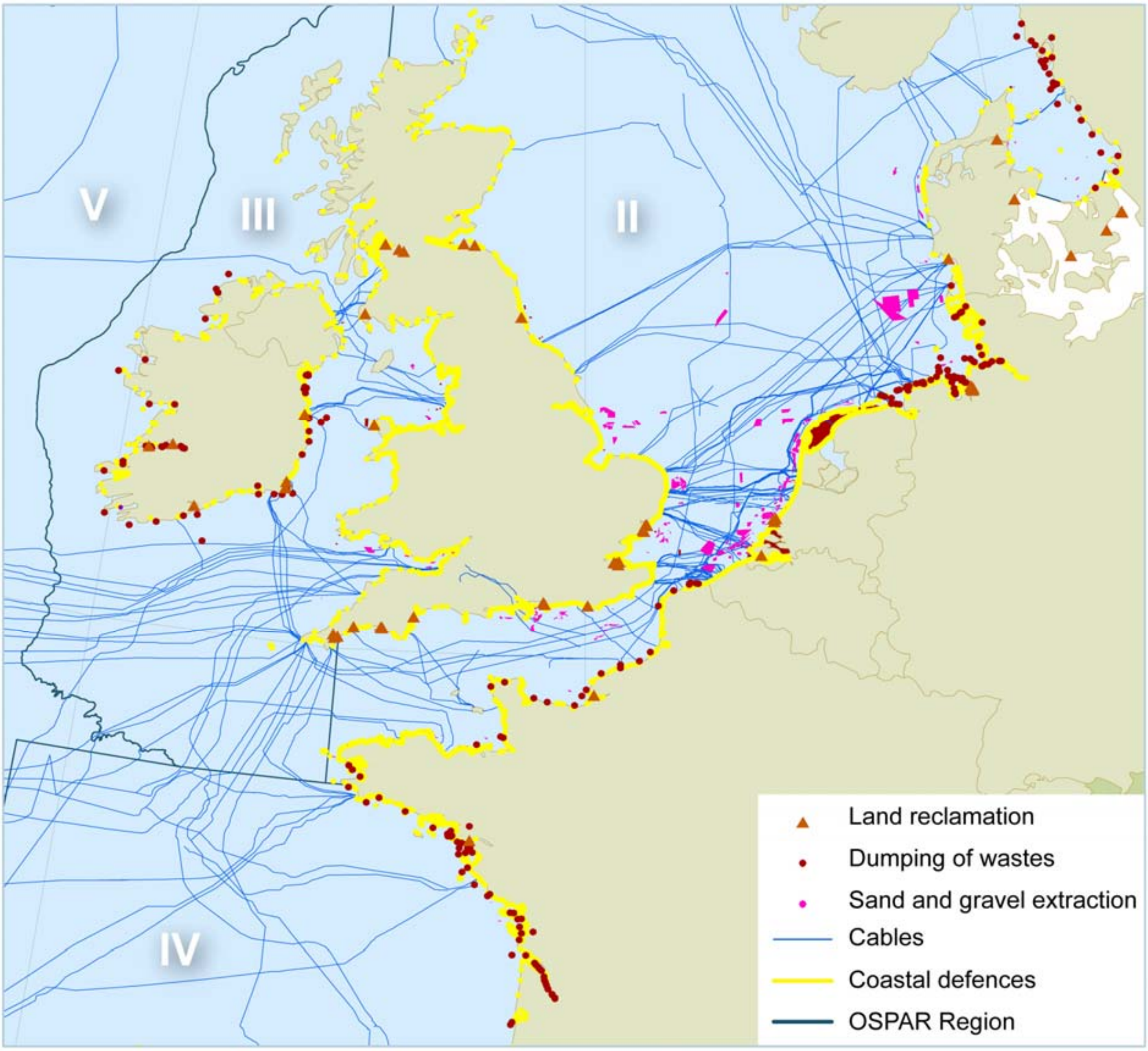

Figure 4.2 *Map showing collective human activities contributing to the pressure of siltation rate changes for an enlarged portion of the OSPAR Regions II, III, IV & V (mariculture activities and dredging for navigational purposes are not displayed on the map).*

Source: Based on shapefiles submitted by OSPAR Contracting Parties for the preparation of JAMP assessments (see Box 1).

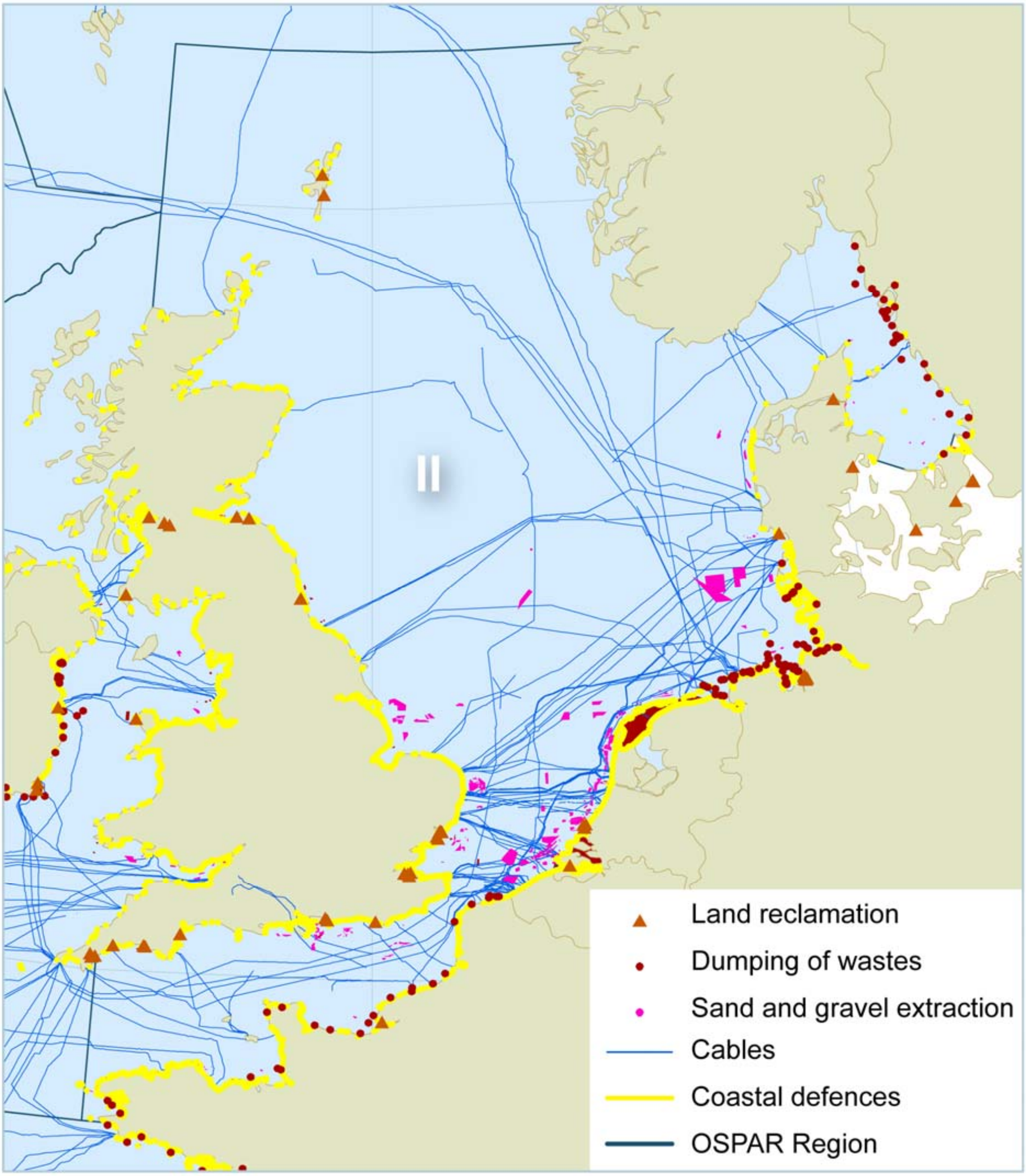

Figure 4.3 *Collective human activities contributing to the pressure of siltation rate changes for an enlarged portion of the OSPAR Region II (mariculture activities and dredging for navigational purposes are not displayed on the map).*

Source: Based on shapefiles submitted by OSPAR Contracting Parties for the preparation of JAMP assessments (see Box 1).

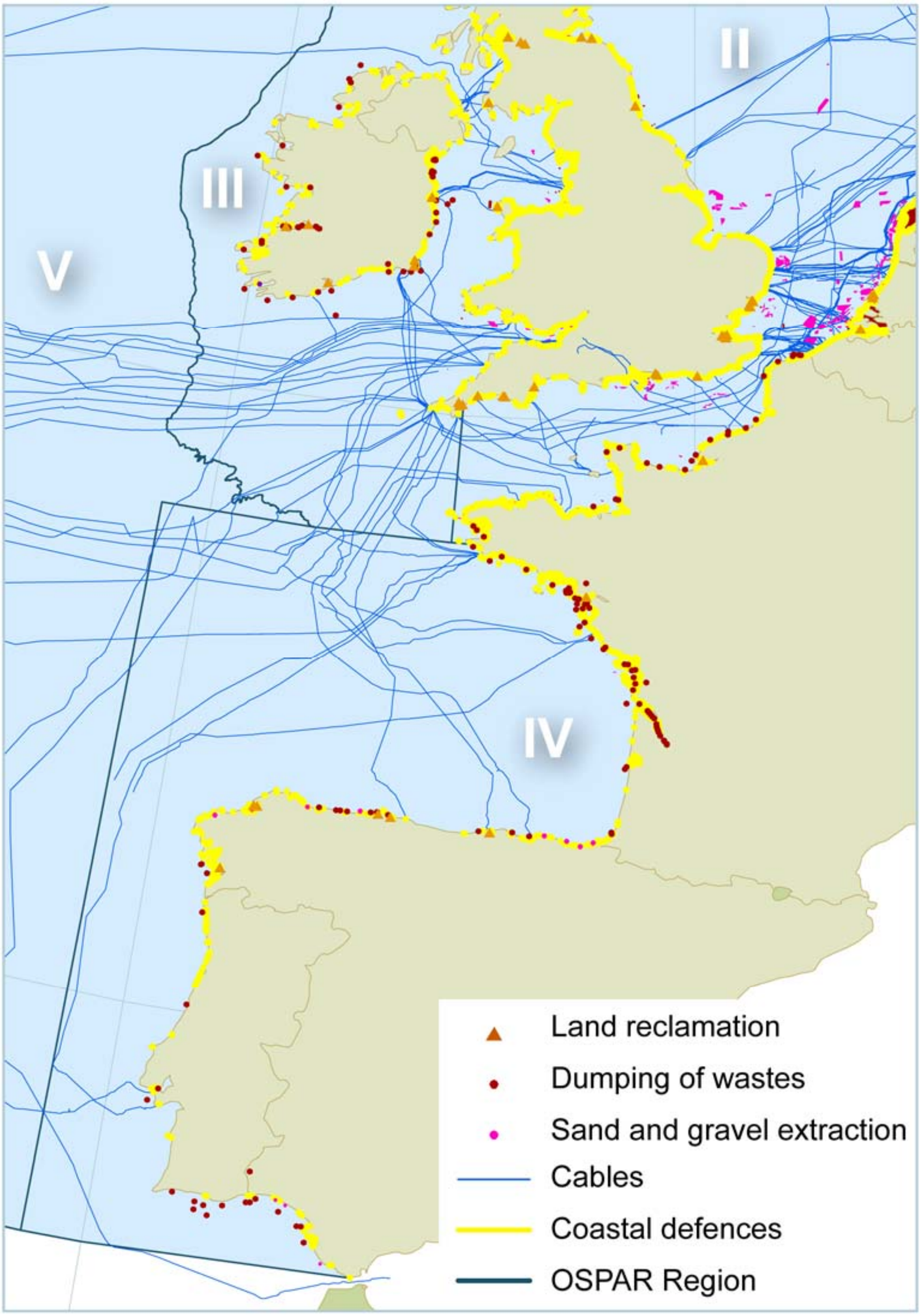

Figure 4.4 *Collective human activities contributing to the pressure of siltation rate changes for an enlarged portion of the OSPAR Regions II, III & IV (mariculture activities and dredging for navigational purposes are not displayed on the map).*

Source: Based on shapefiles submitted by OSPAR Contracting Parties for the preparation of JAMP assessments (see Box 1).

5. Case studies on cumulative effects

A second element of the work undertaken for the BA-6 assessment was the preparation of case studies by Norway and the Netherlands. There is also work ongoing in the United Kingdom to develop practical tools for cumulative effects assessments and marine spatial planning that will be tested in future case studies.

5.1 Cumulative effects in the Norwegian Sea

Norway prepared a case study on cumulative effects in the Norwegian Sea (see Annex 3). The main activities in the area are shipping, oil and gas, fishing. Climate change effects also result in environmental pressure. The effects of these were assessed and the final reports were used to develop an Integrated Management Plan in 2009 (Norwegian Ministry of the Environment, 2009). The methodology used is to assess, as far as possible, the impacts of activities on common ecosystem indicators using a common scale. The activity contributing the most to the anthropogenic cumulative effects is fishing but ocean acidification and its effects have given raise to major concern.

The case study includes a description of the method and results from the work on cumulative effects that has been used as a background document in the process of writing a White Paper on Integrated Management Plan for the Norwegian Sea (Norwegian Ministry of the Environment, 2009). The document includes maps showing areas of high importance for human activities and maps of particular ecological important areas.

5.2 Cumulative effects in the Dutch Exclusive Economic Zone

The Netherlands prepared a Case Study for the Dutch Exclusive Economic Zone (EEZ) (see Annex 4). The Assessment methodology developed for the Dutch EEZ case study assumes that effects are a function of the intensity of pressures caused by activities and the sensitivity of ecosystem components to those pressures. The methodology is semi-quantitative and based on the activity-pressure-ecosystem relationships presented in the UK HBDSEG Regional Assessment Framework (Connor, 2009). A tiered approach is used. The first tier involves scoping, scoring and cumulating, and results in a Cumulative Effect Score (CES) per ecosystem component or activity. A second tier involves geographic distribution in GIS with a sub-set of data to focus on the main issues. An overall map of CES is not presented, since the tier 2 assessment is based only on a sub-set of pressures and ecosystem components, which easily leads to misinterpretation of results. A third tier assessment would account for time dependent variability.

The results presented in the Dutch Case Study are only intended to demonstrate the method. They do not reflect the real situation. The assessment has been based on sub-sets of pressures and the quality of the data is considered moderate. Validation of the results, including a sensitivity analysis, is needed, all pressures/ecosystem elements should be included and time dependent variability should be taken into account. For this reason this report only presents effects on an imaginary ecosystem component.

6. Conclusions

6.1 Trends in activities and pressures

There has been an increase, since 1998, in all Regions in almost all activities. Regions II and III show the greatest increase and, change in Regions I and IV is to a lesser extent. Only dredging for navigational purposes, dumping of dredged material, sand and gravel extraction, land reclamation and encounters with dumped munitions have remained more or less at a constant level. Human activities in Region V are limited. Fisheries have decreased in Regions I, II and III but increased in Region IV. Future trends for almost all activities are expected to increase until 2020, with the exception of fisheries. Human activities are expected to increase significantly in Regions II and III and to a lesser extent in Regions I and IV. This implies that the related pressures are also expected to increase. Different activities can generate the same type of pressure although with different temporal and spatial characteristics.

Increasing human activities will lead to increasing related pressures although not necessarily on a proportional level due to impact-reducing measures over the years. Methods for assessing the cumulative impacts of human uses need to be agreed and implemented.

6.2 Approach and methodology - lessons learned

The methods and frameworks presented in the Norwegian and Dutch case studies are different. The Norwegian Case study is part of a two-year period of assessment project including public consultation. The Dutch Case Study has been carried out especially for the purpose to develop a CEA method. The semi-quantitative approach taken in the Dutch case study has also been used to develop the activity-pressures matrix used in the BA6 Assessment.

The approach used in the BA6 Assessment has shown that by adopting a semi-quantitative methodology it is possible to establish relationships between human activities and pressures. Whilst this approach is only looking at pressures the report does highlight data requirements for robust assessments. It has become apparent that a thorough knowledge of human activities (intensity, location) and ecosystem components (*i.e.* vulnerability, resilience) is needed to assess impacts. Such assessments are complicated due to different pressures from construction phases and operational phases.

This approach presents a systematic way to define relationships between human activities and pressures and to analyse trends and collective impacts of these pressures. It could serve as a useful example of how to deal with cumulative pressures and effects in marine ecosystems and inform the work under the Marine Strategy Framework Directive; however a number of constraints have been identified:

i. In order to quantify and/or relatively score pressure intensities, information on the sensitivity of the ecosystem is needed. This type of information is often not available and not adequately covered in the JAMP assessments of human activities;

ii. It is important to consider how to translate the surface area of a specific activity into surface areas of particular pressures bearing in mind that some pressures are dispersive such as noise or contamination whereas others might not be dispersive for example habitat loss. Draft dispersivity factors developed during the preparation of the BA6 assessment could be used for this purpose;

iii. It was noted that the pressures of some activities should be separated into those that occur during construction and those that are ongoing (operational); in Annex 2 only the operational phase has been reflected (often zero but effects during the construction phase).

The results obtained by this approach can be interpreted in different ways: from an activity perspective, from a pressure perspective and both of these from a regional, local and national perspective.

The descriptive collective pressure information, combined with the geographical information (*i.e.* where does the activity and related pressures take place) is complex, given that pressure can be exerted differently depending on the activity and the ecosystem. Given this variability, the assessment of collective pressures and CEA has to be based on a series of assumptions. The intention of such assumptions is to use expert knowledge and judgement to address uncertainty and data gaps. This provides only a simplified approach to the assessment that may lead to an overestimation of the scale of the effect. Consequently, any management actions taken in response to the collective pressures assessment may be disproportionate to the actual scale of effect. More detailed information on the timing and extent of activities is required in future so that a distinction between discrete and synchronous activities (pressures) can be determined. Consideration should also be given to the spatial scale of assessments. The relationship between different pressures also has yet to be fully investigated.

7. Recommendations

There is the need to further develop cumulative effects assessment methodologies to support the implementation of the ecosystem approach and fulfil requirements under the Marine Strategy Framework Directive. The experience gained in this report and in the national case studies indicate that cumulative effects assessment depend on a thorough knowledge of spatial and temporal extents of human activities, as well as pressures and impacts on the marine environment. OSPAR should continue to promote comprehensive assessments of the environmental impacts of human activities to inform the further development of cumulative effects assessments in the OSPAR maritime area.

In particular OSPAR should:

- Continue to exchange information between Contracting Parties on methods and results of CEA methods currently being developed and applied by Contracting Parties;
- Develop commonly accepted methodologies for CEA;
- Exchange experience with other Regional Seas Conventions;
- Consider whether existing regulation and arrangements adequately cover transboundary cumulative impacts.

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Annex 1 – Clarification of terms

Spatial distribution and extent

Indication of the spatial coverage of the respective activity and related pressures and impacts. If possible, the spatial coverage was given in percentage of the respective OSPAR Regions. Otherwise a range was given according to the following classification:

a. <10 km^2

b. 10 – 100 km^2

c. 100 – 1.000 km^2

d. 1.000 – 10.000 km^2

e. 10.000 – 100.000 km^2

f. 100.000 – 1.000.000 km^2

g. > 1.000.000 km^2

Intensity

General description of the “footprint” of the activity, for example in the case of wind-farms (offshore infrastructure) a description of the average size of individual turbines and the average density of turbines in the areas.

Seasonality

Description of the temporal spreading of an activity and its specific pressures and impacts throughout the season (for example “all year, persistent”, or “seasonal – operating from January – April inclusive”).

Frequency

Description of the frequency of an activity and its related pressures and impacts:

i. Rare: infrequent enough to affect long-term dynamics but not short-term fluctuations (events may only occur once in the assessment period);

ii. Occasional: frequent but irregular in nature (not necessarily every year and not following a regular pattern of occurrence);

iii. Annual or regular: frequent (every year) and often seasonal or periodic in nature (may occur regularly over one season within each year for example);

iv. Persistent: more or less constant all year-round.

Geographical variation

Descriptions of the geographical spreading of an activity and its related pressures and impacts, indicating whether they are confined to particular habitat types (for example pelagic only and offshore; intertidal hard substrates; coastal, out to 50 m depth maximum).

Annex 2 – Summary of activities and pressures[3]

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
Mariculture	Constant, whole year round, in coastal areas	↑ : I	↑: I, II, III, IV	Habitat damage	Smothering from faeces/ uneaten food or from production of monoculture (*for example* mussels on top of existing habitat); also damage through dredging and harvesting	I, II, III, IV
		↓ : II en IV		Habitat loss	Intentional translocations of species (*for example.* Pacific Oyster) could result in permanent habitat transformation	II, III, IV
		↔: III		Removal of target species 1	Industrial fishing for fish oil usually targets species form lower tropic level	I, III
				Removal of target species 2	Seed collection/dredging	II, IV
				Contamination	Aquaculture medicines/chemicals can result in localised water/sediment contamination	II, III, IV
				Siltation rate changes	Structures may reduce waterflow resulting in siltation; dredging activities; faeces/ uneaten food	II, III, IV
				Introduction/spread of non-invasive species 1	Genetic impacts and habitat competition from escapes; impact of sea lice on wild fish stocks	I, III
				Introduction/spread of non-invasive species 2	Can result in translocation of alien species	II, III, IV
				Input of nitrogen&phosphorus	Localised	I, II, III, IV
Munitions	Encounters, (potentially) whole year round	↔: (I),II, III, IV	↔: (I),II, III, IV	Habitat damage	Disturbance of habitat as a result of munitions detonations	II, III, IV
				Contamination		

[3] There may be discrepancies between the content of the information in Annex 2 and the summaries provided in the QSR 2010 synthesis report which has taken into account the results of additional assessments and source material.

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
Land reclamation	All year round; frequency occasional in terms of number of sites constructed but when constructed: persistent	↔: (I),II, III, IV	↑: (I), II, III, IV	Habitat loss	Physical presence of reclaimed land; habitat change due to new substrate.	(I), II, III, IV
				Barriers to species movement	Relevant for large scale reclamation only; displacement of birds will be site- and species specific and relates to feeding and resting grounds; also displaces (temporarily?) mammals (esp. during construction); based on limited data.	II
				Hydrological changes, local	Dependent on scale of site and local circumstances.	(I), II, III, IV
				Siltation rate changes	Only during dredging, in general short period (few hours);very local; mainly caused by overflow; finer particles than w/ sand and gravel extraction; for construction mainly coarse sand is used generating less siltation.	II, (III, IV)
				Underwater noise	Involves extraction of marine material (in some cases, transport to placement area and depositional activities). Extraction same as sand and gravel assessment. Transport same as maritime transportation section. So main consideration is the placement. Noise effects low.	II, III
Coastal Defence	Soft defence primarily in Region II (NL and BE) and IV (N Spain); construction mostly in spring; frequency once every 5 yr; other Regions/countries mostly hard defence; Region V: unknown	↑ : II, III, IV	↑ : II, III, IV	Habitat damage	Material scoured out around the foundation. During construction phase seabed may be disturbed. Preparatory work of the seabottom (might completely overlap with habitat loss due to structure and scouring area). Site and project specific – most at local scale.	II, III, IV
				Habitat loss	Physical presence of the structures. Scour. Habitat change due to new substrate.	II, III, IV

Activity	**Characteristics**	**Historic trend since 2000 (per Region)**	**Future trend until 2020 (per Region)**	**Main pressures**	**Description of pressures**	**Mainly present in Region**
				Underwater noise	Involves extraction of marine material (in some cases, transport to placement area and depositional activities). Main consideration is the placement. Noise effects low.	II, III, IV
				Siltation rate changes	Related to dredging for construction works; changes in the water regime and sediment transportation; scouring; etc.	II, III, IV
				Hydrological changes, local	Purpose of these developments is to modify system – site and project specific.	II, III, IV
				Introduction/spread of non-invasive species	Potential stepping stone (providing opportunities for regional spread of species and also potential barriers).	II, III, IV
Construction of structures	Widespread in Regions II, III and IV; construction seasonal; operation whole year round	↑ : (I), II, III, IV	↑ : (I), II, III, IV	Habitat damage	Material scoured out around the foundation. During construction phase seabed may be disturbed (jack-up barges, chain and anchorage drag). Preparatory work of the sea bottom (might completely overlap with habitat loss due to structure and scouring area).	(I), II, III, IV
				Habitat loss	Related to physical footprint; physical presence of the structures (incl. pipelines if not buried). Scour. Habitat change due to new substrate.	(I), II, III, IV
				Siltation rate changes	Related to dredging for construction works; changes in the water regime and sediment transportation; scouring; etc.	(I), II, III, IV
				Hydrological changes, local	Project/site specific.	(I), II, III, IV
				Wave exposure changes – regional/national	Project/site specific.	(I), II, III, IV

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
Sand and gravel extraction	Persistent, all year round in coastal areas in Region II, III, (IV)			Habitat damage	By extracting you are changing characteristics of the seabed; in most cases grain size is becoming smaller, if new habitat is being created this will be habitat with other substrate; habitat recovering, depending on extraction intensity and total period of extraction habitat recovery can take months and several years.	II, III, (IV)
				Siltation rate changes	Only during extraction, in general short period (few hours);very local; mainly caused by overflow.	II, III, (IV)
				De-oxygenation	Not relevant? Might be relevant with deeper pits (> 10 m depth); pending research.	II?
				underwater noise	Limited information – some literature for sand and gravel but not for navigational dredging. 180 dB, frequency 200 – 500 Hz and higher.	II, III, (IV)
Dredging	Closely related to nearby harbours; all year round in coastal habitats; occasional in case of capital dredging projects and persistent in case of maintenance dredging	↔: (I),II, III, (IV)	↑ : (I), II, III, (IV)	Habitat damage	Harbour areas only; difference between maintenance and capital dredging; By dredging you are changing characteristics of the seabed; if you stop dredging habitat recovery can take several years.	(I), II, III, (IV)
				Underwater noise	Comparable to sand and gravel extraction (noise levels expected to be similar). Limited information – some literature for sand and gravel but not for navigational dredging. 180 dB, frequency 200 – 500 Hz and higher.	(I), II, III, (IV)
				Siltation rate changes	Only during dredging, in general short period (few hours); very local; mainly caused by overflow; finer particles than w/ sand and gravel extraction.	(I), II, III, (IV)
				contamination	Information only on Region II.	(I), II, III, (IV)

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
Dumping of Wastes	Mainly dredged materials; closely related to nearby harbours; all year round in coastal habitats; occasional in case of capital dredging projects and persistent in case of maintenance dredging	↔: (I), II, III, (IV)	↑ : (I), II, III, (IV)	Habitat loss/habitat change	Region I: dumping of rocks Iceland/Norway: habitat change; Region II, III, IV: mainly silty material on sandy material: habitat change and changes in sediment structures; excessive deposition leads to smothering/burial of benthic communities; disposal in high energetic environments like tidal estuaries/coast zones has less impact than in low energy environments for example lagoons; spatial extent of impact approximately 1 km.	I, II, III, IV
				Organic enrichment	Local; limited impact.	I, II, III, IV
				De-oxygenation	Less relevant.	
				Siltation rate changes	Local and temporal (re)suspension of sediments, causing increased turbidity; affects phytoplankton production due to decreased light penetration.	I, II, III, IV
				Contamination	See dumping assessment.	I, II, III, IV
Cables	Especially in Regions II and III (telecom and power); construction seasonal; operation whole year round; persistent	↑ : (I), II, III, IV, (V)	↑ : (I), II, III, IV, (V)	Habitat damage	Related to the burial process.	(I), II, III, IV, (V)
				Habitat loss	Cable protection (crossing / seabed level changes etc); physical presence of the cables. Protection against fishing and anchoring (rock dumps); repeaters (2x0,5 m in size).	(I), II, III, IV, (V)
				Electromagnetic changes	Behavioural effects of more concern than physiological – potential disturbance of feeding, migration & orientation (knowledge progressing slowly), depends on cable type, burial depth, load, AC/DC. Localised. Power cables mainly (optical cables also have lower energy repeaters and associated cabling).	(I), II, III, IV, (V)
				Siltation rate changes	Related to burial of cables.	(I), II, III, IV, (V)

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
				Underwater noise	Low source levels. Cable and pipeline laying and burial techniques – noise will vary. Operational noise lower than construction - limited information – and understanding. Ship noise important for scheduling works.	(I), II, III, IV, (V)
				Temperature changes – local	Local increase in sediment temperatures due to transfer losses. Depends on temperature exchange with water column (ambient temperature, flow etc), sediment type (higher in fine sediments), dependant on load, AC/DC, cable type, burial. Links with benthic infauna, microbial and chemical processes.	(I), II, III, IV, (V)
Wind-farms	Seasonal, occasional construction; persistent, whole year round operation	↑ : II, III	↑ : I, II, III	Habitat damage	Related to the burial process of the cables associated with the wind-farm. Material scoured out around the foundation. During construction phase seabed may be disturbed (jack-up barges, chain and anchorage drag). Preparatory work of the sea bottom (might completely overlap with habitat loss due to structure and scouring area).	II, III
				Habitat loss	Physical presence of the piles (diameter app. 5 m) and scouring (pit) and scour protection. Gravity Base Structure (GBS). Habitat change to new substrate. Loss of habitat due to displacement of (specific) birds (*e.g.* divers: guillimots, based on info from Danish wind-farms). Related cables, farms may have a substation.	II, III
				Underwater noise	Pile driving or drilling. Pile driving highest – 257 dB, frequency mostly below and at 1kHz. 20 kHz max frequency reported. Operational – less than pile driving (depends on turbine capacity) 2MW 130 – 140 dB max. Maintenance vessel – similar to some shipping, condensed area. Helicopters?	II, III
				Visual disturbance	For humans only.	II, III

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
				Barriers to species movement	Displacement of birds will be site- and species specific and relates to feeding grounds (up to 2 km?), migration routes (up 10 km distance?), resting grounds, collision; also displaces (temporarily?) mammals (esp. during construction); based on limited data.	II, III
				Electromagnetic changes	Behavioural effects of more concern than physiological – potential disturbance of feeding, migration & orientation (knowledge progressing slowly), depends on cable type, burial depth, load, AC/DC. Localised. Power cables mainly (optical cables also have lower energy repeaters and associated cabling).	II, III
Artificial Reefs	Majority in Region IV	↑ : I, II, III	↔: I,III	Habitat loss	Physical presence of the structures. Scour. Habitat change due to new substrate.	I, II, III, IV
		↓ : IV	↑ : II, IV	Hydrological changes, local	Project/site specific.	I, II, III, IV
				Organic enrichment	Only for specific type of artificial reef: with aim of improving fish production, as a result of increased (fish) populations.	I, IV
Tourism	Especially in summer, less in spring/autumn; especially in Region IV, less in II and III	↑ : I, II, IV, V	↑ : I, IV, V	Habitat damage	Regions II, III, IV: Mainly for increasing coastal defence. Material scoured out around the foundation. During construction phase seabed may be disturbed. Preparatory work of the sea bottom (might completely overlap with habitat loss due to structure and scouring area). Boating involves anchorage; Regions I, V: Boating involves anchorage.	I, II, III, IV, V
		↔: III	↔: II, III	habitat loss	Mainly increasing erosion. Development of marina's and harbours. Habitat change due to new substrate.	I, II, III, IV, V

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
				Litter	Litter thrown away by tourists on the shoreline, recreational shipping etc. Bags, tins, household garbage, ropes, bottles. Cruise ships may cause special problems (Arctic): Spanish study showed no significant impact. Potential impact on marine mammals. Seabirds (Fulmars). Microplastics might be important. Sources of litter may be in other regions. In Region II: In general 600 – 1300 items/100 m beach (northern part); 200-600 items/100 m beach (southern part). No trend observed; in Region III: In general 600 – 800 items/100 m beach. No trend observed; in Region IV: In general 50 – 200 items/100 m beach. No trend observed; limited data in Regions I, V.	(I), II, III, IV, (V)
				Organic enrichment	Due to increase of waste water disposal in tourist season. Also an issue on recreational and (cruise) ships.	I, II, III, IV, V
				Underwater noise	Recreational vessels (jet skis, power boats, whale watching, sea anglers, cruises).	I, II, III, IV, V
Oil and Gas	Seasonal construction, whole year round operation;	↑ : I, II, III	↑ : I, V	Underwater noise	Seismic surveys – high, low frequency 50 – 100 Hz and higher, source levels as high as 260 dB, strong vertical beam (higher frequency – multidirectional). Pile driving (links with OWF), frequency 100 – 500 Hz and higher (20 kHz max) – varies with pile diameter – has not been measured (or at least not published). Source levels 250 dB. Test wells / drilling - lower than pile driving (2 published studies – 130-140 dB). Maintenance and patrol vessels (links with maritime transportation). Explosives potentially use for decommissioning.	I, II, III, IV, V

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
	Medium intensity in Region I	↔: IV, V	↓ : II en IV	Contamination 1 – Naturally occurring compounds in produced water (hydrocarbons, heavy metals) and drill cuttings	In areas with heavier PW load (region I) indications of effects (biomarker responses in caged mussels and fish inside a 2 km radius from the discharge point are found. Drill cuttings causes local physical covering of the sediments with layers of up to 0,5 m closest to the drilling hole, but with a very limited area receiving more than 0,1 mm. Region I: In the Norwegian sector of the Barents Sea only drill cuttings from the upper part of the wells are allowed to be discharged. Region II: Still contamination from previous discharges of oil based drilling mud, but contaminated areas are decreasing steadily.	I, II, III
	High intensity in Region II		↔: III	Contamination 2 – Deliberately added chemicals (*e.g.* drilling fluids, surface active components, biocides)	Effects of added chemicals not demonstrated. Decreasing amounts of chemicals with hazardous intrinsic properties discharged. Organic compounds in drilling fluids adhered to drill cuttings may cause temporary oxygen depletion in the sediments.	I, II, III
	Low-Medium intensities in Regions III, IV, V			Habitat loss	Physical presence of the structure (rig legs, sub-sea-completions, GBS, pipelines, cutting piles). Habitat change due to new substrate.	I, II, III, IV
				Barrier to species movement		
				Temperature changes – local	Discharge of cooling water; Very local effect because of high dilution factor.	I, II, III
Shipping	Whole year round activity, regular to persistent, mainly in coastal areas;	↑ : I, II, III, IV, V	↑ : I, II, III, IV, V	Underwater noise	Engine noise & cavitation, low frequency (below 1 kHz) ~200 dB (max), proven to increased ambient noise levels in some study areas. Potential for masking of signals – reduced communication ranges (parameters available to measure masling but not behaviour) better data for mammals, some on fish, poor data on invertebrates.	I, II, III, IV, V

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
	Low intensities in region I and V			Litter	Bags, tins, household garbage, ropes, bottles. Potential impact on marine mammals, seabirds (fulmars). Microplastics might be important. Sources of litter may be in other regions. Including nets, lines, etc. 'ghost' fishing. Region II: In general 600 – 1300 items/100 m beach (northern part); 200 – 600 items/100 m beach (southern part). No trend observed. Region III: In general 600-800 items/100 m beach. No trend observed; Region IV: In general 50 – 200 items/100 m beach. No trend observed. Limited data in Regions I and V.	I, II, III, IV, V
	Medium to high intensities in Regions III and IV			Introduction/spread of non-invasive species	160 non-indigenous species have identified in OSPAR area; ballast water – including the sediments it carries - discharges and fouling on ship's is a main route of distribution.	I, II, III, IV, V
	High intensity in Region II			Contamination	TBT is being phased out in antifouling paints so losses of TBT are expected to cease; however losses of TBT substitutes such as copper increase; oil pollution (slicks and oily wastes) appears to be decreasing due to implementation of MARPOL Annex I; air pollution increasing.	I, II, III, IV, V
				Mortality due to collision		I, II, III, IV, V
Fisheries	Demersal: coastal and offshore areas where feasible and economic; spatially variable; whole round with some seasonal variation depending on weather	No information is available for this assessment	No information is available for this assessment	Removal of target species		No information is available for this assessment

Activity	Characteristics	Historic trend since 2000 (per Region)	Future trend until 2020 (per Region)	Main pressures	Description of pressures	Mainly present in Region
	Pelagic: coastal and offshore areas where feasible and economic; spatially variable; highly seasonal	No information is available for this assessment	No information is available for this assessment	Removal of non target species		No information is available for this assessment
				Habitat damage	For demersal fishing only.	No information is available for this assessment
				Underwater noise	From fishing boats (engine noise, cavitation), less than larger vessels – 170 dB – low frequency (links to shipping). Fish finder – sonar mid to high frequencies. Contributes to ambient noise levels. Potential use of acoustic deterrents. Physical contact of fishing gear on seabed – associated noise?	No information is available for this assessment
				Barrier to species movement		No information is available for this assessment
				Litter	Bags, tins, household garbage, ropes, bottles. Potential impact on marine mammals, seabirds (fulmars). Microplastics might be important. Sources of litter may be in other regions. Including nets, lines, etc. 'ghost' fishing. Region II: In general 600 – 1300 items/100 m beach (northern part); 200 – 600 items/100 m beach (southern part). No trend observed. Region III: In general 600 – 800 items/100 m beach. No trend observed; Region IV: In general 50 – 200 items/100 m beach. No trend observed. Limited data in Regions I and V.	No information is available for this assessment
				Input of nitrogen & phosphorus		No information is available for this assessment

Annex 3 – Case study on cumulative effects in the Norwegian Sea – approach and experiences from the process of integrated management of the marine environment for the Norwegian Sea

Background and process

The Norwegian Government in early 2007 initiated a process of Integrated Management of the marine environment of the Norwegian Sea. A two year period of assessment work, including public consultation, was finalised with the release of a governmental white paper in spring 2009 (Norwegian Ministry of the Environment, 2009). Based on the scientific assessment the Government gave notice of relevant measures and requirements to prevent and/or reduce the magnitude of negative impacts of human activities in the area.

Study area

The Norwegian Sea as covered by the Integrated Management Plan (IMP) represents a huge oceanic area; between 62 – 80 °N in latitude and between 15 °W of Jan Mayen to 15 °E (bordering the Barents Sea) in longitude (Figure 1).

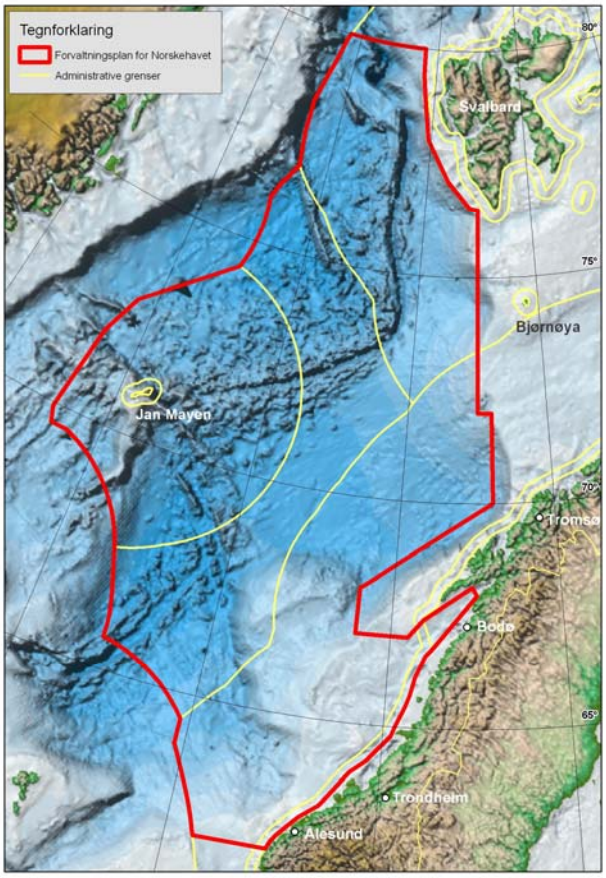

Figure 1 *Study area defined by the red line*

Approach and methodology

An assessment was made of the present situation and of realistic scenarios for 2025, and 2080 with respect to climate change effects.

As a basis for assessment and for later monitoring, several ecosystem indicators were selected. These include specific species of plankton, fish, seabirds and marine mammals as well as benthic and shoreline habitats. Local socio-economic issues were also assessed including local industries, coastal culture and recreational activities.

Each ecosystem indicator was assessed with regard to pre-defined effect parameters and for all relevant human activities/sectors (fisheries, petroleum activities, sea transport, offshore energy generation, *etc.)* as well as external pressure on the area (land based sources, long range pollution, climate change *etc.).* Effects were measured against common denominators, for example population trend, biomass, affected area, *etc*. The scoping documents presenting the planned aspects for assessment were subject to public consultation and valuable input was received.

Baseline data was constituted by existing data following scientific monitoring of the area through several decades. No new field data was collected for the IMP assessment.

The first step of impact assessment was carried out per sector, assessing each indicator and effect parameter. This assessment also covered unplanned events (*i.e.* risk assessments). Available tools and methods were applied as part of the assessment however expert judgement formed an important part of the work. The results were subject to public consultation.

A pre-defined impact scale was applied in order to facilitate cross effect parameter evaluation and further to enable the successive cross sector cumulative assessment. The scale spanned from "insignificant" to "catastrophic" effects (see Table 1).

Table 1 *Scale for evaluating cumulative effects.*

		EFFECT				
CRITERIA	***? / IR***	*Insignificant*	*Minor*	*Moderate*	*Major*	*Catastrophic*
Criteria for evaluating cumulative effects	? Considerable lack of knowledge – unable to predict effects IR Not relevant (no effects and/or no exposure)	No harm on ecosystems	Minor instances of ecosystem damage that could be reversed.	Isolated but significant instances of ecosystem damage that might be reversed.	Severe loss of environmental amenity and danger of irrecoverable damage on the ecosystem.	Major widespread and irrecoverable damage on ecosystems

The assessment results further consisted of expert evaluations of knowledge level and uncertainty in the impact assessments. When the knowledge base was considered too weak no impact assessment was performed. The knowledge base has not given the opportunity for assessing potential synergistic or antagonistic effects. The cumulative effects assessment was subject to a public consultation meeting including key national and local politicians.

Cumulative effects of human activities and external pressure

Generally all human activities in the Norwegian Sea are concentrated in the coastal and shelf areas along the Norwegian coast and some 300 km offshore. Hence impacts of human activities outside this area are limited. The exceptions are impacts related to global climate effects and long-range pollution transport. The main areas of activity and the most ecologically valuable areas identified are presented in Figure 2.

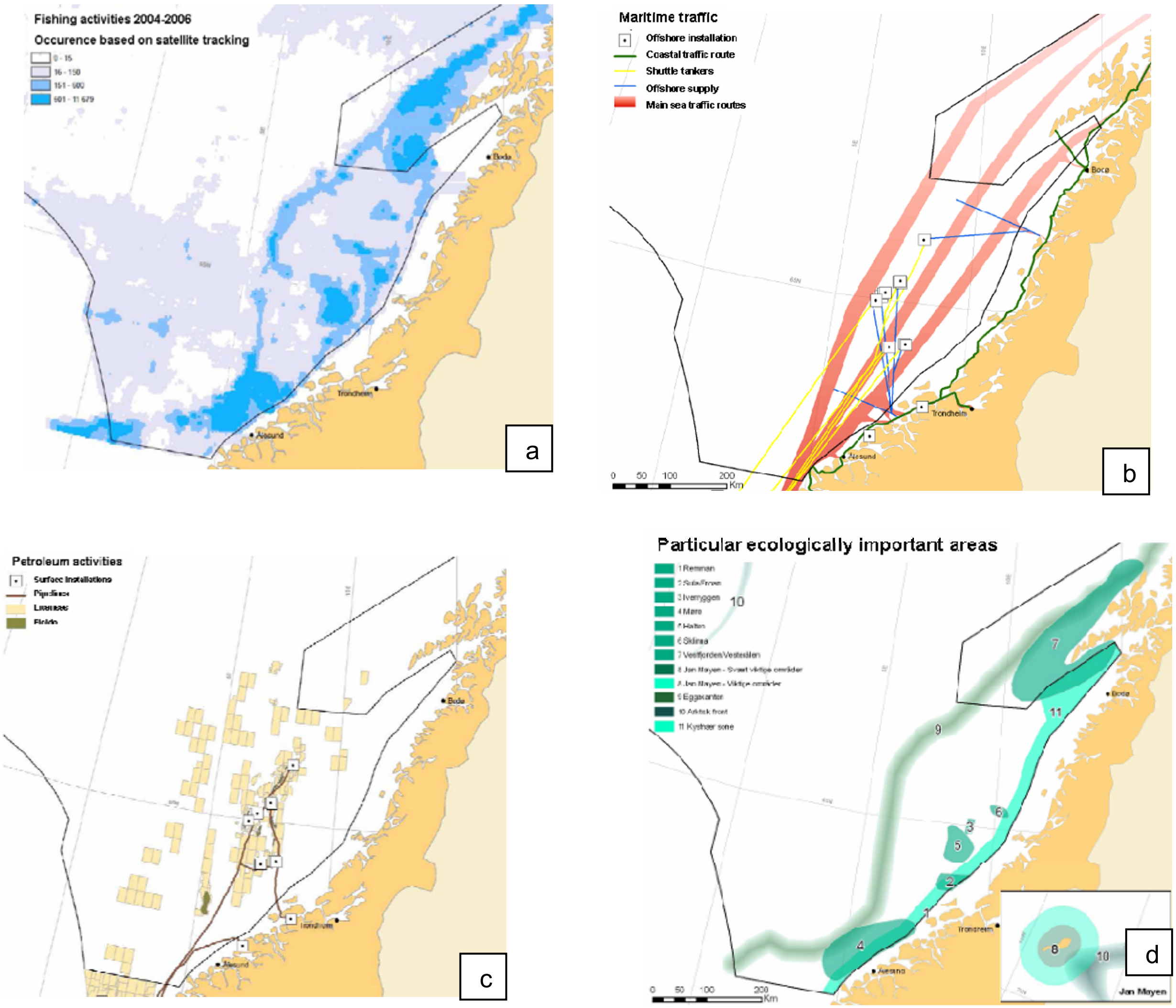

__Figure 2__ Areas of highest importance for human activities: a) fishing, b) maritime traffic, c) petroleum, and e) ecology (biodiversity and biological production).

No impact has been designated as “catastrophic”, either for today’s situation or for the future. This is valid for all scenarios considered both with regard to planned activities and possible accidental discharges.

For the present situation assessment (2006) cumulative effects within the “major effects” category are identified for cold water corals (30 – 50% assumed possibly damaged) and sponges, several fish species (blue whiting, mackerel, coastal cod, halibut, redfish, tusk and salmon) and some marine mammals (harbour seal and porpoise locally in Vestfjorden). Corals are mainly damaged due to fishing gear, particularly bottom trawling. Occurrence of corals in the area is presented in Figure 3. Exploitation through fishing, including by-catches, is the main reason for

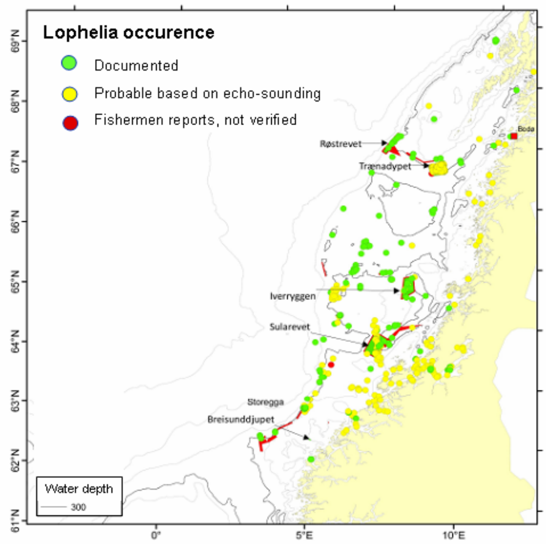

__Figure 3__ Lophelia occurence in the Norwegian Sea.

the fish population effects. Fishing primarily affects the size and demography of the target fish population. In addition it indirectly affects predator and/or prey species. Marine mammals' effects are mainly due to by-catch during fishing but also active hunting with regard to the seal species. External pressure (aquaculture) is the main contributor to the effects on salmon. The contribution from the maritime and offshore petroleum activities is generally ecologically insignificant during normal operations (mainly spatially limited impacts). However, they have a risk contribution. In the 2006 situation, impact potential of oil spills in the "major effects" category has been identified for the coastal zone and some of the particular ecologically important areas, mainly due to maritime traffic and petroleum activities for some areas. The probability for accidental events posing such impacts potential is very low however. A similar risk picture is considered likely for 2025 due to changes in activity level and despite of certain measures likely to be implemented.

Impacts on seabirds due to human activities are considered in the "moderate effects" category in the 2006 situation, however with a high uncertainty. For the 2025 situation the uncertainty is considered too high to assess potential impacts on seabirds. Due to negative population trends for several seabird species, special attention is given to further mapping and monitoring in order to better understand the impact picture and implement appropriate measures.

In the period till 2025 stronger acidification effects are considered likely, due to climate change mechanisms. This will likely affect the entire ecosystem and even more in the 2080 scenario. Main effects will be on plankton, fish eggs and corals but also fish populations and higher trophic levels. For the 2080 situation it is considered likely that the acidification effect may have impacts on plankton, corals and plankton feeding fish (herring) in the "major effects" category. Effects on fish stocks are considered likely to be reduced in the future due to improved fish resource management. This may also positively reduce the negative impacts on habitats, and on other species due to less by-catch.

Even though the assessment process has identified certain negative impacts on specific ecosystem components the Norwegian Sea ecosystem is considered to be in good shape. This is because the pollution situation is very good and both the ecosystem productivity and other main ecosystem functions are intact. No impacts are identified within the "catastrophic effects" category and only a limited number within the "major effects" category. Hence the situation is still in a reversible state where restitution is possible with appropriate management. Most impacts from human activities in the Norwegian Sea on the particular ecologically important areas can be managed on a national level by implementing appropriate measures. However, to meet the main challenges, international effort is necessary in order to sustain the area as a healthy ecosystem.

Annex 4 – Executive Summary of the Report "Cumulative Assessment – case study – the Dutch EEZ"

This Annex summarises the methodology and results of the Dutch EEZ case study, according to the status of 16 January 2009. The report was prepared by IMARES (Wageningen-WUR/Institute for Marine Resources and Ecosystem Studies; C089a/08 – January 2009).

Methodology

The basic approach of this cumulative effects assessment (CEA) is schematically represented in Figure 1. It assumes that effects are a function of the intensity of pressures caused by activities and the sensitivity of ecosystem components to those pressures. A tiered approach is used for the CEA:

1. Scoping, scoring and cumulating;
2. Geographic distribution;
3. Temporal variability.

Tier 1

The first tier is following a worst case approach, assuming that all activities and all ecosystem components overlap in time and space. This tier consists of three steps: scoping, scoring and cumulating.

Scoping

This includes the identification of the ecosystem components, pressures and activities relevant for the Dutch EEZ. A comprehensive matrix presented by the United Kingdom in OSPAR (Connor 2008) has been used as the basis for this process. It comprises of an extensive inventory of activities, impacts and ecosystem components relevant for the UK CS. The content of the matrix was transferred to a Microsoft Access database for easy selection and filtering. Expert opinions were used to identify relevant subjects for the Dutch EEZ. The use of expert opinions is a common approach in CEA (Halpern *et al.,* 2007, Halpern *et al.,* 2008, Rijnsdorp & Heessen 2008). To facilitate the process, an expert workshop was set up (Utrecht, June 11 – 12, 2008). The results, including a brief discussion, are described by (Karman 2008). It is noted that results based on expert opinion should be interpreted with caution, as they may be influenced by the specific expertise of participants (Karman 2008). Nevertheless, it proved to be an efficient way of collecting a lot of information (*i.e.* expert judgment) in a short period of time.

Scoring

After determining the scope of the CEA for the Dutch EEZ case study, the Dutch workshop provided a (preliminary) assessment of priorities. The intensity of pressures from relevant activities and the sensitivity of ecosystem components to those pressures were judged by the experts, according to the classification in Table 1. Each class was then represented by a score, in order to be able to cumulate the effects. The scale was determined as follows: According to the data specifications and the description of measurement scales (Stevens 1946, Wolman 2006), the data are to be classified by the ordinal scale (*i.e.* isotonic or order- preserving group). This includes any monotonic increasing function. For this CEA, the ordinal numbers 0, 1, 2, 4 and 8 are used[4].

[4] Transformations should preserve the order of the data (Wolman 2006). Transformation of the data involves multiplying the intensity of the pressure by the sensitivity of the ecosystem component. In order to avoid additional weighing by the transformation process, the ordinal numbers 0, 1, 2, 4 and 8 are used. Multiplying the data on this scale, results in eight different combinations, instead of ten combinations when using the common scale of 1, 2, 3, and 4.

Table 1 *Classification used within the CEA of the Dutch EEZ.*

Classification for sensitivity of ecosystem components and intensity of pressures	Score used in the CEA
none	0
marginal	1
limited	2
considerable	4
high	8

Cumulating

With the identification of the relevant ecosystem components, pressures and activities, including weighing and scoring, the 'building blocks' of the CEA are developed (Figure 1). Next step is the integration of these building blocks.

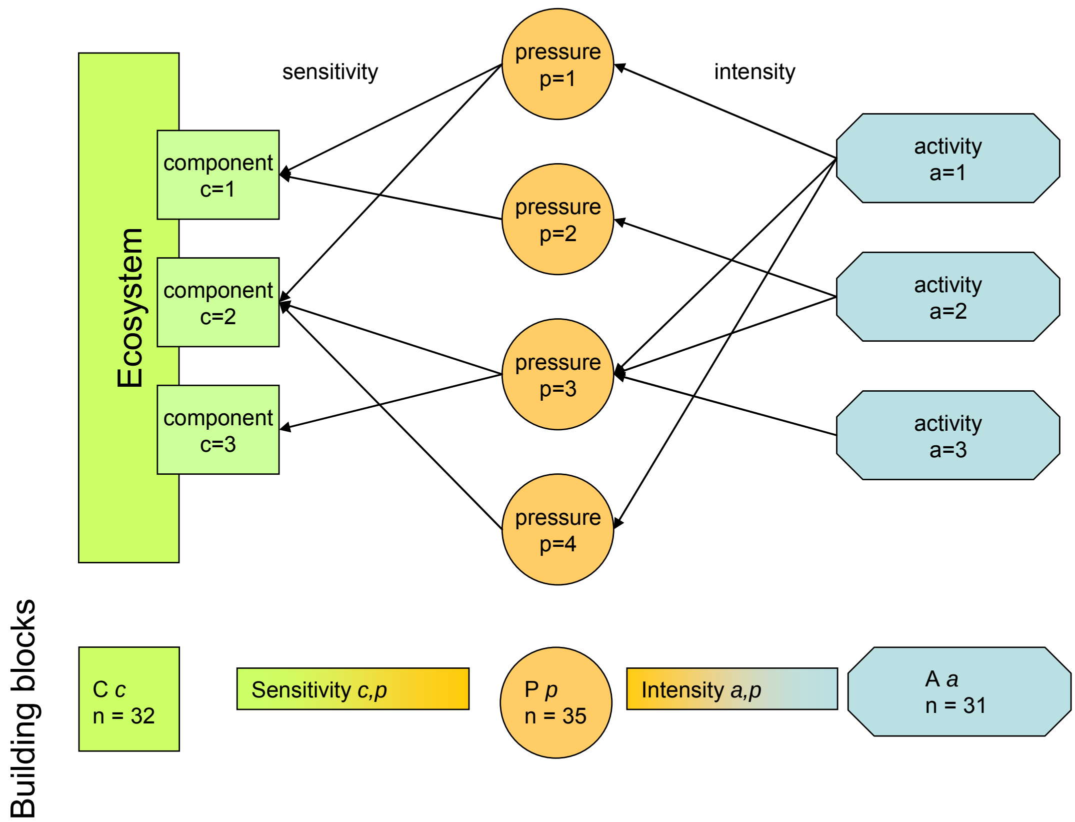

Figure 1. *Building blocks of CEA*

The total score for cumulated effect, or Cumulated Effect Score (CES), can be assessed per ecosystem component (c) or activity (a) and is calculated as follows, respectively:

$CESc = \sum_{1,p} (\text{Sensitivity}_{c,p} * \sum_{1,a} \text{Intensity}_{p,a})$

$CESa = \sum_{1,p} (\sum_{1,a} \text{Intensity}_{p,a} * \text{Sensitivity}_{c,p})$

Note that the spatial and temporal scales have not yet been included (first tier).

Tier 2

As a second tier in our CEA case study, the geographic distribution of the activities, pressures and ecosystem components is implemented in GIS (Geographical Information System). In order to do so, the following steps and assumptions are made:

1. A vector grid covering the Dutch EEZ with a cell size of 4 km2 is used as a basis;
2. The activities that occur on the Dutch EEZ are located on this map (at this stage of the development, a sub-set of data is used[5]). It is assumed that an activity occurs continuously (*i.e*. whole year around);
3. Based on information from the database, the distribution of pressures per activity is derived. The intensity per Activity x Pressure combination is presented in Table 2. Specifically for dispersive pressures (for example, toxicants and noise) a simplified approach was used as detailed information is not readily available. A resolution of 2x2 km blocks was used to map the pressures;
4. This step is to map the ecosystem components of the Dutch EEZ that are to be included in the assessment. The initial intention was to use the ecosystem components as identified in the matrix. However, the level of detail of the ecosystem components as identified in the matrix and 'scored' in the expert workshop does not comply with current available GIS data. An extensive set of up-to-date GIS maps recently became available with the publication of the 'Ecologische Atlas Noordzee' (Ecological Atlas North Sea) in October 2008 (Lindeboom *et al.,* 2008). This data is used to map species or species groups, which represent the ecosystem components;
5. The map of cumulated pressures is combined with the map with the ecosystem components. With use of the information from the database, the Cumulated Effect Score (CES) per ecosystem component or activity is calculated.

Table 2 *Matrix showing the intensity score per activity–pressure combination, selected from the database to be included in the case study (0 = none; 1 = marginal; 2 = limited; 4 = considerable; 8 = high).*

Activity	Habitat structure changes - removal of substratum (extraction)	Habitat structure changes - abrasion & other physical damage	Habitat Change - to another substratum	Under Water Noise Disturbance	Visual disturbance	Pollution and other chemical changes	Temperature changes - regional/nation	Removal of target species	Removal of non-target species
Offshore Wind Turbine Parks (present)	0	0	***8***	**4**	***8***	1	0	0	0
Offshore Wind Turbine Parks (future)	0	0	***8***	**4**	***8***	1	0	0	0
Offshore Oil & Gas	0	0	***8***	*2*	***8***	**4**	0	0	0
Fishing - Benthic Trawling	0	***8***	0	**4**	*2*	1	0	***8***	***8***
Shipping	0	0	0	***8***	**4**	*2*	0	0	0
Beach replenishment	0	***8***	0	**4**	***8***	1	0	0	0
Extraction - Sand	***8***	**4**	1	*2*	*2*	1	0	0	0
Extraction - Nav.Dredge	1	1	1	**4**	0	**4**	0	0	0
Cables & Pipelines	0	1	0	1	0	1	0	0	0
Tourism/Recreation (beach)	0	1	0	0	0	1	0	0	0
Pollution (land-based)	0	0	0	0	1	***8***	0	0	0
Energy Production on land	0	0	0	0	0	1	**4**	0	0

[5] A sub-set of data is used to focus on the issues that are thought to be most significant. From all activities and impacts that were identified during the workshop, 12 activities and 9 pressures are selected because they were judged as being the most important activities and impacts (with high scores).

Tier 3

A third tier assessment could be applied to account for time dependent variability (for example seasons for presence of certain species or activities). The implementation of the aspect of time in the assessment has not yet been included in the Dutch case study. When the aspect of time is disregarded, a short term disturbance caused by the noise of a passing ship for example, could have the same effect as the long term disturbance caused by noise from an offshore wind-farm. Including time will thus further refine the CEA.

The following steps are potential elements of the third tier assessment.

- Temporal distribution of activities and ecosystem components:
  Determining the presence of activities and ecosystem components in time will refine the assessment, *i.e.* reduce overestimations of effects;

- Recovery of ecosystem components:
  The recovery of the ecosystem component is not included in the second tier assessment. During the expert workshop, the expected effect of pressures on ecosystem components was also expressed in terms of resistance (potential of a component to withstand the pressure of an impact) and resilience (potential of a component to recover from the effect of exposure to an impact). This data could be used in the third tier to refine the CEA;

- Population models for selected species:
  Both resistance and resilience (see previous bullet) could be included in the assessment using population models for species that are identified in the 2nd tier assessment to be significantly affected;

- Spatial and temporal distribution of pressures:
  In the second tier assessment, the spatial and temporal distribution of pressures is disregarded. It is assumed that the pressure occurs within the grid cell of its source (*i.e.* activity). The CEA could be refined by including a variance in intensity of pressure with distance to its source and time;

- Intensity:
  In the second tier assessment the intensity of activities is not explicitly included. Including the intensity of activities will mainly have consequences for mobile activities, such as shipping and fishing. For activities that are related to offshore constructions, such as oil and gas production and wind-farms, it will either be negligible or not relevant.

Results

At present, a second tier CEA has been applied to the Dutch EEZ. Figure 2 reflects the (collective) pressures of activities on the Dutch EEZ. The southern part of the Dutch EEZ shows the highest collective pressure. Abrasion and other physical damage to the seabed and underwater noise are present in the highest intensities.

To provide information on the geographical distribution of ecosystem components the following maps were made available from Lindeboom *et al.*, 2008: benthos biodiversity map, fish biodiversity map, birds valuation map, and distribution maps for Harbour porpoise (*Phocoena phocoena),* Common seal (*Phoca vitulina*) and Grey seal (*Halichoerus grypus*). These maps are reproduced here as Figure 3. Please note that the biodiversity maps for benthos and birds have been adapted. By assigning the values from the locations as shown in Lindeboom *et al.*, 2008 to the polygons as shown in the Benthos cluster map from the same source, these maps have full cover for the Dutch Continental Shelf. A similar process was not available for the Bird distribution map, as a result of which the Cumulative Effect maps for Birds are not a full cover either.

The sensitivity of an ecosystem component is represented by the biodiversity value (Figure 3) multiplied by the sensitivity score, as previously described. These intermediate results are not shown in maps, but areas with high diversity thus result in higher sensitivity scores.

The final step in the process involves another set of multiplications: Sensitivity score of a ecosystem component for a possible impact multiplied with the total pressure exerted by that impact. Finally these results are summed across all pressures yielding a Cumulative Effect Score for that ecosystem component (see Figure 4).

Conclusions and recommendations

The cumulative effects assessment (CEA) methodology developed for the Dutch EEZ case study assumes that effects are a function of the intensity of pressures caused by activities and the sensitivity of ecosystem components to those pressures. A tiered approach is used. The first tier involves scoping, scoring and cumulating, and results in a Cumulative Effect Score (CES) per ecosystem component or activity.

The quality of the data, originating from an expert workshop, is considered moderate, because of a limited number of experts and a lack of clear definitions. A validation of the results with an assessment based on literature (*i.e*. RAM) shows a comparable ranking of at least the most important activities. It can therefore be concluded that the case-study, using a semi-quantitative approach using expert-opinion, complies in general with available knowledge from literature.

The second tier involves geographic distribution in GIS with a sub-set of data to focus on the main issues. As a simplified approach, the probability of occurrence is not included. Further, the distribution of species is based on recent observations, while these may already be influenced by activities in the area. The assessment would improve from using the potential distribution of species, based on habitat suitability.

Results show that the southern part of the Dutch EEZ has the highest collective pressure. Abrasion (and other physical damage to the seabed) has the highest intensity, mainly caused by (beamtrawl) fishing. The cumulative effect of pressures has been assessed for benthos, fish, birds, cetaceans and pinnipeds, identifying abrasion, removal of non-target species and noise as important pressures.

An overall map of CES is not presented, since the tier 2 assessment is based only on a subset of pressures and ecosystem components, which easily leads to misinterpretation of the results. It is therefore recommended to do a follow-up of this case-study, including all relevant pressures and ecosystem components.

A third tier assessment is recommended to be implemented in the CEA methodology, to account for time dependent variability. This could include temporal distribution of activities and ecosystem components and the recovery of ecosystem components. Furthermore, the spatial and temporal distribution of pressures, which is disregarded in the second tier, could be implemented. It is to be expected that a 3rd tier assessment makes use of population models for selected key species. Adding a third tier to the CEA methodology will refine the assessment.

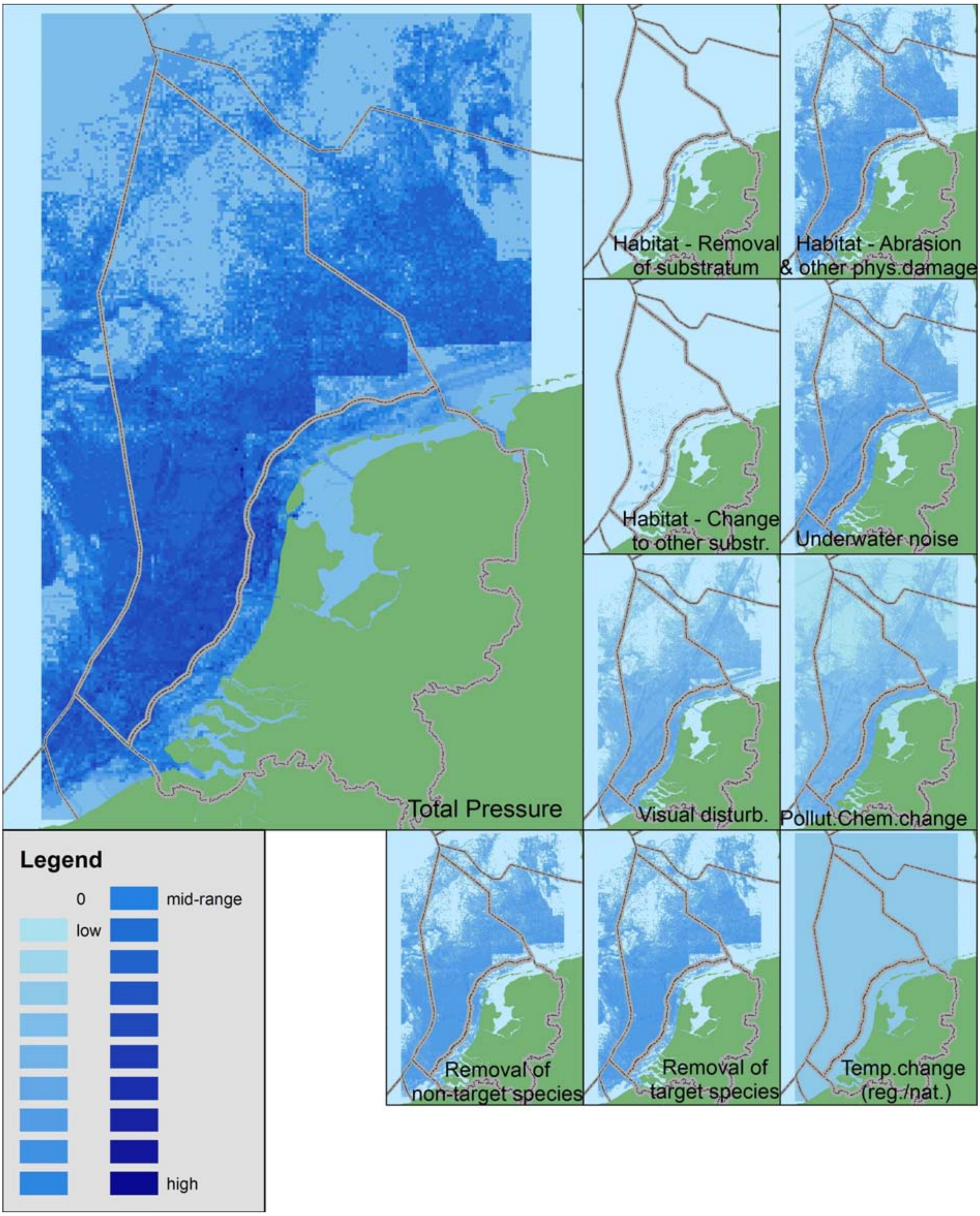

Figure 2 *Intensity of pressures of selected activities, presented per pressure (small pictures) and cumulative pressure (total impact).*

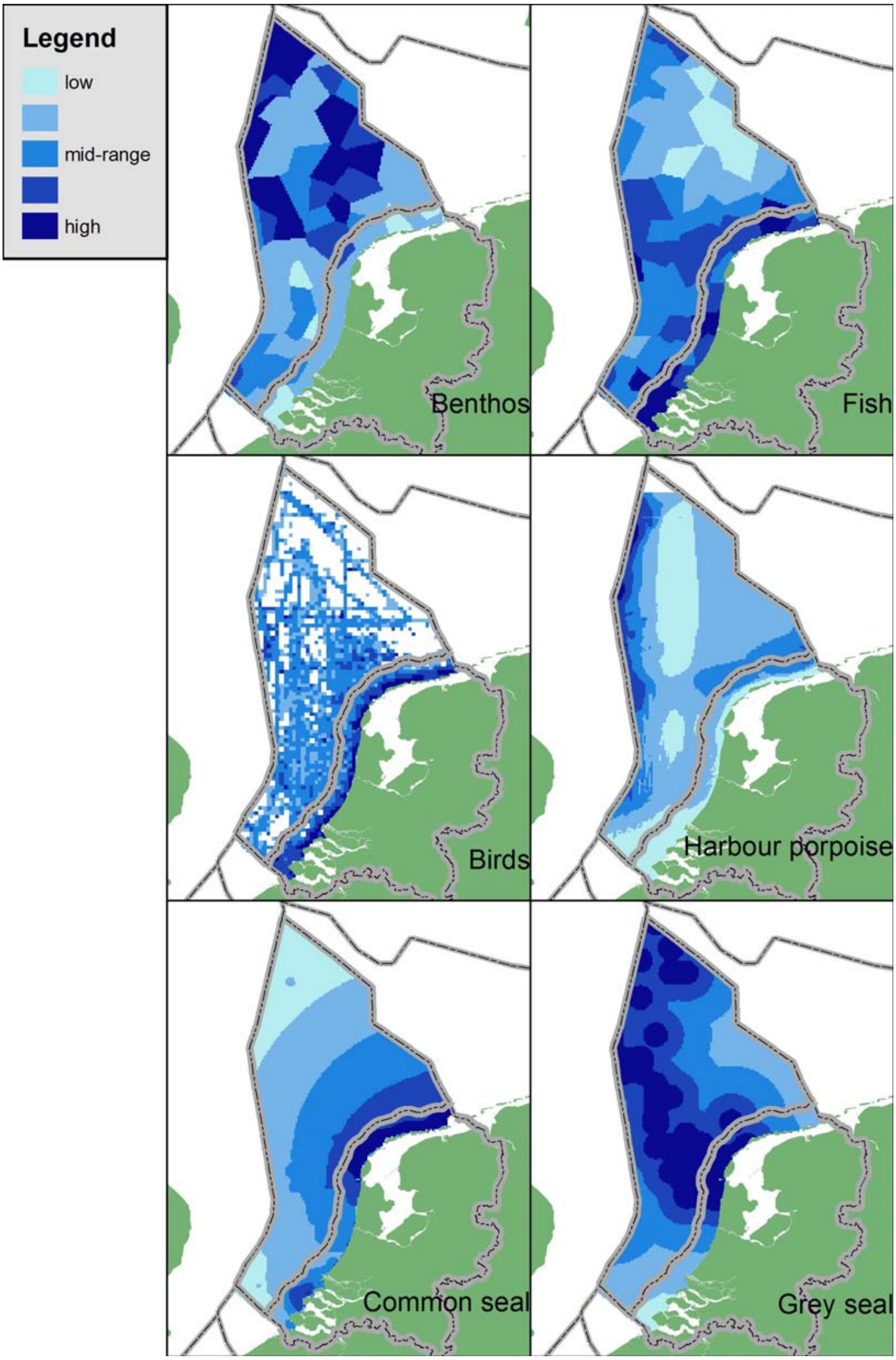

Figure 3 *Distribution of Ecosytem Components: Benthos, Fish, Birds, Harbour porpoise (Cetacean), Common seal and Grey seal. Modified and reproduced from Lindeboom et al., 2008.*

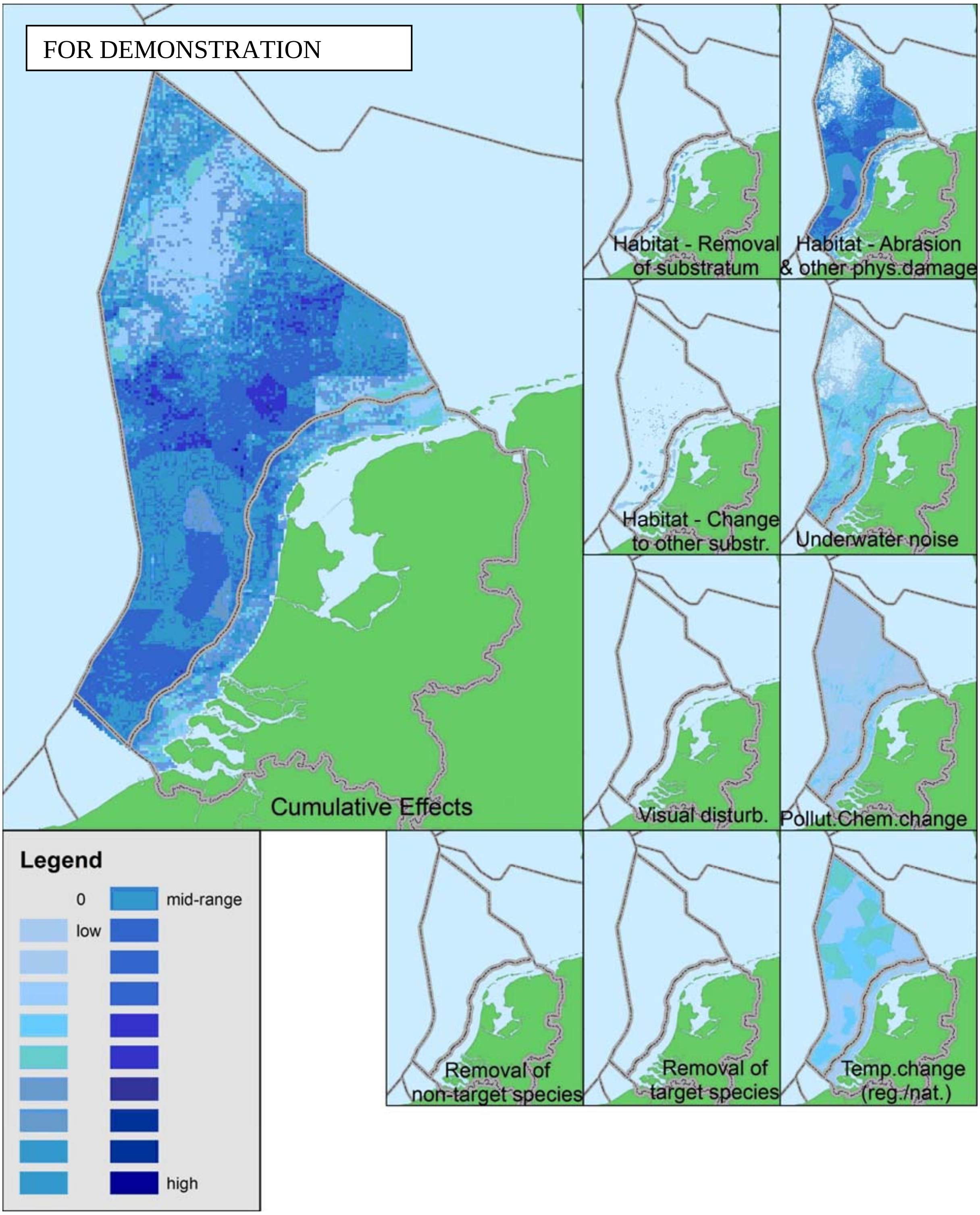

Figure 4 *Demonstration of the Cumulated Effect Score (CES), a relative indicator for the cumulative effect of pressures on species and habitats of the Dutch EEZ (a higher score represents a higher intensity of cumulative effect). As the figure is for demonstration purposes only, the reference to the specific species on which this figure is based has been removed.*

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

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